Proceedings

Ministerie van Volkshuisvesting,
Ruimtelijke Ordening en Milieubeheer

International Conference Sustainable Building 2000

Proceedings

22 -25 October 2000
Maastricht, The Netherlands

International Conference Sustainable Building 2000,
22-25 October 2000, Maastricht, The Netherlands.

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Editors
Chiel Boonstra
Ronald Rovers
Susanne Pauwels

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Novem International

Novem's international work mainly focuses on exchanging knowledge, learning from other countries' experiences, harmonising approach to policies, legislation and measures, the development of a long term vision and a common environment for assessment of sustainable building.
For this we are (co-)operating in many international networks and organisations, mainly in assignment of the Dutch government, and partly in contract of international organisations, as EU, IEA, UN, World Bank. Hosting the SB2000 conference creates a perfect momentum to proceed on these work areas, to establish new co-operations and target for international platform to work on a more structural and harmonised basis towards Sustainable Building.
sustainablebuilding@novem.nl

Contributors

The conference
The main aim of the International Conference Sustainable Building 2000 is to exchange knowledge, bring together all those involved in sustainable building and develop common directives for developing and implementing sustainable building at all levels (policies, measures, assessment methods, design guidelines and product management. The areas to be addressed include urban sustainability, sustainable buildings, construction and services, product development and recycling.

Partners
The conferences is a combined follow-up of earlier CIB W-100 and Green Building Challenge conference with an extended scope provided by the hosts Novem (Netherlands agency for energy and the environment), and VROM (Ministry of Housing, Spatial Planning and the Envirorment in the Netherlands).

Rockwool joined the conference as main sponsor. Rockwool is a world-wide leading manufacturer of stone wool insulation materials. Apart from the fact that their product is a basic material in reducing CO_2 emissions in buildings, the Company is very active with sustainability in their production processes. Rockwool will be present at the conference with an exhibition stand, showing examples of sustainable building from all the countries in which they are active. Co-sponsor ENCI (cement production) will highlight managing of sustainable production, focussing on resource management and landscape planning, and among others offer visits to their production plants in Maastricht. Co-sponsor Kone int, (elevators), key element in the preferred reuse of older buildings, is very active with energy efficiency of elevators, which became a main energy user in very energy efficient buildings. Co-sponsor SBR acts as the research group for the building industry, and is deeply involved in developing sustainable building practise and innovation. The Netherlands association of building product manufacturers (NVTB) is also a co-sponsor. Together they represent the production industry and have initiated standard product sheets with environmental information based on LCA's, known as MRPI.

Supporters
The conference and organisation have also been made possible by a large number of 'Supporters'. Many organisations have assisted by distributing news items, attracting members, and contributing to the programme by organising a workshop or excursion. These include:
IEA, ACE, UIA, EU OPET, ISCOWA, iiSBE, REHVA, OECD, wgbc, FIEC, Æneas publishers.

The organisers wish to thank all the aforementioned organisations, the members of the Advisory Committee and Programme Committee, and everyone else who contributed to the realisation of SB2000 and, not least, contributed to the progress made in the international exchange and development of Sustainable Building visions and directions, which mark the start of a sustainable building era.

Organisation

The International Conference Sustainable Building 2000 is a joint Conference of CIB/GBC and the hosts, Novem: Netherlands agency for energy and the environment, and the Ministry of Housing, Spatial Planning and the Environment in The Netherlands. The Conference Board administrates the activities of the different committees and is advised and supported by the Advisory Committee of Participants.

The Conference Board

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Preface SB2000 proceedings

The International Conference Sustainable Building 2000 (Maastricht, 22-25 October 2000), marks the changes in construction markets throughout the world. Buildings have a considerable life span, and mankind spents substantial time of their lifes inside buildings. Decisions about building design, construction, use, maintenance, renovation, demolition and re-use and recycling of buildings have an impact on the sustainable development of our societies. SB2000 not only addresses technical aspects and latest findings in research, but also policy issues and marketing aspects of sustainable building, cities, buildings, construction technologies, building services and environmental assessment systems.

Sustainable Building 2000 (SB2000) combines two previous series of conferences into one:
CIB W-100 Buildings and the Environment (Watford, 1994 and Paris, 1997) and Green Building Challenge (Vancouver, 1998). It is encouraging to see that SB2000 has attracted contributions from 45 countries all over the world, covering a diversity of approaches and views on possible ways towards a sustainable development.

The SB2000 Programme Committee had the tough job to develop an attractive program that acknowledges the richness of the contributions, and focuses on the latest developments. As it was not possible to schedule over 300 oral presentations within the limition of a three days conference with six parallel sessions, the Proceedings include all submitted papers, irrespective whether they were presented as oral, poster or as exhibition item.

I want to thank the members of the Programme Committee for their active role in the review process: Ilari Aho, Federico Butera, Ray Cole, Drury Crawley, Peter Droege, Huib van Eyk, Anne-Grete Hestnes, Jaap Hogeling, Piet van Luijk, Nigel Howard, Jaap Kortman and Anil Laul. I am also grateful to the Conference Organizing company van Namen Westerlaken who collected and registered all contributions. I should also thank Ronald Rovers for his creative management approach in elaborating the Conference Organization.

Does SB2000 contribute to a sustainable development? Will it be possible to achieve ambitious emission goals? At least, SB2000 provides a worldwide platform to learn and exchange a variety of experiences and results, that create a basis for common interests and programs. I hope these Proceedings shall be of value to many of you.

Chiel Boonstra
SB2000 Program Committee Chair

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Jef Pleumeekers,
Director Netherlands Agency for energy and the environment, Novem .

fragments of Opening adress and Welcome

Ladies and Gentleman,

welcome,
………………

ladies and gentleman,

<u>Welcome to the land of polder models.</u>

The Polder model, as practised here in the Netherlands, is the concept of close co-operation between all parties involved in the realisation of targets, whether these targets are economic or environmental. In agreements between government, market parties and intermediate organisations such as Novem, decisions are made about the route to follow, the speed at which to proceed, and the targets that are to be met. In our country this works out very well. It creates awareness, wide support and many carriers of the message in the short term, which is a basic need in order to prepare society for major changes in the long run. Maybe, by hosting this conference in Maastricht, we will be able to practice the Polder model internationally as well. In three days of intensive co-operation much can be achieved, both in the understanding of each other's specific problems and in the search for a common approach to solutions. We hope of course that you are as dedicated as we are in creating this joint route for the years to come.

The first steps on this route have already been made by the iiSBE. The next days will see the follow-up to this.

Ladies and Gentleman, what we also love here in the Netherlands, and certainly in the building sector, are demonstration projects. In the building sector, seeing is still the basis for believing, and is thus of major importance in the introduction of new developments. As such demonstration projects are a basic instrument for progress in sustainable building, as well as in sustainable living and working.

We have shown this in the past with Ecolonia, and recently with a large series of small projects, and we want to do so again in the near future with a successor of Ecolonia. This project will be developed according to the latest visions, anticipating the requirements for a factor 10 or 20 improvement in sustainability, and will be focussed on the existing building stock. We will keep you informed.

Within the GBC process demonstration projects are central elements that will be covered by many presentations over the next three days, and are key elements in the posters in the National pavilions. But the demonstration project in itself is not necessarily the key. Within the demonstration project, I want to say that Architecture plays a vital role, both from the aesthetic and the social point of view. I am therefore very pleased that we will have a large number of architects participating, including from the UIA, more specifically the working group 'architecture of the future'. Tomorrow they will try to build a bridge between three important strands: the scientific, the social and the aesthetic approach.

The third and last point I would like to make is the marketing of Sustainable Building. This part is of immense importance, but it is just a small part of the Conference. I hope that in your discussions and plans for the future this subject will play a major role, because without a market for sustainable building, there will be little progress. Recent research has shown that agencies for change and knowledge transfer are key elements in the diffusion of Sustainable Building developments, and in achieving actual and broad implementation. I think that developing a mature and effective framework for this will be a task for this conference in the years to come.
………….

…………..
On behalf of all parties involved and of Novem,
I wish you a fruitfull conference.

23-10-2000

OPENING ADRESS OF MR. J.W. REMKES, DUTCH STATE SECRETARY OF HOUSING, SPATIAL PLANNING AND THE ENVIRONMENT AT THE INTERNATIONAL CONFERENCE SUSTAINABLE BUILDING 2000

Ladies and gentlemen,

I would also like to bid you a warm welcome to the Netherlands. And more specifically to Maastricht, a lively city with a rich history. I hope you managed yesterday to see some of what Maastricht has to offer.

It gives me great pleasure to open this international conference. More than seven hundred experts from more than thirty countries are gathered here to talk about their experiences with sustainable building. And there will be three hundred contributions from forty five countries spanning all five continents. Sustainable building is clearly a matter of worldwide concern.

Sustainable building goes back a long time. Just look around the centre of this city. It was built to suit the needs of residents past and present, Its buildings can be used for many different things, and adapted to the needs of present and future users. They have been around for a long time, and will be with us for many years to come. In other words, they were built sustainably before the concept even existed.

Sustainable building in the Netherlands Ladies and gentlemen,

In this presentation I should like to tell you something about sustainable building in the Netherlands. Sustainable building in its more modern form began in this country in the nineteen seventies. The government began to show renewed interest in the interior environment and its effects on health. The energy crisis turned our attention to energy conservation. And so the concept of sustainable building broadened.

In nineteen-ninety sustainable building gained a permanent place in Dutch national policy. And in nineteen ninety-five the government launched its first sustainable building programme. The market has taken up the challenge, and sustainable building is now on track. We are now ready for the next step: broadening the policy and putting it fully into practice. The Sustainable Building Policy Programme 2000-2004 is designed to do this. The policy is expanded to the entire built environment, rather than just individual buildings. And sustainable building is set to become a quality issue.

Sustainable Building Policy Programme 2000-2004 The programme should stimulate policy in three areas. Firstly, energy. The Netherlands' commitment to reduce greenhouse gas emissions will require extra efforts from the construction industry, particularly when it comes to the existing housing stock. This is why we have introduced the voluntary Energy Performance Advice scheme. This advice is designed to help and stimulate house owners to take energy saving measures in their houses. Furthermore, the Dutch government also wants to stimulate solar energy. From next year on, house owners can get subsidies for the purchase of solar panels.

Secondly, sustainable urban planning. In this area, developments in urban regeneration should allow us to take major steps forward. Actually, the progress is being made already, taking sustainability into account as one of the relevant aspects.

Thirdly, consumers - those who live in and use buildings. Due to economy growth, people are demanding higher and higher standards. There is great potential in combining sustainable building with other aspects of quality, such as comfort and proximity to green spaces and water.

The policy programme includes an implementation programme for 2000 and 2001. It consists of a number of projects that will be carried out in close collaboration with the market. The three areas I just mentioned, will be particular focuses of attention. Knowledge will also be a key focus area. Current activities designed to support the application of knowledge will be continued and stepped up, as will support for pioneers of sustainable building.

Throughout the development of sustainable building in the Netherlands, close interaction between the government and the market has been the watchword. Without the help of the construction industry, we would never have come this far. And it is encouraging to see that other parties, including nature conservation groups and environmental groups, like the World Wide Fund for Nature, also actively support the policy.

The Netherlands has deliberately chosen to move step by step away from traditional and towards sustainable building. We have already achieved a great deal. Sustainability has now become an integral part of the quality of a building.

But we still have a long way to go. Sustainable building has to become more than technical measures applied to individual buildings. It has to become part of the quality of both the building and the surrounding environment.

Factors for success

Three factors will determine our success or failure. Firstly, sustainable building has to respond to trends and consumers' wishes - for comfort, a good investment, and liveability. Local authorities and private clients will have more and more responsibility in the future. They, too, are important players in the field of sustainable building.

We must also interpret sustainable building in a broad sense. It is about user-friendliness, comfort, adaptability, investment value, affordability and the environment. So we need an integrated approach. As well as thinking about the environment, we also have to consider the functional and social aspects. We must constantly search for the best solution in every situation, and the role of the consumer will be crucial. A broad view of sustainability is particularly important for sustainable urban planning. We have to design our homes and living environment in such a way that people will still be happy to live there in thirty years' time. Or so that they can be easily adapted to cater for future needs.

The third factor for success is good co-ordination and co-operation between all parties. The history of sustainable building in the Netherlands shows that it is not the technology that is at fault, it is the failure to make the necessary changes in our culture and in how we work. Sustainability has to become second nature. And this will take a lot of time and effort.

Here, too, central government will continue to fulfil its responsibility. Sustainable building must remain a voluntary thing, but this is not the same as freedom from obligation.

I have outlined a number of aspects that are essential to the development of sustainable building in this country, I hope they will prove useful to you.

International Conference Sustainable Building But this conference has a broader perspective. Here you will discover the wide array of sustainable building techniques used in different countries. You will discuss aspects such as energy consumption, water, materials, green spaces and health. You will learn about the different contexts that make each country different and give it its unique qualities. It is precisely from this variety that we can all learn.
Of course we also have a lot in common: instruments, product information, labelling, assessment etcetera. And that is why we must have international co-ordination. Initiatives are already under way, including the EU's sustainable construction initiative, in which the construction industry is playing a major role.

International co-ordination will also involve harmonisation and standardisation at European level. As you can see from the programme, there will be a forum debate on this subject tomorrow.

In more general terms, exchange of knowledge between countries is also vital. This conference offers a perfect opportunity for such exchange, but we should perhaps consider providing it with a more permanent basis.

'Opting for Change'
In the Netherlands, we have opted for a step-by-step transition from traditional building to sustainable building as we now know it. Many sustainable building projects were completed in the nineteen nineties.

These projects would never have happened without close co-operation between all the parties involved. This is absolutely essential if we are actually to build sustainably. The book 'Opting for Change' is to be launched at this conference. It contains a number of fascinating examples of sustainable building projects completed here in the last decade. It also shows how important the process of achieving sustainability is. Before I close I should like to thank the organisers of this conference. Without your efforts it would not have been possible for so many people to attend from so many countries, to talk about their experiences and secure a future for sustainable building.

This kind of exchange is very topical at the moment, with the forthcoming Conference of Parties to the Climate Convention in The Hague. After all, sustainable building is one of the things that will help us cut our energy consumption, thus reducing carbon dioxide emissions and helping curb the greenhouse effect.

Finally, a special word of thanks to the representatives from Japan, Canada, France and the European Union for their willingness to address the conference. It is with great pleasure that I present to them a copy of 'Opting for Change'.

Thank you.

Japanese Policy on Sustainable Building

(Paper for Sustainable Building 2000 in Maastricht, Netherlands, October 23 2000)

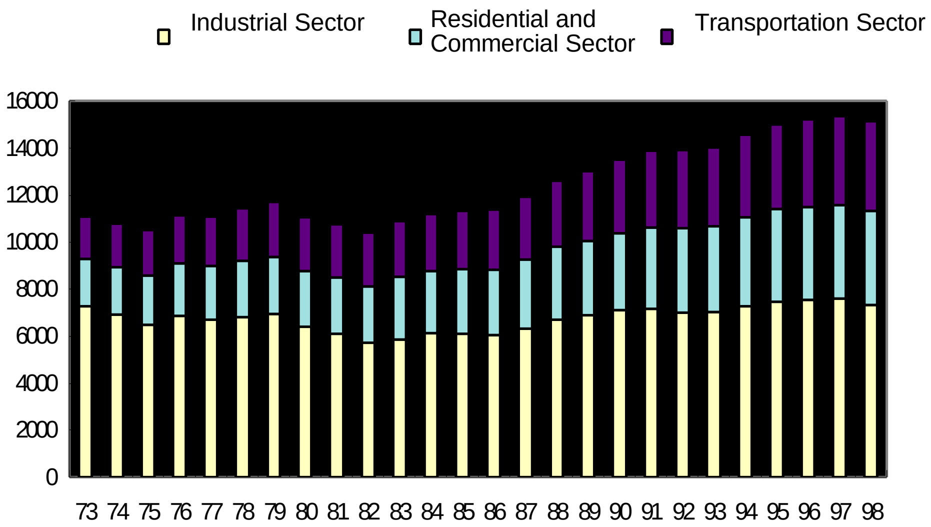
Dr. Shoichi ANDO
Director for Accessible Building, Housing Bureau,
Ministry of Construction, JAPAN

1. Energy Conservation and Climate Change

(1) Energy Consumption in Japan

- Energy consumption in Japan once decreased due to a sudden rise in oil prices when the 1st and 2nd oil crisis had occurred. However, it turned to increase at the rate of about 3 % annually in 1980's, and it shows an increasing tendency at higher rate in recent years.
- Regarding energy consumption by sectors, energy consumption by the transportation (for passenger use) sector increases at the highest rate and the residential and commercial (for household use) sector is in the second place.
- Energy consumption by the residential and commercial sector accounts for about one quarter of the total energy consumption, and its share is expanding in recent decades, from 18.1 % in 1973 to 26.4 % in 1998.

Figure 1. Trends in Final Energy Consumption in Japan



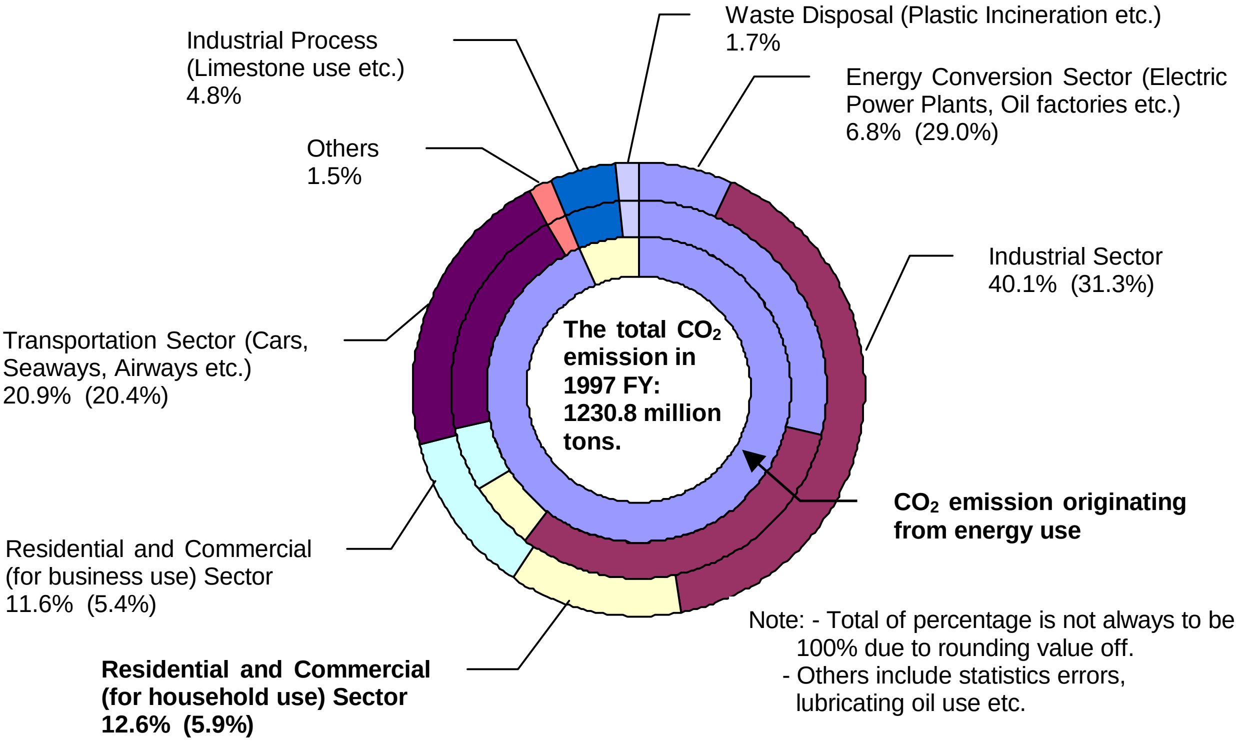
- Energy consumption by both household use and business use shows an increasing tendency. The main reasons for it are the more popularization of electrical appliances, the increasing number of nuclear families and an increasing use of hot-water supply in household, and the more popularization of office automation system in business area.

(2) CO_2 Emission

- CO_2 emission accounts for the maximum amount among greenhouse effect gases, which are thought to have global warming effect.
- As energy consumption increases, the amount of CO_2 emission shows an increasing tendency, and it increases by about 10 % in the period of 1990 – 1997.
- Regarding CO_2 emission by sectors, emission from the residential and commercial sector accounts for about one quarter of the total emission. And household sector accounts for a little more than half of it.

Figure 2. CO_2 Emission by Sectors in 1997 FY, Japan

An inside circle shows rate of actual amount of CO_2 gas emission by each sector to the total (% values in parentheses). An outside circle shows rate of CO_2 gas emission by each sector to the total, calculated on condition that CO_2 emissions from Electric Power Generation is distributed among final demanding sectors according to the amount of electric power use by sectors.



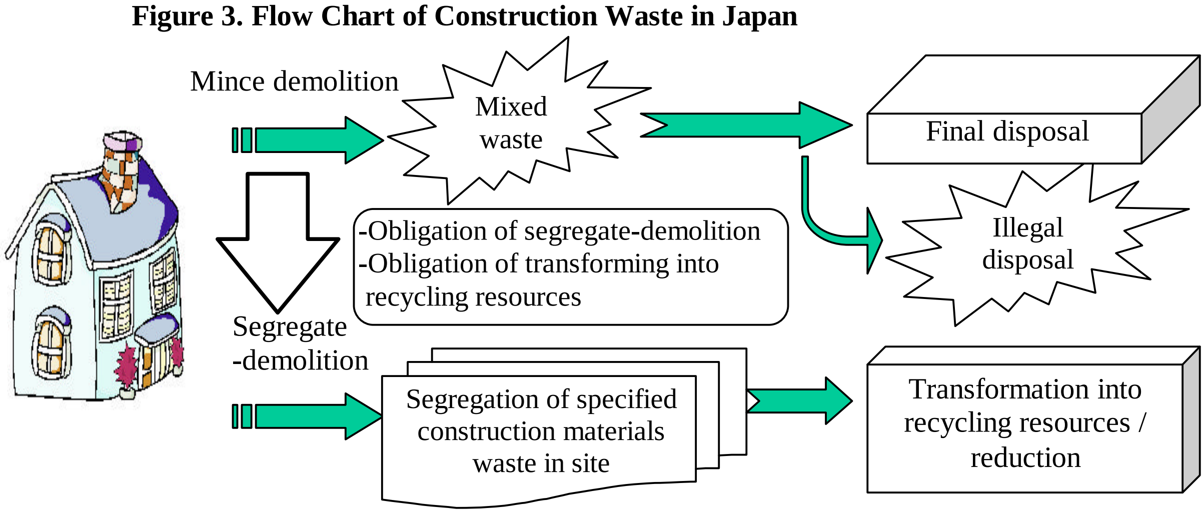
Source: Materials from the Cabinet meeting on conservation of global environment in July 1999.

2. Resource Use and Waste Disposal

(1) Resource Consumption in Japan

- Building industry uses 50% of resource used in all industry as building materials.
- The construction waste released from construction works occupies 20% of the waste amount released from all industry and 40% of the final disposal amount.
- According to the research by the Ministry of Health and Welfare, the construction waste occupies 90% of illegal disposal amount of industrial waste.

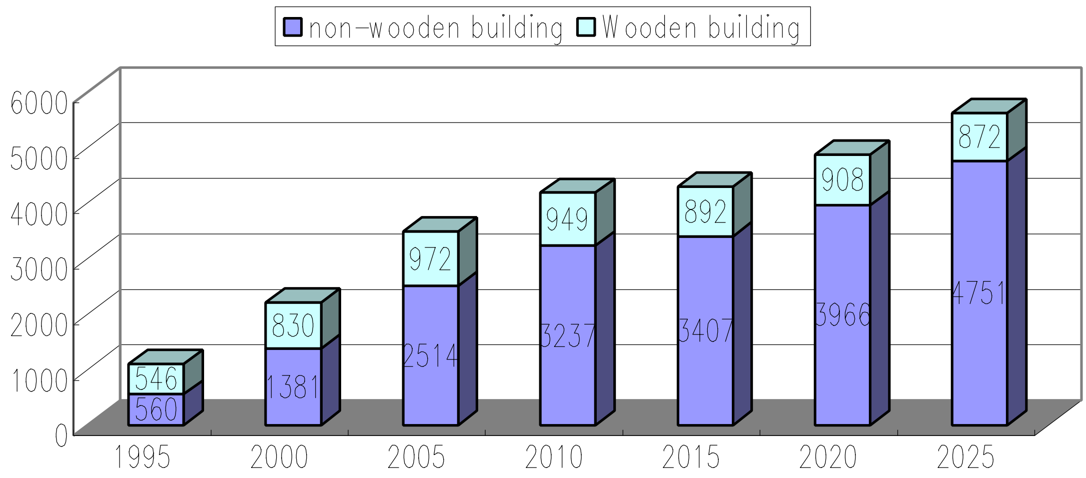
Figure 3. Flow Chart of Construction Waste in Japan



(2) Construction Waste

- The building demolishing waste occupies 60% of the building construction waste.
- Wood scraps occupy large ratio of illegal disposal amount of construction waste. It is said that most of them are released from demolishing of detached houses.
- Concerning the building demolishing waste, it is forecasted that the release amount will increase sharply hereafter as the buildings which were rapidly constructed after 1965 meet the time of renovation.
- The remaining capacity of the final waste disposal place is tight as total remaining capacity of Japan is equivalent to 1.6 years' amount in the end of fiscal year 1999. (Estimation by Ministry of Health and Welfare)

Figure 4 : Future estimation of waste release amount from building demolition



Document : Research by MOC
(subject : Metropolitan and 8 prefectures)

Waste release amount from building demolition increases by approx. twice in 2000, triple in 2005 and four times in 2010 as compared with that in 1995.

(3) Outline of Law for Recycling Resources Transformed from materials of construction work

- Obligation to segregate each material from specified construction materials used in specified buildings by means of segregate-demolition in accordance with certain technical criteria, in case of the intended construction work which means construction work for buildings and other constructions exceeding a certain scale.
- Promotion of recycling by obligating to transform into recycling resources from construction waste of specified materials resulted from segregate-demolition.
- Ensure the proper practice of segregate-demolition by the prior work report by client, the final report from general contractor to client, putting up a notice of the sign on construction site, etc.
- Ensure the payment of proper cost for contractor, by preparing contract procedure between client and contractor.
- Ensuring of the practice of proper demolishing work by the registration system of demolishing contractor and disposition of technical manager on demolishing work site.
- Promote transformation into recycling resources and utilization of construction materials produced by transformation

(See Reference 2)

Reference 1: System of Measures for Environment in Housing and Building

Problems	**Climate Change**	**Construction Waste**	**Sick Housing**
Funda-mental Policy	**Promoting energy conservation, use of natural energy & unutilized energy**	**Promoting Reduce, Reuse & Recycling and proper waste disposal.**	**Ensuring comfortable and healthy living environment.**
Principal Definite Measures	**Standard and Guideline** - Determination of energy conservation standard based on the energy saving law. **Government Support Project** - Promoting construction of residential building to reduce environmental impacts, through Model Project of Environmentally Symbiotic Housing in Urban Area, or Project for Urgent-Promoting Urban Residence in the 21st Century. **Loan System** - Popularization & Promotion of housing development that is well-planed in consideration of environment through housing loan financed by the Government Housing Loan Corporation (GHLC). - Popularization & Promotion of housing development that is well-planed in consideration of environment through housing loan financed by Development Bank of Japan. (DBJ) **Others** - Training up execution engineers of thermal insulation materials.	**Regulation** - Promotion of segregate- demolishing of buildings and recycling use of construction waste based on the Law for recycling in construction work. **Government Support Project** - Promotion of recycling use of construction waste through Housing Industry Restructuring Project. **Loan System** - Promotion of use of recycling materials, proper demolition and waste disposal, and high-durability housing development through housing loan financed by GHLC. - Promotion of use of recycling materials through housing loan financed by DBJ. **Others** - Technical development of long-term durability housing such as Skeleton-Infill Housing. - Promotion of Recycling Project in publicly-operated Housing.	**Standard and Guideline** - Determination and Publication of Guideline for Design and Construction Work, Manuals for Users by the society for the study of healthy housing. - Determination of Guideline for selecting interior finishing materials by Japan Federation of Housing Organization. - Addition of specification on selecting interior finishing materials to Common Specification for Public Housing. **Loan System** - Promotion of housing development that is well-planed in consideration of health through housing loan financed by GHLC. **Others** - Advice on measures for chemical substance in housing. - Lending out simplified measurement instrument for chemical substance concentration by regional public bodies.

Development of Housing Performance Indication System based on the Housing Quality Assurance Law

- Indication of rank of measures for energy conservation.	- Indication of rank of measures for degradation and consideration for maintenance.	- Indication of rank of measures for formaldehyde (HCHO).

Reference 2: Whole image of the Waste-recycle Laws in Japan

Basic Environment law
(Environment agency)

› State the basic policy for the environmental preservation

Basic law of Promotion for formation of recycling society
(Environment agency)

- State the basic principles concerning formation of recycling society

Waste disposal law
(Ministry of Health and Welfare)

› Stipulate the issues of waste disposal
-Measures for inappropriate waste disposal
-Promote the preparation of safety-appropriate facilities by Public participation
-Tighten the regulations of permission for facility

Container/Package recycle law
(Ministry of Health and Welfare, Ministry of International Trade and Industry, etc.)

› Stipulate measures for promotion to collect containers and packages separately and to re-commercialize

Electronic appliances recycle law
(Ministry of Health and Welfare, Ministry of International Trade and Industry)

› Stipulate measures for promotion to re-commercialize abolished electronic appliances as television set, etc.

Law for recycling resources transformed from materials of construction work
(Ministry of Construction, Ministry of Health and Welfare)

-Promote to segregate-demolish construction material waste and to promote recycling

Law for promotion to reclaim the food recycling resources
(Ministry of Agriculture, Forestry and Fisheries, Ministry of Health and Welfare)

-Promote to control release of the food recycling resources, to reduce quantity and to reclaim

Law for the promotion of efficient use of resources
(Ministry of International Trade and Industry, etc.)

› Stipulate measures of the promotion of the utilization of recycling resources
-New stipulation of measures to reduce the waste release by addressing resource- saving product, longer life product, etc. and to reuse the parts from withdrawal products in addition to reinforcing measures of withdrawal-recycling of products for producers.

Law for promotion to reclaim the food recycling resources of environmental articles by Government
(Ministry of Agriculture, Forestry and Fisheries,

-Promotion to procure environmental articles by Government

BRUCE LORIMER

DIRECTOR GENERAL

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

REAL PROPERTY SERVICES BRANCH

SUSTAINABLE BUILDING 2000 CONFERENCE

(INTRODUCTION AND WELCOME)

MAASTRICHT, THE NETHERLANDS

OCTOBER 23, 2000

Thank you, and good morning honoured guests, ladies and gentlemen. It is my pleasure to be here on behalf of the Government of Canada, at Sustainable Buidling 2000.

It is certainly appropriate that Sustainable Building 2000 is being held in the Netherlands. One only needs to fly over Canada and then Holland to see the impact that density has had on planning and design here. There is much for us to learn.

The idea for Sustainable Building 2000 began back at the Green Building Challenge ’98 in Vancouver, Canada, when the Dutch representatives offered to host the next Green Buildings Challenge. Today, I am impressed to see what has evolved from that proposal. The over 800 people in attendance, indicates the excellent job of the organizing committee has done in putting together this conference. Congratulations.

Judging by the continental presentations, we are in for an excellent conference.

Sustainable Building 2000 is part of a global movement - a movement that brings the environmental issues of buildings to the fore. The exhibition demonstrates a move in the right direction.

Over the next few days you, the experts from around the world, will exchange information and experiences on the issue of sustainability in buildings, particularly on the use of specific building assessment tools and methods. We will be exposed to an exciting range of innovative planning, design, and construction ideas as well as advanced green products and services. We will hear about both the challenges and opportunities for environmental assessment tools and green buildings. It promises to be a busy and informative time.

In 1998, the Government of Canada initiated consultations with other levels of government, the private sector and environmental groups to develop a national Implementation Strategy for Climate Change. This strategy expected to be complete by the end of this year, will outline a comprehensive plan to meet Canada's international climate change commitments.

In the interim, the Government of Canada has announced a number of measures to help us respond effectively to the challenges of climate change.

A $360 million Climate Change Action Fund is laying the foundation for consultation and cooperation between the Canadian federal government and the private sector. It is also supporting early action projects aimed at reducing CO_2 emissions.

We are investing $700 million over the next 3 years to preserve and improve Canada's natural environment while harnessing new technology. Some of the initiatives relevant to us there today include, the $125 million Green Municipal Enabling Fund that helps communities assess their environmental needs and leverage private sector investment in areas such as building retrofit, waste management and water conservation. The Government of Canada has also allocated $550 million for municipal infrastructure in cities and rural communities across Canada, including affordable housing and green infrastructure.

In addition, a $100 million Sustainable Development Technology Fund will help develop and deploy new environmental technologies, particularly those aimed at reducing greenhouse gas emissions.

Internationally, Canada is contributing to new approaches to reducing greenhouse gas emission though energy efficiency and renewable energy projects in both developing countries and economies in transition. The official Development Assistance initiative, allocates $100 million for technology transfer and related initiatives to help developing countries reduce their green house gas emissions and promote sustainable development. An additional $15 million supports the World Bank's Prototype Carbon Fund.

The Government of Canada is not only advocating and funding environmentally sustainable projects jointly with industry, we are also "getting our own house in order".

We are showing leadership by taking responsibility for our own emissions of greenhouse gases through continued emphasis on energy efficiency and the use of renewable energy within government operations.

Our greening activities are starting to show positive outcomes. They are reducing waste and greenhouse gas emissions, saving energy, improving waste management practices, making for sound choices in materials used in projects, enhancing work practices and transferring knowledge to the private sector.

This bring me to Sustainable Building 2000. This gathering marks an important phase in The Green Building Challenge.   The Challenge, is to objectively assess the performance of buildings and arrive at an appropriate level of "greenness" in them. This gathering is also a way of informing the international community of scientists, designers, engineers and builders about the result of green building evaluation, and to explore how we can move forward from the research focus to practical and readily usable assessment systems. This is also a way to learn from each other.

The ultimate goal of GBC, and in fact this entire conference, is sustainability. Currently GBC is concerned with assessment. This is important in order to have a benchmark.....measurability.....a reference point. In order to achieve truly sustainable buildings, all facets of planning, design, construction, operation, and renovation must be addressed. In short, a holistic approach to develop all of a building's life cycle in an harmonious way.

The Green Building Assessment System and its software, know as the Green building Tool, was the driving force behind GBC '98. GBTool's design is based on first-generation systems developed in several countries, beginning in the early 1990s. The system has now been tested on more that 70 buildings in 20 countries.

The GBTool has progressed from a first phase tool that was rather difficult to use, to one that is currently acknowledged to be relatively easy to use, while maintaining the depth of coverage. However, it should be remembered that this is an R&D process, and the tool requires further refinement for implementation. Nevertheless, GBC represents the first attempt to establish a generic framework that is adaptable to various regional and local conditions.

If the system can be made practical, technically-complete and cost-effective in the near future, it offers a great potential to serve as the basis for the development of the third-generation green building design guidelines and a third-generation tool for building eco-labelling. In this context, I should note that the developers of existing systems in the UK, USA and Canada, and those under development in Norway, Sweden and France, have all been involved in the GBC work, and there continues to be a fruitful exchange of experience between all parties. Because of this, when it comes to implementation - no matter what systems countries use - they will certainly benefit from the GBC experience, whether they are based on GBTool or the national systems.

Canada's objective since we launched the Green Building Challenge in 1996 is to have a workable system in place at the industry level, and this continues to be the case.

Partnership are the best way for us to achieve progress on green buildings, both within our won countries and internationally. In Canada, one of our most important partners has been the building industry itself, which has been a key player in the Green building challenge. Industry has brought a different, but important perspective to the green building Challenge - the need to ensure that green buildings are not only environmentally friendly but affordable, functional and competitive in the market place.

We are in the process of forming a working group with national associations representing the design professions and the construction industry. The intent is to ensure that there is a broad base of designers and constructors capable of understanding and delivering sustainability. We want to make this mainstream.

Research, science and technology are the backbone or our efforts to design and construct better buildings. But without industry cooperation and commitment, commercialization of these new technologies and approaches would not be possible. Therefore, we plan to involves industry to an even greater extent during the next phase of work.

Our efforts need to go beyond pure research, science and technology. They must go to practical, easy to use tools, standards and processes that can be implemented through the broadest possible base of engineers and constructors - but particularly, we need tools which can easily demonstrate the economic and other benefits of sustainability to those in financial or funding approval times.

We have come a long way since we last met two years ago in Vancouver. We have gone from 15 teams representing 14 countries, to this year's 19 teams from 18 countries. All of these participating countries have volunteered personnel with boundless energy, enthusiasm and efforts to work on GBC. They, and their supporting organizations, should be commended for such dedication, especially considering the great efforts many of them had made in raising funds for their work.

In the future we can foresee a continuation of the GBC process. The Government of Canada will continue to take responsibility for coordination, but other options are developing. One of these is the International Initiative for Sustainable Building, a proposed new body to promote sustainable building. The International Initiative for Sustainable Building held a meeting just prior to SUSTAINABLE BUILDING 2000 and the current scenario calls for them to take over responsibility for the international GBC process in 2001. If this does not come to pass, I am sure that some other permanent international home will be found for GBC in the future. IN the meantime, Norwegian agencies have offered to host a conference for GBC 2002, so the prospects look bright.

There are many important themes and issues being discussed over the nest few days. As you attend various sessions I urge you to take in at least one or two of the national team presentations in the Green Building Challenge series of workshops, as well as the national pavilions, where you will se the assessment results in addition of the background on national environmental issues. This presents an excellent opportunity to learn from each other.

We will all benefit from the rich international make-up of Sustainable Building 2000, which will enhance the value of this conference by allowing us to share our varied knowledge and experience across the globe.

I congratulate the organizers and I wish you all in informative and productive conference.

Thank you.

Brussels. 18.10.00

Sustainable Construction A challenge for the European Union - a European view point –

Karlheinz Zachmann EC Commission

Introduction: Sustainability - in fact a major challenge for the 21st Century

1. Looking for a definition from simplicity to complexity

2. The four priorities of the EC

3. Sustainability for construction in the EC frame

4. Sustainability of construction, a key element for construction competitiveness? The three key points of attention; the relevant recommendations.

5. Is there a way forward?

Final reflection: the role of Commission and Member States - a must to play the game.

Sustainable Construction - a challenge for the European Union

Sustainability is certainly not a discovery of the beginning 211" Century but it is one of its major challenges. Sustainability as most of us are ready to understand is besides preservation of the environment, of careful use of the scarce resources and safeguarding of our living, one of the key factors of the survival of mankind on Earth. I don't need to remind you the degradations on wildlife and forests. the pollution of rivers, lakes and the oceans, the deterioration of the environment and the global warming since the first serious admonitions of the Club of Rome. Today we have to cope with information and globalisation of our economies on the one side. and with the problem of safeguarding of mankind on Earth on the other. I doubt if these two extremes are at this moment quite in balance - or ever will be.

For some Sustainability is quite simple, being more or less a synonym to protection and safeguarding the environment in a wide sense. For others Sustainability is a notion hiding a high degree of complexity and interdependence of hypothesis, assumptions data and factors.
As far as I am concerned I think for the sake of this congress we can stick to the following definition, drawn from a relevant draft report worked out in co-operation with industry within the Commission services.

"Sustainable development is meant as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This implies saine social progress, effective protection of the environment. prudent use of natural resources and maintenance of a high level of economy growth and employment.

11 is quite evident: on the EU level what actions or recommendations so ever, they have to respond and fit in the four major priorities set out by President Prodi for the

coming 5 years:

- governance — that means a better co-operation between European Institutions. Member States and their administrations;

- to improve the voice of Europe in the world (this including enlargement):

- to combat social exclusion;

- to absorb the new technologies.

a) Good governance - here far beyond the fencing between EU competence and subsidiarity - for the sake of a sustainable development - EU institutions, Member States, as well as their regional and even local entities have to work together. In tact sustainability does not stop at frontiers. It is a world problem!

Within the EU the EC must here be able to play the role of catalyser offering common parameters, benchmarks and comparisons. However. all that means that the EC must have the relevant means for this tasks and that all. Commission services, Member States' governments and administrations and industry play honestly the game.

b) Enlargement - the change of Europe is coming if we want this or not. The only question is will this be in a democratic and orderly way or in a more or less chaotic and hazardous one, giving room to all sorts of centrifugal forces.

We all know environment and sustainability are one of the key points in this undertaking.

The challenge is high. We have to make more efforts to help the candidate countries not to make the same errors as we did in the western world after World War II. The candidate countries have a lot to preserve, to safeguard and to restore let's do it or even better Lets build together in a new way e.g. in response to the criteria of sustainability

c)Combat of social exclusion and d)Absorption of new technologies: also these priorities have without saying an impact on sustainability policy.

Who speaks of sustainability and requires its full respect in various sectors, he will be also confronted with economic questions of the price, the costs to bear and the defence of positions and markets and of competitiveness.

That is why in the frame of ongoing reflection on a competitiveness action plan we in the EC have placed sustainability in construction — I think quite rightly - in the centre of our work.

Working for the time being mainly with the European construction and related industries the task groups have focused on three key areas:

Environmentally friendly construction materials
Energy efficiency in buildings Construction and
Demolition Waste management.

The work of the relevant working group on sustainable construction has. as agreed for all other WGs within the framework of the planed competitiveness action plan. concentrated on work and projects not already covered by other EU actions and initiatives in order to assure a real added value of this undertaking.

There are quite a lot of activities and initiatives which are directly or indirectly linked to sustainable construction: *waste* and waste management, eco-labeling of products, energy and energy saving programs, R+D and last but not least collection of data in various areas.

Considering the importance of the construction sector and the range and multitude of construction and construction related activities going from prospection and planning (of single buildings to whole townships and complex civil engineering works) to demolition, recycling and reuse, it is quite evident that the practical fulfilment of the requirements for a sustainable construction is quite more than the three key areas cited. Compared to other sectors of our economy construction is. I believe, the biggest and most complex.

At the moment the ongoing preparatory work has already come to a series of recommendations - to be quite well understood = addressed to all three parties involved - Commission, Member States and Industry:

- **To launch a study to analyse the issue of incorporating environmental aspects in construction product standards.**
- **To benchmark regulatory, fiscal and financial measures oriented to increase the energy efficiency of buildings in order to establish, disseminate and promote best practice.**
- **To develop codes of good practice by all parties involved in the construction process, in particular promoters, designers, contractors, subcontractors and material producers regarding construction and demolition waste. These codes should aim at:**

  - selective demolition and/or waste segregation,
  - promotion of prevention, re-use and recycling of construction and demolition waste,
  - no mixing of hazardous/non hazardous waste, including separate storage and collection.

Sustainability is also for construction and our build environment one of the biggest challenges for the 21" Century.

Every day on which we lose grip on controlled. well-guided and disciplined developments our habitat of life is more and more degrading and our next generation and generations are less and less sure of their living conditions. we have failed in this noble task.

By the way construction — one of the oldest activities of mankind - can contribute a lot - there are knowledge and skills, Lets use them!

What is the way forward for e.g. Europe? Despite overall budgetary constraints of public and private entities sustainability must range highly before lowest price. Europe must, if I may say so, in most, if not all aspects of sustainability be the benchmark. This has a price! Are we ready - for the sake of our neighbours and our children, to invest here? Or are we making further business as usual: waiting that our neighbours start, bring offers first and then see if we cannot use for short term advantages our — might be - dominant position?

There must be in Europe and in the world - in the whole world - another way of thinking and acting. The Kyoto Conference and its pursuing are really not very hope giving in this respect, if I may say so.

Certainly we can and must already now act and do a lot but we must. and that is even more pressing, educate our children and grand-children that they can make it in a world where sustainable living is an absolute must for survival on our globe Earth.

As limited and decent as the means of the Commission are a day now and may be also in the coming future. The Commission is ready to play its role as initiator. catalyser and even as surveyor and warner, of this I am convinced. It is up to the members of this and the future Union to play fully the game.

My I express my hope that this Congress will procure good presentations and reflections leading to clear and convincing statements and recommendations -being a help and tool for all policy makers around the world.
l wish this gathering a good success.
KhZ

GTM

Nous œuvrons pour demain

BUILT ENVIRONMENT

&

SUSTAINABLE DEVELOPMENT

GREDD : Marc COLOMBARD-PROUT & Christophe GOBIN

Sustainable Development is not a status but a dynamic of change :

The issue for GTM Construction is : How to take part in a collective work ?

SUSTAINABLE DEVELOPMENT FOR A CONSTRUCTION FIRM

Within a national perimeter

Implementation
of the principles of
Sustainable Development

Modify attitudes and behaviours

I

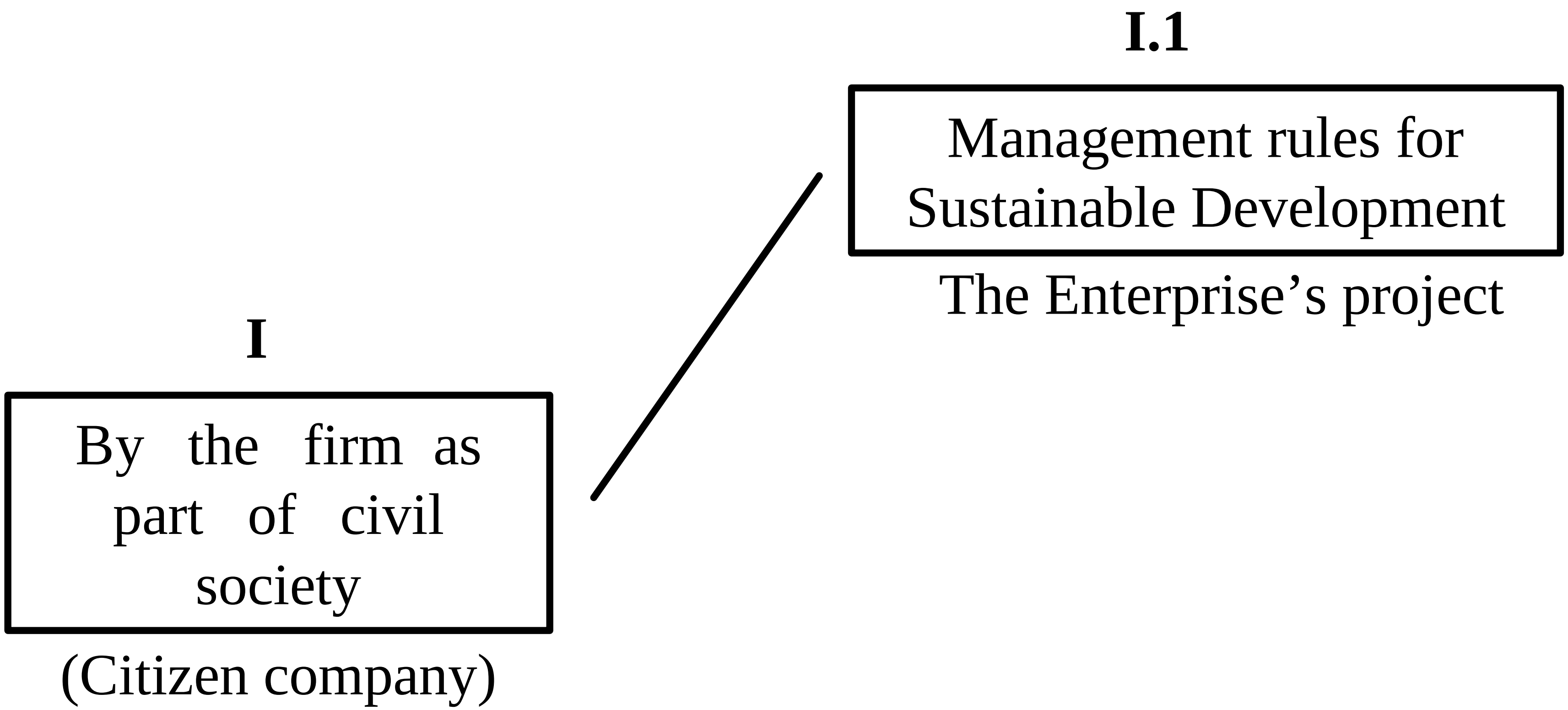
By the firm as part of civil society

(Citizen company)

II

By the firm as part of the « project enterprise »

(Activities)


I.1
Management rules for Sustainable Development
The Enterprise's project
I
By the firm as part of civil society
(Citizen company)

I.1.1 GTM CONSTRUCTION'S PROJECT

1 QUI SOMMES-NOUS ?

Nous sommes des bâtis
de la conception d'un p

NOUS SOMMES DES HOMMES ET DES FE

► *d'un professionnalisme éprouvé*

Être un professionnel, c'est disposer d'une compéte
de les perfectionner sans cesse et de les exercer so

► *ayant un sens aigu de nos responsabil*

ouvrages innovants que savoir imaginer des solutio

► *possédant une grande capacité de réa*

Être réactif, c'est savoir répondre aux contraintes d
de chantier, mais aussi s'adapter à l'évolution cons

NOUS AVONS UNE ÉTHIQUE DES RELATI

dont les maîtres mots sont

► la solidarité et le respect de l'autre à l'intérieur d
► le respect de nos engagements à l'égard de no
► la loyauté envers nos partenaires – co-traitants, s

2 QUELLE EST NOT

“ PRIVILÉGIANT TECHNICITÉ ET INNOVATIO

► *initient, conçoivent, pilotent, construise*
► *assurent les prestations de service ass*
pour leurs clients en France et, en collabo

3 QUE VOULONS-NOUS ?

En toutes circonstances, nous voulons être fier
de notre œuvre de bâtisseurs

car notre métier contribue au bien commun et à l'amélioration de
et nous expose à l'admiration comme à la critique de tous ceux qu

un haut degré de professionnalisme, le sens des responsabilités et de
la capacité d'adaptation et la mobilité nécessaires ;
et que, fiers d'appartenir à des entreprises communicantes, aux régl
et aux repères clairs, ouvertes aux jeunes, les collaborateurs bénéficie
formation qualifiante et de possibilités d'évolution de carrière ;

► *que GTM Construction apporte à son* ***actionnaire*** *des résultats régu*
recherche avec lui des synergies humaines, commerciales et technique
collabore avec profit à la politique de concessions et de promotion im
de Groupe GTM, et contribue à l'image du Groupe par ses réalisatio

► *que GTM Construction et ses filiales, respectées dans la profession*
pour leurs compétences et leur compétitivité, maintiennent, avec leurs p
des relations loyales et fructueuses.

AINSI NOUS RÉUSSIRONS ENSEMBLE

► à développer notre activité dans l'intérêt mutuel du groupe GTM Construction et d
► à créer entre nous des relations durables de respect, d'estime et d'amitié,
propices au développement d'un véritable esprit de corps,
► à renforcer les liens de confiance qui nous unissent à notre actionnaire,
► à resserrer le réseau de partenaires fidèles qui nous soutient.

Destiné à toutes les sociétés du groupe GTM
Tourné vers nos clients, notre projet implique c
Fidèle à nos valeurs, BATISSEURS 98 nous in
à assurer la pérennité de nos entreprises au s

4 COMMENT RÉALISER NOS AMBITIONS ?

EN NOUS APPUYANT SUR NOS POINTS FORTS POUR AMÉLIORER

EN DÉVELOPPANT LES SYNERGIES ENTRE NOS ÉQUIPES OU NOS SOCIÉTÉS,
notamment au plan régional

EN METTANT EN ŒUVRE LES ACTIONS CONCRÈTES NÉCESSAIRES
POUR CORRIGER SANS RELÂCHE NOS POINTS FAIBLES, ET D'ABORD

► ***fidéliser nos clients,***
aller au devant d'eux pour mieux anticiper et comprendre leurs besoins, imaginer de nouveaux services à leur rendre, améliorer les offres que nous leur faisons, et être toujours plus exigeants sur la qualité de nos travaux dans le respect des délais et des coûts ;

► ***partager nos connaissances,***
mettre à la disposition de chacun l'énorme capital d'informations, de compétences, de connaissances et d'innovations dont nous disposons au sein de nos sociétés, dans l'intérêt de nos clients ;

► ***améliorer notre gestion des ressources humaines,***
nous appuyer sur notre éthique et la qualité de nos relations humaines pour systématiser les entretiens annuels, optimiser l'organisation de notre travail et développer notre politique de formation ;

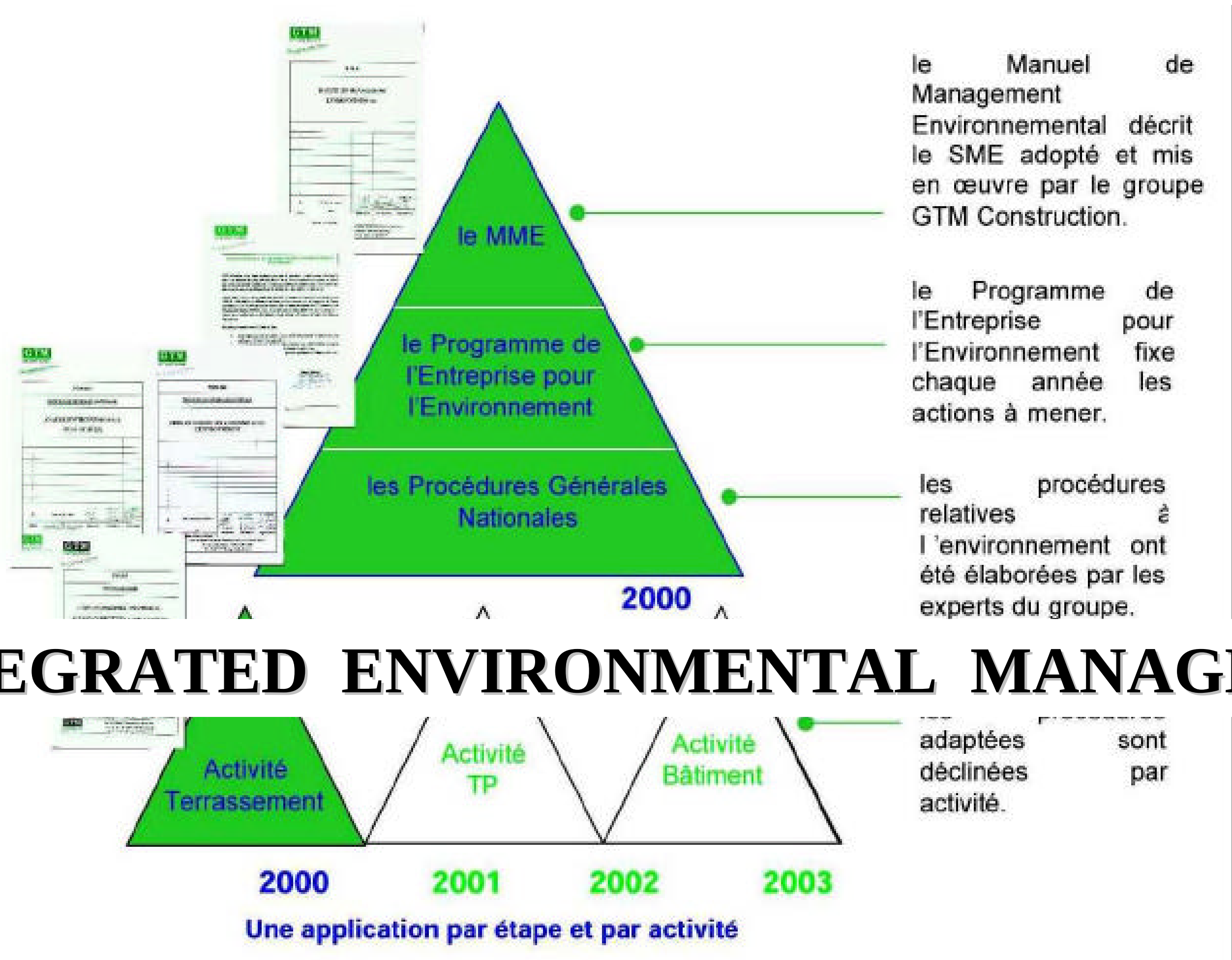
► ***renforcer notre communication,***
à l'intérieur de l'entreprise, impliquer tous les niveaux – directions régionales, filiales et agences – pour les fédérer davantage et, à l'extérieur, conduire toutes les actions qui valorisent l'image de GTM Construction et de ses filiales.

Il nous faut donc poursuivre la démarche participative
de progrès continu BATISSEURS 98.

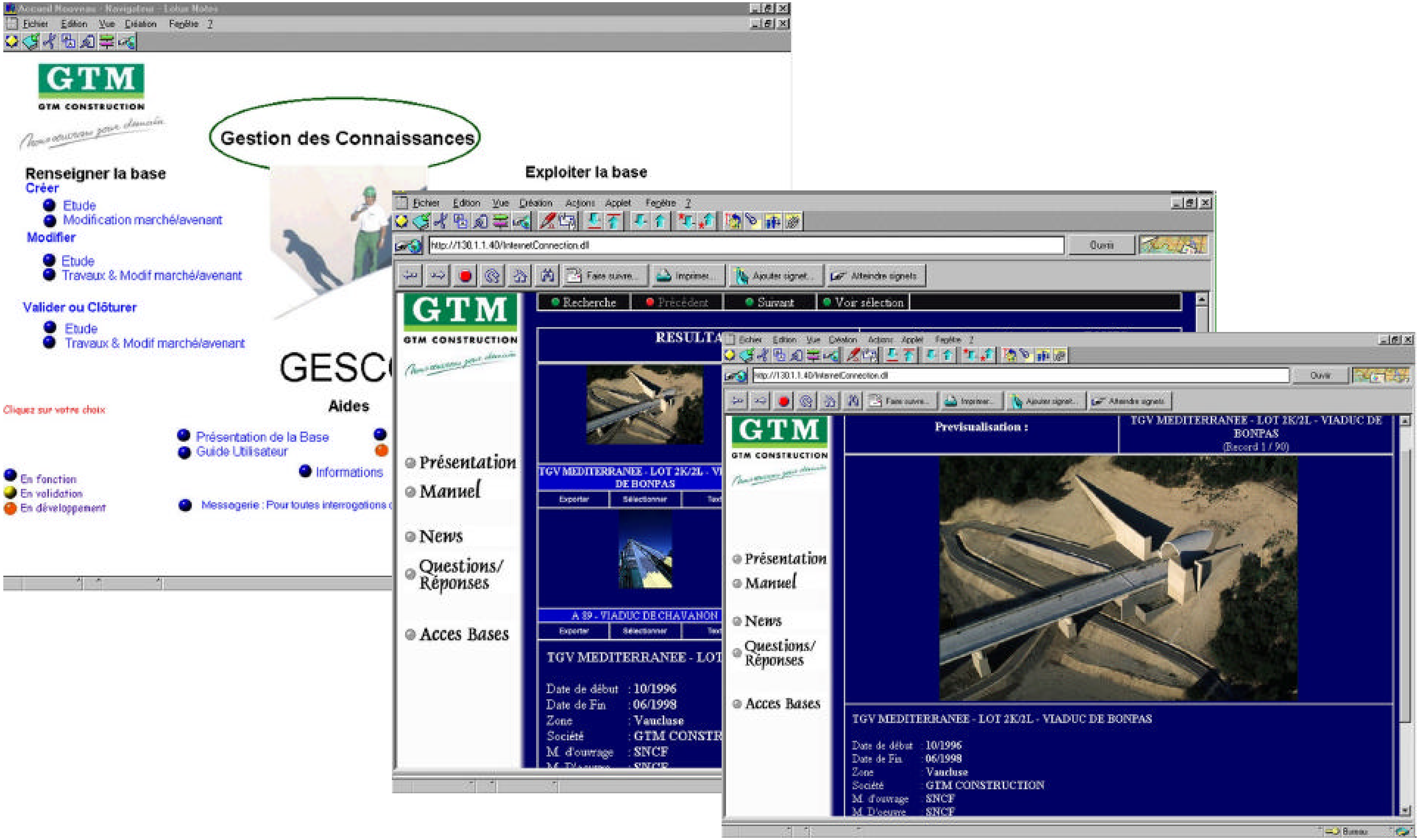
d'entreprise vise à améliorer de façon permanente nos pratiques et nos comportements.
notre objectif primordial, qui sous-tend tous les autres et qui nous rassemble.
monde qui change, à consolider notre position de premier plan dans nos métiers,
à préparer notre avenir ensemble en additionnant nos talents.

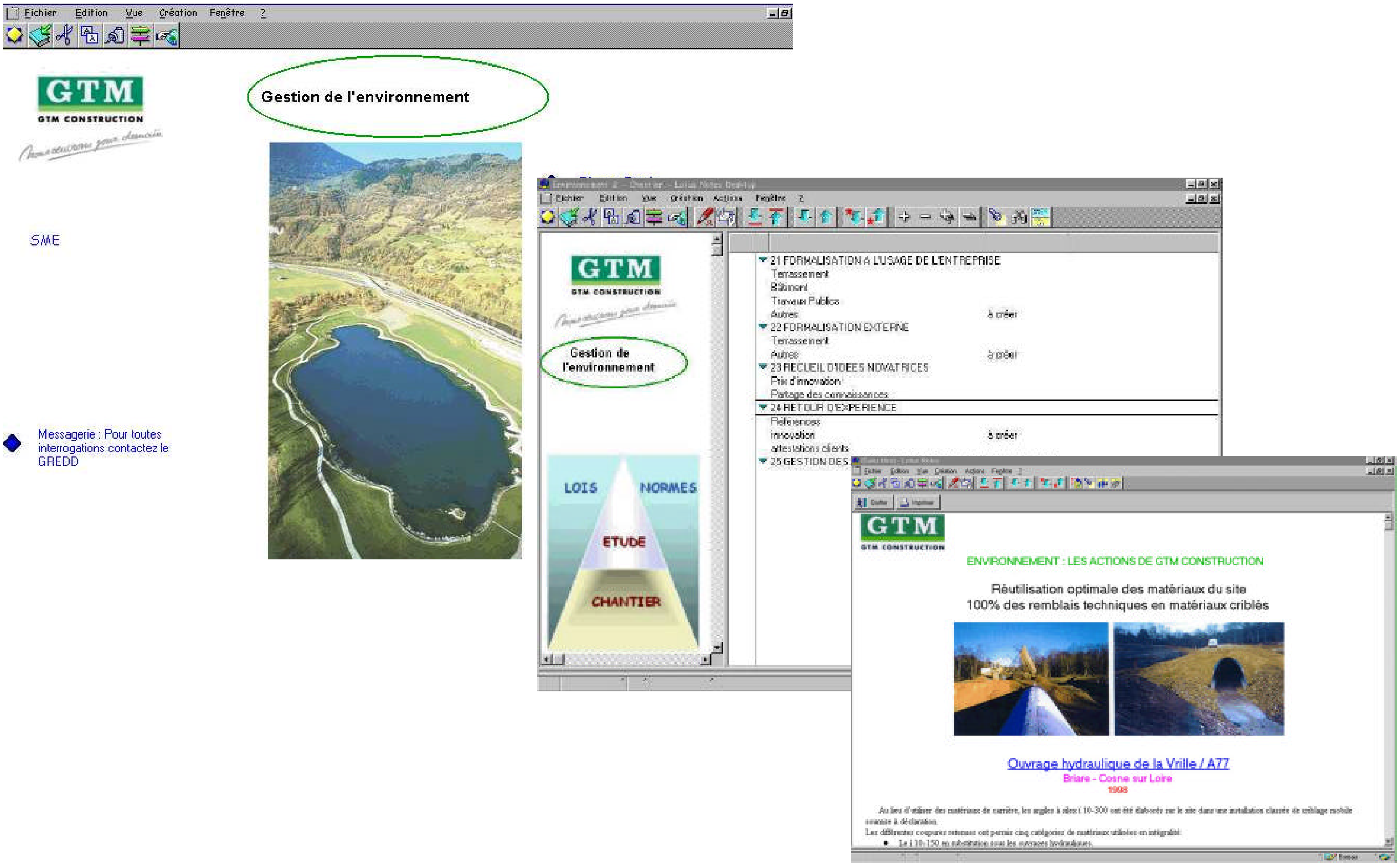
Nous œuvrons pour demain

I.1.2 AN INTEGRATED ENVIRONMENTAL MANAGEMENT

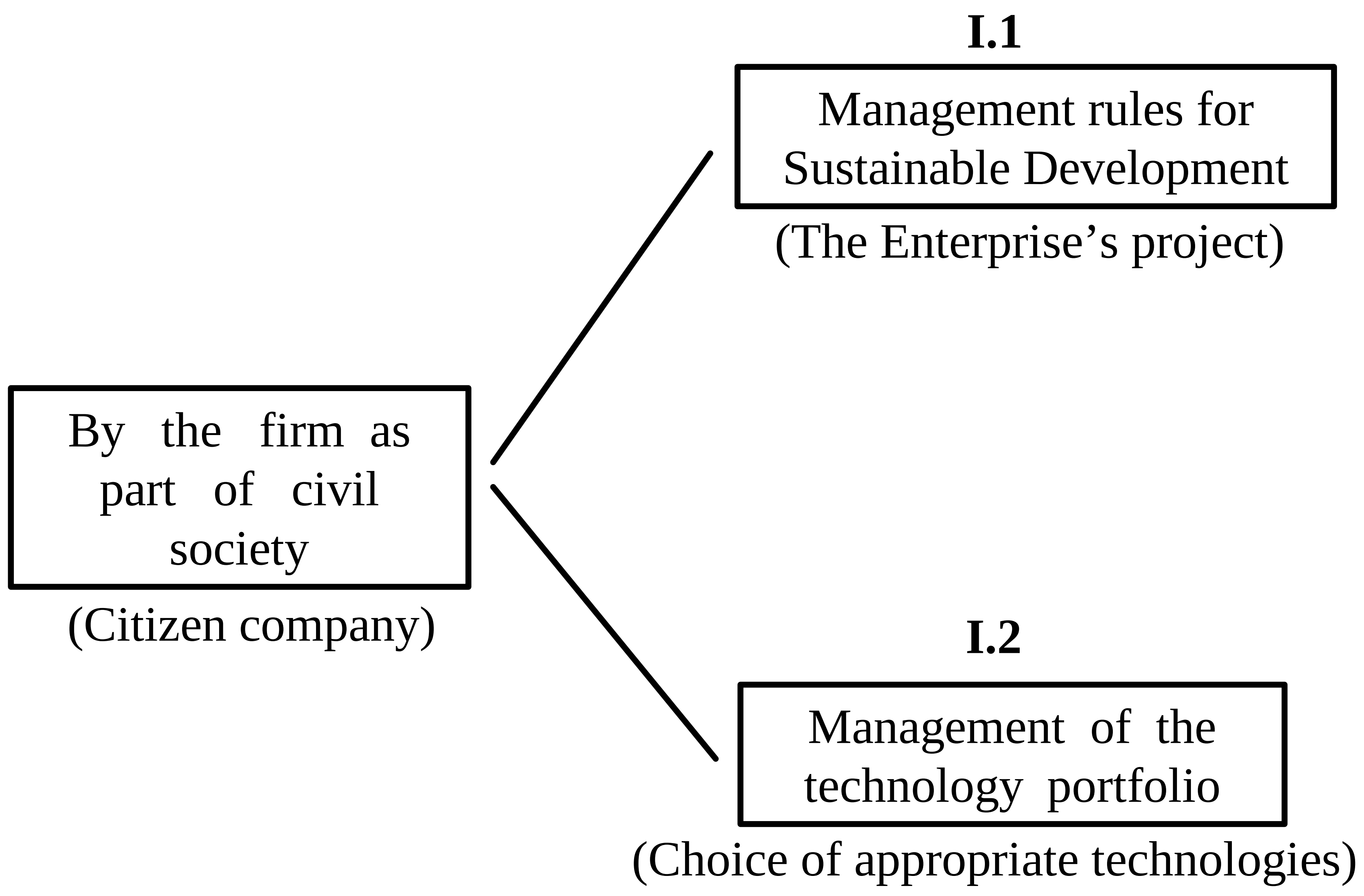


I.1.3 KNOWLEDGE MANAGEMENT OF THE TECHNICAL KNOW HOW



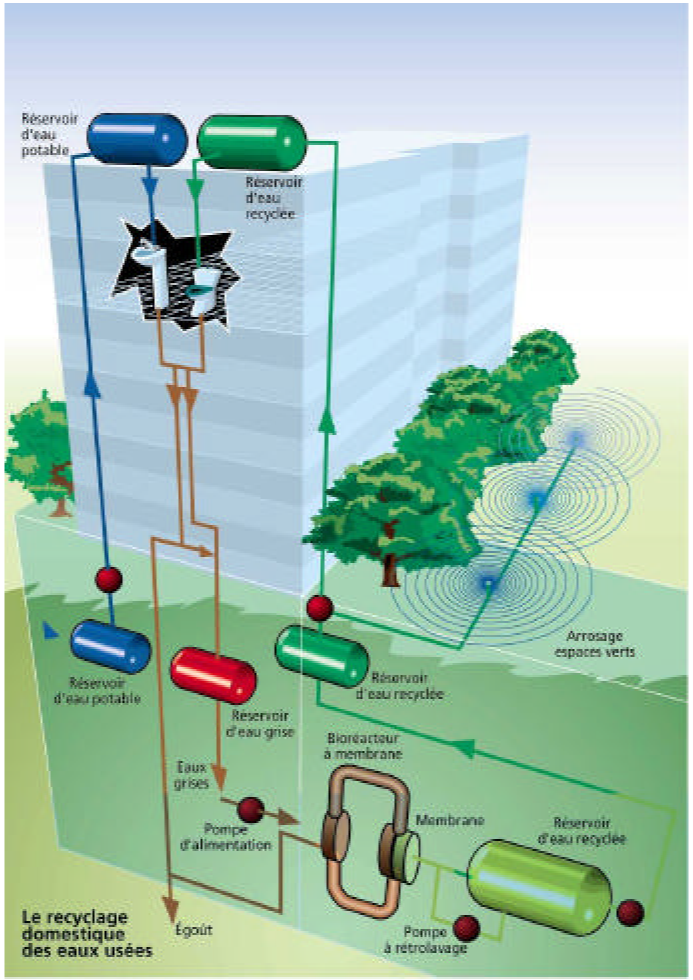


I.1.4 AN ENVIRONMENTAL KNOWLEDGE BASE


I.1
Management rules for Sustainable Development
(The Enterprise's project)
By the firm as part of civil society
(Citizen company)
I.2
Management of the technology portfolio
(Choice of appropriate technologies)

I.2.1 RECYCLING OF GRAY WATER

SOCIAL HOUSING
ANNECY

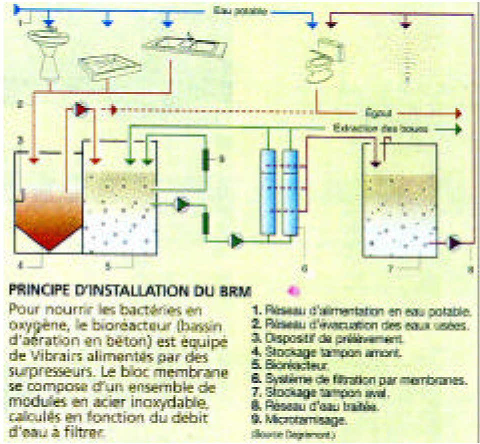


THE PRINCIPLE

Architect :
Cabinet Jacquet

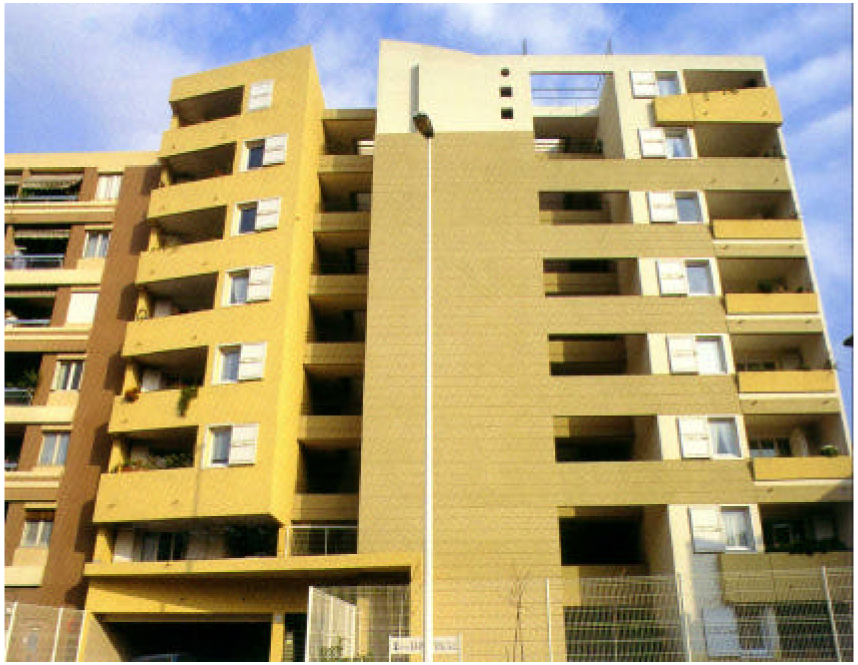
Owner :
HALPADES

1993



MEMBRANE
BIO REACTOR

I.2.2 INSIDE COMFORT



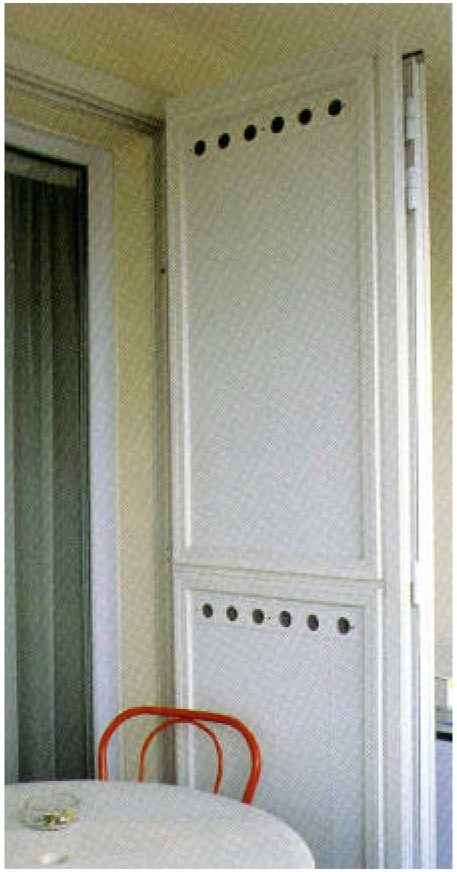
SOCIAL HOUSING NICE

BIOCLIMATIC ARCHITECTURE

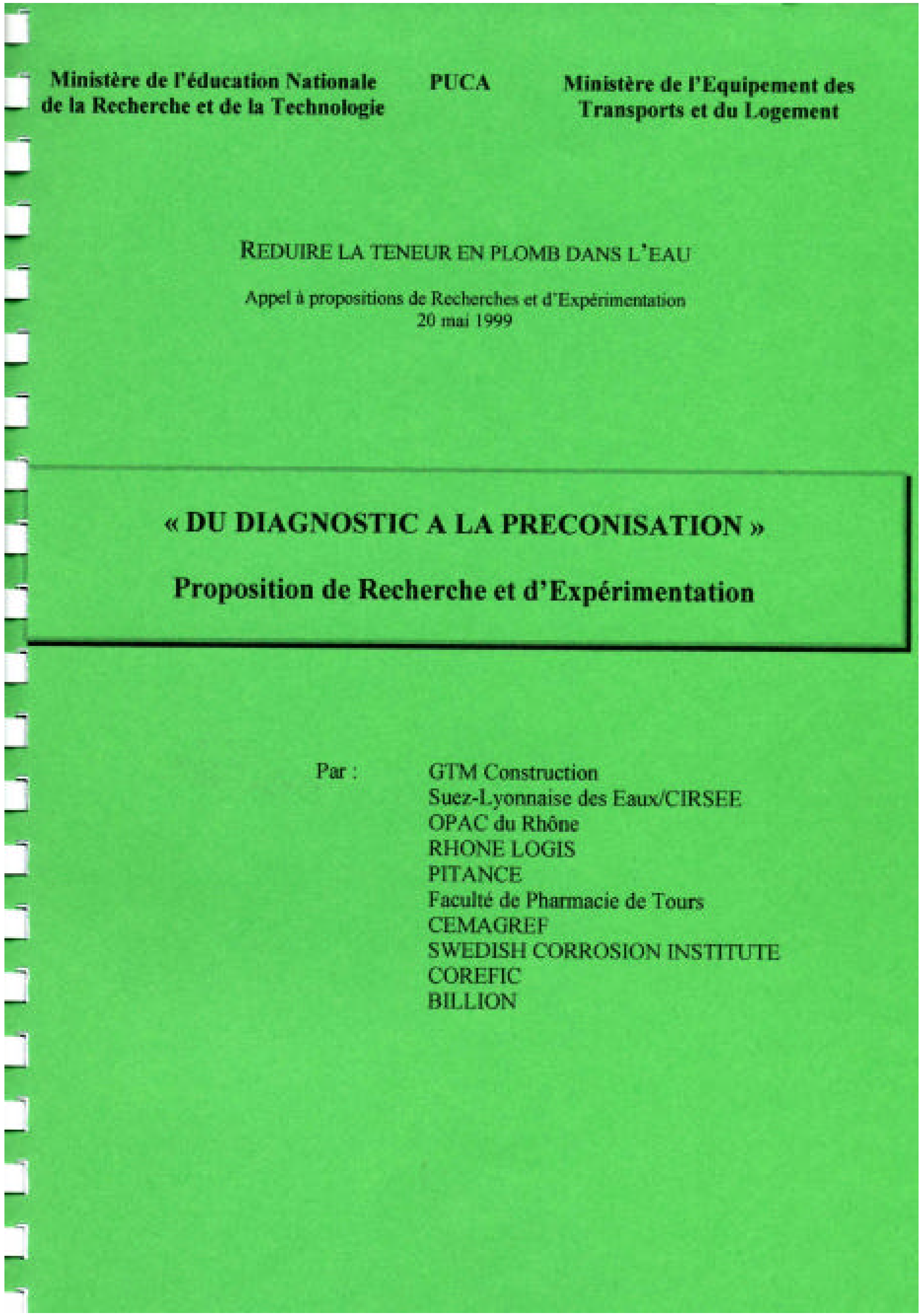
Architect : Atelier d'Architecture Capelier

Owner : Logis Familial November 1996

ACOUSTIC SHUTTER



SUMMER COMFORT


Ministère de l'éducation Nationale
de la Recherche et de la Technologie

PUCA

Ministère de l'Equipement des
Transports et du Logement

REDUIRE LA TENEUR EN PLOMB DANS L'EAU

Appel à propositions de Recherches et d'Expérimentation
20 mai 1999

« DU DIAGNOSTIC A LA PRECONISATION »

Proposition de Recherche et d'Expérimentation

Par :

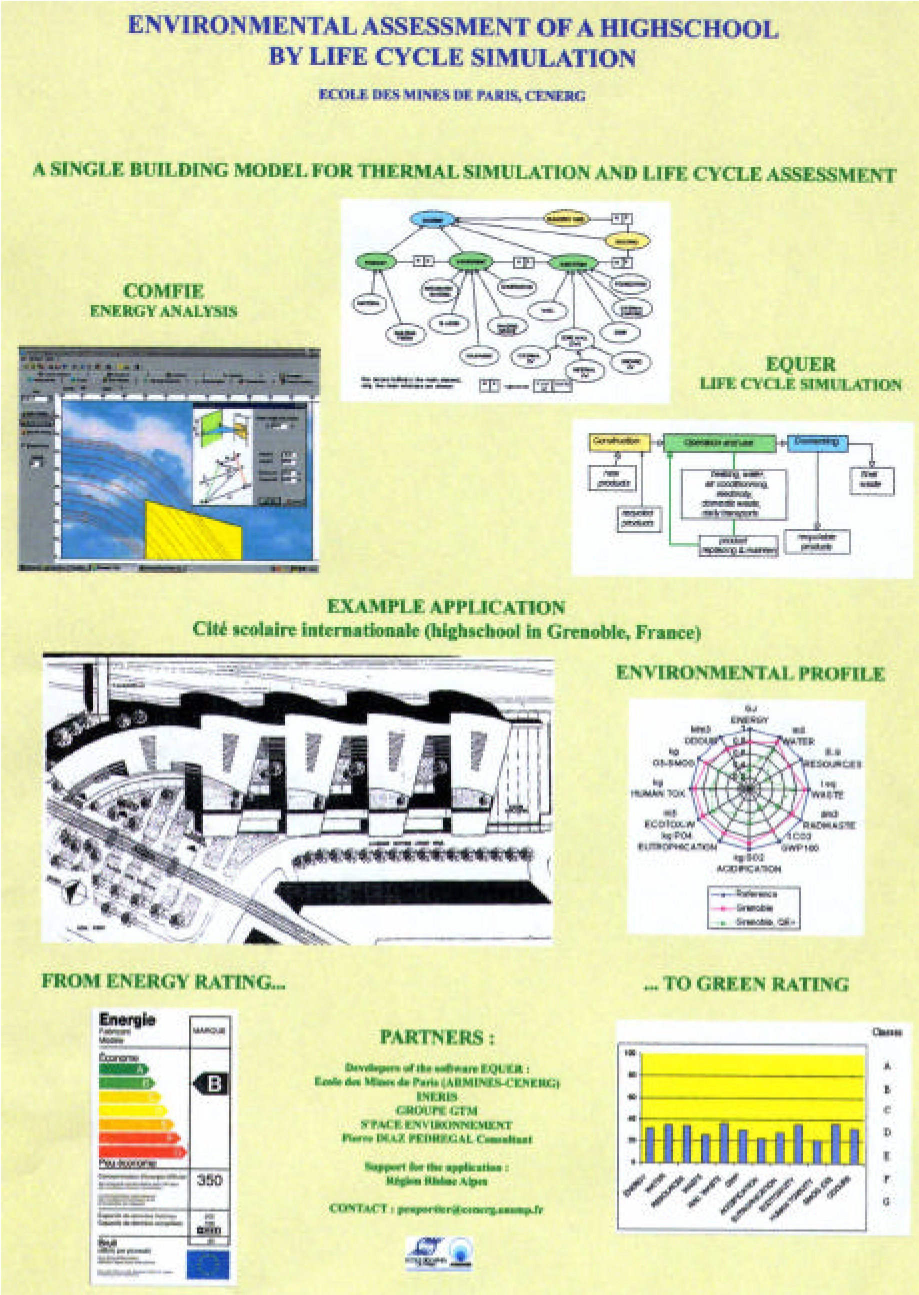
GTM Construction
Suez-Lyonnaise des Eaux/CIRSEE
OPAC du Rhône
RHONE LOGIS
PITANCE
Faculté de Pharmacie de Tours
CEMAGREF
SWEDISH CORROSION INSTITUTE
COREFIC
BILLION

I.2.3

HEALTHY BUILDINGS

PB H2O

FROM DIAGNOSIS TO RECOMMENDATION

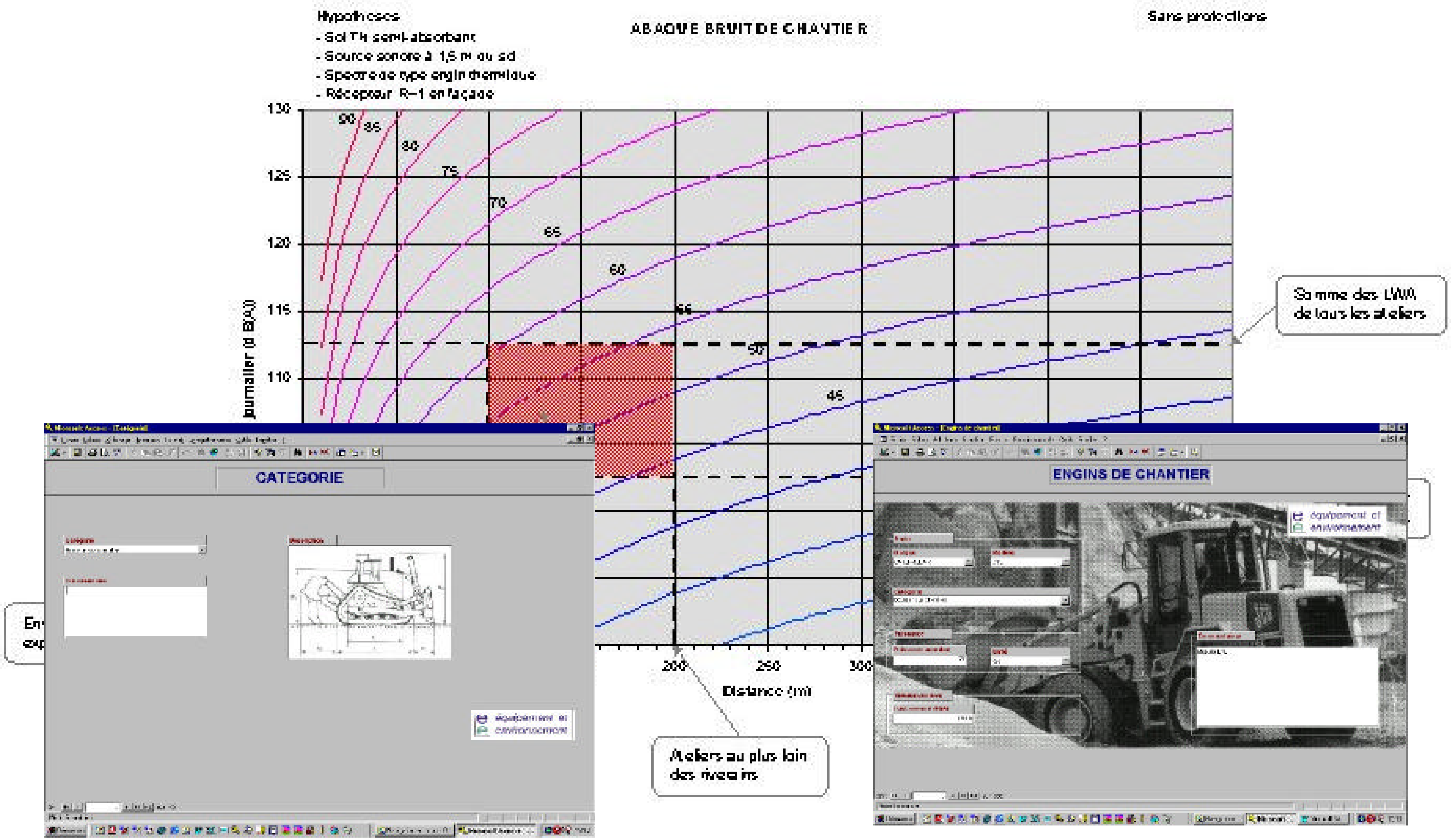


I.2.4

LIFE CYCLE ASSESSMENT WITH EQUER

I.2.5

ANTICIPATION OF CONSTRUCTION SITE NOISE POLLUTION TO REDUCE IMPACTS ON RESIDENTS



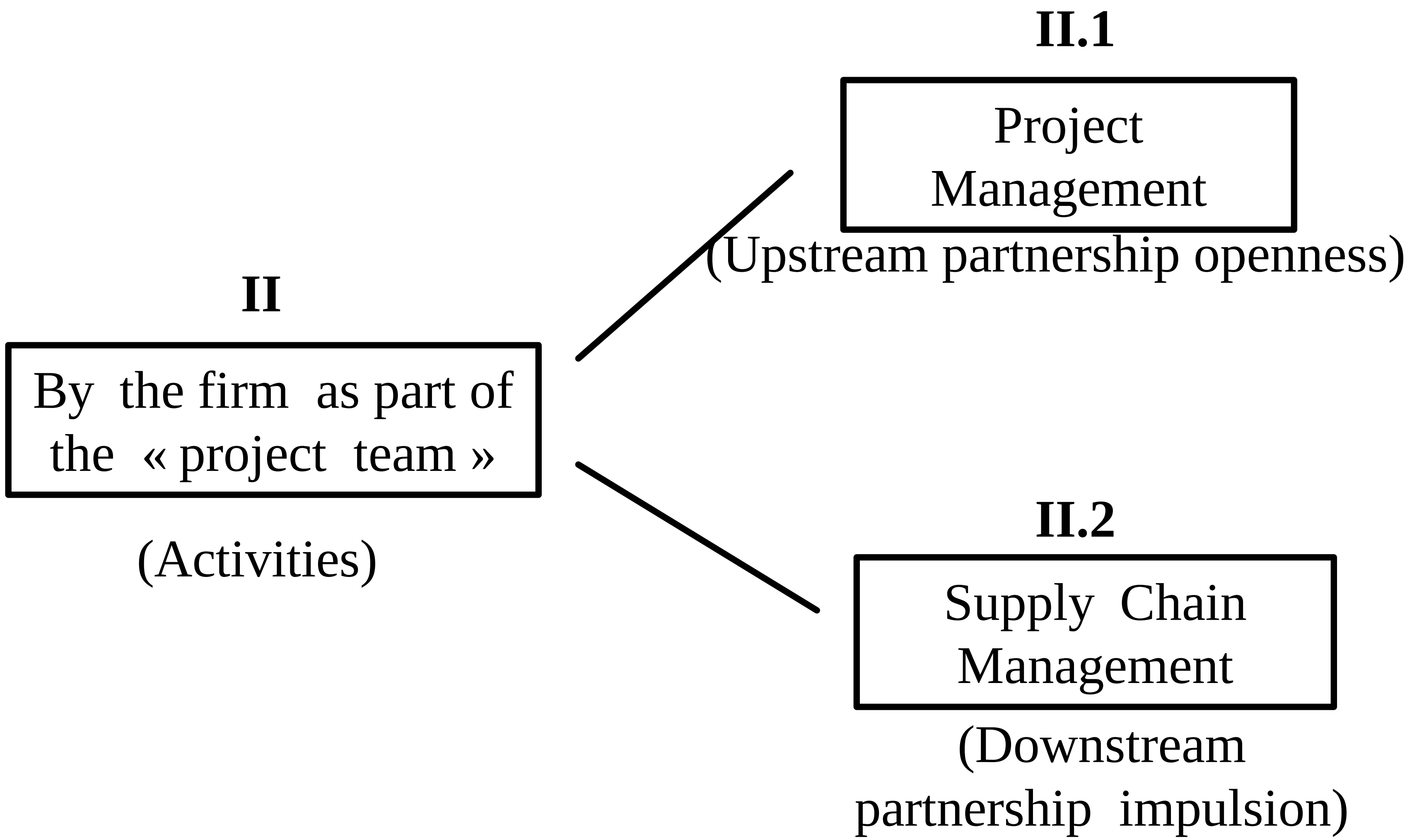
I.2.6

ONSITE WASTE TREATMENT TECHNOLOGIES

WOOD GRINDER

I.2.7 PRESERVATION OF HISTORICAL/CULTURAL HERITAGE

LAMA LASER


II.1
Project Management
(Upstream partnership openness)
II
By the firm as part of the « project team »
(Activities)
II.2
Supply Chain Management
(Downstream partnership impulsion)

II.1.1 A CHARTER FOR STAKE HOLDER TEAM WORK

1.1 THE OPERATION GUIDELINES

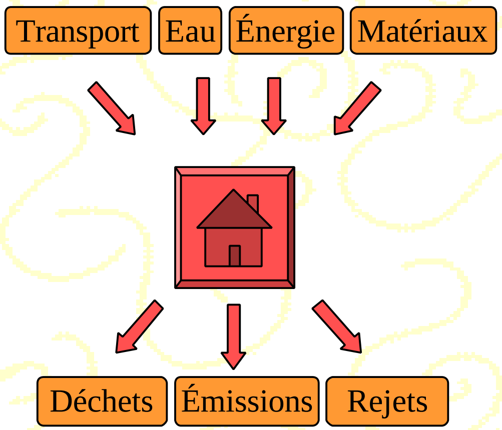
1.2 GTM Construction's COMMITMENT

II.1.2 GUIDE TO HEIGHTEN DESIGNERS AWARENESS

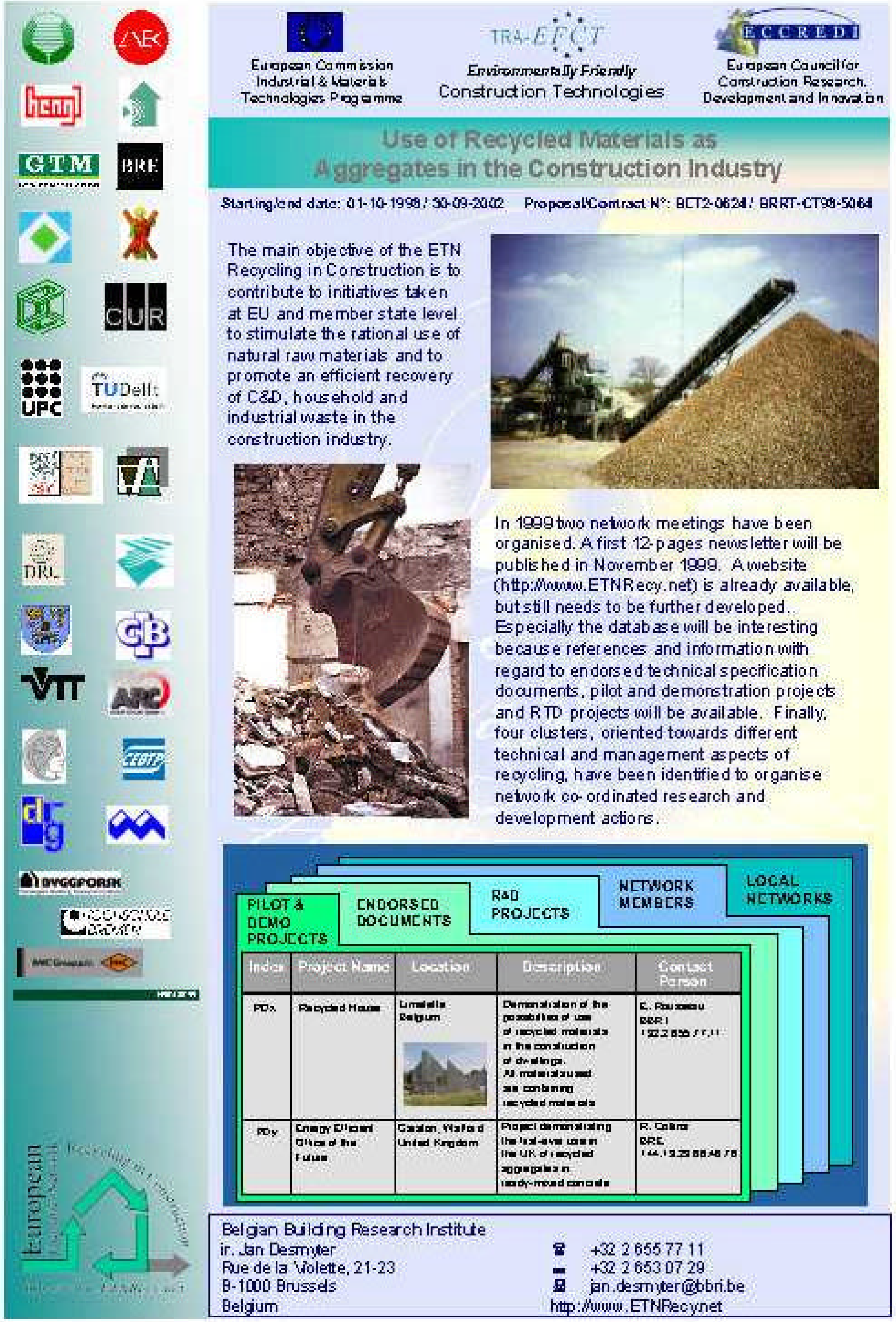
L'ENVIRONNEMENT ET LE CADRE BATI

(Les voies d 'un développement durable)

INTRODUCTION



Cette présentation est destinée à mesurer et maîtriser l'impact sur l'environnement tant pendant sa phase de conception et construction, que pendant sa phase d'exploitation.
Elle doit permettre d'apporter une aide à la décision pour les acteurs en intégrant la dimension environnementale dans leur choix.



II.1.3 IMPLICATION IN EUROPEAN NETWORKS

- ➔ ETN RECY
- ➔ PRESCO
- ➔ ENCORD

MIEUX PRODUIRE ENSEMBLE :

Pour un partage inter-entreprises des compétences en conduite de travaux

Appel à propositions du 19 mai 2000

PUCA

« Formations, Emplois, Compétences dans le Bâtiment »

PROPOSANT :

GTM Construction
Direction Recherche et Développement Bâtiment
61, avenue Jules Quentin
92000 NANTERRE

II.2.1

PROVIDING IMPETUS TO SUPPLIERS AND SUBCONTRACTORS

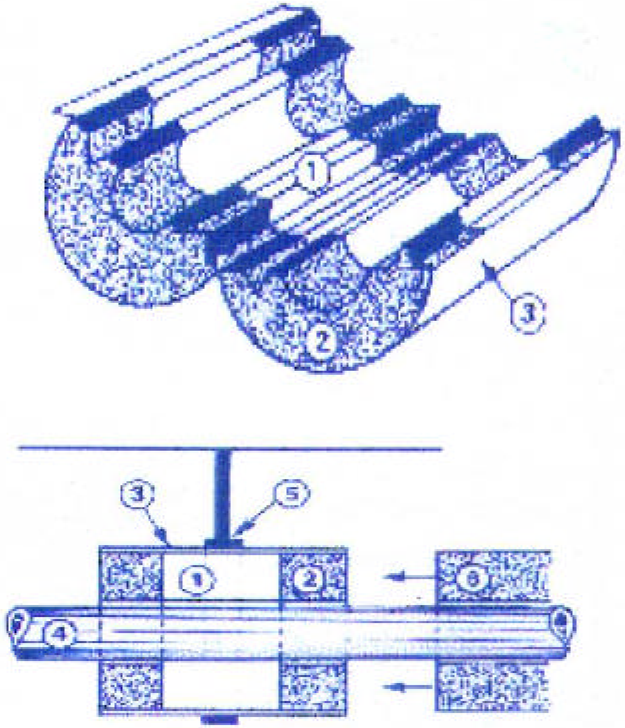
THE PARTNERSHIP WORKSHOPS

AIR CONDITIONING

Detail of the support system

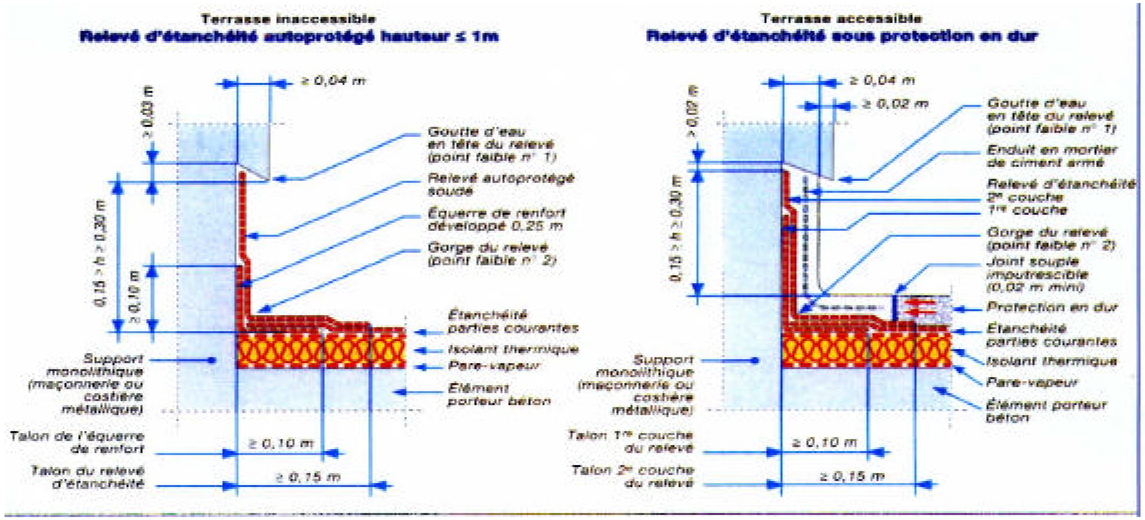
Noter la discontinuité de l'isolant et l'absence de coquilles sous les consoles.

Wrong



Distanceurs IOTOFLEX H 2001 (HUTCHINSON) à mettre en place lors de la pose des tuyauterie.

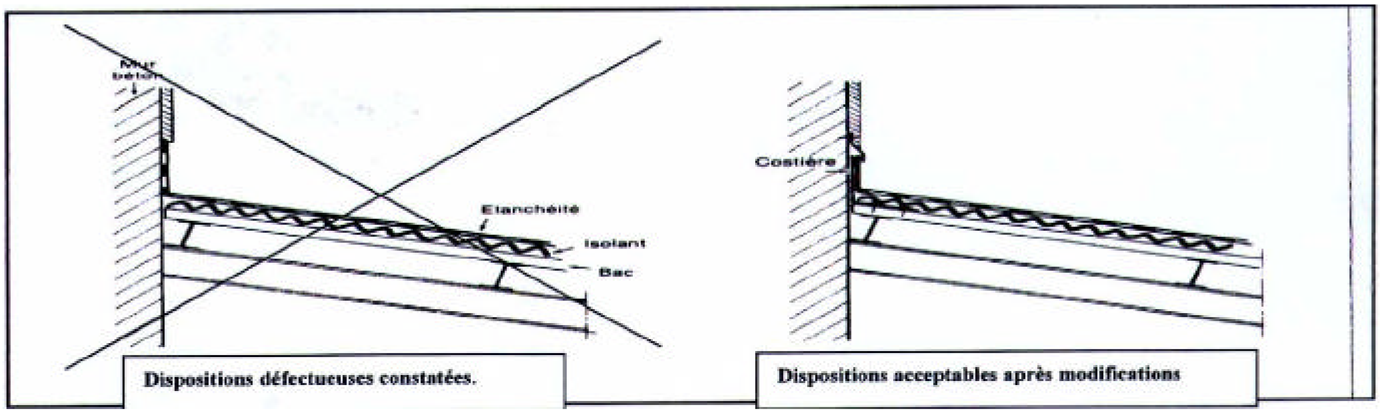
Good



WATERTIGHTNESS

Control of singular points on platform roofs

Main dispositions to realize impervious flashing



The sustainable built environment can be mainly achieved by responsible and durable construction firms

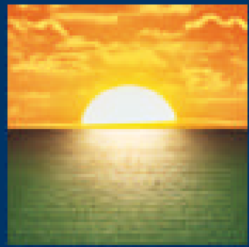
GTM Construction's motto

« We add our talents to develop customer loyalty »

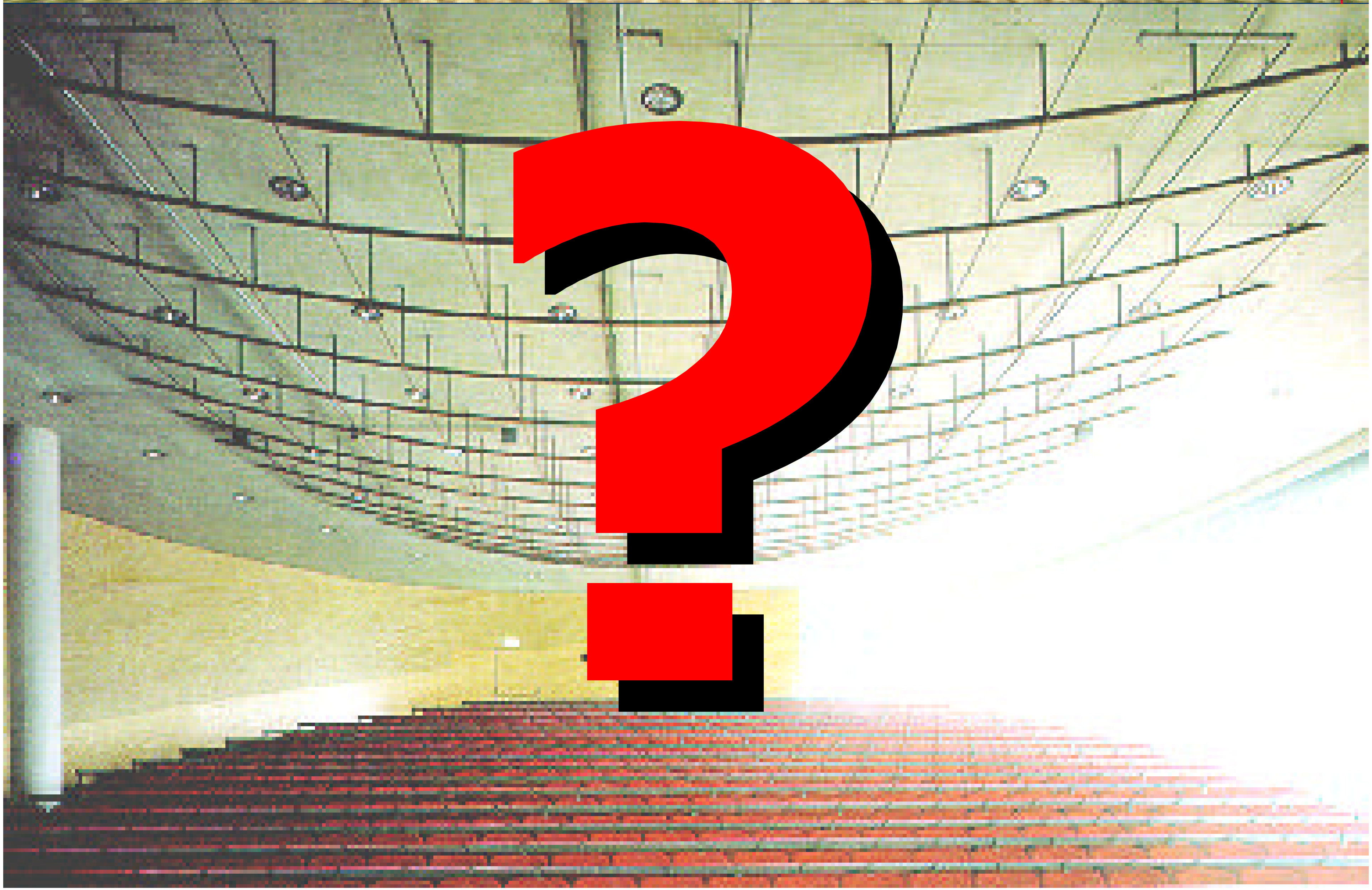
« We design - build - maintain and operate works of lasting significance for tomorrow »

ROCKWOOL
BRANDVEILIGE ISOLATIE

Protect mankind and its environment



Eric M.A.M. Offermans MSc.



Welcome on behalf of Rockwool

RIO

Kyoto

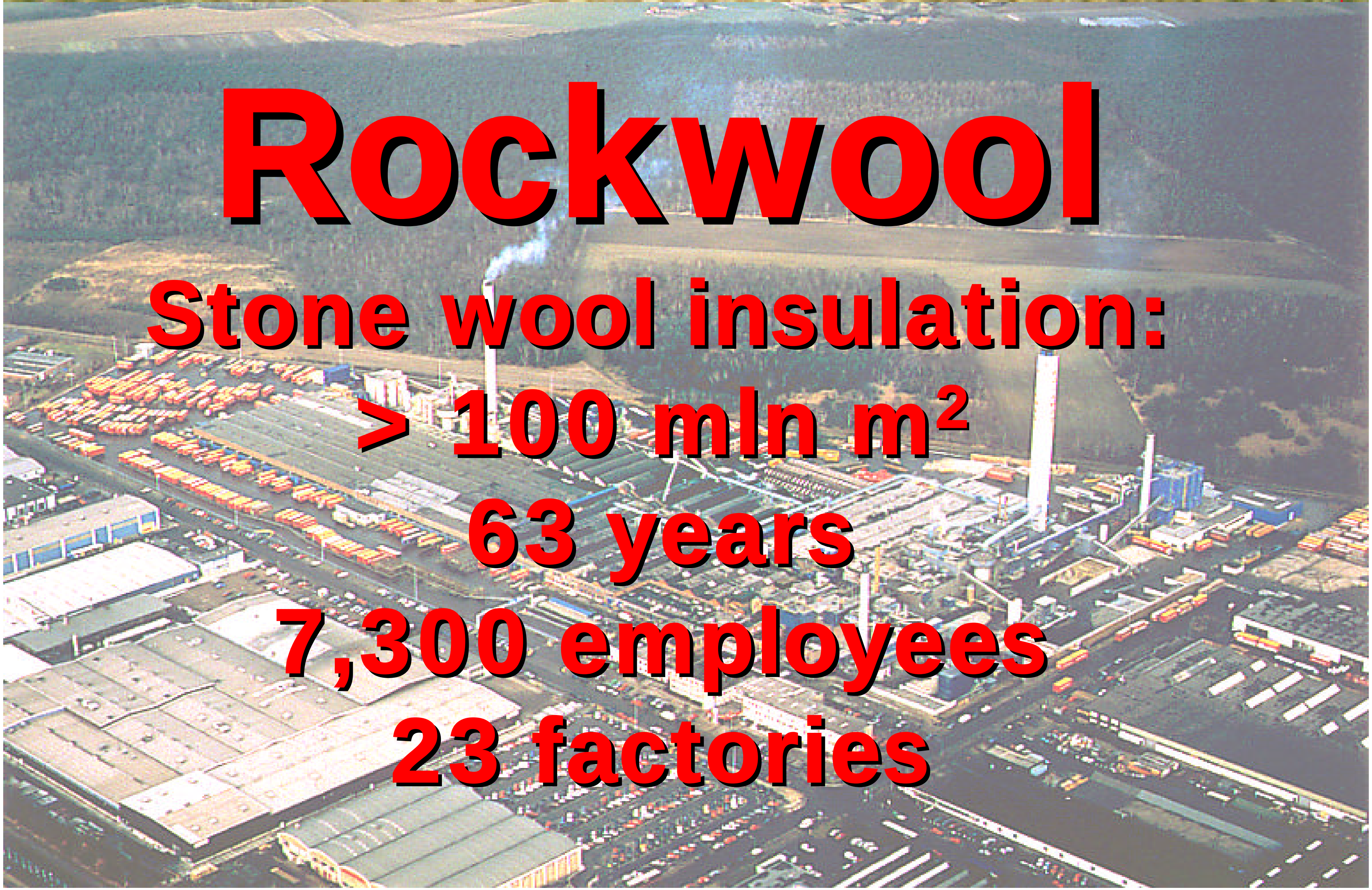
Greenhouse gas emissions

COP 6

ROCKWOOL
BRANDVEILIGE ISOLATIE

Rockwool Sustainable Building Congress

ROCKWOOL
BRANDVEILIGE ISOLATIE



Rockwool

Stone wool insulation:

> 100 mln m^2

63 years

7,300 employees

23 factories


ROCKWOOL
BRANDVEILIGE ISOLATIE
Insulation
Heat Cold Fire Noise
Sustainable as characteristic

PROTECT MANKIND AND ITS ENVIRONMENT

The COMPANY and its PRODUCTS

Sustainable manufacturing

Emission reduction up to 50 x
Recycling factory built
ISO 14001 and EMAS
etc.

Some data:

Heating consumption:	> 70 %
EU dwellings:	160 mln
Dwelling aged average:	25 y
Dwellings last:	50 y
1 m^3 gas:	eq 1 kg CO_2
Housing CO_2 emission:	600 mln t/y
UK dwelling CO_2	14,4 t/y
UK dwelling heating costs:	1200 £/y
Domestic emissions part:	> 45 %
CO_2 housing emission EU:	600 mln t/y

What insulation can do:

Saving UK insulated dwelling: 8,2 t CO_2 / y

50 % saving on the heating bill: 600 £ / y

EU savings insulation: 310 mln CO_2 / y

Side effect:
renovating 1 % = 150,000 man-years of work

Results:

-	Mexico	2 mln / y
-	Australia	3 mln t CO_2 / y
-	Switzerland	Minergy
-	US	Federal examples
-	and so on	

Studies on reduction:

		potential
-	Argentina	8.4 mln t CO_2 / y
-	Canada	5.5 % CO_2 reduction
-	Japan	27,5 mln t CO_2 / y
-	and so on	

Instruments:

- regulatory approach
- building codes
- market based incentives
- tax reductions
- etc.

Cost efficiency:

- use existing technology like thermal insulation

Communication campaign:

- contribute to save environment

Thank you and let us help you

N. America	NAIMA
Australia	FARIMA
Mexico	AMFATAFM
Europe	Eurima
Japan	RWA/GFA
Canada	CAMMVFM

Sustainable building for our children and our environment

Towards Sustainable Construction in Skanska

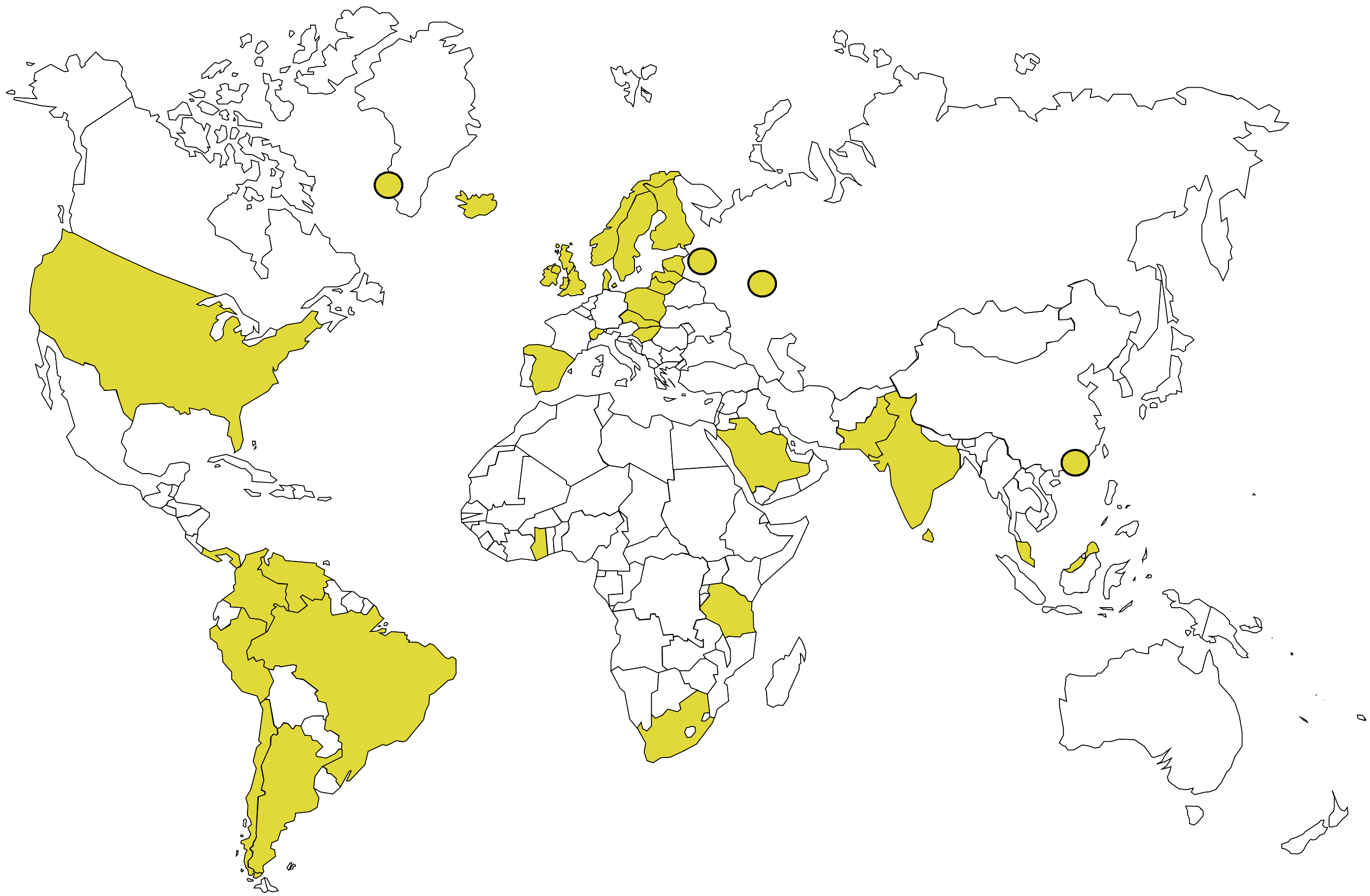
Axel Wenblad
Vice President Environmental Affairs
Skanska AB

SB2000 Maastricht, October 22-25

Skanska today

- Skanska is one of the world’s leading companies in construction services and project development
- Founded in 1887
- Sales last 12 months SEK 100 billion
- 80,000 employees
- Operations in 60 countries
- Primary markets are Sweden, USA, Denmark, Finland, Norway, UK, Poland, the Czech Republic, Argentine and Hong Kong

Global presence



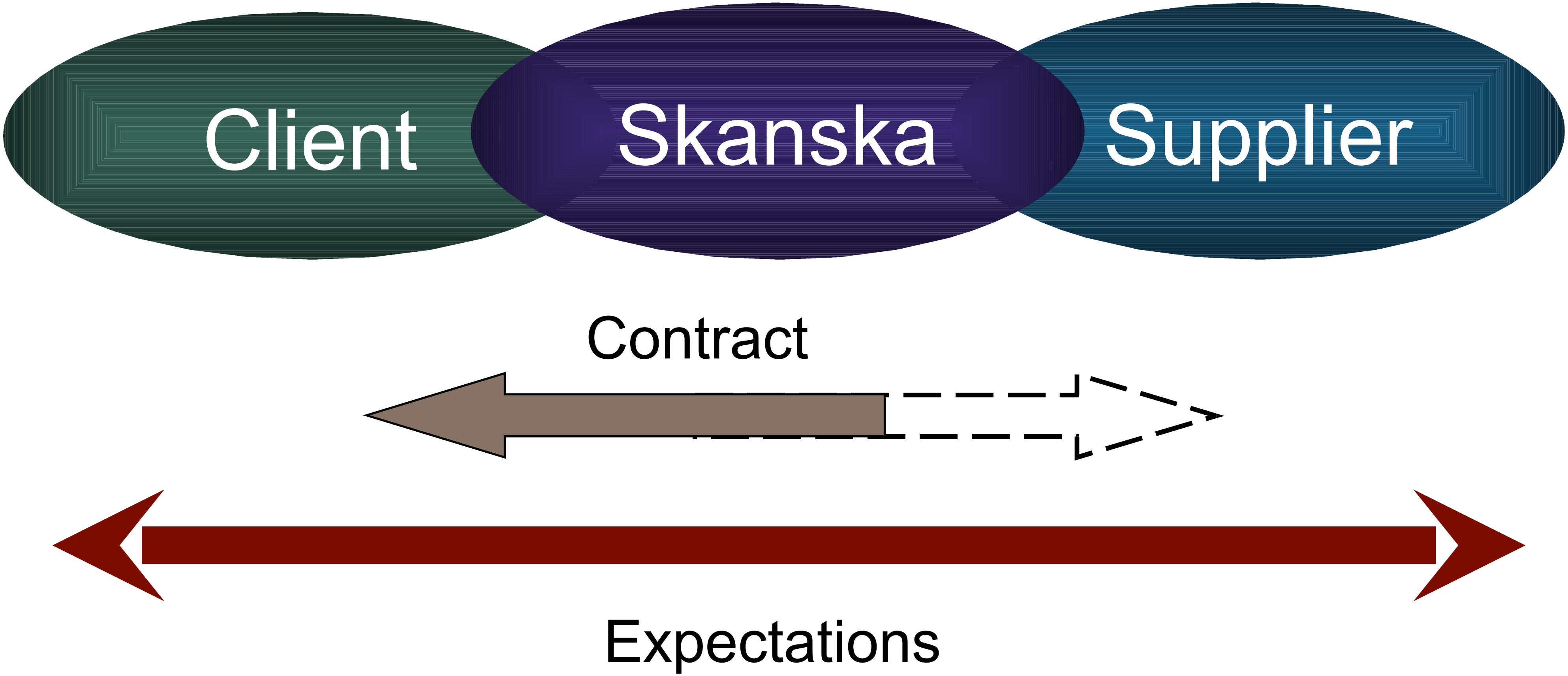
SKANSKA

Environment and Skanska Opportunities and risks

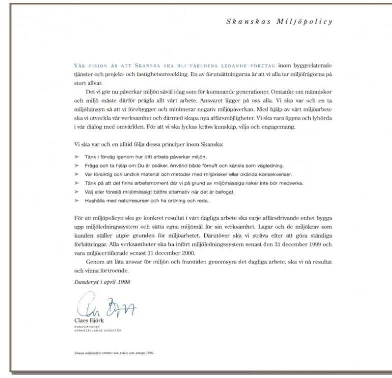
Effective use of resources
New business opportunities
Goodwill

Accidents, badwill
Cost for cleaning up
Insurance costs

Skanska's role



Skanska's Environmental Policy - Principles



Skanskas Miljöpolicy

VÅR VISION ÄR ATT SKANSKA SKA BLI VÄRLDENS LEDANDE FÖRETAG inom byggrelaterade tjänster och projekt- och fastighetsutveckling. En av förutsättningarna är att vi alla tar miljöfrågorna på stort allvar.

Det vi gör nu påverkar miljön såväl idag som för kommande generationer. Omtanke om människor och miljö måste därför prägla allt vårt arbete. Ansvaret ligger på oss alla. Vi ska var och en ta miljöhänsyn så att vi förebygger och minimerar negativ miljöpåverkan. Med hjälp av vårt miljöarbete ska vi utveckla vår verksamhet och därmed skapa nya affärsmöjligheter. Vi ska vara öppna och lyhörda i vår dialog med omvärlden. För att vi ska lyckas krävs kunskap, vilja och engagemang.

Vi ska var och en alltid följa dessa principer inom Skanska:

- Tänk i förväg igenom hur ditt arbete påverkar miljön.
- Fråga och ta hjälp om Du är osäker. Använd både förnuft och känsla som vägledning.
- Var försiktig och undvik material och metoder med miljörisker eller okända konsekvenser.
- Tänk på att det finns arbetsmoment där vi på grund av miljömässiga risker inte bör medverka.
- Välj eller föreslå miljömässigt bättre alternativ när det är befogat.
- Hushålla med naturresurser och ha ordning och reda.

För att miljöpolicyn ska ge konkret resultat i vårt dagliga arbete ska varje affärsdrivande enhet bygga upp miljöledningssystem och sätta egna miljömål för sin verksamhet. Lagar och de miljökrav som kunden ställer utgör grunden för miljöarbetet. Därutöver ska vi sträva efter att göra ständiga förbättringar. Alla verksamheter ska ha infört miljöledningssystem senast den 31 december 1999 och vara miljöcertifierade senast 31 december 2000.

Genom att låta ansvar för miljön och framtiden genomsyra det dagliga arbete, ska vi nå resultat och vinna förtroende.

Danderyd i april 1998

Claes Björk
KONCERNCHEF
VERKSTÄLLANDE DIREKTÖR

Denna miljöpolicy ersätter den policy som antogs 1996.

Think ahead
Ask when unsure
Be cautious and avoid materials or methods with assoicated environmental risks and unknown consequences
Consider that there are activities or projects where we, due to environmental risks, should not participate.
Chose and propose alternatives
Minimize the use of natural resources

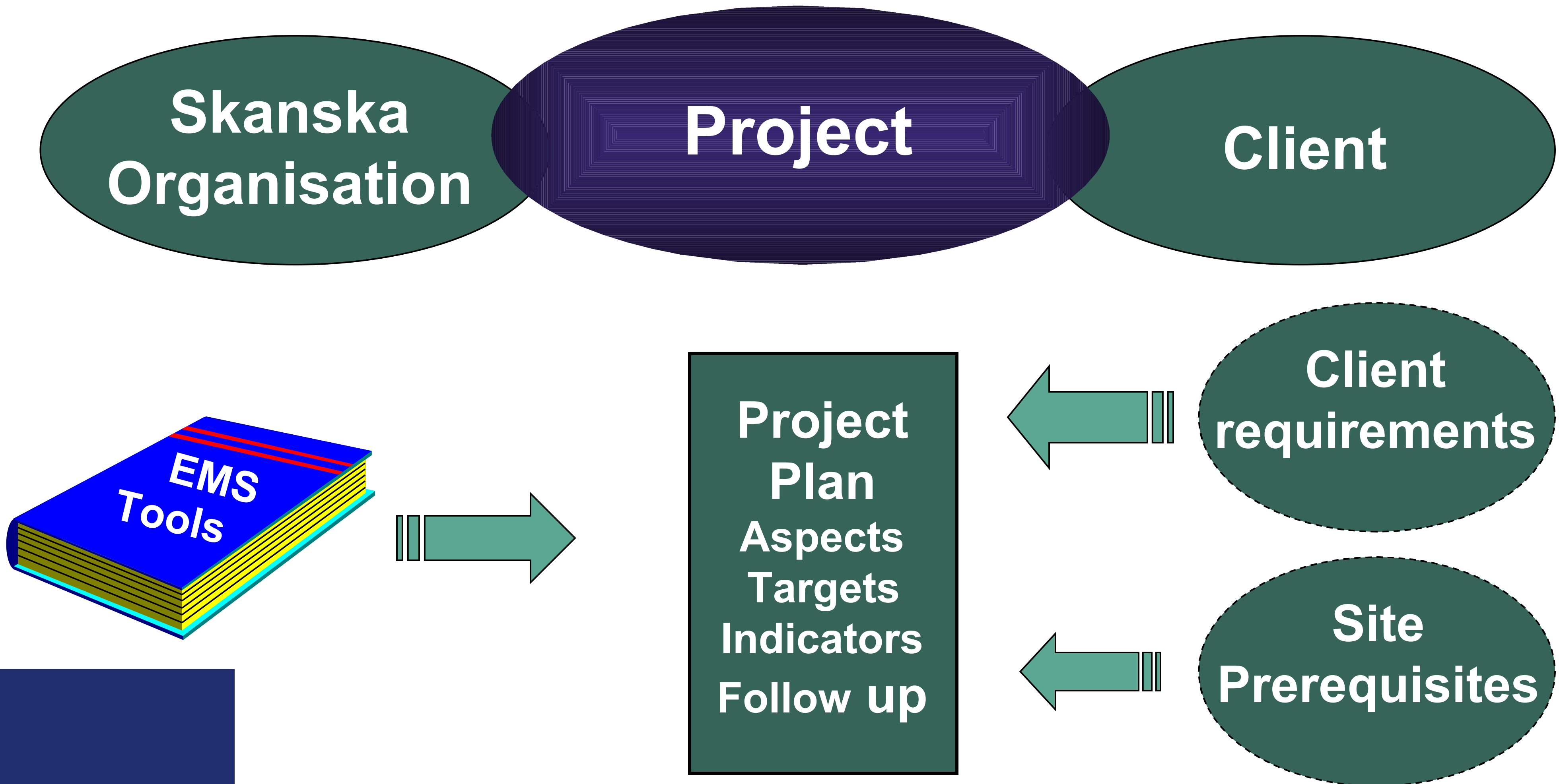
SKANSKA

Skanska's Environmental Management System

- First in our industry in the world to be ISO 14001 certified
- 97 % of all units had environmental management systems in place by the end of 1999
- All units will be certified by the end of 2000
- Investment of more than100 MSEK.

SKANSKA

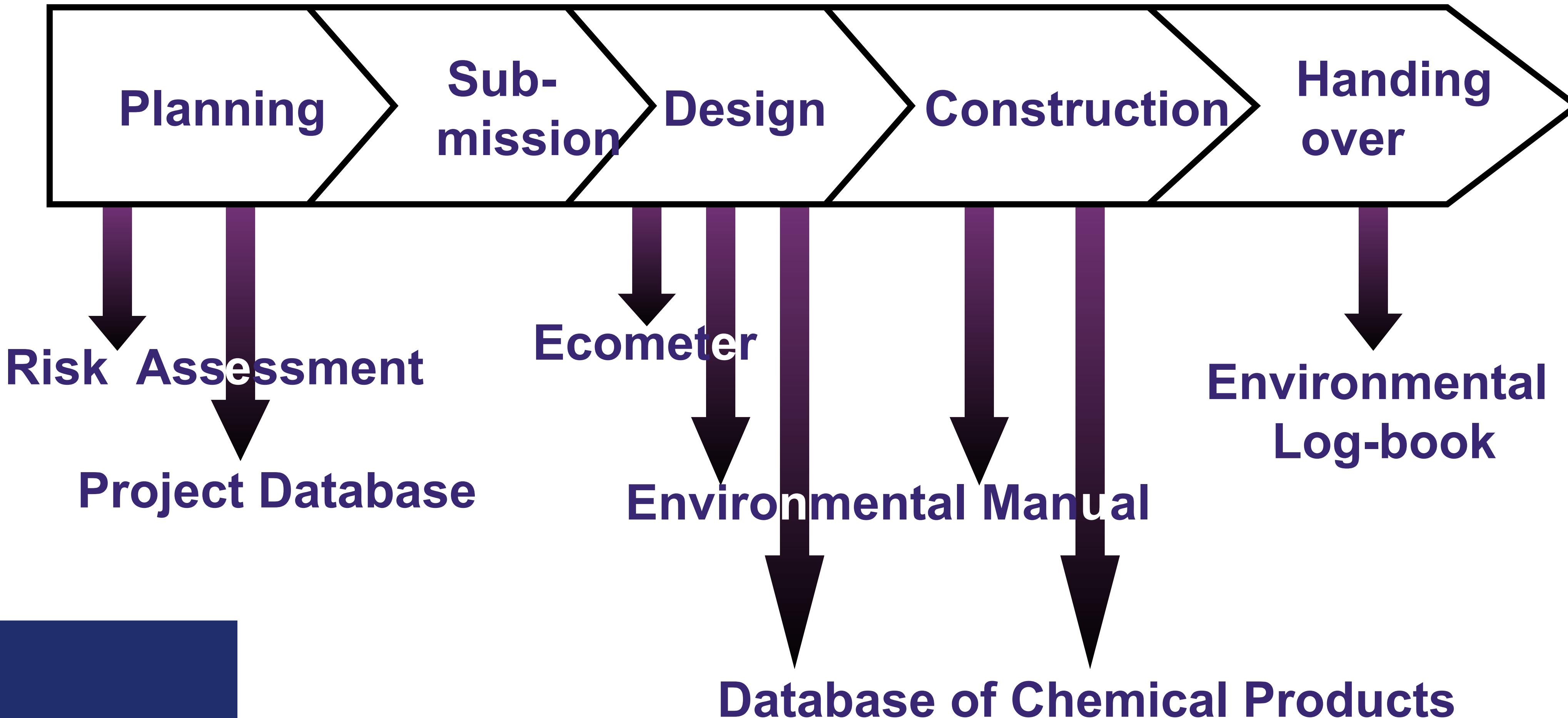
Project oriented EMS



Significant environmental aspects - an overview

	Material	Chemicals	Energy. Cons.	Soil Cont.	Waste
Land use planning				✓	
Design	✓	✓	✓	✓	✓
Construction	✓	✓			✓
Service life			✓		✓
Renovation	✓	✓	✓		✓
Demolition	✓			✓	✓

A Construction Project



SKANSKA

Skanska's Project Database

- information about projects that involve special environmental demands or interesting solutions
- 30 projects described
- available on www.skanska.com

SKANSKA

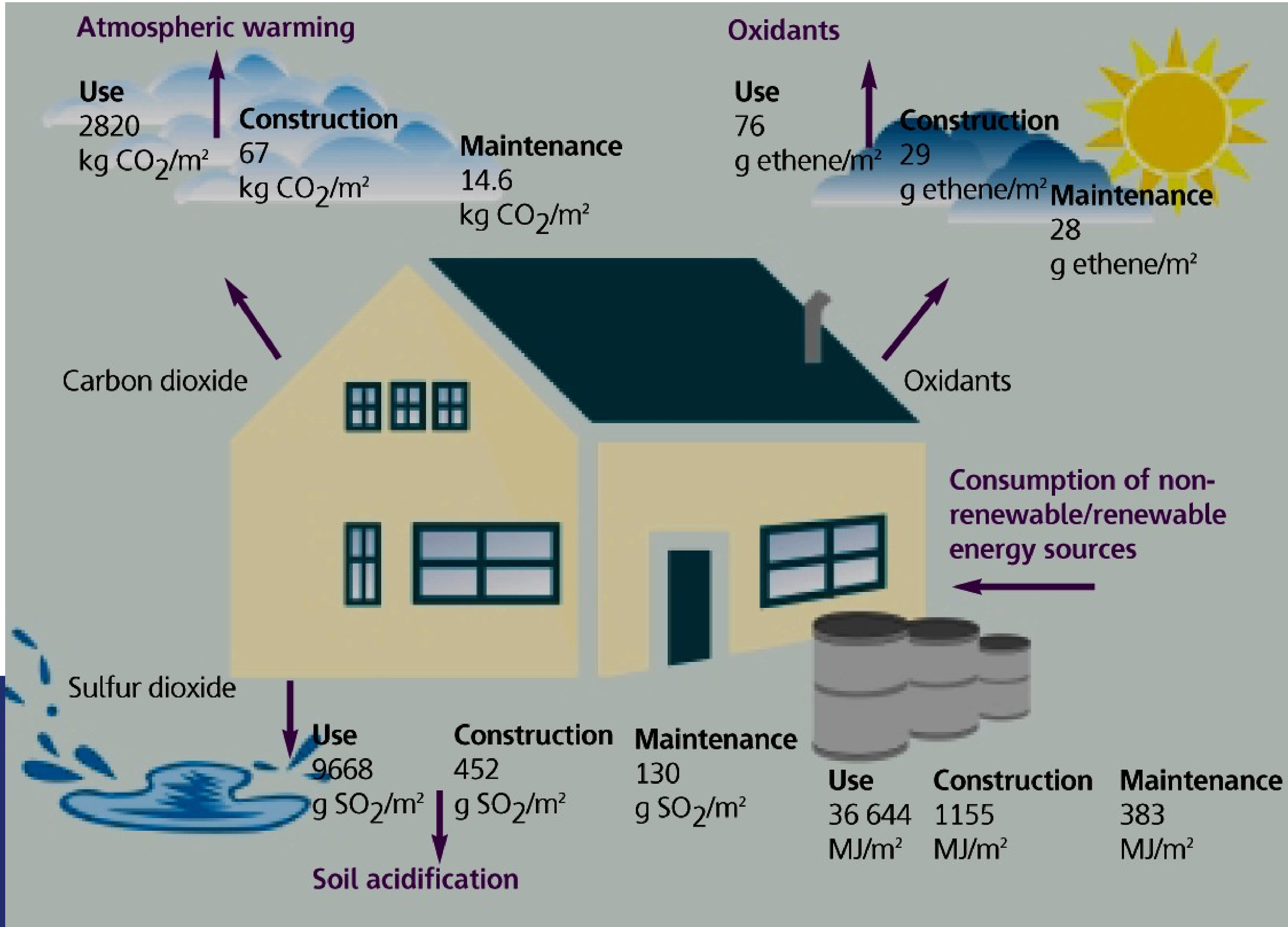
Skanska's Ecometer

Tool for comparing and choosing ecologically better materials, building components, systems etc.

- Size, shape, location
- Technical solutions
  - ventilation, water consumption etc.
- Building components
  - units, materials etc.
- Details
  - k-value etc.

SKANSKA

Skanska's Ecometer



SKANSKA

Database of chemical products

- Five chemicals not allowed on a global level
- Each Business Area develops its own "black-", "grey-" or "green lists"
- Database in Sweden with 2500 products
- Database in Denmark together with the construction sector

SKANSKA

Environmental Evaluation of Suppliers

- In 1999, more than 7000 suppliers were contacted
- So far, 100 of the 120 most important suppliers in Sweden were evaluated

  => classification in four classes:
  - not approved
  - approved
  - good
  - very good

SKANSKA

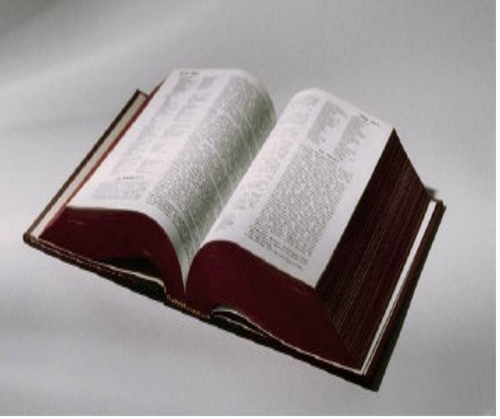
Classification of largest suppliers in Sweden

Not approved: no documented legal compliance

Approved: legal compliance, product declarations with environmental data

Good: policy, targets and programs, plan for phase-out of chemicals, requirements on vehicles

Very good: certified EMS, eco-labelling and environmental product declarations



Environmental Log-book

Includes:

- Building Product Declarations (Type II)
- Description of technical systems
- Directions for maintenance

... and practical advice on how to make your daily life more environmentally friendly

SKANSKA

Indoor Environment

- Focused allergy packages
  - contact allergy
  - “dust allergy”
  - pollen allergy
  - food allergy
- Skanska’s “Council of Experts”
- Training of employees
- Evaluation of building materials
- Inspections

Conclusions

- The client plays a key role
- Regulations: What - not how
- ISO 14000 a useful toolbox
- More cooperation client - architect - builder - supplier
- More research:
  - systems
  - energy
  - materials
  - chemicals

SKANSKA

Act local, think global

It looks so easy: starting from *energy* your attention widens to include *materials*, then to *social environment* and *urban infrastructures*. Before you know it you are working on the entire subject of sustainable building. But is that so? Or is it just a narrow view of a local situation?

Inspiring continents

by Anke van Hal and Ronald Rovers

To find the answers to these questions we need to consult people from other regions, countries or even continents. This is exactly what we did during the opening session of the International Conference on Sustainable Building in Maastricht, last October. Six participants, each representing a continent, were asked to present an unofficial view of sustainable building on their continents. The result – indeed, most of us take a very narrow view of sustainable building.

As starting point in this search, we begin with CIB's (International Council for Research and Innovation in Building and Construction) 'Agenda 21 for sustainable building', which was issued in 2000. This Agenda 21 (see box) aims to set general sustainable building guidelines for use over the entire world, with the main emphasis on clarifying the terminology used. An extensive worldwide study took place prior to publication.

Two statements borrowed from this research were central to the conference session:

– sustainable technique cannot be separated from sustainable economy and sustainable sociology;
– priorities for sustainable building do not need to focus on energy and material use, but on urban development.

It will not be surprising that all six representatives supported both these statements. But that was also where the similarities ended. In this respect the additional information given about the situation in Africa, where 58% of the world's nations exist on the lowest incomes, was very illustrative. This continent has the fastest growing urban development, so that towns are least able to meet elementary needs, resulting in dirt and disease.

When considering sustainable building in Africa, many other aspects were discussed than the new energy-saving technologies. However, does this necessarily mean that rich westerners can learn little from this continent? No. The African story of reaching the necessary agreement for housing in these social-cultural circumstances was fascinating. Homes built by the government are low, because the people for whom the homes are designed prefer rooms that they have created themselves, because this improves social interaction.

Sustainable building in Africa does not mean technical knowledge, but cultural knowledge. Listening to the voice of the people – this was the message that everyone, whatever their background, could agree with. The four African principles for sustainable building (see box), based on centuries old wisdom and experience, were an inspiration to everyone.

CIB'S AGENDA 21

The publication 'Agenda 21 on sustainable construction' is an initial attempt at international collaboration concerning sustainable building. The starting point is that each country should define its individual themes and priorities. Those drawing up the report confirm that the situation in the countries is so different that trying to use the same approach throughout all these countries is simply not feasible. Defining the terminology more clearly and developing a platform for collaboration is the first priority.

The aforementioned report is published by the International Council for Research and Innovation in Building and Construction (CIB). The CIB is an international organisation in which 50 committees focus on building aspects. Sustainable construction is one of the priority issues. The report is available on the CIB website (www.cibworld.nl) or via the secretariat (telephone number +31-10-4110240).

National blinkers

The value of such international meetings became clear right at the start of the Maastricht conference: it brings a worldwide perspective that makes it possible to (temporarily) shake off our national blinkers. Not only was the African viewpoint inspiring, the Eastern Block countries also offered food for thought (see separate article).

Sustainable building in Asia also has a unique approach. In the cities, the price of land is are sky-high, which leads, for example, to completely different values for buildings and materials. There is a lesson to be learned here: land should not be owned by anyone. This was also an ancient Indian belief in the North American regions. However, densely populated Europe will also be facing this problem within a few decades or even earlier. First signs of trouble are already being noticed.

Then there is the interaction between the developed (western) world and the struggle for survival in the developing countries. In his policy session paper, Mr Ngowi of Botswana discussed an additional problem for Africa and South America. "There are many cultures with sustainable principles but, due to western influences and 'colonial' use of developing countries, their resources become limited, and little space is left to act on these principles. Now the main task is to survive, rather than be sustainable. But in pushing for survival people are acting in an unsustainable way (within the remaining restrictions of space and resources), thus speeding up the process."

This shows the strong relationship between the activities in the western world and those of the developing world: in other words: if the western world embraces sustainability in a serious way, this also gives the developing nations space for sustainability. Or, to put it another way: the western world faces an immense task, to become independent of the developing countries, allowing sustainability in both worlds, within their own individual cultural approach.

Product development is a subject area where many countries can learn from each other, and is relatively independent of local circumstances. Exchanging knowledge of construction and materials could lead to fruitful initiatives.

This continental approach was an eye-opener that was much appreciated and could inspire new initiatives. The first of these is that a new Agenda 21 has been drawn up for sustainable building in developing countries (see page 20).

at SB2000

SUSTAINABLE BUILDING - THE AFRICAN WAY

The following African principles contribute to sustainable building.

1. **Use no more than you need (sufficiency).**
2. **Respect life and all relationships between species (spirituality).**
3. **Nature cannot be owned, but man should take good care of it (stewardship).**
4. **Without respect and attention to others there can be no peace and prosperity (social responsibility).**

Europe

Sustainability requires a new approach to building activities, e.g. integrating practical aspects, a long-term perspective and multi-generation responsibility. Europe currently enjoys industrialisation, high mobility, high urbanisation, and cultural and social diversity. Characteristic for industrialisation is the high income per capita in Western Europe, high energy and mass flows per capita and domination of technologies. The current high-mobility problems include the strain on the infrastructure and the uncontrolled development of mobility. High urbanisation levels have resulted in population density and show the importance of the building stock. The cultural and social diversity is obvious (between Western and Eastern Europe) but there are also differences in Western Europe between the north and south. In most European countries the state still plays a central role. Almost all towns have some kind of historic centre that is maintained by the local authorities.


Photo: R. Rovers, Sittard

The main protection goals focus on ecology, economy, and the social and cultural circumstances. To achieve ecological protection goals we need to limit our resources and reuse existing ones. The health of the environment requires a great deal of attention. Economic protection goals focus on funding and running costs, i.e. maximising capital and reducing running costs where possible. Social and cultural protection goals concern human health, urban development, landscape and towns. Allergies, respiration and the food chain are the main human health topics. Decentralisation forms the main problem for urban development. The cultural and natural dimensions of the landscape need to be protected just as much as the old towns, as it consists of non-renewable cultural resources.

Many parties need to work together to tackle all the aforementioned problems, but users (consumers) also need to take their individual responsibility. We are now used to having luxury around us, but it is a new luxury that we should be striving for – time, space and attention. Construction companies need to change their strategy from flow management to stock management and from production to service. Long-term political objectives and the fiscal basis of external costs are important for national policies.

The importance of education and research is undervalued. More education towards individual and collective responsibility, as well as more multidisciplinary research, is required in the future.

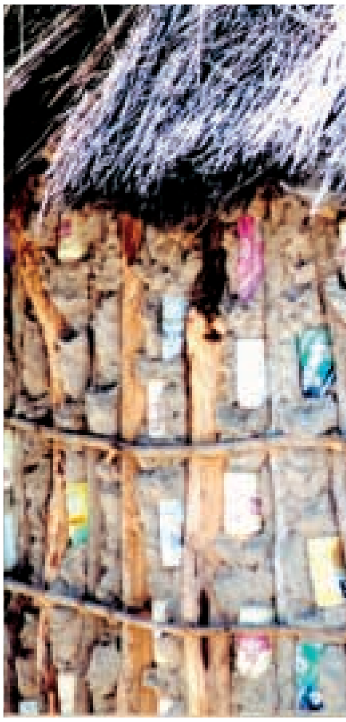
Niklaus Kohler
Institut für Industrielle Bauproduktion
Universität Karlsruhe
E-mail: niklaus@ifib7.ifib.uni-karlsruhe.de

Africa

Africa consists of two points of view that coexist and interweave without ever really becoming one, and these two viewpoints have widely diverging notions of sustainability.

The first is imported from the West – the steel and concrete buildings of Johannesburg, Lagos and Harare – where sustainable building is based on the western model of sustainability with its emphasis on resource efficiency, durability and creating economic wealth.

The other side of the coin shows the real Africa with its brutal problems posing a very different development challenge. Of the 45 African countries, 38 are categorised as low-income nations. There are no high-income countries in Africa. Only 20% of the available land area is arable and the continent is losing arable soil eight times faster than natural processes can create it, yet 70% of the people in Africa make a living out of agriculture. In the 10 fastest growing African towns, the average population density is 193 people/hectare. Most people live in what can only be called enormous villages where only 47% of households are connected to the water supply in some way, and 22% are connected to a sewer system. Every day droughts, flooding and civil unrest are sending millions of rural people to the urban areas. The urban population in Africa doubles every 20 years, a rate that far exceeds the ability of cash-strapped local authorities to provide the necessary infrastructure. These towns are rapidly reaching their limits, which in turn causes other problems, such as ill health. It is safe to say that issues such as energy efficiency and improved ventilation systems are very far down the list of priorities for sustainable construction on the African continent.



From an African perspective, sustainable urban development is the focus for sustainable building, and while considerable technical innovation and know-how is needed, there is no way the development problems of Africa are going to be addressed in a sustainable manner if the social and economic sustainability issues are not addressed at the same time. A reinterpretation of the African viewpoint and traditions provides some guiding principles for African understanding of sustainable development that is relevant to the problems of the continent.

These principles are based on two

ideas that are integral to life in Africa. One is impermanence – the acceptance that everything must die, including buildings. This allows buildings to be built according to deep ecological standards of sustainability. The other is interconnectedness – an almost spiritual understanding of the connection and interdependence of individual and community, humans and nature, and the visible and invisible worlds.

From these grow the following four principles that Africa contributes to the understanding of sustainable development:

- sufficiency - don't use more than you need;
- stewardship – people cannot own nature, but can only take care of it in a responsible manner;
- social responsibility – without respect and consideration for others, there can be no peace and no prosperity;
- spirituality – revere and respect the web of life and the individual's connection to the greater whole.

To achieve a sustainable building strategy that is relevant to Africa, the two perspectives of sustainability – Western and African – need to be integrated so that together they can become far more effective than the two individual perspectives.

Chrisna Du Plessis
CSIR (formerly known as the Council for Scientific & Industrial Research)
E-mail: cdupless@csir.co.za
Internet: www.csir.co.za

Photo: R. Rovers, Sittard

Asia

For over a century the modern-day social framework has ensured that towns have developed parallel to political and economic resources. In other words, as long as there is ample money available and access to other resources, most modern towns have rapidly developed with little consideration for their natural environment and long-term sustainability.

Land is the basic matrix of life and all development activities generate on or from it. The other essential item for generating development activities is capital. In most developing countries absolute value is based on land holdings. The fact that land can be traded is, in itself, the core of the problem.

Sustainable and appropriate water supply systems are vital for any urban centre. At present, most water supply lines are installed underground, which is a primary cause of water-related disease problems. Since the water supply in a centralised system, as we now have in India, cannot be guaranteed around the clock, local authorities can only supply water during specific times, forcing households to store water, often in unhygienic receptacles. Shutting down the water supply at intervals also causes vacuums in the pipes, resulting in their deterioration, thus contaminating the water with debris.

Building activity and building-related industrial production accounts for a large proportion of the developing nations' gross national product (GNP). Using inappropriate building technologies is the largest single contributor to environmental degradation, depletion of natural resources and unequal distribution of wealth and opportunity. Developing nations should therefore focus on using appropriate technologies in their building industry.

At least 50% of a developing nation's GNP is spent on building technologies. Of this, around 60% is spent on materials and 40% on labour costs. Therefore, in order to have sustainable development it is imperative that we identify the areas where large-scale industry and small enterprises are required. If, as in the case of most large industries, the add-on is more than 40%, there is clearly unsustainable and inappropriate development.

Misusing building materials is probably the largest single factor contributing to environmental degradation. Traditionally, a considerable amount of importance was given to the selection of materials, to ensure conservation of natural resources. It is the incorrect choice of materials that has resulted in the environmental degradation that we see today.

These are just a few of the issues concerning sustainable development, building technologies and materials, and yet they form the core of sustainable development policy. Once the question of large-scale industry versus small enterprises is addressed it becomes obvious that there is more

Asia continued

at stake here than just building materials. To ensure consistent sustainable development at all levels, long-term strategies must encompass the manufacturing processes, creating viable livelihoods, appropriate technologies and materials. Once these strategies are combined with the necessary policies for land and water, sustainable urban strategies for developing countries can be implemented and a healthy future ensured. Raising public awareness of environmental and equity issues is indispensable for this process.

Anil Laul, Anagpur Building Centre, India
E-mail: anillaul@del2.vsnl.net.in

Using local materials and building methods in constructing an orphanage in the Gorka district, Nepal

Photo by H.O. Hesseberg & S. Rahlff

Afterthought

After the first day of conference deliberations and presentations I was totally amazed to see the tremendous pace of the work towards sustainable buildings taking place all over the world. The variety of directions being adopted to achieve sustainability was extremely inspiring. There is complete realisation all over the world that we must take a good hard look at the towns that we are creating for ourselves, and urgently evaluate whether we are driving ourselves to an extremely unsustainable limit.

The daily conference sessions were a huge learning experience expressing the need to move forward. The evenings spent in the town also showed us the warmth of the traditional.

One could not have hoped for a more appropriate setting for this conference than Maastricht, where we saw the futuristic alongside the traditional. The fact that people responded differently by day to during the evening was an eye-opener in itself.

Considering the fact that around 60% of a nation's gross national product is spent on the construction industry (in one form or another), the next decade will see a tremendous amount of stress on sustainability and the SB2000 conference is a good forerunner in this area. Apart from spending the most money, the construction industry is also the largest single contributor to environmental degradation. It is therefore most appropriate that we go beyond the realms of sustainable building and examine sustainable human settlements as a whole. Man has made tremendous progress over the last century but has constantly refused to look back and learn from the mistakes of the past. The frenzy with which man has worked during the Industrial Revolution is stunning, but the environmental degradation has also been alarming and never before has mankind been faced with the prospect of total destruction.

There was so much to learn from the SB2000 conference as far as looking ahead is concerned, but equally important was the fact that we need to re-evaluate and take stock.

Maybe we need to step back – into the future.

South America

South America encompasses an extremely wide range of environmental, social and economic conditions. Excluding the Antarctic region, the range of latitudes covers a distance equivalent to that from Darwin, Australia, to Central Siberia. The range of climatic zones includes the equatorial rainforests, tropical deserts, temperate pampas grasslands, cold deserts, cool Andean forests and permanent ice fields. The social and economic contrasts are also extreme, with concentrations of wealth held by small groups while large sections of the population live close to the poverty line. The government is weaker than in the more developed regions of the world due to:

- long periods of military rule without democracy in most countries of the region;
- pressure from powerful local interest groups and foreign investors;

Photo: Frans de Haas, Voorburg

Curitiba, Brasil; very active city in sustainable development

– legal traditions that defend individual rights;
– the lack of technical expertise and scientific capacity in many state organisations.

While the environmental impact of forest clearance in the Amazon region and petrol extraction in the north are well known, local industrial and agricultural pollution continues with little control in most regions of the continent. In most countries both legislation and public awareness of environmental issues are still limited, though this is increasing due to improved international communication.

However, the region still has low environmental costs compared to other regions of the world. The environmental impact of buildings is also lower than in many other regions due to a series of complementary factors, e.g.:

– fewer materials are used due to lower spatial standards in housing and other buildings;
– average climatic conditions require less heating as winters are mild in most parts of the region;
– comfort expectations are also lower than in more developed countries;
– building methods are conventional and using locally available materials also reduces transportation.

However, the growing impact of globalisation is rapidly changing this panorama, as the introduction of new technologies and design, synthetic materials, higher environmental standards, and more sophisticated installations will inevitably increase environmental impacts. The growing use of air conditioning is beginning to put a strain on the energy infrastructure as well as increasing energy use in the building and urban sector.

Faced with this changing situation, two courses of action could be implemented to promote sustainable development in this region. On the one hand, there is a need to analyse, evaluate and improve the environmental performance of the new high-impact modern buildings but, on the other hand, there is a clear requirement to study the low-impact traditions of the region to guide the transition process.

For this reason, the built environment is a key sector in promoting sustainability in the social and economic development context. However, for the majority of the South American population, sustainable development will require basic improvements in living standards and working conditions, e.g.:

– access to clean drinking water;
– improved construction to reduce diseases such as malaria;
– control of climatic extremes within the dwelling to achieve thermal comfort and healthy living conditions.

The response to many of these issues will depend on design factors rather than, for example, the estimated emissions of greenhouse gases. It is argued that design quality which promotes long-term durability, flexibility, adaptability etc., thus providing high-quality environments, will provide an important contribution to sustainable development.

Despite the lack of formal environmental awareness in the region, much of the building construction and urban development uses sustainable materials with a fairly low environmental impact. However, globalisation is introducing new materials and technologies as well as higher expectations with the emulation of 'first world' images and models that may be inappropriate in this context.

Conclusions

Continued globalisation is rapidly changing the environmental impact of buildings by introducing new technologies, design trends, synthetic materials and new installations. More air conditioning is already straining the energy infrastructure. Specific design variables should be contemplated to ensure 'sustainability' that responds to the requirements of user and site, while international frameworks may allow a common methodological approach.

Increasing environmental awareness is a key priority but the following actions would also go a long way towards promoting sustainable development in Latin America.

1. Analysis, evaluation and improvement of the environmental performance of high-impact modern buildings.
2. The study of regional low-impact traditions could guide the transition towards a sustainable future.

Silvia de Schiller
Reserach Centre Habitat and Energy
Faculty of Architecture, Design and Urbanism
University of Buenos Aires
E-mail: schiller@fadu.uba.ar

continents

CONTINENT SESSION: SB2000

Sustainable Building in South America: a regional report

Silvia de Schiller
Research Centre Habitat and Energy
Faculty of Architecture, Design and Urbanism
University of Buenos Aires

Introduction

South America covers an extremely wide range of environmental, social and economic conditions. Excluding the Antarctic Sector, the range of latitudes covers 15° N to 55° S, a distance equivalent to that from Dar-es-Salam to Copenhagen or Darwin, Australia, to Central Siberia. With such a wide range of conditions, the sweeping generalisations given in this report does not reflect the extremely wide range of regional variations. However, it is hoped that the insights provided help to explain the specific requirements and problems related to **green building** in the context of **sustainable development** for this region.

The range of climatic zones include the equatorial rainforests, tropical deserts, temperate pampas grasslands, cold deserts, cool Andean forests and permanent ice fields. The energy sources are also varied, with high proportions of hydroelectricity in Brazil and Argentina, important gas deposits in Bolivia, Argentina and Venezuela, major petrol fields in Venezuela and Ecuador, as well as significant fields in many South American countries. However, traditional fuels such as firewood are still and important energy source in many countries of the region.

Industrial development is also varied, with high concentrations of modern production in cities such as Sao Paulo and Buenos Aires, while local small scale cottage industries predominate in the rural areas. Major multinational companies operate in the modern sector, though many of the extractive industries such as copper, precious metals and logging, are still controlled by local firms or nationalised industries. The rapid privatisation process of the 90's has strongly modified the decision making structure and transferred many key industries, including the energy sector, into private hands. With the reduction of national governments influence, social inequality is becoming more evident with increasing environmental problems.

The social and economic contrasts are also extreme with concentrations of wealth held by small groups while large sections of the population live close to the poverty line. Government is weaker than in the more developed regions of the world due to a series of factors; long periods of military rule without democracy in most countries of the region, pressure from powerful local interest groups and foreign investors, legal traditions that defend individual rights and the lack of technical expertise and scientific capacity in many state organisations.

While the environmental impact of forest clearance in the Amazon and petrol extraction in the north are well know, local industrial and agricultural pollution continues with little control in most regions of the continent. In most countries, legislation to promote environmental impact studies has only been introduced recently and public awareness of environmental issues is still limited, though increasing due to international communication.

However, the region still emits low environmental impacts compared with other regions of the world. Per capita energy consumption is well below the values found in Europe and North America, while industry has reduced impacts compared with other regions with higher production levels. The population density is generally low and, on average, agricultural impacts are reduced when compared with the intensive methods used in other regions.
In the energy field, the change to natural gas and the large proportion of hydroelectricity implies that carbon emissions per kilowatt hour are lower than in previous decades and less than many other regions of the world, especially those where coal is still used for electrical generation and industrial processes.

Environmental impact of building.

On average, the environmental impact of buildings is lower than many other regions of the world due to a series of complementary factors:

- With lower per capita space standards in housing and other buildings, fewer materials are used.
- Average climatic conditions require less heating as winters are mild in most parts of the region, with no heating requirements at all in the vast equatorial zone. Comfort expectations are also lower than in more developed regions.
- Building methods are conventional, with simple masonry construction techniques, such as hollow brick and clay blocks, or simple traditional timber building construction.
- In rural zones, many renewable and low impact materials are used such as thatch, adobe, un-sawn timber, lime. This use of locally available materials also reduces transportation.

Materials that may adversely affect indoor air quality and health are few, though there is a lack ok knowledge as to the potential impact of many materials. Indoor air quality is not generally considered to be a problem as most buildings are naturally conditioned and infiltration rates are high, especially in the residential sector. Modern office buildings tend to suffer the same problems are their counterparts in other regions of the world, though energy demand is high due to climatic impacts, and maintenance standards may be lower.

The growing impact of globalisation is rapidly changing this panorama, as the introduction of new technology and design, synthetic materials, higher environmental standards and more sophisticated installations will inevitably increase environmental impacts. The growing use of air conditioning in most countries of the region is beginning to put a strain on the energy infrastructure as well as increasing energy use in the building and urban sector.

Building for sustainable development

The built environment is a key sector to promote sustainability in the context of social and economic development. However, for the majority of the population in South America, sustainable development will require basic improvements in living standards and working conditions, such as:

- Access to clean drinking water and the introduction of basic urban sanitation infrastructure is a vital issue.
- Improved construction can eliminate or reduce endemic diseases such as Chagas, malaria, carried by insect vectors, etc.

- Control of climatic extremes within the dwelling can achieve thermal comfort, improve productivity, reduce stress and promote healthy living environments.
- The built environment and the building materials sector is potentially an important generator of local employment, especially for the absorption of migrants from rural areas, who move to growing urban settlements.
- Appropriately planned urban development can also favour access to employment, health and educational facilities, important component of sustainability from the socio-economic point of view.
- An important proportion of all buildings are designed and built without professional intervention, and many residential buildings will be modified over time by their owner occupiers.
- Building codes and planning regulations should include environmental issues, expressed in a clear and comprehensible manner to achieve effective implementation, complemented with design guidelines.
- Mega-cities attract population growth and create increasing environmental conflicts.

Design for sustainability.

The response to many of these issues will depend on design factors rather than detailed analysis of energy demand for materials production, the availability of raw materials or the estimated emissions of green house gases.

With globalisation trends, large scale industrial plants tend to have very similar efficiencies, regardless of location. While the embodied energy of cement is fairly constant for the majority of factories in the region, the design of concrete structures can reduce the quantity of material used. The energy content and environmental impact of a sheet of glass is also fixed, but the effect of the glazing on the inhabitants will vary greatly according to facade orientation.

For instance, a low rise building that can be adapted over time and can be modified by the users will be more sustainable than a less flexible multi-story construction. Many large cities of the region have examples of the large scale housing projects that experience major maintenance and social problems. It is therefore argued that design quality that promotes durability, flexibility, adaptability over time and provide high quality environments will provide an important contribution to sustainable development.

Conclusions

Although there is a clear lack of formal environmental awareness in the region, this does not necessarily mean that buildings have high environmental impacts. On the contrary, much of the construction and urban development uses sustainable materials with low environmental impact. However, the impact of globalisation in architecture and urban design is not only introducing new materials and technology, but also higher expectations and emulation of ‘first world’ images and models that may be inappropriate for the environmental, economic and social context.

Faced with this changing situation, of rapid and uneven evolution, two lines of action could be implemented to promote sustainable development in this region. On the one hand, there is a need to analyse, evaluate and improve the environmental performance of the high impact modern buildings, such as high rise offices, private sector multi-storey flats, etc. On the other hand, there is a clear requirement to study the low impact traditions of the region to guide the transitions taking place at present.

In the context of South America, my response to the issues proposed by Anke van Hal include:

- Sustainable construction is directly related to development and therefore interacts with the socio-economic context.
- Though technical aspects of sustainable building are quantifiable and more amenable to detailed technical analysis, this aspect alone will not ensure sustainability.
- In the region, energy efficiency is required primarily to improve availability and avoid expensive generating and distribution infrastructure, rather than to reduce environmental impacts.
- Sustainable development is also related the configuration of the built environment at the urban scale, involving issues under discussion such as the “compact city concept” and the revision of “greening the cities”.
- Both at the urban and building scale, design variables should be contemplated, such as building and urban form, orientation for sun and wind, use of outdoor and intermediate spaces, etc.

With globalisation and rapid urban development, environmental impacts of the built environment are increasing. Green building is not yet a wide spread demand, but is an essential prerequisite to ensure the sustainable development of the region.

Sustainable Building Maastricht

The International Conference on Sustainable Building 2000 (held in Maastricht, 22-25 October 2000), marks the changes in construction markets throughout the world. Buildings have a considerable lifespan, and people spend a great deal of time inside buildings. Decisions about building design, construction, use, maintenance, renovation, demolition and reuse and recycling of buildings therefore have a huge impact on the sustainable development of our societies. SB2000 not only addressed the technical aspects and latest research findings, but also policy issues and marketing aspects of sustainable buildings, cities, construction technologies, building services and environmental assessment systems.

by Chiel Boonstra – Ronald Rovers

Sustainable Building 2000 (SB2000) combined two previous series of conferences into one: CIB W-100 Buildings and the Environment (Watford, 1994 and Paris, 1997) and Green Building Challenge (Vancouver, 1998). It is encouraging to see that SB2000 attracted contributions from 45 countries all over the world, covering a wide range of approaches and views on possible ways of achieving a sustainable development. Even more inspiring was the number of participants (over 800, from 49 countries), with backgrounds ranging from: property developers, architects, manufacturers, contractors, consultants, university researchers and students, as well as local, regional and national government representatives.

The overall objective of SB2000 was to address long-term sustainability goals for the building sector and directives towards implementation. Based on the understanding that sustainability in the building sector can only be achieved if it involves both bottom-up and top-down approaches, as well as markets and governments, individual buildings and cities, citizens and industry.

SB2000 was structured into a programme consisting of plenary sessions, parallel sessions, Green Building Challenge 2000 results and an exhibition of 18 national pavilions and sponsored contributions. A number of formal and informal side events were held to launch new initiatives.

In order to reach conclusions based on the audience's view, each parallel session was concluded by a reflection of three issues:

– What is the striking news of each session?
– Does it contribute to factor X goals?
– How can we further develop and implement this issue?

Policy and overview

– We need performance targets to make political commitments meaningful and

Plenary opening speakers receiving the first copies of Options for Change, 10 years of sustainable building in the Netherlands, From left to right:
Jef Pleumeekers, director Novem; Johan Remkes, state secretary for housing, Netherlands; Karlheinz Zachmann, construction contact EU; Shoici Ando, director, Min. of Construction Japan; Bruce Lorimer, director general, Ministry of Public Works and Government Services, Canada.
See for their speeches at :
http://www.novem.nl/sb2000/Documenten/papers&reports/Papers&reports_frames.htm

2000,

Luc Bourdeau, author of CIB's Agenda 21 for Sustainable Construction, chairing the Industry session

to move the industry.

- Quantified targets can make semi-philosophical discussion of factor X meaningful.
- We need to interface environmental issues with economic and social sustainability.

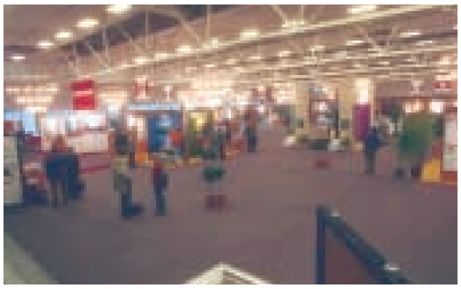
Environmental assessment and tools

- Performance assessment systems and sustainability indicators can support the implementation of quantified political targets.
- There is a need for international procedures on environmental information concerning building materials.

One discussion addressed the need for harmonisation of policies and tools on sustainable building. Participants recommended that we distinguish between the harmonisation of methods/tools and that of regulation/legislation, as well as distinguishing between environmental assessment of building products and complete buildings.

Conclusions were:

- to harmonise an LCA-based (life cycle analysis) environmental assessment method for (building) products and perhaps a product declaration format. Harmonising assessment methods is expected to take less time than producing a uniform product declaration model. It may be useful to separate the product declaration format into a harmonised part and a country-specific part. This takes into account cultural differences and leaves space for innovation.
- further research is needed to harmonise environmental assessment methods at the complete building level, taking into account the local aspects in different countries and the differences between residential and office buildings.



Seventeen countries at the expo

Urban sustainability

- Urban sustainability issues need more analysis and development. These are very complex issues with a great deal of regional variation.

The relationships between the aforementioned conclusions were well illustrated in a contribution by Ray Cole and others (SB2000 Proceedings pp. 22-24). LCA methodologies attempt to profile the performance of materials, components and buildings through time, and successfully entrench the notion of an extended time context for discussing buildings. Green building design is cited as incremental improvements in the environmental performance of buildings beyond typical practice, but typically without reference to timeframes or matched to other contextual factors. By contrast, environmental sustainability implies long timeframes of responsibility – well beyond that currently practiced or envisaged, and beyond the building life expectancy embodied within typically in the form of easy, 'win-win' strategies such as energy efficiency or using a few environmentally friendly materials. But in this incremental process, increasing degrees of 'greenness' involve looking at broader timescales and issues, such as:

- initially focusing on the most immediate issues: initial costs and usage strategies, such as energy efficiency, water conservation, and indoor air quality;
- taking a slightly broader view, looking perhaps at upstream environmental impacts of materials or recycled content of materials;
- embracing the entire lifecycle of the project and its components, including issues of durability and adaptability.

This is also the current extent of most building environmental assessment systems. There is an implicit assumption that green design, by continually reducing resource use and ecological loading, is charting a sustainable path. However, a significant realignment towards a more holistic and sustainable approach, both in design and its assessment, may not be possible until the links between building performance and larger scales are acknowledged. The individual building, it would seem, is a too

Lucien Kroll speaks at one of the sessions

Continuous discussions during the conference

Photo's: R. Nijpels, Sittard

Manifest on increased implementation of sustainable building in Central and Northern Europe

The integrated approach to building while caring for the environment is only just starting to take off in Central and Northern European countries. The concept of sustainable building includes aspects such as water, energy, waste, materials, traffic, health, flora and fauna and social issues. Awareness of this concept is still fairly low in these regions. However, members of the international network of Organisations for the Promotion of Energy Technology (OPET) in Latvia, Slovenia, Hungary, Bulgaria, and Slovakia, together with Novem (the Netherlands), have made a joint effort to take the first steps towards increased implementation of sustainable building in their countries.

By analysing the national situation, organising a training session, workshop and discussions, the participants have defined requirements for successful implementation of sustainable building. These requirements cover not only technical capabilities, but also institutional, strategic and financial aspects. The participants also defined the relevant parties in their countries. The steps that can be taken to increase sustainable building implementation were set out in a Manifest during the International Conference on Sustainable Building 2000, which was held in Maastricht, the Netherlands. These steps range from identifying parties and creating awareness, to creating a network and a dialogue on the topic, or preparing strategies, policies and programmes. The role of the OPET organisations will mainly focus on transferring national and international knowledge, creating awareness and acting as intermediary in the coalition building process and bringing the various parties together. Each OPET will organise a national workshop in the near future as a follow-up to SB2000. The results of these workshops will be published in due course.

AS

constraining level to define sustainable practice and the next significant advances in environmental assessment methods will invariably have to explicitly extend boundaries of assessment, i.e.:

- relating to the community or region in which a building is located – considering regional economic and social issues along with environmental issues;
- relating to a global context and the associated environmental economic and social issues.

Assessment systems reflect the prevailing ‘world view’ and an associated value set – the criteria that are included in the assessment system are considered priorities. By embodying the notion of the ideal performance they can be important tools for transforming building design.

Sustainability will necessitate systems-style thinking – one which emphasises complete units rather than their constituent parts, relationships not specific entities, processes and transformations not physical structure, quality not quantity and inclusiveness rather than exclusiveness. These are not the underpinnings of current environmental assessment methods and are not easily superimposed on them.

Design process and construction

- Glocal (global + local) approach.
- A design process for sustainable architecture should be more open, comprehensive and cyclic.

Sustainable building services

- Large potential for energy savings in large office buildings.
- Look for win-win situations in normal maintenance cycles from short-term to long-term.

Professor Kazuo Iwamura referred to the Glocal Approach that architects should follow in order to contribute to the creation of a sustainable society, taking into consideration both global issues and local matters. (SB2000 Proceeedings, pp. 132-134). In other words, architects must adopt a global vision regarding the effects of architecture on energy, natural resources, the economy and the environment. Even more importantly, they must develop beautiful solutions. Their solutions should not only be compatible with local characteristics of the building site, but compatible with the human and socio-cultural environment as well. While these two elements are often considered to be opposing in principle, the holistic view of sustainability requires integration of both in terms of time, space and humanity – which can be best expressed by the term: Glocal (global + local approach).

Reuse, renovation, recycling

- Promising examples of reused buildings have been shown.
- It is possible to assess and quantify how (and if) building renovation is more sustainable than new construction.
- High-potential materials needed to achieve sustainability goals.

Marketing sustainable building

- Industry is starting to take up sustainability as part of mainstream business.
- A continuous active government involvement is required in establishing a sustainable built environment.

Section 24 of the South African Bill of Rights states that (SB2000 Proceedings p. 301): "Everyone has the right to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development".

A paper on Sustainable Building Implementation from a Japanese Perspective (SB2000 Proceedings pp. 58-60) concludes that problems relating to sustainable building cannot be solved only through traditional academic approaches. The integration process has connections with geographical, demographic and cultural context in the region.

The Dutch approach showed a project where industry develops product declaration sheets, market parties developed environmental assessment methods, while the government establishes benchmark targets for energy and materials.

SB2000 marked changes in the construction markets all over the world. There is a clear notion that sustainability is a common issue irrespective of location and economy. It is also clear that solutions differ in time and place to acknowledge the variety in culture, climate and conditions. During the final plenary discussion it was concluded that SB2000 was useful and inspiring, but participants were recommended to "plant a tree, plus an additional tree for every 1,000 miles travelled, to compensate for the environmental load of attending the conference".

Photo: R. Nijpels, Sittard

Nils Larsson receives the 'spirit of Maastricht', for never ending promotion of Sustainable Building

Closing Document SB2000

As presented in the closing session and based on reports from the various sessions and meetings, the closing document consists of three sections:

- outcome;
- conclusions;
- recommendations.

Outcome

- *This is the first in a series of official Sustainable Building Conferences, the next event, SB2002, will be held in Oslo, Norway.*
- *The international initiative for Sustainable Built Environment (SBE) has been officially established and new members are welcome.*
- *Five Central and North European countries have signed a manifesto agreeing to collectively organise national SB2000 follow-up events, to enhance awareness and find solutions to financial obstacles.*
- *A third period for GBC (Global Building Challenge) has been established. The next meeting will be in March in Santiago, Chile, with an additional five new and very ambitious countries.*
- *A new magazine, entitled Sustainable Building, was established to address the topics discussed in the series of conferences.*

Conclusions

- *A sustainable agenda operates on scales of materials, buildings, and urban regions, and should also include functional, social, economic, and ecological factors.*
- *Strategies for reaching a sustainable built environment should reflect varied regional conditions and priorities, and various implementation models: think global, act local.*
  Industry is starting to take up sustainability as part of its mainstream business, but there still is a need for continuous active government involvement in establishing a sustainable built environment.
- *Quantified performance targets are required to make political commitments meaningful. Performance assessment systems and sustainability indicators can support this.*
- *There is a need for an international initiative aimed at addressing sustainable construction using materials and material cycles, including reuse and recycling.*

Recommendations

- *CIB should stimulate further worldwide dissemination of agenda 21 as the basis for debate on sustainable building, and translating this into other languages, where necessary.*
  All organisations involved in sustainable building should initiate regional conferences, in addition to the international sustainable building conferences.
- *CIB should initiate activities to further develop urban issues, sustainable building in developing countries, and social and economical aspects of sustainability.*
  UIA (Union International des Architectes) should initiate activities and improve links between local traditions, citizen's requirements for architectural and urban quality, and sustainable building.
- *Organisations such as, UIA, IEA, CIB, ASHRAE, Rilem, ACE etc. should become involved in SBE.*
  The outcome of the GBC process should be incorporated into other activities, e.g. within organisations such as ISO, CIB, IEA, ISCOWA, Rilem etc.
- *SB2002 should pay particular attention to urban issues, materials, social and economic issues, and to developing countries.*

Closing document session resolution

All delegates were asked to plant a tree, plus additional trees for every 1,000 miles travelled, to compensate for the environmental load of attending the conference.

25 October 2000,
Maastricht, the Netherlands

THE CONFLICT BETWEEN SURVIVAL AND SUSTAINABILITY

A.B.Ngowi
Department of Civil Engineering
University of Botswana
Private Bag 0061
Gaborone

ABSTRACT

The traditional societies intuitively recognized the importance of the environment and natural processes for their survival, and so they thrived to coexist with nature. They were cautious on the extent to which they exploited natural products such as trees for the construction of their shelters as well as the products that they released to the atmosphere.

Over the years, however, this coexistence has been disrupted by modern techniques for the exploitation of natural products, which often release disruptive bye-products to the atmosphere. While the modern techniques for the exploitation of nature have benefited large corporations over the years, the traditional communities have benefited very little if at all. I has recently been documented that the way nature is currently been exploited will lead to serious repercussions and therefore drastic measures are required to ensure sustainable building.

This paper argues that the concern of traditional societies and most of the developing communities is not sustainability but mere survival. With case studies from developing countries, the paper shows how preoccupation with survival conflicts with the drive for sustainability. It concludes that sustainability will only make sense to these communities when measures are taken to retrace how they coexisted with nature and then build up from there.

INTRODUCTION

Human history shows that the early generations intuitively recognized the importance of utilizing the resources provided by nature carefully and had practical experience of the fact that humans are dependent on the earth's life support systems for survival (Mead, 1964; Van der Post and Taylor, 1984). In other words, humans recognized that all elements of earthly life, including human beings, are mutually dependent. This interdependence manifests itself in natural phenomena that among others, tie rivers to trees, that cause the climate to influence vegetation, and that make particular animals thrive only in particular habitats.

Over the years, however, man has put great efforts in gaining in-depth knowledge about particular elements of a complicated, seemingly chaotic world, on the expense of trying to tie those elements together. Consequently, nature has been assumed to be utterly chaotic and nothing can be done other than trying to control and conquer it. The scientific and technological knowledge, which has been accumulated over the years, has been directed toward constantly improving the exploitation of each individual natural resource, without recognizing the threat posed to the basic ecosystems that create those resources. It has been taken for granted that nature's services have always been there, free for the taking, and man's expectations and economies are based on the premise that they are always there. The tampering with natural phenomena in a quest to control them has ended in serious repercussions. The climate is no longer as predictable as it used to be, underground drinking water is not as safe for drinking as it used to be, the air is not as clean and safe for breathing, and many other phenomena have lost their predictability.

Against this background, this paper argues that the concern of the traditional societies and most of the developing world is not sustainability because as far as they are concerned they have contributed very little to this problem. Instead, their main concern is mere survival using as many natural products and resources as possible.

BUILDINGS AND SUSTAINABLE DEVELOPMENT

Development efforts, which seek to address social needs, such as housing while taking care to minimize potential negative environmental impacts, have been called sustainable development (Hill and Bowen, 1997). However, each of the life-cycle-stages of buildings, which include planning, designing, construction, operation, maintenance and demolition, has some impact on the environment. Building construction is one of man's activities, which is acknowledged to have real and potential adverse impacts on the environment and well being of the populations of the world (UNCHS, 1993, 1996). Construction in general and buildings in particular contribute to the environment crisis through resource depletion, energy consumption, air pollution, and creation of waste (Spence and Mulligan, 1995). According to Dimson (1996) building construction accounts for 25 percent of the virgin wood and 40 percent of the raw stone, gravel and sand used worldwide each year.

In most developing countries, for instance, environment related problems are related to the fragile environments in these countries (UNCHS, 1996). Many people in the developing countries are still subsistence oriented and meet their basic needs directly from nature. However, owing in part to the rapid expansion of the market economy, extractive industries and infrastructure development have, in many cases degraded the ecosystems upon which these people depend for their needs. Short-term survival pressures often force these rapidly growing rural populations into practices that cause long-term damage to forests, soil and water. These people do not consider their problem to be environmental impacts as they are faced with more pressing and immediate problems. In the densely populated cities of the developing countries, particularly in Asia, the challenge is whether it is physically possible to protect sufficient natural resources in built environments to further contribute to sustainability needs (Briffett et al., 1998).

In developed countries, on the other hand, most of the basic human needs have been met, and the infrastructure is highly developed. However, some of the processes used in the production and maintenance of buildings and infrastructure are either inefficient, hence use unnecessarily large amount of resources or they release harmful emissions into the environment. The major issue in these countries is, therefore, that of making the processes more efficient by replacing them with more environmentally friendly ones.

Under these circumstances, it is not surprising that perceptions of the main elements and principles of sustainability are different in these two general contexts. One of the places where these different perceptions are clearly visible is in the Brazilian reserve of Monte Pascoal. The indigenous people there claim that they are "the voice of the land" who know how to take care of the wilderness. However, a closer look reveals that these people are only interested in reclaiming the land and use it for development projects, but are not necessarily interested in preservation. This is contrary to the perceptions of conservationists, mainly from developed countries that would like the wilderness to remain intact.

VIRTUES OF TRADITIONAL BUILDING PRACTICES

As time goes on, it seems that humans lose their relationship with the environment, and the necessary feeling for its protection and, possibly, enhancement. In construction, the spread of modern ways of building and the use of materials without reference to context, climate and culture is a legitimate target of the effort to attain sustainability.

Most of the damage that has been done to the pristine forests of Amazonia, for instance, is a result of the appetite for hardwood for building purposes in the developed world. Although Brazil and many other countries with tropical forests have put restrictions on cutting of trees, illegal lumbermen in collusion with indigenous tribes harvest most of the hardwood timber. When fires swept the Monte Pascoal, in Brazil in 1989, for instance, the Pataxo who are the indigenous tribe tried to stop the fire fighters. Later, park rangers found that the Pataxo were protecting secret stashes of logs they had sold to outlaw lumbermen. The real tragedy is that nobody has more to lose than the indigenous people, in this case Indians. A handful of their leaders have become famously rich pillaging the forest, but the majority still live in destitution. In a way, Indians are depleting their natural resources, yet they remain as poor and as desperate as ever. The hardwood that has been cut from the tribal lands is hardly used to construct their buildings as it is sold to the developed world where it is in fact out of context.

A closer look at the traditional building practices will reveal that the main materials that were used were either stone of soil in one form or another. These materials can be considered sustainable because of the possibility of recycling them. Where timber was the main building material, it is clear that its selection was done in such a way that no damage was caused to the forests.

CONCLUSION

This paper has attempted to show the relationship between the activities of humans and their effects on the environment. It showed that the attempt of humans to use science and technology to control nature has only resulted in consequences that were never anticipated. It further showed that while the developed world has the ability to take measures that can lead to sustainability, the actions of the poor nations, in their struggle for mere survival, appear to be utterly cruel to the environment.

In the end it appears that the concern of the poor communities is mere survival and not sustainability as would be expected of them.

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SUSTAINABLE BUILDING POLICY IN OECD MEMBER COUNTRIES

by
Takahiko Hasegawa
Pollution Prevention and Control Division
OECD, Environment Directorate

1. Introduction

The notion of "sustainable building policy" is comparatively recent, initiated in the 1990s as a means to integrate the various environmental impacts associated with buildings and the construction sector. As such, it brings together concerns about policy measures such as energy conservation, pollution prevention and control, building material waste minimisation, and the preservation of the built and natural environment.

To address various issues related to sustainable building policies, the Environment Directorate of the OECD initiated 4-year project on Sustainable Building Policies in 1998, and a broad survey on the sustainable building policies in OECD Member countries has already been conducted. This document is intended to present a progress of this project so far.

2. Environmental Significance of the Construction Sector

Buildings have a considerable impact on the natural and built environment in a variety of ways, and in the first stage of the project, a classification of environmental policy objectives was developed: resource efficiency, energy efficiency, pollution prevention, and harmonisation with the built and natural environment.

1)Resource Use

Material flow analyses for Germany, Japan and the United States show that the construction sector accounts for between one-third and one-half of commodity flows, when expressed in terms of weight. Appropriate material selection, waste minimisation, recycling of building materials and efficient use of water, are essential factors to curtail depletion of natural resources. Those factors also promote increased durability of buildings and allow for the cyclical use of materials.

EMBED2) Energy Use

Efforts to increase the efficiency of the use of energy began with the oil shocks in the 1970s. The construction and building sectors were particularly affected since they are large energy users. At present, the residential and commercial sectors are responsible for about 30% of primary energy use in OECD countries. On the basis of a number of analyses it is thought that buildings are directly and indirectly responsible for approximately 30% of total emissions.[1]

3) Pollution Emissions

[1] Statistics Canada (1997) and Houvila (1998).

With regard to pollution originating from buildings and construction activities, important concerns include the health damages and environmental degradation caused by the use of hazardous substances in construction materials, the generation of noise pollution, water and soil contamination from the drainage of buildings. Perhaps the most acute issues are the health problems arising from indoor air pollution, as well as the use of asbestos (a known carcinogen). The latter was introduced in order to meet fire prevention standards.

4) Harmonisation with the Environment

While unquestionably important the results of the survey reveal that harmonisation with the built and natural environment has a rather more ambiguous role in the development of a sustainable building policy in OECD countries. It would appear that whether or not this field is considered as part of a country's sustainable building policy will depend upon the implementing agency in charge. Only one response related to the preservation of historical features.

3. Classification and assessment of policy measures

169 policies were collected through the survey on sustainable building policies in OECD Member countries. Table 1 indicates the result of classification of these policies into 5 categories. A further category ("multi-objectives") was used to cover those measures, which used different types of instruments in a complementary manner.

Table 1 : Number of Sustainable Building Policy Examples

Policy	**Policy Objective**					**Total**
Tool	Resource	Energy	Pollution	Harmony	Multi-Objective	
Regulation	13	17	16	12	23	**81**
Voluntary	4	4	0	1	4	**13**
Economic	0	7	0	3	4	**14**
Information	3	6	1	3	16	**29**
Research and Development	5	5	0	0	11	**21**
Comprehensive	2	6	0	1	2	**11**
TOTAL	**27**	**45**	**17**	**14**	**60**	**169**

4. Criteria for the Evaluation of Policy Tools

The second phase of the project will be on the analysis and assessment of environmental policies for the sector. The four principal criteria by which environmental policy instruments are usually evaluated are as follows (See OECD 1997):

- *Environmental Effectiveness*
- *Economic Efficiency*
- *Dynamic Technological*
- *Administrative Feasibility*

5. Sectoral characteristics and policy design challenges

It is important to look at the characteristics of the sector in concrete terms as follows and assess environmental policies in light of these characteristics.

- Long-Lived Nature of the Building Stock
- Heterogeneous Users with Different Incentives and Constraints
- The Length of the Supply Chain and Policy Targeting
- Heterogeneity of the Building Stock
- Common Agency and Policy Co-ordination

6. Future Work

On the basis of the aforementioned progress, the focus of the next stage of the Sustainable Building project will be on the following two areas:

- Energy use and climate change; and
- Material use and waste generation and re-use.

In both areas the project will examine ambient environmental effects as well as the implications for indoor air quality. The proposed methodology will involve three steps:

- Assessment of the relative merits of alternative policy instruments
- Examine selected policies in greater detail
- Provision of guidelines for Member countries

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FOSTERING GREEN BUILDING THROUGH LOCAL GOVERNMENT INITIATIVES

Susan Barnett
City of Austin/Austin Energy
Green Building Program
721 Barton Springs Road
Austin, Texas 78704-1194
U.S.A.
Web site: www.ci.austin.tx.us/greenbuilder

GREEN
BUILDING
Program

Nine years ago, the City of Austin, Texas recognized the direct local environmental impacts associated with residential building. This realization and the need to protect dwindling natural resources prompted the City's efforts in establishing the Green building Program, now regarded as a leader in environmental building practices. Since that time, it has expanded its efforts to provide incentives and technical assistance programs for all residential, commercial, and multifamily building projects. The municipality is setting their own example by requiring all municipal buildings to be built with sustainable standards. For the private sector, the Green Building Program fosters "market transformation" by providing education; marketing and monetary incentives to develop both the demand side (the buying public) as well as the supply side (building professionals). The program is primarily funded through our municipal electric utility and supplemented by the water utility, environmental, and solid waste departments.

PROGRAM CONCEPT

Fundamentally, the program is based on a market-pull mechanism whereby the Green Building Program promotes green building practices, rates buildings that feature these practices, thus creating more demand from the public because these buildings are perceived as more attractive products for people to buy.

The technical staff provides design guidelines and rating systems in easy to understand language for each type of building construction. Staff also provides technical assistance to the public and our building professional participants, as well as assists in marketing and promoting green projects. Consumer education and awareness are just as important as fostering acceptance within the building professions.

PROGRAM COMPONENTS

Technical Assistance

The program offers several kinds of technical assistance. Our Sourcebook covers a broad range of information with general discussion of the building material, technique, or concern, as well as resources and references – geared more toward building professionals or owner/builders. Concise fact sheets and individual consultations are also available from our web site, by phone, fax or e-mail to our customers.

Green Building Membership

Membership in the program allows technical, logistical, and marketing assistance for participating building professionals, as well as serving as a means to assure that building professionals are educated to a base level of expertise to practice sustainable building.

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Rating System
A menu of sustainable options is available in an electronic spreadsheet for members. It self calculates a Green Building rating. In addition, the commercial building sector is offered a cash incentive and technical support for using a design checklist, which insures an integrated team approach.

Education and Outreach
Educational efforts include conferences and monthly seminars. We write newspaper and magazine articles as well as pay for advertisements. We appear on TV and radio talk shows and exhibit at many trade shows. The latest accomplishment is a CD about the planning process, called Green by Design.

RESULTS/BENEFITS
To date, the program has rated 1,800 homes, 1,400 apartment units, and 10 commercial buildings and has consulted on 85 other commercial projects.
Green Building results in many different types of resource savings but the task of accurately quantifying all impacts is extremely difficult and time consuming. We have not accurately measured the impact we are having. The program staff is presently working on quantifying the effects on peak power capacity reduction, total energy use reduction, water treatment capacity reduction, air and water pollution reduction, landfill reduction, and total water use reduction.

Energy Conservation
By conserving energy, Green buildings have benefits for many groups. Reducing a building's energy use saves money for the owner. Conserving energy reduces "peak demand" for the electric utility, which allows for a more efficient use of power plant capacity and reduces the need to build new power plants to keep up with demand. Saving energy also reduces pollution caused by the production of energy, which benefits all citizens, plants, and animals.

Avoided Emissions
Green Buildings avoid emissions by reducing requirements for electricity production required for manufacturing building materials, for reducing electricity for operating the building over its life span, by discouraging automobile use, and by reducing heat island effect. In 1999, Green Building participants reduced 3,644,066 kg CO_2, 3,882 kg SO_2, 7,365 kg NO_x from energy conservation alone.

Weighing the dollar value of these emissions' impacts is a highly customized process. While the value of an avoided ton of carbon dioxide has been assigned dollar values by various experts ranging from $5 to $30, Austin Energy has selected $20 for its calculations. This is considered a suitable mid-range number to ascertain the dollar value of its programs' environmental benefit. We determined that the Austin Green Building Program resulted in over *$50,000* worth of annual environmental costs through electrical savings. This is approximately one-fifth the cost of administering the program in 1998.

Water Conservation
Green Buildings use less water, both interior (plumbing fixtures) and exterior water (landscaping). This reduces costs to the owner, costs to the local environment, and stress on water delivery and discharge systems, as well as delaying the need for increased capacity.

Waste Reduction
The program's holistic orientation also espouses a waste reduction approach, whether considering the choice of materials (re-used or recycled content) or managing construction waste and recycling. We also encourage planned recycling centers in homes as well as composting. Naturally, such an emphasis will alleviate pressure on local landfills. To assist salvage process we have a collaborative Internet site for salvaged materials.

Water Pollution Prevention
Green Buildings reduce water pollution by promoting better land use and through requiring native vegetation (reducing pesticide necessity) In addition, water quality concepts such as stormwater filtration via wet ponds, constructed wetlands, and pervious paving methods are encouraged.

Building Materials and Indoor Air Quality:
The program's emphasis on ecologically friendly building materials addresses 'up-stream' resource consumption (for instance fewer toxins used in product manufacturing). This is also essential to a key program result: improved air quality. Green Building provides for healthier spaces, an important feature given the increasing concerns about indoor air pollution.

Economic Development
The Green Building program saves building owners money on their utility and maintenance bills. It also reduces liability from future indoor air quality and water pollution litigation. The Program has also stimulated new businesses. Businesses now sell new products such as Faswall, Rastra, and low-VOC paints. Other businesses provide services such as installation of; autoclaved aerated concrete, straw bale and cobb walls, and gray water and rainwater harvesting systems. The program's emphasis on sustainability creates a shift towards maximizing use of local products and services, which stimulates the local economy and minimizes transportation's toll on the environment. The Green Building Program benefits real estate and mortgage markets by creating a new niche with 'green' homes and commercial buildings. This further supports the real estate market through product differentiation and value-added services. Two local mortgage companies now have special financing available for green buildings.

Community
The concept of combating sprawl by encouraging remodeling before new construction, reducing building size with better designs, developing in areas which already are serviced with electricity and water, is basic to Green Building and healthy communities. By encouraging infill air quality is enhanced through automobile trip reduction. One Green Building project, the Brown Building could prevent—1040 pounds of hydrocarbons, 480 pounds of nitrogen oxides, 9020 pounds of carbon monoxide, and 139,580 pounds of carbon dioxide from entering Austin's atmosphere, through tenants' automobile trip reduction alone.

Austin's Green Building Program will not single-handedly alter the culture but it does attempt to put key information in the hands of consumers as well as the mainstream building industry. This is done with the belief that people will make the choices that have the best chance of improving the quality of their lives. In reality, we have seen that a variety of forces drive green building practices. Consumer demand, resulting from public education and awareness, is ever on the rise. Environmental responsibility on the part of building professionals and our own municipality is also growing. All of this serves to benefit the city government in its efforts to provide a well managed city, and our citizens benefit with a better quality of life.

PENNSYLVANIA AS A NATIONAL MODEL FOR SUSTAINABLE BUILDING PRACTICES

James S. Toothaker
Pennsylvania Department of Environmental Protection
Rachel Carson State Office Building
Harrisburg, PA 17105

INTRODUCTION

The Commonwealth of Pennsylvania, spearheaded by the Governor's Green Government Council and the Pennsylvania Department of Environmental Protection (DEP), is transforming the way its facilities are conceptualized, designed and constructed. Sustainable, high-performance design is integrated in guidelines, specifications, performance standards, lease documents and building operations. The initial pursuit of sustainable design recognized four primary objectives within an integrated process or "systems thinking" approach that differs from the traditional "linear" process of designing and building disciplines. The integrated process began with these four guiding principles.

- Utilization of appropriate high-performance technology to significantly reduce energy consumption and operational costs.
- Maximize the use of sustainable materials throughout the project.
- Minimize negative impacts on interior air quality.
- Improve health, motivation and productivity of building users through the creation of an improved, highly flexible environment.

The South Central Regional Office Building

DEP's South Central Regional Office Building is a 73,000 square foot leased office building in Harrisburg, Pennsylvania. It was designed with the intention of becoming Pennsylvania's first "model" green technology building. DEP achieved the four primary objectives for the South Central Regional Office Building by perceiving them as inextricably interrelated issues and as part of the integrated design process that produced a synthesis of all building components.

The South Central Regional Office Building design process included site issues of brownfield utilization, sustainability, improved energy efficiency, sustainable materials and resource conservation, enhanced indoor air quality and reduced water consumption. The outcomes of the design and process considerations resulted in a coordinated and planned application of various categories of technology for sustainable development. The incorporation of integrated design, inclusion of academic resources, (The Center for Building Performance and Diagnostics in the School of Architecture at Carnegie Mellon University) and teaming with manufacturers, contractors, material suppliers and building owners and occupants resulted in innovative and groundbreaking creative concepts in state government functions.

The South Central Regional Office Building was occupied in May 1998. The actual hard construction costs, excluding site costs, totaled just over $78 per square foot. The energy costs are expected to exceed ASHRAE 90.1-1989 by 20%. Also, the building is one of the first 12 ever to earn the United States Green Building Council's LEED™ certification for sustainable design and construction.

The Commonwealth's first green building introduced integrated sustainable design and high-performance technology to Commonwealth projects. There were successes and also lessons learned. In future design and construction projects Green Team consultants will be more closely involved in the decision-making process and systems detail associated with the construction of a high-performance building. Additional active involvement will assure that chillers are optimally sized, and HVAC systems will avoid operation and maintenance problems adversely impacting the building population. Criteria associated with the thermal envelope, indoor air quality and building performance will be emphasized. Permanent energy and air quality monitoring systems have been installed to analyze the interactions between comfort, air quality, energy use and HVAC operations. One of the greatest benefits to come from South Central Regional Office Building is its educational value.

Ebensburg District Mining Office

The Ebensburg District Mining Office, a 34,500 square foot building, is emerging as an enhanced "High-Performance Green Building". Ebensburg satisfies the requirements for this by achieving the functional elements of employee adjustable HVAC, superior indoor air quality, indirect ambient lighting and it is a flexible facility, a "people space" that enhances work flow and incorporates appropriate telecommunications, acoustical performance, ergonomic seating and furniture and tasteful use of color, texture and materials. The American Institute of Architects (AIA) selected the Ebensburg project as one of the Earth Day Top Ten examples of viable architecture design solutions that protect and enhance the environment. July 2000 is the scheduled occupancy date.

The objectives of this high-performance project; utilization of integrated design process, improved energy efficiency, sustainable materials and resource conservation, enhanced air quality and reduced water consumption are retained from the Commonwealth's first project. The implementation process required to carry out the objectives has been substantially refined. Additionally, high-performance buildings are flexible facilities, (initial facility design must support cost efficient reconfiguration) which have other characteristics including superior indoor air quality, daylighting, energy efficiency and renewable energy resources, and are cost efficient. A final objective of the Ebensburg project was to design and build a facility that meets the USGBC's LEED™ Silver Criteria.

This high-performance building is designed with a 14 KW photovoltaic array (the second largest in Pennsylvania), under floor supply air plenum distribution and coupled with a ground-source heat pump supply (this may be the first project nationwide to integrate these systems). PowerDOE modeling indicates annual energy consumption will be under 25,000 BTU/sq. ft., or 45% better than ASHRAE standard 90.1. Ebensburg is highly energy efficient with lighting power density of 0.7 watts per sq. ft. and an HVAC system sized at 663 sq. ft. per ton. Construction costs will be $80-90 per sq. ft. Material selection criteria also resulted in specifying over 30% of building materials by cost manufactured within 300 miles of the project site. The Ebensburg project demonstrated the value and power of material modeling software such as BEES (used for materials life cycle cost analysis comparisons) and PowerDOE to create energy simulation models prior to construction. Also, preliminary analysis of this building indicates that this building will meet the USGBC's Gold Criteria of LEED™.

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Conclusion

The Commonwealth's strategic initiative through the Governor's Green Government Council to institutionalize the policies, standards and environmental benefits of high-performance green and sustainable buildings has clearly positioned itself as the first state in the United States to officially declare integrated design, energy efficiency and sustainable development as the bedrock for all future building programs.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

"Building Green in Pennsylvania" has evolved as the tactical means to incorporate high performance green and sustainable development in our built environment as we pursue our objective of environmentally neutral impact buildings.

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THAMESMEAD ECOPARK, UK – NETHERLANDS PRIVATE COOPERATION TO ACHIEVE SUSTAINABLE HOUSING IN THE UNITED KINGDOM

Chiel Boonstra [1], Phil Humby [2], Ken Walker [3]

1. DHV Accommodation and Real Estate, P.O. Box 1427, 3800 BK Amersfoort, The Netherlands, Tel : +31 33 476 06 41, E-mail : chiel.boonstra@dhv.nl
2. Tilfen, Harrow Manor Way, Thamesmead South, London SE2 9XH, United Kingdom, Tel : +44 208 320 3443, E-mail : phumby@tilfen.co.uk
3. Chart Cottage, Graffham, Nr. Pethworth, West Sussex GU28 OPX, United Kingdom, Tel : +44 1798 867 609, E-mail : kwalker@ukonline.co.uk

The aim of Thamesmead Ecopark is to demonstrate how new housing contribute to environmental sustainability. Through the design and construction of state-of-the-art Dutch housing concepts, energy and environmental technologies in the UK social housing and construction market, so that these can be replicated throughout the United Kingdom.

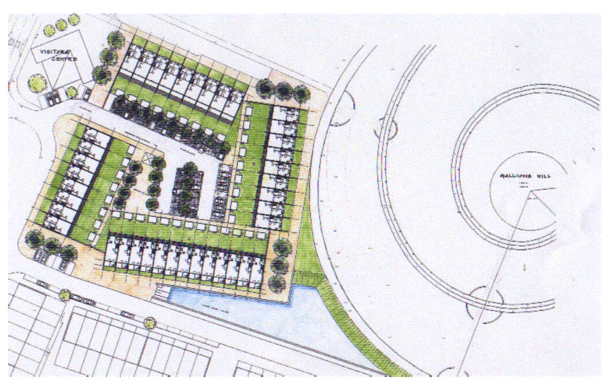
In the Kyoto conference environmental targets have been agreed aiming at reducing the environmental impact of human society. Already in 1987 the Brundtland UN Commission concluded that in order to allow developing countries a share in worlds' economical growth, even more substantial environmental targets must be achieved in western societies.

Thamesmead Town is a private company limited by guarantee, located South East London. Any profits are returned to Thamesmead community. There are no capital shares involved. Thamesmead is controlled by 12 Non Executive Directors, of which nine are elected by and from local residents. Thamesmead owns about 4,600 rented units, 200 commercial units and has its onw radio station, called Millenium 106.8. Thamesmead owns 180 ha of development land of which Gallions Reach Urban Village is the recent housing development.

Thamesmead Ecopark is a housing scheme of 40 two to four bedroom units in Gallions Reach Urban Village, South East London. Thamesmead Ecopark is meant to show how environmental sustainability. Consultants from The Netherlands advised on the sustainable concepts, based on 20 years experience in sustainable building in The Netherlands and Europe. Most important environmental principles on urban and building scale are integrated in innovative housing designs of the Dutch architect Jan Splinter.

Preliminary design has been completed in 1998. Planning approval has been provided by the local authority, i.e. Greenwich. Final design was completed in 1999, while on site construction is anticipated in 2001.

The aims of environmental sustainability in the building sector are to reduce the environmental impact of the use of energy, materials and water. The Trias Energetica points out a generic strategy to achieve this: at first demand reduction, secondly the application of renewable sources and finally efficient use of non-renewable sources.



REPLICABLE STRATEGIES

In particular fairly robust and known measures and strategies have been selected to achieve maximum replication potential. The strategies have been chosen by identifying consistent conceptual approaches for different house types. The measures are implemented by applying criteria of the Dutch Green Financing scheme for sustainable housing, thereby confronting views from the different countries involved, and integrating it in the architectural design.

ENERGY

The energy strategies aim at reduction of fossil fuels, direct and indirect CO_2 emissions, and increasing the role of renewables energies in the energy supply.

Neighbourhood scale

- Roof design integrates daylighting and solar collectors and prepares for solar PV
- Sunspaces in South facing units.

Buildings

- High insulation levels for facades, roofs and ground floors (U=0.25 W/m2K)
- Super insulating windows (low E glazing, U=1.1 W/m2K)
- Wind pressure controlled natural ventilation air supply
- Solar collectors for preheating domestic hot water
- Low temperature heating
- Individual condensing gas boiler

WATER

The water strategies aim at closing the water cycles into appropriate loops in order
1. to reduce the demand of drinking water, to reduce the environmental impact of exploiting water resources.
2. to reduce the capacity of sewage-water treatment plants
3. to balance ground water levels with rainwater instead of supply from other areas.

Neighbourhood scale

- Rainwater infiltration into the ground, through limitation of pavement and the application of half-open pavement.
- Biological treatment of rainwater before entering canals. Street water via ‘oil-separators’ to biological water treatment pond

Buildings

- Low flush toilets (4 – 6 liter per flush)
- Water saving taps
- Rainwater collection for toilet flushing in 6 units

MATERIALS

The aim is efficient use of materials, application of renewable, recycled and recycleble sources and limitation of the direct and indirect environmental impact of building materials.

Neighbourhood scale

- Efficient streetplan and parking provisions
- Flexible and half open pavement.

Buildings

- Timber frame construction
- Cellulose insulation in roof constructions
- Long service life and low maintenance cladding and roofing:
- Natural slates roofing, brickwork at ground floor level and clay tiles at second floor level

DISSEMINATION STRATEGY

A temporary Ecopark Information Centre shall be built. The aim of the Ecopark dissemination strategy is to manage, exhibit and promote a replicable example of the use of sustainable building techniques and their viability in an engaged community as an ambassador for sustainable living.

- at a local level: to use the Ecopark to illustrate and influence the local community and those concerned with local planning and construction

- to use the Ecopark at a UK national level as a focal point for Gallions Housing Association and its social housing colleagues throughout the country to influence policy and decision makers, professionals and contractors in the relevance of promoting sustainable housing, its quality, viability and environmental benefit as the norm.

- at a European level: to use the Ecopark as an example of good practice through the networks of social housing organisations and partnerships in which Gallions Housing Association is an active participant; and so as to receive information, European ideas and experiences in return.

Having planned and constructed 39 dwellings in Thamesmead, South-East London, using sustainable materials, construction principles and energy efficient systems, it is intended to pursue the objectives set out above, by using the project as an example to show that sustainability is an available option and can become the norm. This will be done by

- actively involving the tenants and occupiers in the understanding and perpetuation of the sustainable principles, features and services and bringing them to the attention of the wider community of which the neighbourhood forms part.

- Initiating a continuing programme of education in conjunction with local schools to promote an understanding and acceptance of the principles of sustainability.

- Establishing and carrying out a programme of informing and educating specific groups of people, (such as politicians, administrators, regulators, manufacturers, social and private developers, contractors and professionals), in the principles, features and results of sustainability.

Finally, in conjunction with local residents and the local authority an exit-strategy will be developed so as to pass on responsibilities within the community and to perpetuate and multiply the impact and results.

Conclusion

The private UK – Netherlands co-operation resulted in the exploitation of succesfull elements of Dutch sustainable construction principles in the UK housing market, e.g. the application of Green Finance criteria for housing.

The international cooperation took place at the level of a private organisation involved in new housing development in South East London, resulting in an immediate on site application of results.

Conclusions shall be drawn on these experiences through a UK funded evaluation program by the end of 2000.

The 'Dutch' design of the houses is another innovation compared to the relative traditional

Increasing Environmental Performance of Residential Buildings by Quality Competition on Public Subsidies - The Viennese Model

Author: Robert Korab, raum & kommunikation, A-1140 Wien, Matznergasse 8 / Top 54

Framework of the Viennese Model

Traditionally, the housing sector is a strong policy field in Austria, and especially in Vienna. Hence, public funding of the social housing sector (applied to new construction and renovation) is a key issue of state and federal social policy. Actually every year new housing projects comprising about 6.000 apartments – that amounts to 90% of annual Viennese construction volume of new apartments – are granted public subsidies.

From 1995 the city of Vienna adopted a new way of granting subsidies to the social housing sector. Every developer of social housing projects has to take part in quality competitions to obtain public subsidies. This policy framework challenged a structural revolution in the social housing sector and a dramatic raise of project qualities. Cornerstones of the model are:

Priciple goal was to raise environmental standards, living conditions and economical efficiency in construction of high volume, multi storey residential buildings

Target group is the housing sector and developers, hence in the first place investors were forced to think about quality and not architects and planners

Quality driving mechanism is developers competition for public subsidies by

(a) direct competition on large scale development areas, where best of competing projects are selected by an interdisciplinary jury (approximately ¼ of the annual construction volume), and

(b) relative competition by assessment of single projects by an expert group equivalent to the jury (appr. ¾ of the construction volume)

Quality labelling relies on relative competition in comparison of different projects, and is not based on fixed standards (by means of regulatory policies)

Since end of 1995 more than 170 projects were assessed in large scale competitions, more than 250 projects by the expert group, all together more than 55.000 apartment units were assessed. Thereof projects totalling more than 25.000 apartments were recommended to be realised and granted public subsidies. The projects are actually under construction or in state of final planning. Overall financing volume of the recommended projects yields to approximately 3 billion Euro.

General assessment criteria

The jury and the expert group, holding planners and scientific experts, representatives of the housing sector and key actors of the administration, evaluate all residential building projects that rely on public subsidies and select best projects to be realized. Remarkable is the weight of environmental criteria, which contribute by 1/3 to the choice. There are 3 assessment fields each holding 4 mayor assessment categories and more than 50 assessment criteria, namely

PLANNING (architecture, planning quality)

General quality of the development

Floor Plan, functionality

Quality of living and working conditions

Architecture and urban design

ECONOMY (economic efficiency, costs)

Overall construction costs

Costs for users/buyers

Relation of costs to quality standards

Consumer-friendlyness of user contracts

ECOLOGY (general ecology, environmentally sound technology)
Construction base lines, technical facilities
Building ecology, use of ecologically sound materials
Indoor quality, sunlight exposition, lighting, human toxics
Urban ecology (ecosystems approach), landscape architecture, open and green spaces

Assessment procedure

As basis of assessment the housing company or developer has to deliver a partially standardised project description to the jury respectively the expert group. The description has to hold

- Standardised plans (e.g. floor plans, site and free space plan)
- A detailed project description based on standardised data sheets, containing physical indicators, economic indicators, numerical data and qualitative description of the buildings
- Additional drawings, graphics and textual descriptions up to a poster size limit

Base lines of assessment procedure are:

- 3 equivalent fields of assessment (planning/architecture, economy, ecology)
- Collective judgement: every member of the jury/expert group judges in every field
- Judgement is supported/objectivated by means of a numbering system
- Outcome of the assessment procedure is a summarizing testimony/certificate for the submitter of the project. Positive assessment results in recommendation to receive public subsidies

Quality driving mechanism

Due to the decision-supporting numbering system a project has to gain a minimum of points. In every field as a whole and in every criterion of the assessment 0-100 points (20 point-steps) can be gained. Minimum standards for positive assessment and subsidy recommendation are:

a. gaining at least 50 points in each of the fields (planning, economy, ecology)
b. gaining at least 60 points summed up over all of the three fields

Remarkable is that there are no fixed quality standards except common legal and technical guidelines. Projects are assessed in comparison to average project qualities concluded from the series of earlier reviewed projects. Ongoing raise of project quality is a consequence of competition among the companies and not of predefined standards. Phantasy and skills of most innovative planners and companies constitute the quality driving mechanism. Best projects create the landmarks of quality. Consequently standards rose automatically and lead to a quite high quality standard until now. The quality driving mechanism also forces further innovations.

General outcomes of the competition

General outcomes of the Viennese model are:

- Large scale competitions set up and established new common standards for all of the Viennese residential building sector
- Environmental quality standards of new buildings have risen significantly since propagation of the model
- Competition evolved the described autodynamics mechanism of quality development: for beeing positively assessed today projects have to match comparatively higher quality standards than projects launched maybe a jear ago
- Construction costs lowered by more than 10 % despite of better environmental standards and improved planning and architectural qualities
- Extra costs for ecological measures amount to Euro 20,- to 100,- per m^2 net area (where average overall construction costs amount to approximately Euro 1.000,- to 1.150,- per m^2)
- Total extra investments for ecologically sound measures from 1996 until now sum up to more than 250 million Euro

- Regional innovation potentials got a remarkable kick-off, especially concerning the promotion of higher planning standards, and new construction and environment technologies (e.g. new construction materials and techniques, new forms of interdisciplinary project development).

Ecological performance gains

Among ecological performance gains are:

Construction and technical facilities

- Low Energy Standard: heating energy demand less than 35 kWh per square meter and year. Reduction of heating energy demand by 40 % compared to 1995 average.
- Increasing respect for the principles of solar planning. First high volume multi storey passive houses to be realized soon
- Widespread use of co-generated heating; use of regenerative energy sources in an increasing number of projects, with focus on solar water heating; reuse of lost energy
- Water saving measures: drinking water savings, water cycles, process water use in the majority of projects (as far as geotechnically practicable)

Building ecology

- Rising building ecology standards: increased use of environmentally sound construction materials, especially eco-labelled constructions, products and materials
- Resource saving by use of recycled materials; use of renewable resources, e.g. high volume multi storey wooden residential buildings to be realized soon
- Complete renunciation of products, materials and substances with high impact on climatic change respectively high global warming potential (concerning especially foamed products containing HCFCs, HFCs; perfluorated substances). Avoidance of PVC

Indoor quality

- Improved sunlight exposition and daylighting by optimization of building orientation, volume shaping and floor plans
- Improvements in indoor health and physiological comfort of appartments by use of biologically favorable, non-toxic materials and biophysical measures (e.g. low temperature radiation heating systems, respect for electrobiology)
- Increasing proportion of apartments (on an average far more than 50 % of apartments) that own small gardens, balconies, terraces

Urban ecology and open spaces

- Significant decrease of built on or paved areas by optimization of garages and minimization of pavement in open space, widespread construction of roof gardens
- More respect for conservation and reuse of on-site natural soils; extended measures to trickle away high proportion of drain waters on the ground
- Improvements in design of outdoor areas and open spaces: in the first place better understanding of peoples demands on open and green spaces, integration of landscape architects, ecologically sound design of open spaces, improved ecological quality of green spaces

In conclusion

The Viennese model of quality competition on public subsidies in the housing sector met its function to raise quality standards and decrease building costs with a minimum of regulatory politics in a highly satisfactory way. In my opinion the most important outcome of the model – beyond physical improvements of the houses itself – lies in the promotion of structural changes in the housing sector. Characteristic of those changes are the strengthening of multidisciplinarity in the planning process and the enhancement of competence and knowledge among the key actors and professionals. Future buildings will incorporate more intelligence and diligence than present buildings do. In the first place it's that kind of mental change that paves our way towards more sustainability in the housing sector.

Evaluation of sustainable building in Denmark

Ib Steen Olsen
Ministry of Housing and Urban Affairs
Slotsholmsgade 1, 3rd floor
DK-1216 Copenhagen
Denmark
Telephone: +45 33 92 61 00
Fax: +45 33 92 61 04
E-mail: iso@bm.dk

In the evaluation of a completed building project, it is normally the actual performance of the work and technical factors that are evaluated. Has the budget been met? Has the project been completed on time? Is there any building damage?

However, a number of other factors are also of interest to the client – for example, the architecture, user satisfaction and environmental factors. Particularly in experimental building projects it is of interest to get a more thorough evaluation of the completed project as a basis for judging the advantages and disadvantages of new methods and products.

In the case of sustainable building projects, a number of indicators have been chosen in consultation with the Danish Building Research Institute to evaluate the results in three new building complexes.

ECO HOUSE '99 – a competition
The building projects that form part of the action area ECO HOUSE '99 were selected through a competition in which completely new ideas were requested for planning and designing buildings as a sustainable and architectural whole.

Furthermore, competitors were given the possibility of operating with larger construction costs than usual if this appeared to be viable on the basis of lifetime economy calculations.

The competition brought in ideas from 36 consortia. Of these, 5 were asked to translate their idea into a proposal – through participation in a turnkey contract competition.

So far, 3 sustainable demonstration building projects have been completed by the two winning consortia.

These are building projects in which great importance has been attached to environmental solutions, both in the design of the dwellings itself and in the choice of materials and installations.

For example, the buildings have great depth and a small facade area, the dwellings are divided into zones; daylight and passive solar heat are utilised; and the projects include a communal building with a launderette.

As far as construction is concerned, the projects include solar heat accumulation in heavy units, extra insulation, environmentally sound materials and super-insulated thermal glazing, heat exchange and CTS plant.

As far as installations are concerned, the projects include water-saving fittings and wc's, a particularly service-friendly service core, individual meters, solar panels for hot water, heat exchange and CTS plant.

So far, three housing projects have been built in Århus, Ikast and Kolding. The environmental solutions vary somewhat from town to town, depending, for example, on local supply prices.

Indicators chosen
The purpose of ECO HOUSE '99 is not only that it should act as an incentive for environmentally managed design, but also for the development of a basis for measuring and comparing environmental management in connection with building.

In consultation with the Danish Building Research Institute, SBI, the following factors or indicators were chosen as a basis for the evaluation

- Architecture
- Lifetime economy
- Life-cycle analysis
- Conditions concerning the environment
- Nature resources and open spaces
- Occupants' satisfaction

These indicators are defined and recorded as shown below:

Indicator	Comprises	Registration	Reference
Architecture	The architectural design of the projects	Evaluations by the panel of judges, the awarding of prizes, press coverage, etc.	Evaluation, panel of architects
Lifetime economy	Evaluation of the individual solutions and the buildings as a whole	The use of profitability figures according to special calculations	Contribution to the overall economy
Environment, energy	Energy consumption and energy-related atmospheric emissions (greenhouse effect and acidification)	SBI's database programme	Regulations 95 house
Environment, other factors	Chemicals in building products, health and safety and indoor climate	Information on building materials, recordings at the building site and measurements in connection with use of the dwellings	Documentation, normal practice
Open spaces	Surrounding nature resources and the establishment of open spaces	Examination of the completed housing project	Evaluation, experts
Occupants' satisfaction	The occupants' experience of the completed housing project	Questionnaires	Other building projects

Some of the recordings are objective or are things that can be directly measured, while others are subjective. For each of the six indicators, a comparison is made with relevant references.

Conclusions

In Denmark, a model has been prepared for evaluation of sustainable building projects. The model must be regarded as the first step in the direction of a more systematic follow-up on the part of the client as to whether the goals defined in connection with programming of the housing project have been met.

The evaluation has included the following phases:

- determination of the most important indicators
- a detailed description of these indicators
- determination of methods for recording the indicators, and
- the preparation of a reference basis

The indicators in question are:

- architecture
- lifetime economy
- life-cycle analysis of energy consumption and energy-related emissions
- evaluation of chemicals in building products, health and safety and indoor climate
- evaluation of nature resources and open spaces
- the occupants' satisfaction with the architecture, the indoor climate and conditions concerning the environment

So far the model has been applied to 3 housing projects resulting from a competition.

The evaluations made show that there is still much work ahead with the development of recording methods and reference bases if it is to be possible for developers to make evaluations that can be compared.

The results will form part of the work in Denmark on the development of methods for benchmarking that will make it possible for clients and companies to compare their own results with normal practice or other best results – and in that way improve their own practice.

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ASSESSING LIFE CYCLES: SHIFTING FROM GREEN TO SUSTAINABLE DESIGN

Raymond J. Cole[1], Gail Lindsey[2] and Joel Ann Todd[3]

[1]University of British Columbia, Vancouver, Canada
[2]Design Harmony, North Carolina, USA
[3]The Scientific Consulting Group, Gaithersburg, Maryland USA

INTRODUCTION

Notwithstanding the importance of social and 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, 1991]. Unfortunately, irrespective of current efforts to curb environmental degradation, the time-scale of loadings such as greenhouse gas emissions and subsequent stabilization of tolerable CO2 levels within the atmosphere, mean that the consequences of past and current actions will persist for decades to come. The life-cycles of such processes is therefore critical.

Life–Cycle Assessment (LCA) methodologies attempt to profile the performance of materials, components and buildings through time, and have successfully entrenched the notion of an extended time context for discussing buildings. Green building design is posited as incremental improvements in the environmental performance of building beyond typical practice but typically without reference to time-frames or matched to other contextual factors. By contrast, environmental sustainability implies long time frames of responsibility - well beyond those currently practiced or envisaged, and beyond the building life expectancy embodied within LCA models. Realigning societies toward sustainability may profoundly influence what we build, where we building and how we build. Assuming rational transition toward sustainability – meaningful change *can only* occur over a long time frame.

This paper examines the implications of a more extended view of time on green building design and assessment methodologies. The paper positions the twin requirements of technical and cultural change within the transition toward sustainability and explores whether existing building environmental assessment methods are capable of evolving incrementally within this process.

TECHNICAL AND CULTURAL CHANGE

Current environmental research, proposals for change and building practices are typically blind to past technological and cultural endeavors - almost invariably choosing to re-invent. Moreover, we have witnessed an unprecedented rate of increase in technological advance. If, as Brand references, any tenfold quantitative change in a technology creates a fundamentally new condition that cannot be readily anticipated or understood by simple extrapolation, then indeed we are becoming increasingly constrained by having to cope with the immediacy created by this phenomenon (Brand, 1999).

Although environmental issues - resource use and environmental degradation – will continue to be recognized as limiting factors, and although there will continue to be buildings that are directly shaped, sometimes quite profoundly, by responses to environmental concerns, their *direct* impact on *mainstream* building practice may well be modest. Sufficient evidence exists to remind us that the performance of buildings through time will be compromised unless technological advances are respectful of personal and cultural values. Roslin posits that "architecture makes manifest, in built form, the social organization of a culture and gives us strong messages about its priorities and aspirations." [Roslin, 1996, p8] Similarly, studies of vernacular and indigenous cultures show that "what finally decides the form of a dwelling and moulds the spaces and their relationships, is the vision that people have of the *ideal* life." [Rapoport, 1969] Sustainability is presumably an "ideal" goal. But it must be a *shared* goal.

A NEW WORLD VIEW

The "world view" held by a society operates silently to "channel attention, filter information, categorize experience, anchor interpretation, orient learning, establish moods, secrete norms, and legitimates narratives, ideologies, and power structures." (Gladwin, Newberry and Reiskin, 1997, p245) World-views have, historically, embodied different notions of the relationship of humans to the natural world. They have also taken centuries to mature and become manifest in the shaping of human settlement and building practices. Western societies remain entrapped in the dominant Cartesian Newtonian mechanistic worldview of the mid-seventeenth century, one that implicitly places human enterprise dominant over and essentially independent of nature. A key question in seeking an understanding of future developments in building, therefore, is what value set or "world view" will prevail.

There seem to be two conflicting trends that are shaping the emergence of a new world view, one that speaks of the recognition of the ecological constraint, the other of the freedoms permitted by technology.

Ecological Constraint

At the centre of an ecological-based world-view is that humans are an integral part of the natural world and are constrained by it production and assimilative abilities. The underlying message in environmental debate over the past two or three decades, above all, has been about respecting natural limits and understanding how to live within them.

Technological Freedom

Other significant advances are occurring in parallel with our emerging understanding of environmental and sustainability issues and the possible directions that society could take to address these issues. The extent to which other technological and cultural scenarios conflict or support the notions embodied in environmental responsibility is critical:

- Information technologies dominate contemporary technological change - a tenfold structural change in computer capability every three years over the past five decades - with no signs of abatement.
- A "decarbonization" of energy is occurring, reflecting greater conversion efficiencies and the substitution of fuels that are progressively lighter in carbon - we are on a steady trajectory toward a methane, and eventually hydrogen, economy. Solar and renewable technologies may eventually be used to generate hydrogen that would then be the primary storage medium and one capable of fulfilling human need but without the adverse environmental consequences associated with the combustion of fossil fuels. Rather than global warming and climatic change limiting energy use, the promise may be for yet another seemingly unconstrained increase in energy use (Ausubel, 1996).

Depending on the rate and extent of their adoption, the emergence of the Internet and the promise of a "New Economy," a new "Energy Economy" – the "Hydrogen Economy" – may well change human preference and expectation and action. They may also transform what we understand to be the energy and environmental problem, future environmental policy, the strategies that we implement, and what and how we build.

GREEN DESIGN AND ASSESSMENT

During the past decade, an increasing numbers of architects, designers, and building owners have embraced the concept of 'green' design, typically in the form of easy, 'win-win' strategies such as energy efficiency or using a few 'environmentally friendly' materials. But in this incremental process, increasing degrees of "green-ness" involves looking at broader time frames and issues:

- Initially focusing on the most immediate issues: first costs and use stage strategies, such as energy efficiency, water conservation, and indoor air quality.
- Taking a slightly broader view, looking perhaps at upstream environmental impacts of materials or recycled content of materials.
- Embracing the entire life cycle of the project and its components including issues of durability and adaptability.

This is also the current extent of most building environmental assessment systems. There is an implicit assumption that "green design," by continually reducing resource use and ecological loadings, is charting a sustainable path. However, a significant realignment toward a more holistic "sustainable" approach, both in design and its assessment, may not be possible until the links between "building" performance and larger scales are acknowledged. The "individual" building, it would seem, is a too constraining level to define "sustainable" practice and the next significant advances in environmental assessment methods will invariably have to explicitly extend boundaries of analysis:

- Relating to the community or regional in which a building is located - considering regional economic and social issues along with environmental issues.
- Relating to a global context and the associated environmental, economic, and social issues.

CONCLUSION

Building environmental assessment tools have already made a significant contribution by institutionalizing a broader range of environmental considerations and life-cycle approaches to decision-making. Although developments in the near future will be primarily one of refinement, assessment tools might trigger a shift forward from "green" to "sustainable" design. A key issue is whether building environmental assessment tools can adjust to a new agenda by evolving in an incremental manner or whether a conceptual leap is required.

Assessment systems reflect the prevailing 'world view' and an associated value set - the criteria that are included in the assessment system are those items that are considered priorities. By embodying a notion of the 'ideal' performance they can, therefore, be important tools for transforming building design practice. Current efforts are directed at developing practical assessment tools for measuring improvements in the environmental performance of buildings relative to current typical practice. Through the structure and emphasis of these tools we have launched ourselves on a trajectory in the hope that we are going in the right direction.

Building environmental assessment methods set within the context of sustainability would require measuring the extent of progress *toward* a declared "sustainable" condition. However whereas we can define "green" and even "greener" as well as the incremental process for improving performance, we cannot currently envision a sustainable future – either in general terms or as related to the configuration of human settlement. It is hard to have confidence that we have designed effective assessment systems when we cannot link them to final results. Furthermore, it is not only envisioning sustainable paradigms and enlarging the scope of concern - be it the range of issues considered, timeframe or scale of influence. Sustainability will necessitate systems thinking – one which emphasizes wholes over constituent parts, relationships over specific entities, processes and transformations over physical structure, quality over quantity and inclusiveness over exclusiveness. (Gladwin, Newberry and Reiskin, 1997) These are not the underpinnings of current building environmental assessment methods and are not easily superimposed on them.

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SUSTAINABLE ARCHITECTURE - CITIES, BUILDINGS AND TECHNOLOGY
PAPER FOR PRESENTATION AT SUSTAINABLE BUILDING 2000, MAASTRICHT

Robert Webb
Robert Webb Associates, 1-3 Leonard Street, London EC2A 4AQ UK
T: +44 20 7689 6345 F: +44 20 7689 6346 E: info@rw-a.co.uk W: www.rw-a.co.uk

INTRODUCTION

Experts agree that developed countries need to reduce their consumption of energy and vital resources by between 75% and 90% (ref 1, ref 2) in order to stabilise climate change and deterioration of the biosphere, while allowing continued growth in living standards for the world's poor.

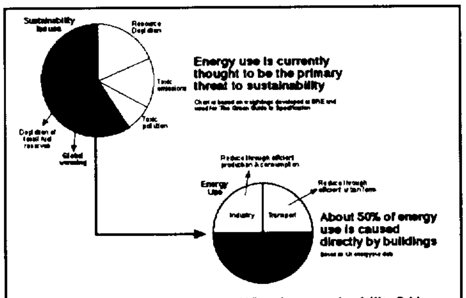
Some architects and engineers believe that reductions of this level are an impossible task, or that sustainability is an illusory goal which can not assist us to design and make decisions (ref 3).

This paper argues through example that good design and analysis applied to buildings, cities and technology can help us achieve these goals while also improving the quality of life for all citizens. The critical starting point is for sustainability and energy use to take its place alongside other issues as a driving force for design. The projects we will present begin to show how this can inspire positive design which improves the quality of life.

Our approach combines analysis with design response, allowing the critical invisible forces shaping buildings and cities to operate efficiently, in turn revealing themselves through the urban and built form.

UNDERSTANDING SUSTAINABILITY

Sustainability is a very complex issue but there is general agreement that the single largest problem is that of climate change, caused by fossil fuel energy use leading to carbon dioxide emissions (ref 3), and this must be considered first. This is not to ignore



What is sustainability? How do buildings contribute?

other threats, especially damage to eco-systems and biodiversity, which must also be considered - but there is evidence that reductions in biosphere damage arise naturally from low-energy solutions.

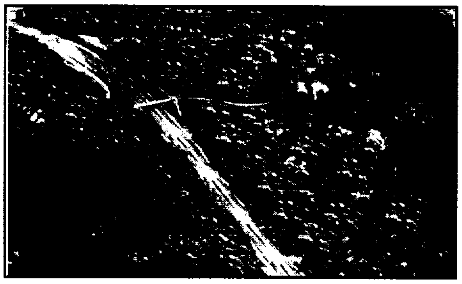
We know that the built environment through transport and buildings makes the majority contribution to energy use. (Worldwide, energy use outside industry is responsible for 50% of global warming (ref 4). 50% of this energy use is in buildings, with a further 25% in transport.)

It is clear that we need to act simultanaeously on very large and very small structures in order to achieve effective change. Design presents a methodology which can be applied to problems at all scales, (Planning - Urban design - Building design - Technology) using a process of analysis, response and synthesis.

Our projects show how this approach can be followed, from planning and urban design to building design, and that it is an inspiration to creating high-quality spaces, not a limitation.

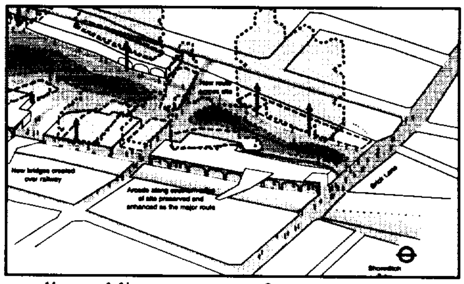
LONDON - RATIONAL PLANNING

Patterns of transport and urban form must be directed towards lower-impact structures, while the large-scale use of renewables will also change the way in which we manage land use and the landscape. The London Project, an ongoing research project, gives insight into the potential for sophisticated planning using computer-based graphical analysis, as well as the potential for energy crops and other renewables in and around our urban centres. We show how this approach will reduce congestion and stress in the city, creating better places to live and work in.

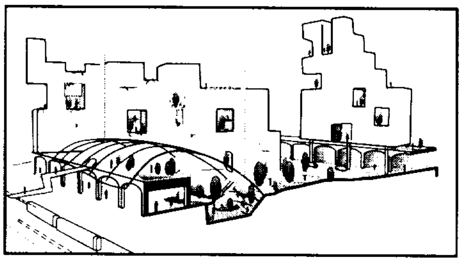


LIVING IN THE CITY- URBAN BLOCK

At the scale of the street and the urban block, it is critical to achieve successful densities, good mix of uses in close proximity and create clear routes for pedestrian movement. For the Bishopsgate site in central London, we have proposed a mix of medium to high density housing in close proximity to workplaces and good public transport. Good patterns of pedestrian movement create successful spaces enlivened by the presence of people, and encourage walking as the preferred mode of movement, while high-

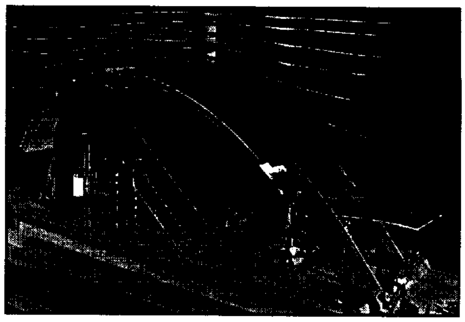


quality public open space forms a core to the scheme and contributes to surrounding activities. A biomass energy system, with crops brought in directly from the farm by train, supplies the whole site with zero-carbon electricity and heat.



RENUE ZERO-ENERGY BUILDING

Our design for the RENUE exhibition building, to be on site early in 2001, is an educational resource and visitor attraction that is self-sufficient in energy. Each aspect of the building, from its overall form to the energy systems, is designed to tell a clear story about how it contibutes to maximising sustainability.



Accompanying exhibition material and demonstration models aim to enlighten the

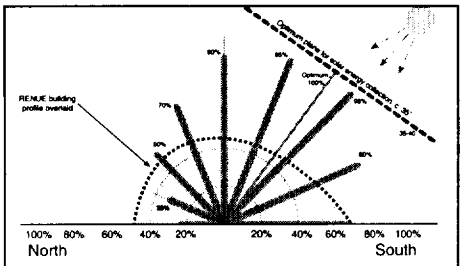
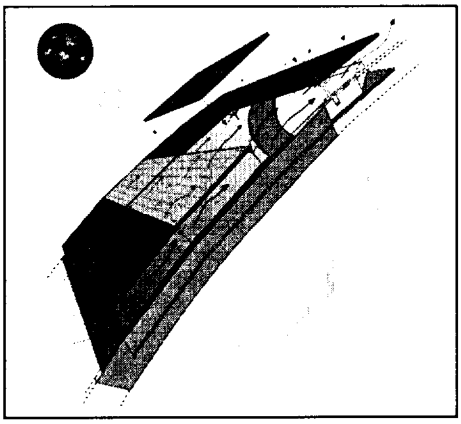


Diagram showing the sun's energy from different inclinations for 51.7°N - the RENUE building profile overlaid

visitor. The building is an asymmetric arch designed to optimise wind flow and solar energy collection, incorporating a 20kWp photovoltaic array, biomass boiler, greywater treatment system, and a range of other features.

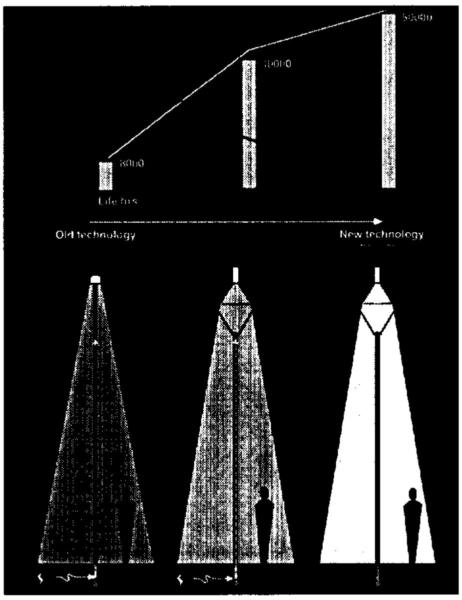
PHOTOVOLTAIC CLADDING SYSTEM; AUTONOMOUS STREET LIGHTING

Building on the design work at the RENUE building, we are developing a design for a photovoltaic array installed as a ventilated rainscreen system over a lightweight timber stressed-skin construction, optimising the energy output of the PV. This concept is particularly appropriate for roof-top extensions to existing buildings, allowing increased residential densities in city-centre sites. We are also developing designs for autonomous street furniture incorporating lighting, which uses photovoltaic and wind energy to achieve energy autonomy from the grid.



CONCLUSIONS

Design and technology provide us with the tools and the expertise to achieve the high reductions in fossil fuel energy use required to achieve sustainability. But this will only be achieved if sustainability objectives are realised alongside other quality of life and design criteria. There is no conflict here: sustainable design provides an approach which demands and allows a more sophisticated and inspirational understanding of the way in which the static and the dynamic interact in our cities, buildings, and objects, than has ever been proposed before.



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DEFINING STRATEGIES FOR SUSTAINABLE BUILDING IN GREECE

Assoc. Prof Dr. D.K Bikas[1] & Dipl. Eng. S.K Milonas[2]
Department of Civil Engineering, Laboratory of Building Construction and Physics
Aristotle University of Thessaloniki - Gr-54006 Thessaloniki, Greece
Email: bikasd@civil.auth.gr[1], milonas@compulink.gr[2]

INTRODUCTION

Energy production and consumption in Greece releases 25.4 million tons of carbon dioxide and it is accounted to be the 0.4% of world carbon emissions. The residential sector requires the 21.6% of annual energy demand while transport is the dominant consuming sector accounting for 34.2%. The increased energy demand, air and water pollution are the main environmental problems in Greece.

National policy dictates the harnessing of more renewable energy sources at regional and local levels, given the fact that the country possesses large amounts of solar, wind, wave and geothermal energy. The legal framework of National Law for the protection of the environment has adopted the majority of EC environmental regulation and directives as well as and the obligations of Greece with respect to International environmental Agreement and Conventions.

PRESENT SITUATION AND POLICIES

The construction industry is a major constituent of the Greek economy. Greece has over 3.821.175 buildings of all uses (1990). Residential buildings represent the *73,3%* of the existing building stock. Another important statistic aspect concerns the age of the existing building stock where the *89,4%* are constructed before 1981 and only *6,7%* are constructed after. The above separation is important, as the reference year 1981 is when the enactment of Thermal Insulation Regulation has been activated in building construction.

The construction materials that are commonly used in Greece for residential and office buildings are reinforced concrete for the structural framework and brick and mortar for internal and external walls. The life span of this type of construction is over 80 years. The production of building materials in Greece uses mainly locally raw materials, which can be found, throughout the country (local markets). This results in low consumption of energy for transportation (20-30km for distribution). The production processes are based on the combustion of fossil fuels and on electrical power.

A classification of buildings according to thermal quality of their main parts showed that the minority are insulated.

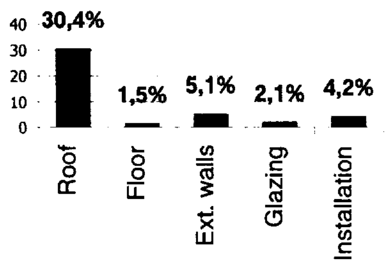

Fig 1. Insulated building parts of existing building stock.

This means that the operation of the existing building stock has a dramatical effect on the total national energy consumption. Buildings energy consumption is mainly for heating, cooling and lighting purposes, while electrical appliances and office equipment also consume significant amount of energy. The application of energy saving techniques and the use of solar or other renewable energy in buildings requires the knowledge of their special characteristics.

According to results of a research project the total energy consumption of multi-use buildings varies from 60-500 kWh/m^2 annually, depending on the type and uses of buildings and the geographical area as well [1]. The annual consumed energy for the various purposes was found to be as follows: (Figure 2)

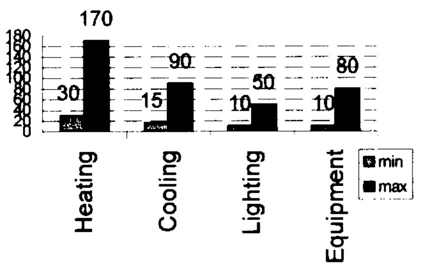

Fig 2. Annual energy consumption (KWh/m^2)

More information about environmental performance characteristics of typical Greek buildings arise when these are examined in terms of embodied energy. An extensive analysis of various case studies showed that the integrated building elements of the loadbearing structure, including the roof slabs, represent 45-55 percent of the initial embodied energy for high-rise building. Figure 3 presents the percentage participation of building elements and CO_2 equivalent of typical high-rise buildings [2][3].

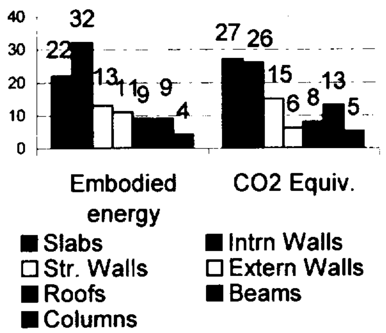

Fig. 3 Embodied energy and CO_2 equiv. of building elements.

For example in a case study building located in the northern part of Greece, the required energy consumption for heating is calculated to be 256MJ/m^{2}a if the building is insulated and 724MJ/m^{2}a if the building is not. Also the embodied energy of the building elements associated with the above and the total heated area rises to be approximately equivalent to 17,6 years of operational energy for heating. Furthermore, for a life expectancy of 80 years and due to building element replacement cycles, it is calculated that 72,7MJ/m^{2}a is required for the initial embodied energy, which represents 10% of the energy consumption for heating the entire building when it is insulated and 28,4 MJ/m^{2}a when it is not.

TOWARDS SUSTAINABLE CONSTRUCTION STRATEGIES

Existing regulations and thermal insulation standards lead to the reduction of operational energy consumption in the functional building lifetime. The new legislation for energy efficiency in the building sector implements the SAVE Directive 93/76/EEC and establishes criteria for the application of energy efficient technologies in the building design and refurbishment process as well as energy audits, certification and labeling procedures. When auditing, the required information is extensive and evaluates the frequency distribution of the building, total energy consumption, the specific energy requirements per use and per purpose (heating, cooling, lighting e.t.c), the specifications of the installed systems and indoor environment issues as well.

Balanced environmental performance of buildings suggests an effective way of design, construction, operation, maintenance, demolition or deconstruction. Reducing environmental impacts of buildings in their life cycle stages increase overall performance over their long life span. Sustainable construction strategies can be applied for various fields (A) and for the different building categories (B).

(A) Fields of interest

1. Land

Respect for green areas and open spaces. Efficient use of land. Multi-functional buildings. Design for life cycle performance and high quality. Longevity. Planning for renovation of existing building stock. More refurbishment and retrofit activities.

2. Energy

Energy-efficient buildings. Use of renewable energy sources. Optimizing heating/ cooling/lighting. Hybrid systems for heating.

3. Resources - Materials and construction techniques.

Saving of resources in construction activities. Use of environmental friendly materials. Support of local materials and traditional building methods. Low embodied energy materials. Recycling of materials. Reuse. Collection of rainwater for secondary uses.

(B) Building categories

Existing buildings.
Ensure energy efficiency performance, control maintenance and adopt end life strategies. The aim is to optimize the existing building stock in accordance with environmental criteria.

Traditional & Historical buildings.
The aim is to apply reuse with different functional demands, to those originally existed and incorporate modern installation – services and environmental friendly technologies, while ensuring the implementation of restoration principles.

New buildings.
Ensure that all aspects of sustainable construction are adopted in all buildings life cycle stages and evaluate the procedure with the application of assessment tools.

CONCLUSIONS

The adoption of sustainable development in the construction industry and the built environment can improve the quality of environmental requirements as well as the effects of economic and social consequences. Supporting sustainable strategies in construction should take into consideration the increasing rate of new buildings and the enormous amount of existing building stock. New strategies must be followed by supplementary actions as development of programs, responsibilities and budgets.

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GREEN[1] BUILDING DEVELOPMENT AND PRACTICE IN HONG KONG

Z P Xu (1), S S Y Lau (2), Q M M Zaman(3)

1. Z P Xu, B.Arch. (Tianjin), Department of Architecture, The University of Hong Kong, Pokfulam Road, Hong Kong
2. S S Y Lau, M.Sc.Arch. (London), Department of Architecture, The University of Hong Kong, Pokfulam Road, Hong Kong
3. Q M M Zaman, B. Arch. (Bangladesh), M. Urban Design, Ph.D. (Hong Kong), Department of Architecture, The University of Hong Kong, Pokfulam Road, Hong Kong

INTRODUCTION

The objective of the paper is to present the current constraints in achieving environmentally sustainable built form in Hong Kong through 'green building' approaches; and to argue that although Hong Kong's 'compact city' is inherently a sustainable urban development pattern that preserves majority of the green areas, most of the buildings in Hong Kong are far behind the 'green building' concept, and therefore, fails collectively to produce sustainable urban environment.

The main reason for the prevailing constraints in achieving a sustainable built form is the lack of consciousness for the green issues that arise from the following factors:

a) Shortage of buildable land,
b) Demand for built form [in quantitative term] is always higher than the environmental quality,
c) Prevailing profit driven market where quick profit on investment doesn't allow sufficient time for developer to adopt 'green building' concept,
d) In general, the life-style in Hong Kong does not care for the economic use of resources, such as, frequent self-refurbishment works of flats that generate construction wastes and the habit of managing domestic energy resources.
e) Resources (building materials, food, water, energy) are imported from various countries making it difficult to keep track of the origin of production with environmental values, and
f) 'Green building' is a new emerging concept and is less familiar to professionals as well as to clients.

CHALLENGES FOR 'GREEN BUILDING' PRACTICE IN HONG KONG

Challenge: Land versus Building Demand

Hong Kong is a well-developed international metropolis in Asia with a consistent economic growth. But the current demographic pressure (7 million people in the year 2000) on a limited buildable land (17% of the 1,096 square kilometers of land area is intensively developed) created a tremendous challenge for urban managers to adopt a 'high-density' compact city pattern (Zaman and Lau, 2000) (Figure 1) by introducing a common architectural language (Figure 2).

Figure 1: Hong Kong (black area: developed land)

In some of the dense region like Mongkok, the density reaches 116,000 persons per square kilometer (Gilchriest, 1994), thus, creating challenges for urban managers as to how the life quality could be managed in the compact vertical landuse pattern (Figure 3).

Figure 2: Compact City

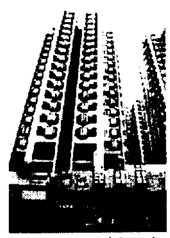

Figure 3: Vertical Land use

Challenge: Energy Resources
Hong Kong depends entirely on the imported building materials, water, energy and food making it difficult to keep track on the embodied energy sources. The frequent demolition of buildings generates construction wastes, which cannot be recycled back to its original use but to end up only in the landfill and in the road base works.

Challenge: Building Design
The climate in Hong Kong is sub-tropical with an average temperature of 25°C for half of the year with high average relative humidity (70% to 98%), which makes it necessary to use air-conditioning in most of the buildings. High-polluted environment in the urban areas also support the concept of design segregation of the indoor environment from the outside harsh weather by way of total air-conditioning. Moreover, the present design of the majority of mass housing adopts the cruciform design (Figure 4 & 5), thus, generating large external building surface areas with huge embodied energy that offers less recyclable potentiality in future.

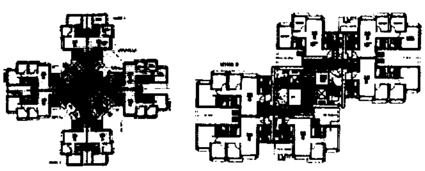

Figure 4 & 5: 40 and 30 Storeys Concord Modular Housing (Hong Kong Housing Authority, 1996)

Due to the shear demand for housing (at the rate of 85,000 units per year), mass production of building modules is used widely in the public housing estate development. This has brought the problems of low quality indoor living environment. The 'high-density' and 'compact built' form also limits designed outdoor open space for social activities.

Challenge: Construction Waste
Hong Kong's majority of built forms are constantly under refurbishment and redevelopment time-to-time due to the change and expansion of inhabitants and their usages. The wastage of building materials due to the frequent construction and demolition works produces huge construction wastes, around 33,000 tonnes per day recorded in 1998 (Civil Engineering Department, 1999). Although, public mass housing has adopted the prefabricated modular design (Figure 6), the frequent refurbishment works are conducted with less or no consideration on the 'green building' issues, such as, recycling existing building materials for new construction works.

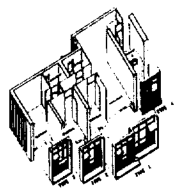

Figure 6: Modular Prefabricated Housing (Hong Kong Housing Authority, 1996)

EMERGENCE OF 'GREEN BUILDING' MOVEMENT IN HONG KONG

With the increase of the worldwide awareness on environmental crises in the recent years, and the promotion of the 'sustainable development' in Hong Kong, the 'green building' or the 'environmental friendly building' or the 'environmental responsive building' are gradually recognized, although in slow-pace, but seriously by professionals and clients of the building industries in Hong Kong.

The foremost step that Hong Kong has taken is the green assessment tool, called the HK-BEAM (derived from the UK-BREEAM). Beside the assessment tool, recently architects are introducing 'sustainable design' criterion in their building designs. For example, the Kadoorie Biological Sciences Building is a newly built energy conscious building in Hong Kong. According to the designer (Leigh & Orange, 2000), the building possesses innovative solutions that answer not only the architectural requirements but also 'the issues of functionality, flexibility, safety, energy efficiency, environmental friendliness, lifetime economy, sustainability, buildability, and ease of maintenance' - all of which set a new standard of 'sustainable design' in Hong Kong (Figure 6 & 7).

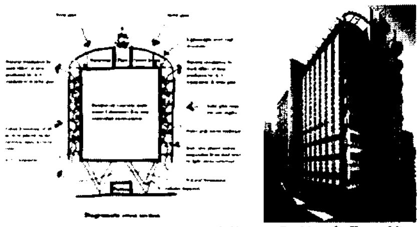

Figure 6: Cross Section and Figure7: North East View of the Kadoorie Biological Sciences Building - HKU
Source: (Leigh & Orange, 2000)

'High-density' and 'High-rise' living' as an Opportunity

For 'sustainable development' and 'green building' practice, 'high-density' and 'high-rise' patterns can be an appropriate solution for many cities in Asia, since these patterns bring advantages both ecologically and economically. For ecology, it means less utilization of urban space, thus, less ecological footprint, which is favorable for the maintenance of the local bio-diversity. For economy, the 'high-density' and 'high-rise' create less road networking and low consumption of energy for transportation compared with the dispersed settlement. The integrated urban functions in a compact built form allow more people to use the common functions (i.e. public transport, recreational facilities etc.) economically with less journey-to-work and low energy-use.

CONCLUSION

The 'green building' practice in Hong Kong is a new concept and is now getting its momentum due to the recent sustainable initiative of the Planning Department's Sustainable Development Agenda 21, which, although in its preliminary stage, has influenced every sector of the building industries. As the 'high-density' is a pragmatic approach for Hong Kong, it should conform to the principles of 'sustainable development' and 'green building' practices. Relatively little has been done to improve the 'high-rise' living environment with the prime consideration to the benefits of the society, especially the middle and lower income group of people those who rely less on the artificial environment. The cost-benefit analyses on 'green building' must be equated both quantitatively and qualitatively, which would work as leverage for developers to use 'green building' elements as a competitive edge. Techniques harnessing the benefits of the 'Green Skyscraper'[2] (as initiated by Ken Yeang) should be explored innovatively. To this point, 'green building' practice in Hong Kong should emphasize on the mass housing, especially the public housing, to deal with the poor indoor living environment that exists not only in Hong Kong, but also in other Asian 'high-density' cities.

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[1] 'GREEN' refers to mainly the environmental friendly criterion in building (less embodied energy/energy use in construction and maintenance of buildings, indoor thermal comfort, easy to recycle building materials after demolition or refurbishment etc.)

[2] For further details on 'Green Skyscraper' please see Yeang, K (1998), The Skyscraper, Bioclimatically Considered, Scott, A (ed.), *Dimensions of sustainability: architecture form, technology, environment, culture*, E & FN Spon, London.

THE EFFECTS OF ACTIVITY IN SUSTAINABLE BUILDINGS IN POLAND

Ph. D. hab. eng. arch. Prof. at ITB Maria Stawicka-Wałkowska

Introduction

In a majority of cases, the idea of balanced development, which is defined in accordance with the Constitution of the Republic of Poland as *„a process of integration of political, economic and social measures while concurrently maintaining the balance of nature and the continuity of basic natural processes, with the goal of balancing the chances of societies or their members, now and in the future, to enjoy access to the natural environment*", has not yet been properly understood.

The foundations for the Polish system of permitting use of building materials were laid down in the act of 7 July 1994 (Building Law) and in the executive regulations, and mainly consist in definition of basic technical requirements pursuant to Directive 89 / 106 / EEC on building materials.

The state of buildings and building industry in Poland

Some action is taken to conserve natural resources, including energy carriers, and to recycle waste and utilize by-products, but it is neither systematic nor aimed to develop a uniform system of classification of materials that would incorporate environmental norms ISO / TC 207 SC 5 (Life Cycle Assessment).

This also refers to the assessment of buildings in the course of construction, use, conservation or utilization of their elements after an end of lifetime.

The last-mentioned problem is particularly relevant to large-panel building industry in Poland. Out of 6 million apartments built under housing projects, over 3 million are located in large-panel buildings, which were mainly raised in the 60s and 70s, the times when large-scale housing developed due to the abundance of mineral resources and the existence of national cement industry.

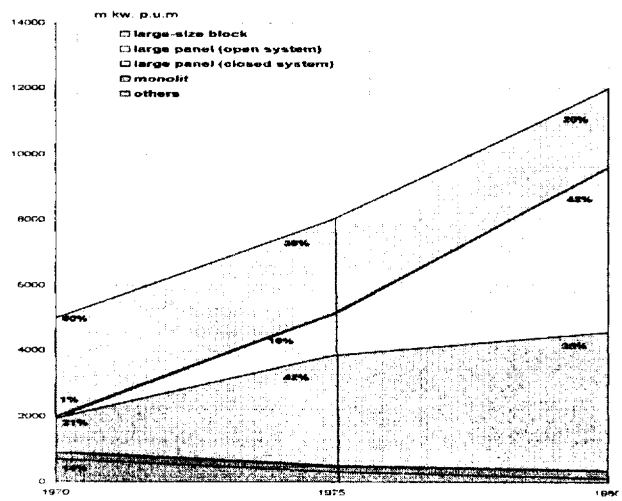

Fig. 1. Prefabricated systems implemented in Poland [1.1].

In practice, technical solutions, as adopted by law, could not be implemented due to the low quality of building materials and products which frequently had much lower technical parameters than assumed. Such practice was an offspring of save-at-all-cost policy of governments at that time.

Next to the false saving assumptions that resulted in a low quality of construction elements, technical degradation of buildings was caused by the "moral aging" process due to housing design norms in force since 1959 (from 20 m^2 single-person apartments to 71 m^2 apartments for 7 persons) and the impossibility to freely change functional arrangement of apartments, combined with a limited technical capacity of applied systems.

Three types of prefabricated systems were implemented in Poland: large-size block, large-panel (open system) and large-panel (closed system).

We do not want to discuss these systems in detail, let us only say that buildings raised in the 60s and 70s are of substandard quality and account for a substantial percent of housing in Polish towns and cities, some of them historical places.

Not only individual buildings but also whole complexes were built under large-panel technology. Sometimes large-size housing estates, the so-called city bedrooms, were not even provided with the required engineering or communication infrastructure.

Conclusions

It is clear, then, that another issue related to Life Cycle Assessment to be raised when discussing the concept of sustainable development is modernization or other form of rehabilitation of buildings. This is not only a question of safety and durability of main construction elements, but first of all that of functional rehabilitation.

The requirements and needs of residents have changed. Now people frequently demolish internal walls to enlarge living area and freely arrange it, which results in a total change of apartment structure.

These should not be isolated measures, but an organized large-scale action applied wherever it is technically and economically viable.

Several international conferences were organized to address the problem of balanced building, e.g. the conference "Technical potential for modernization of large-panel buildings" organized by Building Research Institute in 1999 in Mrągów.

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Tom Woolley and Warwick Fox

The Ethical Dimension of Environmental Assessment and Sustainable Building.

Tom Woolley School of Architecture , Queens University Belfast 80 Church Road, Crossgar, Downpatrick, Northern Ireland, UK BT 30 9HR
Warwick Fox Centre for Professional Ethics , University of Central Lancashire
16 Bairstow Street. Preston PR1 3TN

Introduction

The issue of Environmental Ethics has largely been overlooked by those engaged in the development of environmental assessment methods in the construction industry. We try to show how many of these methods have been driven by technocratic and pragmatic aims based on a reduction to scientific or mathematical models which do not take account of moral or ethical issues. We give an introduction to the concept of environmental ethics and explain why this should be essential in the future.

Broader Issues of Environmental Assessment

Green (1998) has characterised much current thinking in the construction industry as "technocratic totalitarianism." He says that academic research is compromised by the need to partner with industry and that little independent and critical work is funded by Government programmes. He also claims that much innovation is stifled by vested interests. Lansley,(1997), in a critique of the work of the UK Building Research Establishment, has shown how powerful industrialists have an increasing influence over the British construction research agenda. These pressures extend to much of the work on the environmental assessment of buildings, materials and products and there has been a growing tendency for the main stream construction and building materials industry to present conventional products and processes as environmentally friendly. An example of industrial pressure can be seen in the BRE Green Guide to Specification (Howard et al 1998), the PVC industry forced the inclusion of a statement that "designers should take note of the industry's guidance as well as that of environmental groups when judging this issue."

In producing the Green Building Handbooks (Woolley & Kimmins 1997 and 2000) we have found a demand for independent advice on green issues, free of commercial pressures, but there is little support in terms of Government or European funding to assist this. The recently published UK Government strategy for sustainable construction (DETR 2000) appears to have been watered down from earlier drafts and does not even make reference to a much more radical Government publication (Greening Government Team 1999). The concept of sustainability has become 'economic viability' for business rather than environmental responsibility.

While these examples are from the UK, the increasing globalisation of the production of building materials suggest that similar problems will occur elsewhere. Despite the proliferation of environmental assessment systems in many countries, it is not easy to tell if any have been free of industrial and governmental pressures. Kohler(1999), Cooper(1999) and others have added another dimension to this critique by pointing out that many environmental assessment systems found in Green Building Challenge are context specific and do not necessarily consider a global agenda. A 'green building' in Europe may use 10 times as much energy and resources as a 'green building' in a developing country. Thus environmental assessment criteria are adjusted to relate to local circumstances and are not based on globally agreed or absolute measures of performance or impact, raising questions about their validity.

Environmental Assessment methods

The complexity of environmental assessment in building is a key factor in this discussion. There are multiple factors which must be considered. Howard (1998) uses 7 criteria when assessing materials, but Froeschle (1998) uses 16. Different weights are given to each factor by different systems. Life cycle assessment methodologies vary widely and many include assumptions about the scope of measurement and analysis which are not scientific or mathematical in origin.

Attending the discussion of Green Building Challenge in Paris in the spring of 2000 was illuminating as the process of selection of criteria for GBC seemed very pragmatic. There may be good reasons for this, but criteria or factors in some countries, particularly in relation to the health effects of buildings and the impact on people, could be deleted simply on the basis that it didn't fit into the computer software!

While such a pragmatic approach is often defended on the basis that something is better than nothing, 'benchmarking' seems a flexible and movable concept and is not tied to absolute or objective concepts. Despite the absence of clear consensus about standards much of the literature fails to make this clear.

A comparison of two recent books demonstrates the variation in emphasis. Vale and Vale (2000) do not mention indoor air quality or human health, except the possible effects of cats and mould growth! Nor do they have much to say about resource depletion. Their influential work appears to emphasise energy (in use) efficiency to the exclusion of other issues. On the other hand health and resource depletion are central to Berge (2000). The Vales advocate the use of largely conventional and synthetic materials such as glass fibre insulation whereas Berge emphasises the use of natural and renewable materials such as earth and straw. There is a huge gap between the approaches and yet little debate occurs as to the validity of each.

Much architectural literature presents green building in largely stylistic terms and an influential book on 'bio-climatic architecture' (Lloyd Jones 1998) has been criticised for including examples of "banal and gas guzzler offices" (Connolly 1998). Lloyd Jones is at least transparent by arguing that only by "jumping on the materialistic bandwagon" will green issues be accepted.

Ethical principles

These issues were discussed at a conference in 1999 and will be published in the Ethics of the Built Environment (Fox ed. due Nov. 2000). The case for environmental ethics may be unfamiliar to many and will be argued in the book. Put simply, it can be shown that when considering the environment we make many value judgements about what is good or bad and in human interests . Even where a numerical value may be placed on an assessment or measurement, this may involve some judgement as to the consequences to other humans, to the ecosystem, or simply to our feeling of well being. Environmental ethical theory represents the means by which a discourse on this aspect of human judgement might be maintained. This has been characterised as 'the method of reflective equilibrium' (Rawls 1972) in which principles and considered judgements are subject to some kind of mutual adjustment. There is little doubt that this process is constantly taking place in the environmental construction field, but it takes place in an implicit rather than explicit way. The basis of the judgements, the values that underlie them, the consideration of the possible impacts are not always out on the table. Indeed many of the assessment system methodologies are commercially confidential and the numeric basis of them, such as embodied energy calculations, are not divulged. Thus judgements are not always open to challenge or debate as their exponents are frequently defensive or unwilling to open their assumptions to question or challenge by others.

The concept of rationally based ethical discussion, described by Fox as 'responsive cohesion,' has much to offer the field of environmental construction. Responsive cohesion assumes a form of mutual feedback and debate which would be very much in the spirit of those who wish to ensure an approach to the built environment which protects the planet ecosystems, uses resources responsibly, and benefits all of humankind. However, there is a danger that many of the environmental systems which have developed in many countries may become rigid and codified and incorporated into regulations and standards, before there has been a genuine exchange about the basis on which they have been formulated.

The holy grail of assessment systems

Much of the discussion to date in Paris, Vancouver and through working groups in CIB and so on, together with much of the scientific research under way, focuses on the search for the holy grail of mathematical systems of environmental assessment which will allow hard pressed architects , developers and regulatory officials to monitor the environmental impact of their decisions. Can a material be rated 4 or 5 on the scale of greenness or a building rated A, B or C? Complicated matrices, correlating a huge range of possibly incompatible variables, are formulated in this search. However if such an objective was achieved it would hold within it the danger that those making use of such a tool would then be divorced from the thinking which went into its development.

Anyone who has had the experience of trying to persuade a client to adopt a green approach to their building knows that the decision is not simply based on numerical issues such as how much energy will be saved. Decisions based on the upstream impact of specification are not made out of self interest but rather out of a sense of moral responsibility about the consequences. The choice to install a compost toilet instead of a 'flush and forget' w.c. has an element of concern as to what will happen to the waste downstream. Whether we like it not, therefore, moral or ethical decisions are an inevitable part of the process of green design and specification. Dealing with them in a more explicit and open way would greatly assist the development of environmentally responsible building, though it may initially raise more questions than answers. These questions need to be tackled energetically and, painful conflicts of interests between campaigners, designers, researchers and vested interests, become a key part of the agenda.

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TOWARDS SUSTAINABLE HOUSING: COMPASS – A METHODOLOGY TO MEASURE AND COMMUNICATE ECONOMIC, SOCIAL AND ENVIRONMENTAL PERFORMANCE

Holger Wallbaum (holger.wallbaum@wupperinst.org)
Wuppertal Institute for Climate, Environment and Energy (http://www.wupperinst.org)
Eco-efficiency and Sustainable Enterprise Group
Doeppersberg 19, 42103 Wuppertal, Germany, Phone: +49-202-2492-302, Fax: +49-202-2492-138

Introduction

Since the conference in Rio and the drawing up of Agenda 21 there has been a need to operationalise the normative concept of sustainable development at the micro level. To translate strategies into action the Wuppertal Institute has developed COMPASS (**comp**anies' and **s**ectors' path to **s**ustainability) (Kuhndt and Liedtke 1999). The main aim of COMPASS is to question, analyse and assess where necessary optimise individual processes, process chains, products or also services, taking into consideration the economic, social and ecological aspects for sustainably satisfying needs. In doing this COMPASS considers the entire course of these processes and all aspects concerning them from the cradle to the grave, and even to the cradle again, i.e. the reuse of parts or raw materials in new applications. COMPASS has already been successfully used in numerous companies and at a stakeholder roundtable to discuss the sustainability performance of economic areas of relevance.
One of the areas most relevant is that of construction and housing, explained as follows:
By providing housing and infrastructure, the construction sector makes on the one hand a vital contribution to the social and economic development of every country. On the other hand this sector is an important consumer of non-renewable resources, a substantial source of waste, a polluter of air and water, and an important contributor to land dereliction. Material flows analyses for Germany, Japan and the United States show that the construction sector accounts for between one-third and one-half of commodity flows, when expressed in terms of weight (Adriaanse et al. 1997). That means, the building sector is also partly responsible for the destruction of forests and rivers, air and water pollution, and last but not least climate destabilisation. In many cases buildings are simultaneously harmful to their occupants on the inside by unhealthy air as well as for the building worker in the construction period. Longer-term environmental impacts result from the use and maintenance of the buildings. In Germany about one-third of global primary energy is used just to maintain existing structures and keep them running. Finally, demolition generates enormous amounts of waste to be deposed of.
Because of the economic, social and environmental relevance of this sector it is vital therefore that COMPASS has been used in the building sector first, e.g. to select and define indicators to assess the sustainability performance of different building types and concepts. One of the defined indicators is MIPS (Material Input per Service Unit) (Schmidt-Bleek 1994). MIPS represents an internationally well-established indicator to measure the life cycle-wide resource productivity of products, processes, services and economic areas. According to Schmidt-Bleek the aims of sustainable economic performance can only be attained if the economies of the industrialised countries succeed in securing their prosperity by reducing their current resource consumption by a factor of ten by 2050.

Presentation

In cooperation with a company of the housing industry, the sustainability of the company's product range, in this case four houses, was investigated whereby the economic and ecological issues were the main focus of attention. Social criteria were at first deliberately kept in the background partly because the social aspects of sustainability have up to now been very neglected in both national as well as international discussions. It was important, however, to record the acceptance by tenants or buyers of the houses being offered. In talks with those persons involved in COMPASS other indicators specific to the product apart from MIPS (compare Introduction) were determined. The products in question were detached houses of varied design appealing mostly to the same type of prospective buyers. The company considers the following indicators: resource consumption (production and use), energy consumption, reduction in costs, effects on man, effects on the eco-system, acceptance by tenants, profitability. All indicators will be applied to the service unit "living space and year". Only the indicator "acceptance" will be assessed per tenant or buyer questioned. Taking the indicator "resource productivity" as an example, the structure and procedure are explained in short. The indicator "system-wide resource consumption" can be subdivided into part indicators (Figure 1). The subdivision into part and sub-indicators depends on the production processes and the responsibilities in companies and is independent of the desired and necessary validity of the individual indicator values.

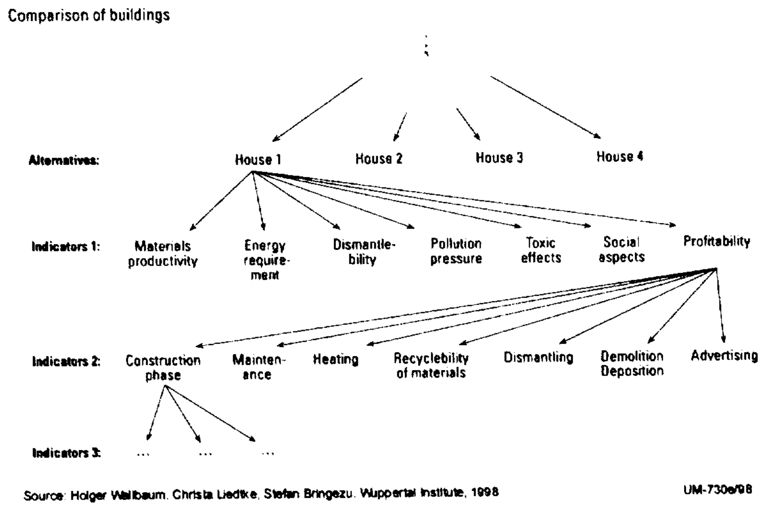

Figure 1: Indicator tree – Material intensity (system-wide resource consumption per product and service)

An assessment scale (performance comparison) for all indicators was determined ranging from 1 (very good) to 6 (unsatisfactory) based on the German school grading system. The grade 4 (satisfactory) corresponds to the state of the art. With the help of "traffic lights", grade 5 and 6 (red), grade 2, 3 and 4 (amber) and grade 1 (green), management decisions or measures introduced can be observed, discussed and evaluated regarding their effects on all indicator levels. The grades will then be equally weighted from the bottom upwards and identified as the arithmetical mean of the overall grade of the indicator at the next higher level. The grading system can of course be freely chosen and can also be shown in the standards of other countries. It is important that the assessment is known to each employee and understandable with a minimum of explanation. Thus measures, responsibilities and deadlines can be determined for the fields of action marked red. Improvements or deterioration can easily be entered and followed in the indicator tree.
For comparing houses of a company in the housing industry the results were clearly presented on the topmost indicator level as in Figure 2. In the so-called "Sustainable Development Radar" ($COMPASS_{radar}$) the economic, ecological and social efforts of entrepreneurial development are portrayed. The axes show the selected indicators whereby the determined grades describe the distance to the defined target (grade 1) and the state of the art (grade 4).

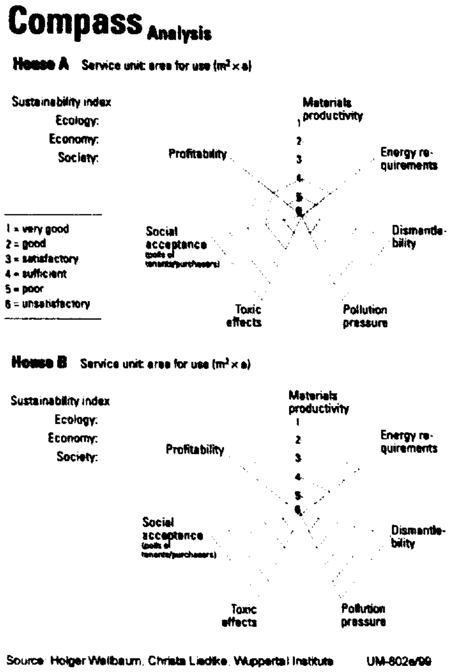

Figure 2: Comparison of two different buildings with the COMPASS methodology.

Conclusions and recommendations

COMPASS structures and supports the dialogue process of the persons and institutions involved, their communication and conflict management. With the help of COMPASS it could be fathomed out here as an example for the construction and housing area what alternative courses of action are available which lead the way towards more sustainability in practice. At the end of the process is a "Sustainability Agenda" for this sector or company derived from and following Agenda 21 formulated at the UN Conference in Rio.

Within the framework of "sustainable businesses" companies could be persuaded by a "triple win strategy": save resources, create wealth and strengthen competitiveness. Results gained with COMPASS are also therefore suitable for improving information provided the public and for conveying a company's efforts for more sustainability. Contrary to conventional opinion, previous investigations by the Wuppertal Institute have proven that within the whole live cycle of a building the largest consumption of natural resources (abiotic and biotic material) and therewith an enormous environmental impact, with approximately 5 t per square metre living space and year, results from the construction of buildings. Even by low-energy houses the consumption of natural resources in the construction period exceeds the phase buildings are used by more than a factor ten. With the steadily increasing number of "passive houses", this trend is strengthened further. From the point of view of climate protection, it is of course still necessary to perceptibly reduce CO_2 emissions during the phase of use and primarily in the building stock. That the currently practised construction methods for new buildings do not fulfil the criteria for a sustainable development could clearly be proven in our work. Truly ecological buildings must combine resource conservation and climate protection over the entire life cycle in a harmonious and aesthetic way; sustainable buildings must in addition also be economically lucrative and socially acceptable.

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FINNISH ACTIVITIES IN THE FIELD OF LIFE CYCLE ASSESSMENT (LCA) AND LIFE CYCLE COSTS (LCC) IN THE BUILDING SERVICES SECTOR

Tähti, Esko, M.Sc. (Tech) [1]
Sakari Sainio, M.Sc. (Tech) [2]
[1] Finnish Development Center for Building Services (TAKE), Yrjönkatu 13, FIN-00120 Helsinki
[2] Espoon- Vantaa Institute of Technology (EVTEK), Vanha Maantie 6, FIN-02600 Espoo

INTRODUCTION

This paper summarizes the background, activities and achieved results to develop a systematic methodology for LCA and LCC in the building services sector.

Building owners, HVAC practitioners and clients have in recent years paid attention to reasonable total costs including construction *and* usage costs. This can mean even better quality of building services technology with slightly higher construction costs but lower usage costs because of better energy economy.

Better energy economy results more environmental friendly building. Major part of environmental burdens during the whole life cycle of a building can be controlled by building services technology.

The Finnish Development Centre for Building Services has collected up more than 40 companies and major clients (the cities of Helsinki, Espoo and Vantaa, Finnish State Real Property Agency) to prepare a common approach to life cycle cost calculation (LCC) and life cycle assessment (LCA) of building services systems and components.

MAIN GOALS AND SCOPES

There has been numerous discussions behind the present activities, about *how* to estimate the environmental impact and life cycle costs of building services. These questions concerned both individual products and complete HVAC systems and buildings.

One of main coals is to be able to present environmental declarations to customers and clients.

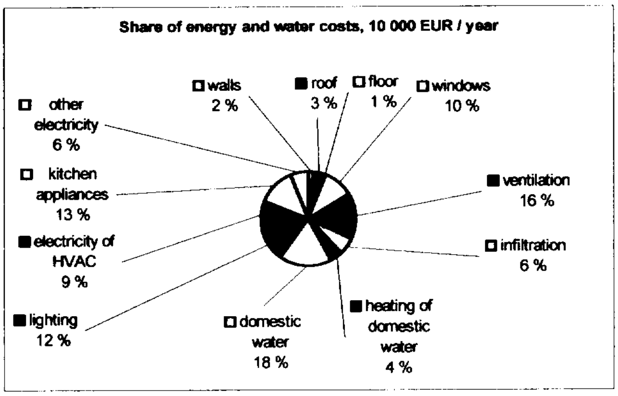

Fig. 1. More than 80 % of energy and domestic water usage costs can be controlled by Building Services technology. Example from pilot project kindergarten "Kamomilla", City of Helsinki.

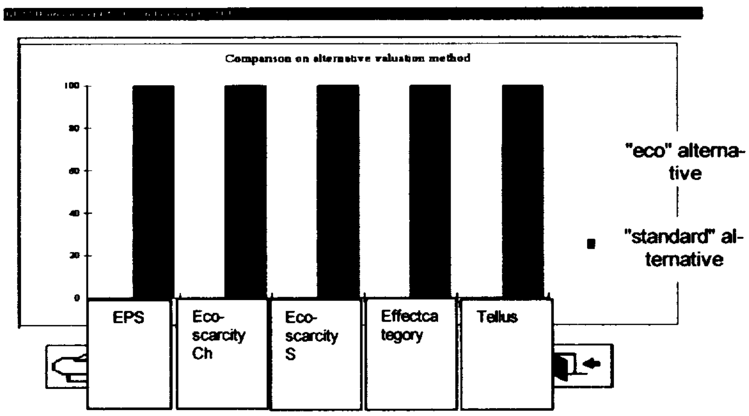

Fig 2. When comparing two energy consumpting Building Services system ,"which is better, A or B", different weighting methods give same result. This is because of a process nature. Major part of environmental burdens are from energy consumption in both cases "A" and "B".

For this purpose, as a rule accepted calculation methods are needed, for both LCC and LCA.

To tackle this problem, a series of projects started in spring 1997 by TAKE. In the first phase of the project a decision was made to make pilot calculations, *on product level*. The first chosen pilot products were an air handling unit for a typical office building, air distribution system for office room cooling and boiler/oil-burner for single family house.

The results from the calculations will be presented in more detail in another papers.

In second phase, spring 1999, total equipment systems were taken to pilot targets *on system level*. Pilots cases are on the other hand building services systems in theoretical building models and on the other hand real building design processes.

Theoretical models are approximately five different heating and ventilation system in single family house.

Practical building design projects are alltogether four: kindergarten 3600 m^3, school 50 000 m^3, office buildings 10 000 m^3 and 50 000 m^3 .

RESULTS FROM FIRST PILOT CASES

The pilot calculations gave a realistic view about the complexity of LCA and LCC calculations for building services.

It was also revealed that there are lots of of methods available, but no reliable information about the validity and limitations of e.g. different LCC calculation methods.

In general, a common methodology has been developed to assess both the environmental impact and Life Cycle Costs of HVAC products and systems

On product level, it is still possible to achieve a standard methodology to present the affecting factors and calculation results in a reliable way.

In first practical design cases the need not only for calculation methods but for clients clear targets was obvious. For example if client can set a target: 30 % less energy and water con

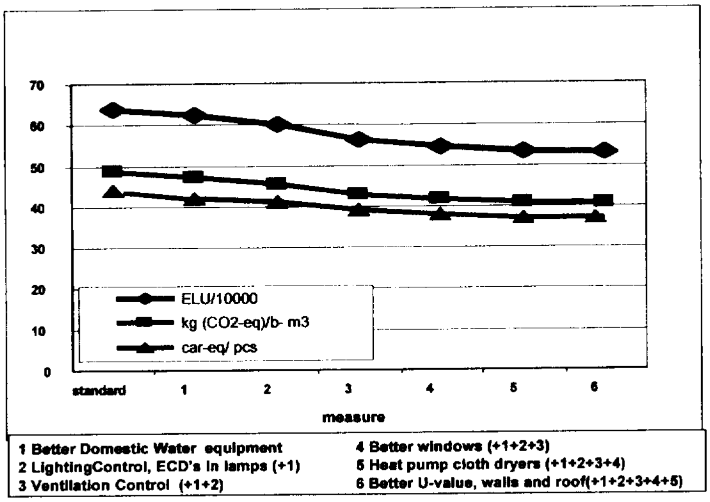

Fig 3. In pilot-case, the energy saving measures were first put in economical order (1..6) with LCC calculations and then cumulative effects in environmental burden or in impacts were examinated. Car equivalent in this case is equal to one cars yearly CO_2-emissions when its driven 20 000 km/year. Kindergarten "Kamomilla", City of Helsinki.

sumption with 5 % higher construction costs than in average building.

This methodology, probably to be presented using some "default value principle" will be validated in parallel with the ongoing LCA and LCC activities for entire systems and real pilot buildings.

FUTURE DEVELOPMENT

The development work continues in ongoing TAKEs projects. Some main development items are:

- data bases for building services product materials (commonly accepted and transparent)
- data bases for energy production emissions (commonly accepted and transparent)
- to find evaluation criteria for suitable LCA/LCC-tool concept
- further development of building systems design tools and procedure for sustainable buildings

The work continues with growing amount of partners on national and international level.

ACKNOWLEDGEMENTS

The study was a part of a technology project in Finland, co-financed by TEKES (National Technology Agency) and a number of companies participating in the completed and ongoing projects.

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ENVIRONMENTAL MANAGEMENT FOR SUSTAINABLE COMMUNITIES

Chris Barnett and Andrew Myer

Chris Barnett Associates, PO Box 14, Tewkesbury, Gloucestershire GL20 7YL, United Kingdom

INTRODUCTION

Few today doubt the desirability of reducing or eliminating adverse environmental impacts, yet many organisations are unclear of the particular issues relevant to their activities, let alone the scale of their own impacts - and even after identifying these may still have difficulty assessing the organisation's abilities or in devising a programme to improve their environmental performance.

Organisations dealing with a number of buildings, whether housing or otherwise, need to be able to organise and deliver systematic improvement, in a methodical manner. 'One off' flagship or demonstration projects may have some PR or R&D benefit but are of limited value in establishing convincing environmental credentials or even a sound business position. Conversely a transparent environmental management system (EMS), able to deliver consistent progress across the whole building stock, will enhance an organisation's 'product' and promote confidence (both internally and externally) in its ability to meet stated objectives.

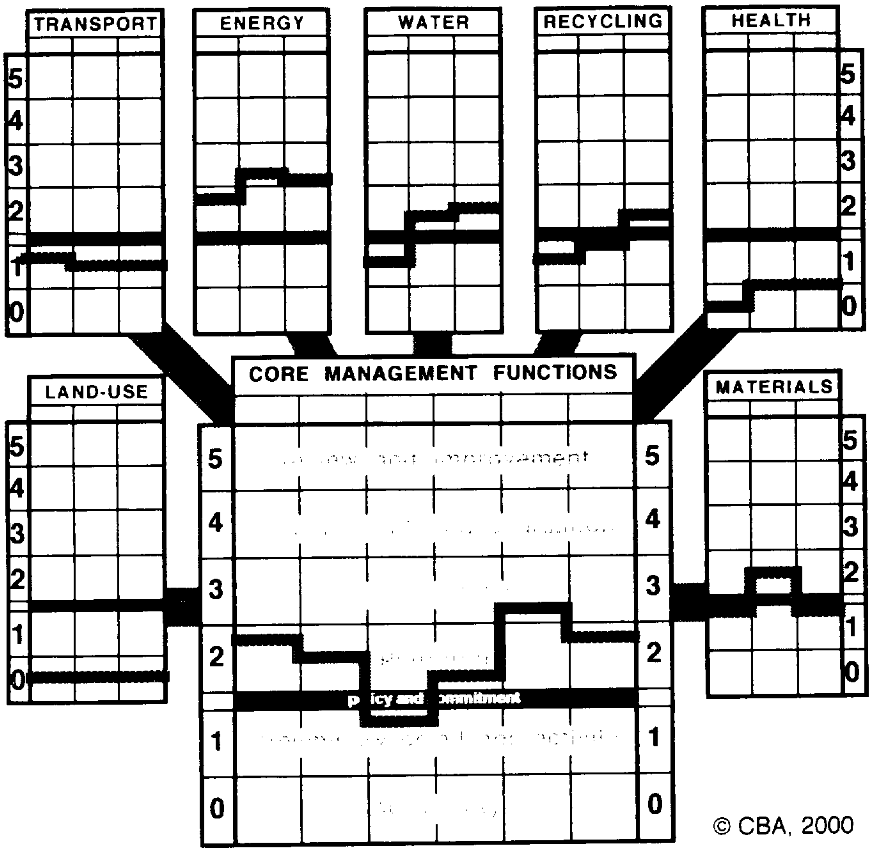
The environmental management matrix (the matrix) described below provides an interactive system designed to help identify and deliver higher levels of environmental performance, integrated into mainstream business activity. The system has been designed specifically for UK social housing landlords in conjunction with the Housing Corporation - the regulator for social housing in England.

PRESENTATION

Development and management of housing can have a range of environmental impacts, and an increasing number of landlords are adopting environmental and/or sustainability policies to address these. For many, however, the task of turning generic policy statements into co-ordinated, practical and manageable actions can be a significant obstacle. The UK has a huge stock of existing housing, built to standards which were largely uninformed by possible impacts on the environment, and so possibly requiring considerable remedial intervention. Furthermore the Government estimates that four million new homes need to be built over the next few years - to meet demographic changes in the population - and incorporation of improved environmental standards now will help reduce the immediate impacts but also reduce the likely need for expensive remediation works in the future.

Landlords and developers need increasingly to be aware of environmental issues - particularly how these relate to their own activity - and improvements need not only to be achieved but also reported, as low environmental standards or the inability to report performance can have adverse effect on business potential. A growing number of the UK's 2,500 social housing landlords are thus commissioning environmental assessments of their activities, but so far the subject matter, level of practicality, and outputs of these appear to vary considerably. The Housing Corporation recently adopted its own environmental policy, and is supporting development of this matrix-based EMS software as a common standard and working methodology for use by landlords across the country - to contribute to more consistent implementation of policies, and to help landlords compare and learn from the experiences of others. This has been carried out in consultation with the British Standards Institute, and the system designed to help landlords meet the requirements of ISO 14001.

The system is based on a set of matrices - similar to the Housing Corporation's existing Energy Management Matrix - and operates in a number of 'layers', best seen as a series of doors for landlords to pass through as their activities progress: firstly identifying the key issues to be addressed; secondly assessing their current level of activity in these areas; thirdly assessing the scale of their current impacts and suggesting possible responses to these; fourthly prioritising the responses into action plans; and lastly developing the detailed tasks and procedures to be followed. This layered approach allows users to 'join' the EMS at the point relevant to their own situation - for example if they have already been implementing an energy policy for some years, or have recently carried out an assessment of environmental impacts.



Layer 1 provides a visual summary, for simple presentation of issues, performance and targets. Each key environmental issue has its own 'satellite' matrix - ie transport, energy, water, recycling and waste reduction, heath, land-use and landscape, and materials - which relate in turn to a central matrix describing core management activities relevant to all landlords. [*Note: these matrix headings are not absolute or definitive, but have been selected for likely relevance to social housing. There may be some overlap between them*] Separating the issues in this way enables landlords to: identify and report varying levels of progress in the different areas; allocate different priorities to the different subjects; and select those subjects most relevant to their own activities. New issues can also be added when appropriate, without requiring wholesale revision of the environmental management programme.

The summary matrix scores progress in accordance with the stages an organisation is likely to pass through in implementing an ISO 14001 EMS, ie: Level 0 - no activity; Level 1 - preliminary or *ad hoc* activity; Level 2 - planning; Level 3 - implementation; Level 4 - measurement and evaluation; and Level 5 - review and improvement. A 'policy and commitment bar' between levels 1 and 2 cannot be passed until a landlord has made a formal policy commitment for that subject area.

The satellite matrices are divided into three columns, describing the physical measures to be taken and the services to be provided for the particular subject, as well as the benchmarking standards against which performance can be measured. Each matrix can be used to show a baseline assessment score, to set target objectives, and to monitor progress towards these targets - and can be further divided, if desirable, to identify differences in performance between, say, the existing housing stock, new build development, and in house, corporate activity; or between general needs, sheltered and market-rent housing, if these are provided to different standards. The graphical nature of the matrices then makes it a simple task to compare performance between different issues and sectors within them. Experience with the energy matrix has shown this level of simplicity can contribute to a wide understanding and acceptance of a landlord's environmental programme both within and outside of the organisation.

Layer 2 provides detailed questionnaires, to allow landlords to assess their current 'baseline' performance in each of the subject areas - which are then plotted onto the summary matrix as the starting point for future action. It is generally easier for landlords to plan a cost-effective programme of improvements when they understand clearly where they are starting from, though this often seems to be ignored by those keener to get started than to make the most of their resources.

In Layer 3 of the system, landlords carry out a detailed examination of the impacts of their activities for each of the subject areas. EMSs typically require organisations to investigate their impacts 'from scratch' which can be a significant undertaking, but the impacts of social housing are likely to be fairly similar across the country and so the most common have been listed and described in the software package - to make the process more accessible to landlords who have not considered such issues before. Additional, local impacts can also be added where appropriate, and 'social' as well as 'environmental' impacts are listed, as a 'sustainable' EMS process will also need to fit in with broader community concerns. Landlords are asked to assess the scale of each listed impact as 'significant', 'some' or 'negligible', based on knowledge of their own sites, properties, tenants, and management processes. Many of these assessments will be highly subjective in the short term, but it is hoped that more objective tools will become available in due course. For impacts where landlords do not yet have enough information to make an assessment, the software also generates a list of 'don't knows', requiring further research.

Each of the 'standard' impacts is linked automatically to a range of possible responses, from which landlords can choose the types of measures needed to improve their environmental performance. These standard responses are also provided for guidance purposes, and can be supplemented where necessary by specific measures more appropriate to the way in which the landlord is organised. By the end of this stage, the landlord should have a comprehensive list of impacts and a range of possible responses to them - eventually to form the basis of the organisation's environmental action plan.

At Layer 4 the possible responses are assessed for resource implications and then prioritised in terms of both scale of impact and other landlord commitments, for either inclusion in the first stage action plan or consideration in future stages - or omitted, if no longer considered desirable or achievable.

And finally, at Layer 5, individual procedures are drawn up for implementing the action plan, broken down into the tasks and sub-tasks needed to progress each action from the planning stage through to implementation, and eventually monitoring and evaluation. These 'task sheets' provide a permanent record of how the various activities are to be carried out, contributing to greater consistency across the organisation, and a wider understanding among users as to how they are expected to carry out their duties - consistent with the approaches to Quality Assurance' increasingly adopted by housing organisations. Furthermore, however, the task sheets can also provide an objective scoring methodology, with progress of the individual tasks entered into the system over time, and feeding back automatically to update the performance profiles in the Layer 1 summary matrix.

CONCLUSIONS AND RECOMMENDATIONS

Practical, easily understood management tools which help rather than hinder implementation will lead to better understanding and acceptance of environmental issues, and what improvements organisations can realistically achieve in these areas. Systems such as the environmental matrix will allow landlords to compare performance between different parts of their organisations, and will provide regulation agencies and other interested parties with a fair and open method for assessing environmental performance. This EMS is aimed specifically at UK social housing landlords, but the methodology would appear to have potential for a considerably wider audience: ie for housing landlords outside the UK or for other bodies interested in improving environmental performance in buildings of other types - commercial, industrial, health-care, etc - wherever a particular building type is widely replicated, and where the impacts from its management and use are likely to be broadly similar in each instance.

21 ZERO ENERGY HOUSES - ETTEN-LEUR (NL)

ir. Tjerk Reijenga
1. BEAR Architecten, P.O. Box 349, NL-2800 AH Gouda, The Netherlands,
tel.: +31 182 529899, fax: +31 128 582599, e-mail: tjerk@bear.nl, internet: www.bear.nl

The zero energy houses have an overarching 'energy roof' which is in fact independent of orientation or the construction below. The photovoltaic system is designed to produce as much energy as will be used in the houses. To accomplish this, passive solar energy, solar collectors, heat-pumps, and heat recovery will be part of these sustainable houses. The project can be visited on the internet: www.bear.nl.

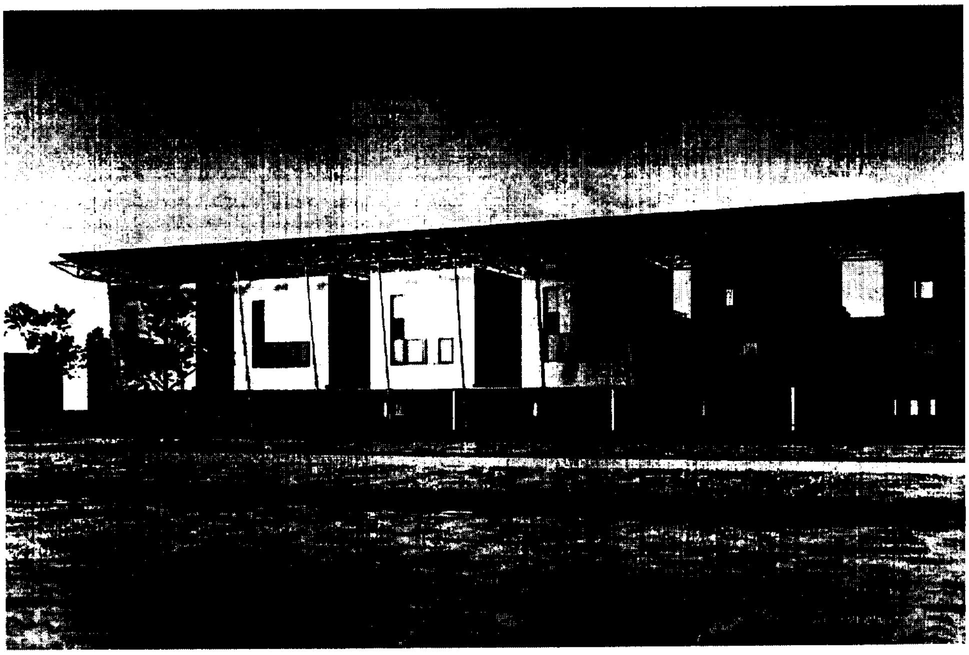


Fig. 1: Down 2 000

INTRODUCTION

Aim of the project

These sustainable houses are designed to produce each year as much energy as they use. The houses are situated in the district 'de Keen' in the city of Etten-Leur. De Keen is the newest extension of Etten-Leur. In this district a total of 43 zero energy houses will be built. Besides these projects another 38 houses in this district are supplied with photovoltaic energy.
The use of photovoltaic energy will reduce the emission of CO_2, which is emphasised as an important issue by the local community of Etten-Leur.
The zero energy houses will provide acknowledgement and experience useful for future development in this area. The next district 'Schoenmakershoek', will be build, as a district where the emission of CO_2 is in balance with the 'use' of CO_2.
To accomplish this, use is made of passive solar energy, photovoltaic solar energy, solar collectors, heat-pumps, and heat recovery.

THE PROJECT

Approach

The zero energy houses (Energy Performance Ratio = 0) are covered with an 'energy-roof'. This roof construction overarches a row of houses. In this way the different energy-systems can easily be reached, maintained and, if necessary, modified. The system can still be optimised in a later stage of progress.

Fig. 2: Front of the houses.

Architectural expression
The project is situated next to the main road of the district 'de Keen'.
The detached dwellings are connected with each other by the garages and storerooms. In this way the row of houses is divided into three blocks of houses. The blocks consist of five, ten and six houses.

The kitchens and living rooms are situated on the ground floor. The first- and second floors give room for bedrooms, study and hobby or working space.

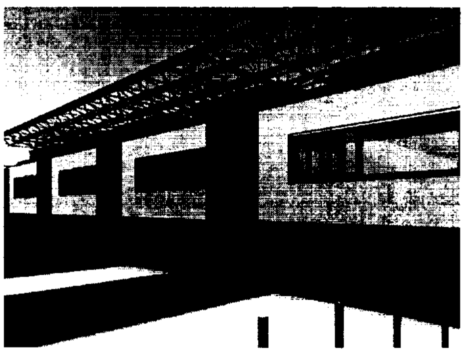


Fig. 3: Back of the houses.

The architectural expression of the houses is modern and progressive. The design expresses the new millennium. The vertical accent in the fronts of the houses provide a continuos rhythm in the total façade, especially when you are passing the road.
The open space between the individual dwellings ensures a transparency between road and other houses in this district. The connecting horizontal base on the ground floor, materialised in brick (red/brown colour) provides a restful classical look.
The design of the volumes in-between the horizontal base on the ground floor and the roof construction is simple without a lot of decoration. The façades are plastered. The roof construction, the finishing touch, is materialised in steel.

The roof
The overarching roof is supplied with as well PV modules (52 m^2 for each dwelling) as collectors for heating (9 m^2 for each dwelling). The 'energy-roof' is an open construction. Because of the good ventilation the efficiency of the PV-system will be higher.

The technical installation
The main installations of the houses are an electric heat pump, a PV- system and a solar thermal system. During the summer, solar gain is stored in the bottom and in winter the bottom is used as exchange for the heat pump.
The PV system of each dwelling produces 5400 kWh a year, the capacity of the total system is about 143 kWp (6,8 kWp each house).

SCIENTIFIC INNOVATION AND RELEVANCE
The use of solar energy takes part of the design process. New designs arises which are architecturally very interesting.
The project shows how new concepts enriches the architectural value of the (flat) roof.

RESULTS / CONCLUSIONS
Good results are expected by this building integration.
The architectural integration has a high relevance. The type of integrating the solar-systems, and the total architecture of this sustainable building project are noticed as very important.

The design is made in 1999. The houses will be built in 2000.

IMAGES
The pictures give an impression of the zero energie houses.
The artist impressions are made by M.Art, Mart van de Laan, Haarlem the Netherlands.

Fig. 4: Back of the houses (overview).

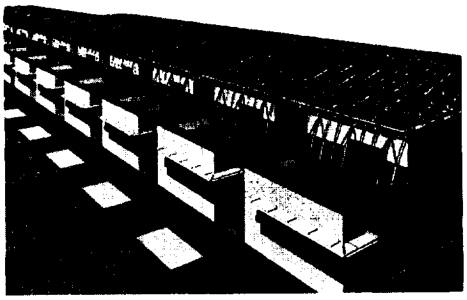


Fig. 5: The roof.

ENVIRONMENTAL STATUS OF BUILDINGS

A system for the environmental auditing and assessment of buildings

Lic. Eng. Per-Olof Carlson, Miljöstatusföreningen och Scandiaconsult, Box 4205, 102 65 Stockholm, Sweden
Website: www.miljostatus.com, www.scc.se

INTRODUCTION

The demand for environmental information on buildings is increasing. More and more people want to know whether buildings are good for our health and how they fit into a sustainable ecocycle-based 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 Environmental Status Model started in 1995 as a research and development project partially financed by the Council for Building Research. On the basis of this project, a commercial instrument was subsequently developed for environmentally oriented real estate management which was brought into use during April 1997.

The Environmental Status Model is being further developed on the basis of the members' requirements. In Nov 1999, version 3 was issued. Close cooperation is maintained in connection with the national project on the environmental evaluation of buildings, Eco Effect. The Environmental Status Model will be developed in harmony with the latest findings of this research project.

The Model is commonly accepted and widely used. Thus great efforts have been made to computerize the model and make it easy to use for different purposes and to compare buildings with each other. The Environmental Status Group has at the moment 34 members, mainly real estate companies.

At the turn of the Millenium, about 1000 environmental status of buildings with a total area of approximately 8 000 000 m^2 had been determined.

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:

Main group	*Number of environmental aspects*
• indoor environment	46
• outdoor environment	8
• energy	6
• natural resources	29
• Total	89

IMAGES
The pictures give an impression of the zero energie houses.
The artist impressions are made by M.Art, Mart van de Laan, Haarlem the Netherlands.

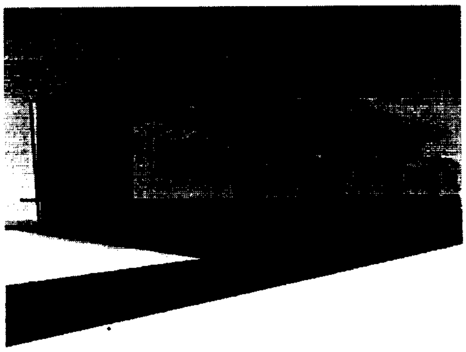


Fig. 4: Back of the houses (overview).

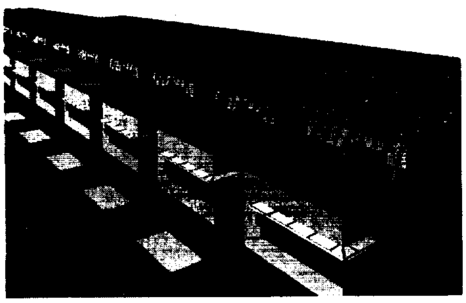


Fig. 5: The roof.

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, 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:

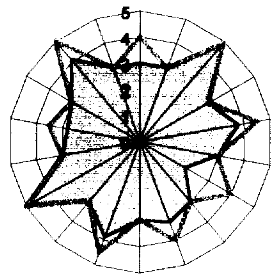
- Main group INDOOR ENVIRONMENT with sub-area AIR QUALITY
- Main group OUTDOOR ENVIRONMENT
- Main group ENERGY
- Main group NATURAL RESOURCES with sub-area ENVIRONMENTALLY DISTURBING SUBSTANCES

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.

For each main group and sub-area an Environmental Status Rose is presented. The larger the rose is the better is the Environmental status. Here the rose i supplemented with environmental goals (thick blue line) – see text below



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.

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 further developed on the basis of the members' requirements. Close cooperation is maintained in connection with the national project on the environmental evaluation of buildings and with our neighbouring Nordic countries. The Environmental Status Model will be developed in harmony with the latest findings of these research projects. The next version is planned to be released in the beginning of 2001.

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TRANSPORT AND BUILDINGS: REDUCING THE ENVIRONMENTAL IMPACT

Matt Thomas, Suzy Edwards, Centre for Sustainable Construction, BRE, Watford, WD2 7JR. UK

INTRODUCTION: THE IMPORTANCE OF TRANSPORT

Approximately 20% of global carbon dioxide (CO_2) emissions come from vehicles, cars being the main polluter. Throughout Europe, 50% of national energy consumption arises from operation of buildings. In the UK, 25% of national energy consumption moves people between buildings. Whilst operational energy is falling due to advances in energy efficient design and new technologies, transport energy is predicted to rise by an unsustainable 4% per annum. Through good practice, 20 % savings in transport related energy and emissions are considered feasible.

Studies by BRE show that transport to and from a workplace can cause environmental impacts as large as those for operating the building. Hence, the transport related environmental consequences of location and the potential for savings are substantial. As part of Transport Related Environmental Impacts of Buildings, ("TRIP") a European Commission SAVE funded project, BRE, ITEC (Spain) and Atelier EO (France) have carried out a series of case studies of reduced transport impacts across Europe. Initiatives have been identified that consistently reduce transport impacts and give rise to significant business, staff and community benefits.

The Importance and relationship of the location of a building

The location of buildings can have a major influence on transport patterns, and particularly on the use of the singly occupied motor car for commuting and business travel. This was initially identified in a 1994 by a project that analysed the travel patterns from two British Council buildings in different locations. [1]

The study shows that the location of buildings can lead to a significant increases in energy use and the production of greenhouse gases. One implication is that energy efficient buildings, built for example in out of town locations and avoiding the use of air conditioning, may use more energy overall than town centre energy in – efficient buildings, unless adequate provision is made for staff travel to and from the building. This was the genesis of the TRIP project.

INITIATIVES

Case study analysis in the UK, Spain and France has revealed a number of initiatives that have been adopted by organisations, resulting in reduced transport related impacts.

- Teleworking
- Hot-Desking
- “Drop in” centres
- Alternative working practices
- Commuter planning - Car sharing, Use of public transport, Cycling and walking
- Optimising a building / developments’ location for access by staff and customers and to benefit from the use of public transport.
- Designing buildings to minimise or alleviate the need for car parking provision.

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[1] Howard, N.P – Environmental Impact of British Council Offices in the UK, 1994.

- Cultural approaches within an organisation and senior management with a "Green" ethos.

SUMMARY OF BENEFITS
There are substantial benefits that can be achieved by addressing the (environmental) transport implications of buildings. These are:
Business Benefits
The strength of the economy rests heavily on good transport. The cost of the current system is that of being late for meetings, of staff held in traffic, of paying travelling expenses, or giving over scarce land to car parking.[2]
The financial benefits are essentially the most important to the majority of organisations, whose primary function is to make a profit from their activities. The benefits include:

- Increased productivity from staff: e.g. 80 % of staff at Scottish Enterprise feel between 10 – 50 % more productive.
- Reduced number and size of buildings required for business, saving construction, maintenance and operational energy costs of buildings. Land and buildings can be released for more productive use.
- Reduced car parking spaces with potential savings of £600 / space (900 EUR/space) to construct and £100 space/annum (EUR 150) to maintain.
- Increasing partnerships and contracts with other businesses by sharing new ideas.
- Improved employee health also leads to reduced sick leave.
- Gaining planning permission for new developments as a result of having a transport / commuter plan in place. This is increasingly common in the UK with a legally binding requirements that obliges the developer to produce, implement and monitor company transport plans.
- Complying with government policy and future regulations. For example, the recent UK Government White Paper on Transport has introduced new legislation enabling local authorities to levy new car parking charges on workplace parking.

Environmental Benefits
The environmental benefits of reducing transport use (especially use of a singly occupied car) include;

- Reduced atmospheric pollution of CO_2, CO, NOx, SO_2 & VOC's.
- A reduction in land use and resources.
- Reduced congestion as a result of decreasing the number of cars on the roads.

Community and Staff Benefits
There are a number of indirect benefits that can be achieved via the introduction of a transport initiative. New working practices and the choice of travelling to work by alternative modes of transport can provide the community and staff with the following benefits:

- Increased flexibility and job satisfaction.
- Increased choice of transport mode - matching mode to individual requirements.
- Travelling to work at off peak times can result in a reduction in stress.
- Improved health and fitness levels from reduced stress, mainly through the promotion of cycling and walking to work.

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[2] Preparing your organisation for transport in the future – The benefits of green transport plans – A summary. DETR 1999.

- Monetary savings can be achieved.
- Local communities benefit from organisations seeking to recruit locally.
- Improved working relationships with management and a sense of increased trust.
- Local organisations can promote and partially subsidise a public transport service such as a bus, which in turn then becomes another form of transport for the local community.

Benchmarks for transport emissions.

Benchmarks for transport have already been incorporated into the Building Research Establishment Environmental Assessment Method (BREEAM). BREEAM 98 for offices is a tool that allows the owners, users and designers of buildings to review and improve environmental performance throughout the life of the building including transport issues.

The table below provides benchmarks of good and typical performance for transport emissions related to a building's location.

Table 1: Benchmarks of good and typical practice within various locations.

Location	**Energy (return)** GJ/person/day	**CO_2 emitted (return)** $KgCO_2$/person/day	**NOx emitted (return)** gNOx/person/day	**VOC's emitted (return)** gVOC/person/day	**CO emitted (return)** gCO/person/day	**SO_2 emitted (return)** gSO_2/person/day
Capital City -						
Good Practice	0.03	3.8	53	17	52	43
Typical Practice	0.05	5.4	75	25	93	55
Major City						
Good Practice	0.06	5.1	44	27	212	22
Typical Practice	0.09	7.8	70	39	284	40
Rural / Out of town						
Typical Practice	0.1	7.9	50	40	354	13

These benchmarks of transport emissions can be used by planners, designers and operators of buildings to set targets for commuting to a building.

CONCLUSIONS

All of the case studies in the TRIP project showed a need or had a problem that resulted in a transport initiative or solution being implemented. The problems and solutions encountered in the case studies can be classified into three operational levels;

- **Organisational Scale**
- **Building Scale**
- **Urban Scale**

Whilst overcoming these problems the case study organisations have realised significant benefits to the business itself, the environment and the staff and the community. In most cases, the business benefits are the most important outcomes and the most likely factors to influence the organisation to continue to support and promote new initiatives. The positive results derived from the project substantiate the case for carrying out the project. The project outputs appear to have considerable value to the broader needs of decision makers for sustainable communities, planning and development.

SUSTAINABLE BUILDING IMPLEMENTATION FROM JAPANESE PERSPECTIVE

Prof. Shuzo Murakami, Dr. Tomonari Yashiro, Dr. Toshihiko Tanaka, Dr. Toshiharu Ikaga, Prof. Kazuo Iwamura

1. Institute of Industrial Science, University of Tokyo, 4-6-1 Komaba Meguro-ku Tokyo 153-8505, JAPAN
2. Institute of Industrial Science, University of Tokyo, 4-6-1 Komaba Meguro-ku Tokyo 153-8505, JAPAN
3. Tokyo Electric Power Company, (TEPCO), 1-1-3 Uchisaiwai-cho, Chiyoda, Tokyo 100-0011, Japan
4. Nikken Sekkei, 2 1 3 Koraku Bunkyo Tokyo 112-8565, Japan
5. Musashi Institute of Technology, 3-3-1 Ushikubo-Nishi Tsuduki Yokohama 224-0015 Japan

INTRODUCTION

In terms of sustainable building implementation, Japan has similar context with Western European and North American countries as an industrialized country. However, Japan also has different geographical and demographic context (Yashiro 1998) such as;

1. Energy use in summer time
2. Limited capacity of space
3. Short life buildings
4. Amount of construction wastes
5. Global supply chain

These contexts affect on perspective in the framework of sustainable building implementation. In 1999, the subcommittee on sustainable buildings in Architectural Institute of Japan (AIJ), academic body with 40 thousands members, made the document titled as 'Proposal for Promoting Sustainable Buildings' through two years' discussion. The proposal well represents Japanese perspective on sustainable building implementation. The paper presents essential contents of the proposal in order to contribute to create global perspective to sustainable building implementation.

STRUCTURE OF THR PROPOSAL

The proposal is composed of the following five chapters;

1. Definition
2. Basic Principles
3. Eco-efficient design and construction
4. Environment-conscious life-styles
5. Collaboration, dissemination, management and continual improvement

The third chapter is the proposal to building professions. The fourth is to users and occupants. The fifth is to policy makers. The following is the essential contents of the proposal.

DEFINITION AND BASIC PRINCIPLES

The proposal defines a 'sustainable building' as a 'building that can moderately maintain or improve the quality of life and harmonize with the climate, tradition, culture, and the environment in the region, while conserving energy and resources, recycling materials, and reducing release of hazardous substances within the capacity of the local and global ecosystems throughout the building life cycle'. In a sense, the definition indicates that sustainable building is 'less-unsustainable' building. The definition is based on the following ideas:

1. Intergenerational ethics (liability for the future generation),
2. The limited capacity of the earth as a small planet, and
3. The right of living creatures to survive.

It is needed to establish the environmental model that is composed of hierarchical sub-models with clearly-defined objectives in terms of both time and spatial scales. The objectives on time scales can be classified into the short-term (about 10 years), the intermediate-term (about 50 years) and the long-term (a few hundred years) objectives. It is realistic to start with the possible transitional measures of 'weak sustainability' and to transfer to the final goal of 'strong sustainability'. The objectives on spatial scales are based on the understanding of the phenomena on hierarchical spatial scales together with their boundary conditions such as those around human beings, rooms, buildings, city blocks, cities, regions, meso-scale regions and the earth. The proposal indicates that the concept of 'eco-efficiency' (the quality of life divided by environmental loads) can be one of the basic indicators to evaluate sustainable buildings.

ECO-EFFICIENT DESIGN AND CONSTRUCTION

The proposal declares the significance of the anticipation of 'the era when fossil fuels cannot be consumed freely', 'the era when natural resources cannot be used freely', 'the era when wastes cannot be dumped freely', 'the era when great impacts of building materials on human health emerge', 'the era when local ecosystems must be preserved', and 'the era when local societies must be cherished'. Based on the recognition, the following four measures are proposed mainly to building professions.

1. Minimization of energy consumption for maintaining the indoor environment
2. Prolongation of building life
3. Utilization of non-hazardous, healthy and safe building materials with life-cycle-based thinking
4. The improvement of the urban environment by reducing the heat released from HVAC systems, by planting trees or grass on roofs and exterior walls, and by forming green networks and increasing green tracts in the site

ENVIRONMENTAL CONCIOUS LIFE STYLE

The proposal emphasizes the need that building users themselves should control the environmental quality appropriately whenever such control is necessary and should determine required levels by taking the balance between the desirable environmental quality and the resultant loads into consideration. The proposal requests users to implement the following measures.

1. Establishment of the life-styles that make efficient use of energy by checking the trends of energy consumption, control of solar radiation and cross ventilation, adjustment of target temperatures for HVAC operations, and clothes adjustment.
2. Use of recycled products, separation of wastes, and re-collection of materials
3. Appropriate and intensive maintenance management to keep buildings in healthy environment
4. Positive participation in the activities related to natural preservation and resource circulation in the region.

COLLABORATION, DISSEMINATION, MANAGEMENT AND CONTINUAL MANAGEMENT

The proposal claims to policy makers the need to change the building construction process including promoting interaction between design and assessment for dissemination of sustainable building implementation. It also requires changing the regulatory framework, the way of stakeholders' involvement, and the way how knowledge is stocked. It also requests policy makers to implement the following measures.

1. Promotion of the users' and occupants' participation in various decision-making processes including the design process to enhance comfort.
2. Establishment of formal and well-defined status of the process of;
   - 'pre-design' during which an 'environmental review' and an 'environmental brief' are drawn up in order to establish common understanding on the environmental impacts of buildings and to assure consistency during design development.
   - 'post-design' during which designers and constructors make continual commitment to promote customization for the whole life cycle.
3. Enhancement of development of elemental technologies as well as of planning techniques that integrate the elemental technologies and balance various

'tradeoffs'.

4. Encouragement to exchange and to share available empirical knowledge through information feedback, collaboration, co-operation, and publication in the form of manuals so that practitioners can use them as 'templates'.
5. Improvement of procurement systems, by revising the 'one-year-based order systems' to 'serial-years'order systems' and by introducing 'think-during-construction' procedures
6. Change of building asset ownership systems and building permit systems.
7. Introduction of the education and training programs that cultivate the ability to understand a comprehensive view, to integrate different perspectives, and to collaborate with the fields other than architecture. This is based on the understanding that it is impossible to design and realize sustainable buildings without understanding the overall context.

CONCLUDING COMMENTS

In the appendix, the proposal exemplifies the research topics that should be addressed to realize the measures involved in the proposal. Many problems related to sustainable buildings cannot be solved only by traditional academic approaches, which describe the whole under one principle. The problems can be mitigated by integration of decisions from multiple criteria. The process of integration has connection with geographical, demographic and cultural context in the region. It is expected that the proposal, drawn from Japanese perspective, would contribute to the discussion to establish global perspective on sustainable building implementation.

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DEVELOPING INTERNATIONAL SCENARIOS FOR THE RAPID REDUCTION OF CARBON DIOXIDE EMISSIONS FROM THE BUILT ENVIRONMENT

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Maastricht

Robert Lowe
Centre for the Built Environment
Leeds Metropolitan University
Leeds LS2 8BU
UK

DEVELOPING INTERNATIONAL SCENARIOS FOR THE RAPID REDUCTION OF CARBON DIOXIDE EMISSIONS FROM THE BUILT ENVIRONMENT

Robert Lowe
Centre for the Built Environment, Leeds Metropolitan University, Leeds, LS2 8BU, UK

BACKGROUND

The purpose of this paper is to explore the possibility of an international collaboration to develop and compare a series of very low carbon scenarios for industrialised countries. The primary emphasis of these scenarios would be on the built environment. The immediate purpose would be to understand the dynamics of creation, liquidation and renewal of this, longest-lived sector of capital stock, in the economies studied, and to improve the understanding of the connections between the built environment and other economic sectors. The broader purpose would be to make a significant contribution to the development of energy & environmental policy capable of achieving large and rapid reductions in carbon dioxide emissions that will be needed to stabilise the earth's atmosphere and climate over the next century (Lowe 2000). The study would define radical policy and technical options against the possibility that negative effects of Climate Change may be more drastic and more rapid than currently expected.

Futures scenarios differ from forecasts in that they are explicitly, only conditionally predictive. The construction of futures scenarios is widely practised. The motives of scenario builders range from the desire to understand consequences - "to illuminate the choices of the present in the light of possible futures" (Berkhout et al. 1999), to an explicit desire to affect policy debate and policy choice, by extending the range of what is thought to be possible, or by attempting to build consensus around one or other alternative.

If the literary genre of utopias is included, then activity of scenario building can be seen to go back millennia and to have produced some of the most enduring works of culture (Plato c360 BC, Moore 1515, Morris 1880, Bellamy 1888). Against this background, the methods used over the last three decades by the builders of technical scenarios, and their focus on mass and energy flows through economies, rather than on the cultural aspects of the societies upon which they focus, represent a new phenomenon. But, despite the clear difference in style, there are fundamental similarities in the purposes of the authors, and in their desire to produce internally consistent and persuasive views of the futures they chose to depict. In the case of technical scenarios, internal consistency and persuasiveness are generally seen to flow from the incorporation of physical and engineering principles into disaggregated numerical models of society. But it is also clear that many builders of technical scenarios are keenly aware of the dense interweaving of the cultural and technical aspects of the societies that they study, and of the degree to which the political, cultural and ethical domains drive the technical (Nørgård & Christensen 1994, Olivier et al 1983).

RECENT HISTORY

The development of very low carbon scenarios has grown out of earlier work on low energy scenarios. Very low energy scenarios go back to the mid 70s and early 80s, with work by Sørensen (1975), Nørgård (1979), Olivier et al (1983) and others in the US and Germany. These were essentially engineering studies of the possibilities for reducing fossil energy use by a factor of 3 or more. The main function of these studies was to challenge the then conventional view that renewable sources of energy could never supply more than a small proportion of a rapidly growing demand for energy. By demonstrating the technical feasibility of reducing total energy demand substantially, these studies were able to demonstrate that renewable energy inputs that were modest in absolute terms, were capable of providing a large proportion of the total energy use, despite substantial economic growth.

The building of carbon scenarios arose naturally from earlier energy scenarios as the focus of energy policy shifted, in the 1980s, from a concern over shortages of fossil fuel, to a concern over climate change. The impact of these studies has varied from country to country. The development of Danish energy & environmental policy over the last quarter century shows that much of the work of Nørgård and his colleagues has been incorporated into mainstream energy policy (Danish Ministry of Energy 1990, Danish Energy Agency 1997). The experience in Germany appears to have been similar, with the work of Bach, Krause and others having had a significant impact on energy policy (Enquete Kommission 1991), albeit complicated by the impact of reunification.

Experience in other countries is that these studies have been marginalised and ignored. In the UK for example, energy scenarios and studies can be divided into two groups – those produced by the energy policy establishment (DOE 1979, BRE 1975, DTI 1992, Shorrock et al 1992) which broadly support a business-as-usual view of the future, and those produced by a small group of outsiders (Leach et el. 1979, Olivier et al. 1983) that challenge that view. The former is characterised by a timidity of vision and technological conservatism, that have rendered it incapable of addressing the problem of climate change. There is little evidence that this establishment has been significantly influenced by, or in some cases that it is even aware of other work.

FOCUS AND OBJECTIVES

As stated at the beginning of this paper, the built environment contains the longest-lived parts of the physical infrastructure of most, if not all developed countries. It is therefore likely to be the rate-limiting sector, determining the maximum rate and extent of overall emissions reductions. The development of policies for dealing with this infrastructure, of minimising its direct and indirect environmental impacts, while respecting the values (economic and cultural) that it embodies, is therefore one of the most important tasks facing governments. That the task requires the active involvement of government is clear. The timescales involved are far longer than the private sector can contemplate.

The central questions posed by the problem of climate change are: the scope for reducing carbon emissions, the time scales needed for achieving significant reductions, under a variety of assumptions and the technical and economic barriers to such reductions.These raise in turn a series of secondary questions that need to be addressed in formulating policy. These include:

- the balance between refurbishing and replacing the existing stock of buildings;
- the likely impact of developments in energy supply (these include fossil technologies such as gas-fired combined cycle generation of electricity with dramatically lower carbon intensity and renewable energy technologies.
- impacts of developments in design and construction (extension of IT, industrialisation, pre-fabrication etc. – referred to in the UK as the Egan Agenda) which promise to significantly affect both the costs of construction and of innovation;
- impact of potential changes in planning policies, patterns of urbanisation and development, and of work, leisure and travel.

These questions themselves raise further questions about the means by which policy is to be implemented, particularly the balance between regulatory and market based measures. Addressing these questions in the context of realistic long-term carbon emission targets will require the construction of detailed stock models for domestic and non-domestic buildings, and the construction of a series of scenarios based upon them. These models and scenarios would need to be up-dated and developed on a rolling basis as developments in policy, technology and climate science open up new possibilities and questions.

The author envisages that governments, national and supranational research councils, the research community, the construction industry and broader society will be both contributors to and beneficiaries of such studies. It is essential to ensure that low carbon scenarios focussing on the built environment, are developed by people with both an intimate and synoptic understanding of the technology (current & potential) and the dynamics of the built environment. There is a tendency for scenarios that are developed by people who lack such a deep understanding, to underestimate the potential for reducing environmental impact, and to fail to identify the steps that must be taken in order to achieve a significant impact. The construction industry, through organisations like CIB, must take responsibility for building its own view of the future.

STRUCTURE AND METHODOLOGY

To be convincing, technical scenarios require detail and depth. The development of low carbon scenarios is therefore costly, and it is essential that this project avoid repeating or duplicating work that is going on already. The greatest added value is likely to be achieved by a layered strategy:

- collating existing work, reviewing, abstracting, critiquing it;
- comparing different national scenarios to identify the widest range of policy and technical options;
- proposing consistent methodologies for future work;
- identifying gaps in existing work, and proposing projects to fill these gaps;
- using the results of low carbon scenarios to identify actual and potential barriers to the successful implementation of low carbon policies for the built environment, and to develop programmes of research, development and demonstration, in collaboration with national and supra-national research funding organisations, aimed at overcoming these barriers;
- communicating the lessons learnt from the construction, analysis and comparison of scenarios to the rest of the construction industry and to the public at large.

We envisage the establishment of a group, initially within CIB W100, which will begin to undertake this task. The membership of this group should contain representatives of at least three industrialised countries, spanning a range of approaches to energy & environmental policy. The initial role of this group will be catalytic, but it is likely that its members will also both propose & undertake work identified.

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ENVIRONMENTAL POSITIONING OF REAL ESTATES

Henrik Berg von Linde, Gunnar Nordberg
SWECO INTERNATIONAL, P. O. Box 17920, SE-118 95 STOCKHOLM, Sweden
henrik.berg.von.linde@sweco.se; gunnar.nordberg@sweco.se

INTRODUCTION

Many real estate companies nowadays choose to organise their quality and environmental management systems according to the ISO-standards 9001 & 14001. As a consequence they have to identify the company's most significant environmental impacts, which normally are caused by operating the building stock of the company. And if you are to promise continual improvement, you must know the environ-mental performance of the building stock at the time you start measuring.

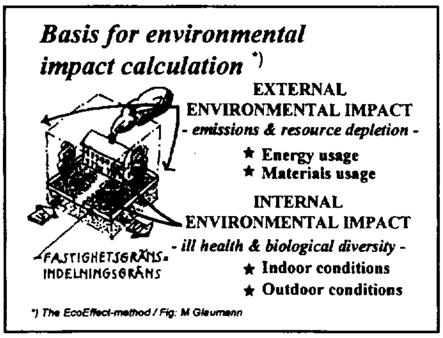
A real estate company may hesitate before ordering a complete environmental assessment on each single property due to the considerable work and cost involved. The **Environmental Positioning** method is a cost-effective way **to receive an accurate environmental overview** of a number of similar properties.

The Positioning method applies to the Swedish EcoEffect (1) approach. Thus, the activities included give an adequate ground for a complete EcoEffect analysis.

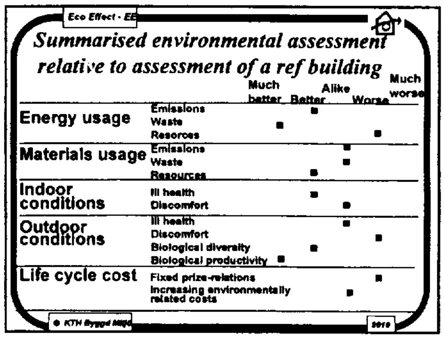
An accomplished Environmental Positioning of a number of properties gives a general basis for prioritising among improvement measures, or for making further surveys on specific aspects, or for carrying on with an in depth environmental analysis.

ECOEFFECT GIVES THE GROUND

The environmental assessment method named **EcoEffect ®** is being developed at the Swedish Royal Institute of Technology. It is influenced by national and international progress, the project team participating in Nordic and international collaboration, among them the GBC.



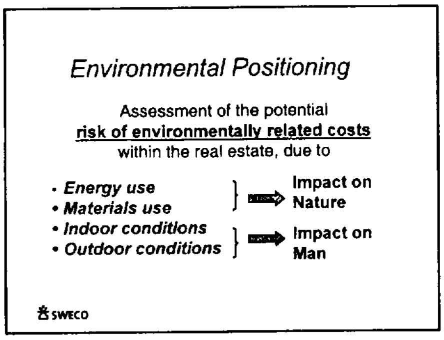
The EcoEffect method differentiates between **external** environmental impact – caused by energy and materials use – and **internal** environmental impact – depending on indoor and outdoor environmental conditions within the estate.



Using a computer programme the method facilitates detailed information on these areas. At the SB 2000 conference the EcoEffect method is being demonstrated as compared with the GBC method applied on the Swedish projects. EcoEffect, however, is being further developed, along with application tools for different purposes.

ENVIRONMENTAL POSITIONING

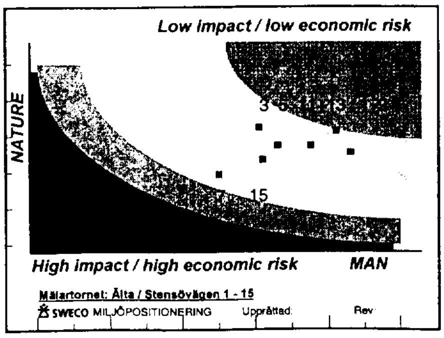
The Environmental Positioning method focuses on **the risk that the real estate owner will be charged with environmentally related costs.**



The method applies to the grounds of EcoEffect, but strongly simplifies the application by choosing *energy consumption* and *indoor conditions* of a building as main parameters.

Energy consumption causes direct impact on the external environment, while reduction of energy consumption means immediate savings for the property owner.

A poor indoor environment – an SBS house at the worst – can on the other hand cause immense costs for the owner, when loosing tenants and catching a bad reputation.

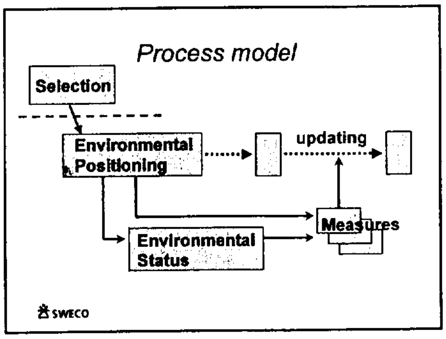


The result may be shown in a diagram as above, where green colour indicates "low environmental risk" and red colour "high environmental risk". In order to communicate the results to non-specialists, "external environmental impact" is being named "**impact on nature**", and "internal environmental impact" is being named "**impact on man**".

There are other significant environmental impacts of importance for the economy of the real estate company – and for the environment. The method, for example, also takes in account the occurrence - or risk of occurrence – of hazardous materials.

PURSUING ENVIRONMENTAL POSITIONING

The main purpose of the Positioning method is to give an environmental overview of a number of similar properties in a cost-effective manner, thus giving the basis for further actions, such as investigations or improvement measures.



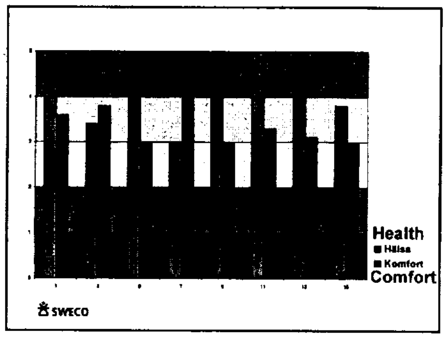
In order to keep the low-cost level, much of the positioning work should be performed by the staff of the estate company. After proper education in one or two days the work starts to gather the necessary input.

The first step of the Positioning method is the **Property input form,** given in Microsoft Excel. The property manager fills in available information concerning:

- **General information** (areas, ongoing and historical usage, construction activities, official environmental information)
- **Media consumption** (energy- and water consumption, energy sources, HVAC-systems)
- **Hazardous materials** (PCB, Hg, asbestos, ozone depleting substances)

- **Indoor conditions** (the general opinion of the manager, radon, electrical fields)
- **Outdoor conditions** (waste systems, electrical fields, noise levels, air & ground pollution)

The *Property input form* gives the necessary information needed for calculating *impact on nature*. This part of the work being is done by an experienced engineer or architect, who has to assess the reliance of the input. The final assessment relates to a specific scale, given by the accurate building type, taking in account actual use of different energy carriers.



The second step of the Positioning method is the so-called **Stockholm-inquiry** (2), given to the tenants of the building. The inquiry questions and the routines for gathering the answers, are standardised and must be strictly followed to guarantee the quality of the result. The answers are related to the answers of more than 10 thousands of inquiries, making it possible to state whether a result is statistic significant, according to type of living - rental or owners house - age, sex and allergic symptoms. The outcome is information on **ill health** and **discomfort** among the occupants. The risk of an SBS (Sick Building Syndrome) house may be assessed.

In the use of the Stockholm-inquiry for existing building stocks, the Positioning method strictly follows the EcoEffect method. The Positioning method however simplifies the evaluation of the enquiry results, leaving the possibility open for deeper analyses when needed

Together with input from *the Property input form* the inquiry gives the necessary information for deciding the grade of *Impact on man*, the work being done by an experienced engineer or architect .

The summarised result given in an **Evaluation form** envisages the property manager to carry on with improvement measures or further investigations, thus achieving a higher environmental grade. In this way, the Positioning method works well as part of an environmental management system.

APPLICATION OF THE METHOD

The Environmental Positioning method has been developed in co-operation with one of the largest estate companies in Sweden, **Fastighets AB Tornet.** The method has initially been applied on various building types, recently on a living estate holding 200 apartments. Tornet is now implementing the method in a large scale, as part of their environmental & quality management system.

CONCLUSIONS

An environmental assessment method must be transparent and apply to commonly agreed systems and vocabularies, being ground for communication with customers and employees . That the Positioning method gives an adequate basis for a complete EcoEffect-analysis is essential.

The Positioning method is a proper tool

- to **make an environmentally survey** of a number of properties
- to **give a visual overview** of the environmental status of a number of properties
- to **define significant environmental aspects** as part of a management system
- to **prioritise** when making decisions on further investigations or future projects
- to **communicate** accomplished improvements.

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A COMPARATIVE ANALYSIS OF DURABLE CONSTRUCTION BETWEEN DIFFERENT TYPES OF COUNTRIES (LESSONS TO BE LEARNED)

Dr. Peter A. Erkelens, Eindhoven University of Technology, Eindhoven, The Netherlands

INTRODUCTION

The meaning of durability very much depends on culture and locality. Certain measures for durability may be of minor importance for one country but of great interest for other countries. The priorities for measures are different for various reasons: climatic and political conditions, the availability of materials and energy, the country's culture, and the specific environmental behaviour of people. The achievement of 100% sustainability in construction is a contradiction in terminus. Each construction activity leads to some form of degradation of the environment. Therefore, the only thing left is to reduce the negative impact on the environment as much as possible and provide for generous compensation (e.g. treeplanting, greenzones).

Many important lessons can be learned by making comparisons between countries.
This paper is a reflection on and analysis of experiences gained during a three-year stay in Peru at the IIUR of the University of Cusco (UNSAAC). As a technical expert attached to the university, I taught courses and did research on low-cost housing in relation to solving environmental problems.

SUSTAINABLE IS NOT ONLY DURABLE

The concept of durable construction differs in various countries. For example, in rural Latin America, farmers usually build their houses with adobe blocks and a roof of poles and thatch. The timber they use comes from the trees in the forest and the thatch is specially grown for the roof. Though the materials and constructions are not especially durable, they nevertheless are sustainable. Improving durability would result in fewer replacements of materials and components. Buildings with short life-spans can only be defined as sustainable under the precondition that all the materials and products will be reused, preferably at the "same level" [Post].

How can the sustainability and durability of structures be improved?

Amongst other things, measures for disaster contribute to sustainability. Building on risky sites has to be discouraged to prevent disasters and problems with the environment. Poor people tend to build on in bad areas for obvious reasons. This requires specific measures in the political sphere and in planning. Building on the wrong sites is not always a matter of poverty: in the Netherlands people tend to build close to the waterfront. This tendency has to be changed because of rising water levels in the winter season. However we know from experience, how difficult it is 1) to discourage people from settling 2) to take measures against this phenomenon.

The development of autonomous buildings and housing blocks may also contribute to sustainability. Good examples of autonomous buildings can be found in many rural areas. The farmers have to build and maintain their own house and infrastructure. This stimulates the development and use of local constructions and building materials, because of a lack of transport means and long distances. An additional advantage of self-help building is that you have a better idea of building details. As a result, repairs and maintenance, including repairing the walls with fresh mud and replacing parts of the roof, can be done by the farmers themselves [Erkelens, 1991].

We can learn from experiences and examples in other countries. Transfer of building technology can speed up the achievement of targets set for durable construction. We will work out two items in this article: Services & Energy Saving and Materials & Structures.

SUGGESTIONS FOR SERVICES & ENERGY

Not all measures in energy saving really contribute to sustainability. The insulation of a wall may reduce the heat loss, for example, but there is no gain if other parts of the wall contain poorly detailed window openings. Therefore, integral measures have to be taken. Some measures are of "basic" importance and may affect living style or comfort, while others just reduce comfort from super comfortable to comfortable. Take, for example, central heating at a level of 19 instead of 20 degrees Celsius. Other measures do not even affect the level of comfort: the use of an energy-saving lamp of 15W to obtain the same effect as a normal lamp of just 75W has no effect on comfort. Below a summary is given of what the Netherlands can learn from Peru and vice versa:

Ideas for Peru

- Every bedroom has its own bathroom: reducing this number results in a simpler infrastructure
- Good and well-executed details reduce rapid deterioration.
- The use of insulating materials and better details etc. give less heat loss and dust.
- Introduce solar collectors for warm water or use simple plastic tubes on flat roofs.
- The use of a flow reducer will diminish water use.
- The use of rainwater gutters along the roofs and additional water receptors may provide for water in the dry season.
- Make more use of the sun by orienting the building towards the north.

Ideas for the Netherlands

- Lowering the internal temperature by a few degrees reduces energy consumption considerably, without degrading comfort (own experience).
- By a lower temperature there is less need for complete sealing; thus a better natural ventilation.
- Reducing the artificial demand for newly designed installations and equipment etc. will increase economic life (e.g. kitchens). Every new owner nowadays replaces the kitchen without there being a technical need.
- Water-saving equipment but, above all, more awareness of limited resources together with a different mentality.

SUGGESTIONS FOR MATERIALS & STRUCTURES

A debate is going on about the use of tropical hardwood. We are striving not to use tropical wood unless it is certified. In the Netherlands we should construct with local materials from our own soil. A good example of improving the qualities of a material is the conversion of softwood into a type of hardwood, using simple techniques, and with the knowledge that the timber can be reused in the future. However, sometimes the use of local timber is questionable. In Peru the eucalyptus tree is often used for construction timber. This is not an indigenous tree originally and this species causes considerable damage to the environment because it depletes nutrients and much water from the neighbouring plants and trees.

A reduction of the use of materials is often seen as a contribution. This is not always the case. Adobe structures should have a width at their footings of eight times the height. Modern constructions of adobes show a considerable reduction in depth at the base from 1.50m to 0.30m at a maximum. Without special measures vulnerability will increase [Erkelens, 1999].

Ideas for Peru

- Peru should restore its own indigenous architecture, which is a mixture of Inca and Spanish traditions. It should stop copying USA building styles. An indigenous architecture has more options to incorporate the specific characteristics of the country (making buildings more sustainable as a result).

- The use of big glass panels. Especially in corners of façades, glass windowpanes are just placed and connected with simple brackets. Apart from a bad look it adds no strength.
- Better detailing of the windows / doors so that they close better and prevent rain and cold.
- The construction of ring beams at different heights improves the resistance against earthquakes.
- Large overhangs above windows and doors are not necessary when using simple lintels and better details. This saves materials and allows more daylight to enter.
- Improve window frames, which do not have good overlaps and windowsills. The use of windowsill tiles reduces leakage considerably.
- Improve timber quality by preventing the use of green timber causing big problems for windows, doors and floors.

Ideas for the Netherlands

- The use of other local building materials: Loam and mud for the walls. This could regulate the indoor temperature and humidity. And the use of local timber for the floors.
- A variation may be a wall of two layers of reeds with a gypsum or loam plaster layer on the outside (Thus creating a cavity wall).

SOME REFLECTIONS / CONCLUSIONS

Achieving an optimum in sustainability in construction is important. However, the majority of people simply do not have time to be engaged with that. They are too busy with surviving; food, drink, health, safety and education are still the primary basic needs. So they simply do not have time to bring in durability and sustainability. On the other hand, there are groups of people who simply do not bother (as long as it is not in their back yard). Therefore, systems of some type should be made auto-sustainable or self-sustainable. This may be an odd expression, but it is meant to mean sustainable by itself, or rectifying undesirable situations and detrimental situations, e.g. self-repairing tyres in the event of a puncture. Take the adobe blocks, for example, even when nothing is done with them, they do not harm the environment as they are natural building materials just like straw for thatched roofs. The qualification of building materials of being recyclable does not provide any guarantee that, in the future (with changed ideas and norms), this recycling will indeed take place. Therefore, a better choice is to develop materials that will decompose automatically after being made redundant.

Development aid to other countries can result in better and more sustainable housing. Transfer of certain technologies both ways can play an important role. However it has its problems, and should therefore not be done blindly but in close co-operation and consent between the parties involved. There is an important role for CIB to transfer knowledge of technologies through its committees.

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AN INVESTIGATION INTO THE CHARACTERISTICS OF JAPANESE SUSTAINABLE BUILDING

Toshimasa Konishi
Utsunomiya University, 7-2-1 Yoto Utsunomiya City Japan

1. Introduction

Ever since the industrial revolution, our way of life has become more prosperous, accompanied by an advanced development in civilization. On the other hand, the energy required to satisfy our needs and the concomitant waste of resources has become exceptional, resulting in environmental contamination of global magnitude. Japan, too, has contributed toward resource depletion and environmental contamination. Japan entered on this road at the close of the Edo Period, when foreign pressures put an end to its isolation and compelled our country to open its doors. Up until then, although Japan had a number of large cities in addition to Edo (the present Tokyo), the system could be characterized as one that was highly recyclable.

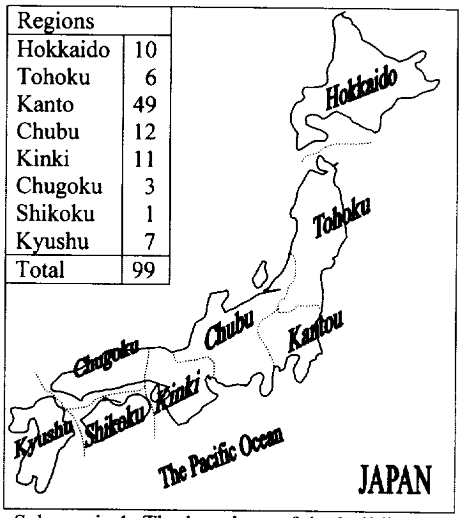
Today, many architects in Japan are going through trial and error in an effort to determine how architecture should be carried out so as to build a sustainable society. Recently, research and analysis has been carried out concerning buildings that have been actually built in Japan by Japanese architects, with an eye to the concept of sustainability. The concept of "sustainable" being related to things in other fields, conclusions cannot be drawn based on the architecture alone. Still, when the works of Japanese architects are analyzed through their architecture, it is clear that conception often derives from a relationship with the traditional Japanese regard for nature. Such an inclination might prove generally useful in protecting the future global environment.

2. Research

Analysis was carried out on buildings chosen by the JIA (Japan Institute of Architects) as being "sustainable," the results of which were adopted in order to create design guidelines for architects (* Reference documents 1, 2, 3 and 4). Reclassification in accordance with current objectives was carried out based on the material thus collected.

As indicated in 99 cases (At first, 45 buildings were chosen, but others were added later), the buildings that were selected had been built between 1976 and 1999, designed by architects to include some sustainability. As indicated in Schematic 1, they are scattered throughout Japan.

Regions	
Hokkaido	10
Tohoku	6
Kanto	49
Chubu	12
Kinki	11
Chugoku	3
Shikoku	1
Kyushu	7
Total	99



Schematic 1: The locations of the buildings, plotted onto the map of Japan

Table 1: Chronological distribution

Year	Nos.				
1985	2	1990	6	1995	15
1986	1	1991	3	1996	13
1987	3	1992	8	1997	4
1988	2	1993	14	1998	5
1989	3	1994	7	1999	3

3. Research results

The functions of the buildings are residential, educational, offices, restaurants, recreational, exercise, commercial, accommodations, cultural, resorts, hospitals, welfare, day care, and senior citizen facilities. They are located in climatic areas ranging from hot and stuffy to moderate and cold. Building floor space/site ratios range from 0.5% to 480%, indicating that some are located on ample campuses while others are in extremely populous areas. The buildings are of reinforced concrete, steel, steel-reinforced concrete, and wood, including all general structural types in Japan. Table 1 indicates chronological distribution. As urged in the "Global Warming Prevention Action Plan," decided upon by the Cabinet in 1990, environmentally "sustainable" structures have rapidly increased since that time.

After 1997, the data is insufficient. When one categorizes the characteristics of buildings which are "sustainable," based on blueprints and comments by the architects, one can roughly identify five types, as follows. The nature of each is also described.

A. Through efficiency, the use of energy and of materials is decreased.
High efficiency of the building itself and of the equipment contained in it.
B. The use of nature
Solar power, wind, water, natural power (renewable capability), other
C. Building longevity
The materials' longevity and the building function's longevity
D. Proposals for lifestyle
Proposals made from the hardware aspect, proposals made from the educational aspect.
E. Protection of the regional
Consideration for the natural environment, environment wastes, and streets (historical view)

Table 2:Evaluation of listed buildings

	Climate*8			Efficiency *9		Utilization of Nature*10					Long Life*11		Life style *12		Regional Environment *13		
Facilities	Ma	Mi	Co	Bu	Eq	Sl	Wi	Wa	Tr	Mi	Ma	Fu	Ha	Ed	Na	Wa	St
Residential*1	3	27	10	22	23	23	12	10	10	1	3	3	2	5	8	2	3
	40			45		56					6		7		13		
Educational*2	1	10	11	18	9	18	10	4	8	0	2	2	1	3	4	1	2
	22			27		40					4		4		7		
Office*3	0	12	4	8	6	11	7	4	3	0	1	2	3	0	1	1	0
	16			14		25					3		3		2		
Commercial*4	0	6	1	4	3	5	4	2	3	0	2	1	1	0	2	0	1
	7			7		14					3		1		3		
Medical*5	0	4	0	2	5	4	1	2	2	0	0	0	1	0	1	0	0
	4			7		9					0		1		1		
Accommodation *6	1	4	0	1	1	1	1	2	1	0	2	0	1	0	4	0	1
	5			2		5					2		1		5		
Miscellaneous*7	0	3	2	5	3	4	4	1	5	0	0	0	2	2	1	2	0
	5			8		14					0		4		3		
Total	5	66	28	60	50	66	39	25	32	1	10	8	11	10	21	6	7
	99			110		163					18		21		34		

*1: separate and condo. *2: include cultural, exercise, training and day care facilities. *3: include government office. *4: include restaurants and recreational facilities. *5: include welfare and senior citizen facilities. *6: include hotels and resort houses. *7: factories, recycle and religious facilities.
*8: Ma: muggy & humid, Mi: mild, Co: cold. *9: high efficiency, Bu: building, Eq: equipment. *10: Sl: sun light, Wi: wind, Wa: water, Tr: tree & wood, Mi: miscellaneous. *11: Ma: material, Fu: function. *12: Ha: hard, Ed: education. *13: Na: nature, Wa: waste, St: street (the look of stores and houses on the street)

The above have been summarized in Table 2. Needless to say, those based on the so-called solar house concept are many. There are 60 cases in which building efficiency, such as high insulation and tightness, are given consideration; and there are 59 cases (of which 15 involve the introduction of passive solar systems) using highly efficient and there are 32 cases involving the employment of natural properties such as the use of wood. On the other hand, there are only 10 cases in which durable materials are used and 8 cases in which functionally-durable materials are employed, indicating relatively few instances of special consideration to longevity. This may be due to the Japanese tradition that structures are not considered to be permanent. Or, it may come from how the Japanese have all along dealt with nature. In other words,

Japan during the Edo Period embraced world-class large cities of more than one million in population, with virtually all of the buildings constructed primarily from wood. They did not aim at building longevity by using stone or bricks. In the case of the Ise Shrine, there is a long-established ceremony for its reconstruction, once every 20 years, in identical form. Nevertheless, Japanese forests and woodlands have continued to play a role as a controllable supply source for building materials, based on reforestation techniques. In recent times, the forest areas of Japan have been on the rise every year; and the volume of reserves for such purposes has been increased.

The reserve ratio for coniferous trees is 62.4%, which is greater than that for broad-leaf trees. Although Japan caused adverse effects to the global environment by harvesting woodlands in Southeast Asia during Japan's economic boom era following World War II, this was done not because of the depletion of woodland resources in Japan but because the domestic lumber price became extremely high due to elevated personnel costs compared to those of Southeast Asia. Thus dependence on imports is not in order to preserve the forests or to protect the national parks; but rather due to equipment. What is noteworthy here is that there are 163 cases in which nature was used. For example, cooperation with nature or the utilization of natural capabilities. There are 66 cases in which special consideration was given to solar light. There are 39 cases involving wind as a consideration, such as for natural ventilation; high management costs. The lumber resources used to build homes in Japan are considered to be manageable within Japan's own forestry resources (*Reference document 5). Furthermore, there are 21 cases (among which 10 cases aim at educational effects) which pursue sustainable life styles through architectural design; and also there are 21 and 7 cases respectively seeking the natural look and the sustenance of street attractiveness.

4. Conclusion

While emphasizing the efficiency of buildings and the conservation of energy, one notes as characteristics some very Japanese "sustainable" concepts, in the buildings and the lifestyles within them, which aim at the utilization of forces of nature which cannot automatically be converted into energy sources.

In the author's opinion, one of the more practical concepts to be adopted widely in the future is that one need not simply be stuck on the idea of structure longevity, but rather perhaps that one should try to divide architecture into structural and finishing elements, and then try to utilize renewable resources for areas in which the usage cycle is short.

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RESULTS FROM FOUR YEARS SUSTAINABLE BUILDING POLICY IN THE NETHERLANDS

Harry Vreuls, Netherlands Agency for Energy and the Environment (Novem)

INTRODUCTION

In 1995 the 'Action Plan for Sustainable Building: Investing in the Future' was presented. A goal oriented and practical document, that aimed to give sustainability a stronger and, in the long-term, fixed place in the decision- making process on the layout and use of buildings and their environment. The follow-up came in 1997 with the Second Action Plan for Sustainable Building. The list of actions and projects from the first edition was, in consultation and close co-operation with all parties involved in the building process, considerably widened, with the aim of helping the development of Dubo (Dubo is the Dutch abbreviation for sustainable building) further along different tracks.

In the two Action Plans, the various Dubo projects and actions are grouped in four main tracks. The first track, Harmonisation, deals with the creation of more clarity and unity in knowledge and information, definitions, etc. in the area of sustainable building. The second one, Implementation, concentrates on the actual application of the available knowledge and information about sustainable building in practice. Consolidation, the third track, holds projects for embedding sustainable building in the daily practice of building. The track Preparation promotes the creation of new insights, knowledge and innovations.

The plans were monitored and the results were presented in the Monitoring Sustainable Building 1995-1999 report. The most important findings are briefly summarised in this paper. We start with the results for each track. Then the state of affairs of sustainable building in the market is presented, with emphasis on investments and the opinions of actors. The expected environmental effects of the sustainable building policy related to energy, water use and building materials are the last items of this paper before presenting the general conclusions.

RESULTS FROM PROJECTS WITHIN THE TRACK HARMONISATION

This track had two major projects: National Packages for all sectors and a National Dubo Centre as a national knowledge and information point.

The two National Packages for residential building (new building and renovation and maintenance) have been available since 1995 and 1998 and, in the meantime especially councils and building corporations have acquired the packages and use them. The package for utility building came out at the end of 1998 and applies both to new building and renovation and maintenance. This package is used for more than half of the recent utility building projects. The package for urban development (primarily aimed at informing and stimulating the user) was introduced in June 1999. The National Package on civil engineering completed in the autumn of 1999 the series.

The National Dubo Centre was set up at the end of 1996 in order to spread knowledge and information about sustainable building amongst building professionals. Since then, numerous activities have unfolded. Half of construction professionals, with the exception of installers and contractors, make use of the information desk From March 1999 the field of activity was widened with an information desk for civil engineering. In various areas regional Dubo information points are also active.

RESULTS FROM PROJECTS WITHIN THE TRACK IMPLEMENTATION

In residential building, where the stimuli were already applied on a large-scale in the first Action Plan, the growing application of sustainable building in practice is already visible; in the other sectors it is primarily the instruments and examples that have made a leap forward. In 1998 32% of building permits for houses fully, and 29% partially satisfied the Dubo measuring stick. The average investment in Dubo measures per dwelling amply exceeded the levels set by the measuring stick and the application of the variable measures is also higher. The development of sustainable

building in the existing housing stock has received a strong stimulus through a covenant with the social sector and the Temporary Stimulating Measure on Sustainable Building. Around 56,000 existing dwellings have been renovated with an average contribution of about 2,000 guilders per dwelling. Furthermore, a start has been made with the integration of sustainable building in the measure Investment Budget for Urban Regeneration.
The application of sustainable building in utility building was especially stimulated with the introduction of the Sustainable Utility Building Register. Here, central government, acting as a principle, sets an important example for sustainable building. Dubo activities in this sector until now have mostly taken place in the new building sector.
Preparations for sustainable urban development are in full swing especially with the instruments Energy Performance on Location and the Stimulating Intensive Use of Space programme. The actual application of sustainable building here is really only beginning.
The Ministry of Waterways and Public Works sets an example in the civil engineering sector. Within this sector the principals of sustainable building have already been applied many times, without always labelling this as sustainable building.

RESULTS FROM PROJECTS WITHIN THE TRACK CONSOLIDATION

In order to bring the stragglers along, sustainable building is integrated in increasingly more legal frameworks. In addition, a number of fiscal instruments primarily intended to stimulate the leaders, have been developed. With the addition of the fifth pillar "Environment" to the Housing Law in 1998 the translation from Dubo measure to the Building Regulation was set in motion. A number of aspects have been taken up since 1995. One is to sharpen the Energy Performance Coefficient (EPC) for residential and utility buildings, from the 1st of January 1998 and 2000.
Since 1996 the fiscal measure Green Investment has been opened for sustainable residential new building and from1999 for sustainable housing renovations as well. Full use is not yet made of this measure, but 1999 has seen a large increase in the number of applicants.

RESULTS FROM PROJECTS WITHIN THE TRACK PREPARATION

Within this track two major projects are related to putting sustainable building on the education and research agenda for the coming period. Integrating Dubo in education contributes to the continuity and further development and thereby the future of sustainable building. Since April1999 the 'Basic Document for Knowledge and Skills in Sustainable Building in Vocational Training" exists. The advanced and medium levels of vocational training (VBO and MBO) can get working with this basic document; for the higher level of vocational training (HBO) the basic document has been prepared. The environmental measures instrument and the environmental care systems are extended and further developed. Through this, they acquire more scope and reliability.
The Demonstration Projects Sustainable and Energy Efficient Building have given the building professionals an insight into what is possible in practice with sustainable building. This approach is continued with the Industrial Flexible and Demountable Building (IFD) project and in the Stimulating Intensive Use of Space (STIR) programme.
The research agenda makes up part of the "Building to Factor 20' programme. The central question is what research agenda is necessary for the short medium and long-term? Here it is assumed that the importance of knowledge about sustainable building will increase but that the shelf life of the knowledge will diminish. The exchange of knowledge about sustainable building and the achievement of more unity will be built up through international contacts and consultation.

STATE OF AFFAIRS OF SUSTAINABLE BUILDING IN THE MARKET

The market is taking up sustainable building well. In most of the cases many "fixed' Dubo measures are planned and applied, but not all. Moreover, extra investments are made in 'variable' Dubo measures. Also in utility building a lot is already being done for sustainability. The pursuit of supplementary price reduction through standardisation and wider application has been partly

achieved. After a hesitant start in 1995 and 1996, the average intended investment in Dubo measures for new residential building has risen in 1998 to an average investment of circa 11,000 guilders. The investment in Dubo measures was less than 2,500 guilders in only a very small number of the building permits issued in 1998. The extra investments mainly are attributable to a few "expensive' variable Dubo measures that are usually linked to improving comfort or reducing energy or water use. It appears that since 1995 the supplementary costs of Dubo measures connected with energy saving, water saving and noise insulation has fallen. This concerns fifty Dubo measures in total. In the period 1995-1997, the prices of newly developed products have also fallen sharply.
All the parties in the building process show evidence of their readiness to build sustainably, but are still reserved in their Dubo ambitions in the development of building projects. About three-quarters of project developers and nine out of ten housing corporations claim to take Dubo into account as standard. In the utility building sector and the existing housing stock it is clearly less the case. Amongst architects, the interest in sustainable building seems to be stabilising. Contractors seem to be more aware of the extent of the concept sustainable building, but the number of contractors who claim to have experience in this field is not increasing. Installers still have little knowledge of sustainable building and don't see for themselves a big role to play in this area.Councils fulfil an important stimulating role in achieving Dubo in practice and covenants seem to be an important aid: only in one fifth of the councils there is (yet) a Dubo covenant. In general the government does not, on a large scale, check on the implementation of Dubo measures.
Almost half of the potential buyers of new housing in 1998 were aware of the concept of sustainable building. About one in two buyers were also prepared to pay more for Dubo. This is really strongly related to the possibility of recuperating the investment. Most buyers are prepared to pay 10.000 guilders extra. The interest of tenants did not seem relatively much lower than that of buyers. Little is known yet about the use of Dubo housing. There are however indications that residents value Dubo measures in various ways.

EXPECTED ENVIRONMENTAL EFFECTS

A prognosis shows that the energy use linked to construction for an average dwelling in 2020 will be a quarter less than in 1995. Through the volume effect (increase in the number of dwellings) the total energy saving (of the part linked to construction) will actually be lower. In utility building, as well, a falling energy use per unit of floor surface area is expected, there being differences between the examined sectors. Through the strong growth in the number of square metres of utility building, the total (linked to construction) use of energy will actually stay practically constant. In 2020 water savings of 10 percent are expected in residential building. The greatest savings are expected in the existing stock. Nevertheless the water usage in total is still higher than in 1980. In the utility sector it is expected that primarily new building, through rain water systems, contribute to the saving of drinking water. The contribution of building materials gives various impressions: a small (3%) reduction in the gravel use, a sharp reduction (50%) in VOS emissions, a saving of between 3% and 27% in the emissions of copper, zinc and lead (into water) and more use of renewable raw materials (sustainably produced wood).

GENERAL CONCLUSIONS

The general conclusion from the Monitoring Sustainable Building 1995-1999 report is that, in the second half of the 90's, sustainable building has received a large stimulus from the two Action Plans. Knowledge about sustainable building has been brought together and made available for all sectors of the building industry. Many parties have become involved in sustainable building through numerous projects and the development of instruments. In short, sustainable building is on track and a good basis has been laid for the next step: embedding it in management and practice.
So the ongoing Programme 2000-2004 concentrates on embedding Sustainable Building in policy as well as in practice.

WHAT ABOUT DEMAND? DO INVESTORS WANT GREEN BUILDINGS?

Miles Keeping
C.I.B. Research Fellow, Oxford Centre for Sustainable Development, Oxford Brookes University, Oxford, U.K.

INTRODUCTION

This paper considers the desperate need for clear indicators of sustainable construction if it is to be promoted by investors in real estate. There is continuing discussion as to what the indicators should encompass. They will, obviously, have to include environmental and social capital as well as economic value. In terms of monitoring the use of environmental capital, benchmarks might include the extent to which non-renewable resources have been used (or avoided) and waste products generated. Social accounting includes the extent to which the consequences of pollution arising from production have been suffered by different social groups and the degree to which society has been involved in the decision-making that affects its well being. As far as recording economic aspects, it could be argued that the inter-play between social and economic issues is inextricably linked – where wealth creation fosters "*social integration and cohesion*" (Forum for the Future, 1996). These concepts challenge the liberal economic hegemony and suggest that a sustainable economy will be quite different from today's. Whether the reform of the economy be 'radical' or 'achievable' is not relevant to the central discussion in this paper. However, it is interesting to note that in the UK, the DETR's (1999) strategy for sustainable development has incorporated the principles of reform. This is not a radical shift, but another gentle move by the UK's government along the road towards a 'weak form' of sustainability.

PRESENTATION

Interpreting "sustainability" in the world of real estate

A danger exists in the misinterpretation of "sustainability". Environmental issues are perhaps relevant to a third of the concept of sustainability; the former is a sub-set of the latter. A reason for noting this is that there are many examples (e.g. Anon, 1994; PAG, 1998) in the relevant literature of confusion as to the difference between sustainable development and environmental stewardship. Other examples sometimes tend to limit the concept of sustainability to predominately environmental themes. Parnell & Sayce (1999) refer to the Brundtland definition of sustainable development (World Commission on Environment and Development, 1987) and state that as far as property is concerned, this suggests issues pertaining to a building's siting, materials, energy efficiency and efficient resource use. The survey results contained within this work (Parnell & Sayce, 1999) are useful in helping us to understand the views of property professionals towards 'green' buildings, but do not help us to learn about their attitudes to sustainability or definition(s) of sustainable construction. Misinterpretation of sustainable development and limitation of its scope have been found to be common in property investment circles.

The extent to which this matters is subject to some debate. Whilst some might argue that the promotion of 'green' buildings is of high importance (see Kibert (1994) amongst many), others suggest that their promotion will be of little overall impact in terms of sustainability. Amongst many, Cooper (1999) puts forward the view that 'green' buildings will not: "*… make a substantive contribution to sustainability. Unless their (global) environmental impact has been reduced dramatically – perhaps by a factor of ten as measured against current consumption and pollution norms in 'developed' OECD countries, then they are unlikely to represent an adequate response to the doubling of the world population anticipated during their lifetime (by 2030-2040).*"

Central to the problem faced by investors, developers, governments, sustainability lobby groups and academic researchers is that assessments of buildings are bound by their nature to be prescriptive – they will have to have limits to the number of assessment criteria. It needs to be asked, therefore, whether we can develop a single method of sustainability assessment that will satisfy the interests of all stakeholders and whether this is by any means feasible? Many commentators (such as Kibert, 1994) think not and that the maintenance or development of individual methods of assessment, which can be used successively and to measure different aspects of sustainability, will be more beneficial.

A number of commentators have proposed assessment criteria and these are examined below. The variety in depth & breadth of the different criteria are interesting and, it is argued, problematic as far as the furtherance of sustainable development is concerned. Consider this UK example:

Table 1. What is sustainable construction? (adapted from DETR, 2000)
1. Investment in people & equipment for a competitive industry
2. Achieving high growth while reducing pollution & resource use
3. Sharing the benefits of growth widely & fairly
4. Improving towns and cities & protecting countryside's quality
5. Contributing to sustainable development internationally
6. Being more profitable and competitive
7. Delivering buildings that provide greater satisfaction, well-being and value to customers & users
8. Respecting & treating stakeholders fairly
9. Enhancing and better protecting the natural environment
10. Minimising energy consumption and natural resources

Investors' demand

Preliminary research by this author suggests that demand by institutional investors in the UK for sustainable property is so low as to be negligible. When approached, most investors acknowledged their ignorance of the meaning of the term 'sustainable' and preferred to address the concept of 'green' buildings. It is clear that investors cannot agree on a definition of sustainable construction. Most were happy to give a hybrid version of the Brundtland definition but admitted that this was not understood in the real estate construction or investment context. Little or no link was seen between the UK government's criteria in Table 1 above (particularly items 1, 3 & 5) and real estate investment – i.e. there is a lack of holistic thinking or consideration of a life-cycle approach to investment decision-making. Essentially, investors state that they still see procurement as a cost-based exercise and that they need to see clear occupier demand for sustainable construction before they will fund its construction. This finding is supported by the Sustainable Construction Focus Group (2000).

CONCLUSIONS & RECOMMENDATIONS

It is clear from the research undertaken, both secondary and primary, that while there is relatively widespread and considerable interest in the topic of sustainability and sustainable construction, there is also a great deal of confusion over the terms that are used. Many confuse the term sustainable development with environmental protection and many limit the scope of sustainability to consideration only of environmental issues. Within the property context, this is manifested in the apparent interchangeability of the terms 'sustainable buildings' and ''green' buildings', reasons for which have been considered above. Largely, confusion about and limitation of the term comes from a lack of understanding of the relevant issues which is hardly surprising given the complexity of the issues that are relevant. It is easier for investors and occupiers to grasp the nettle of 'green' buildings than sustainable ones and this is what often seems to happen. It could be contended that until such a time as workable definitions are available, little progress is likely to be made in this sphere. However, such a contention could be questioned given the advances that have been made in other countries, notably the USA, in this area. It is suggested that a transfer of relevant knowledge from the USA to the UK would be of considerable benefit to the UK property market in this respect.

Operators within property markets, often noted for their preference for the status quo, should note the changes that are taking place towards a more sustainable form of economy. All around us we see evidence of this, not least as the result of a push in this direction, however mild at present, by the Government. It must be accepted that the change in the nature of the market represents a new form of uncertainty and risk for investors. They will need new methods of investment analysis and risk assessment to adapt to a new market paradigm, just as they have done in the past to adapt to new forms of property investment (e.g. changing lease structures and changing preferences for locations and types of retailing). More fundamentally, however, it is clear that there is a desperate need for education about sustainable development and construction as well as useful indicators of these. If the "vicious circle of blame" is to be broken, as it must be if sustainable construction is to be delivered, these must be provided. It is suggested that more demonstration projects will help in this respect.

Investors need not see these changes only as threats. As was noted earlier, the technological case for 'green' buildings has been made, whereas once this would have been thought of as impossible, and evidence for the business case for them is beginning to look more widely reliable. As with all risks, those that take them will win and lose but, as this writer believes, the long-term opportunity in the market for sustainable buildings is likely to be more fruitful than that for unsustainable buildings.

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Driving Market Demand for Green Buildings in Pittsburgh

Rebecca L. Flora, AICP, Executive Director
Megan Moser, Ph.D., Director of Education & Research
Green Building Alliance, www.gbapgh.org
Pittsburgh, PA, United States

INTRODUCTION

The Green Building Alliance (GBA) is a non-profit educator and facilitator, that aligns with key partners to create a market demand for green building in the tri-state region of Pennsylvania, Ohio and West Virginia with a base in Pittsburgh, Pennsylvania. GBA's strategic approach to driving market demand is focused on educating progressive thinking decision makers within the commercial sector. GBA has determined that the successful implementation of green building depends on buy in from this top level sector of the market. A clear message that is backed up with factual data and case studies is critical to the buy in process. GBA's study of market perceptions and needs has been invaluable in the creation of this regional education initiative.

MARKETING GREEN BUILDING

Green building – what is it? Why is it important? Who's doing it? How to get started? These are all questions that are frequently asked by the demand side of the market when first presented with the term green building. Despite what we "green" people would like to believe, most decision makers have never heard of green building, don't understand how to manage a green project to ensure optimization of their building, and have no means of establishing value for the end product. At the other end of the spectrum, are projects that are promoted for all their green features with little actual data to back up the performance. If green building is to survive and become mainstream it must be communicated to the demand side of the market in a consistent and accurate manner. Good projects must be quantitatively evaluated for performance and poor performing projects must not be held up as examples. GBA utilizes its objective, professional staff to sort through the complexities and jargon of green building to provide decision makers with the accurate and appropriate information they need to consider and effectively implement a green project.

Market Realities

GBA has worked to make a direct connection between green building and successful economic development. To accomplish this GBA first undertook several means of data collection to understand the market's understanding or perception of green building. Through the use of personal interviews and group discussions[i], and later a market analysis that utilized focus groups[ii], GBA identified several market perspectives and underlying key issues that have influenced GBA's market education efforts. While this learning process is ongoing, it was determined that green building was perceived by uninformed decision makers in the financial, real estate, development, human resource and facility management sectors to:

- cost more
- be technologically experimental and therefore financially risky
- focus only on energy conservation
- be applicable to only new construction
- look weird and not fit standard office user needs
- be anti-development

GBA also examined the market supply side's (design and construction professionals) perspective of green building. Response was varied but typically could be summarized as: ***the client wasn't asking for green building.*** It was later concluded through interviews and roundtable discussions that most often:

- the team members were uninformed and it was not cost effective to change practices
- the project team members didn't educate the client about green options
- the client didn't want to pay for modeling or commissioning costs to optimize the building
- the schedule didn't allow for an integrated team process in design
- financial markets and government regulations do not encourage green standards

Market Drivers
It is clearly not easy to be green, it requires a change in behavior and the development process. The activites summarized above provided information and an understanding of the issues that have informed GBA's response to the market realities and our approach to driving market demand for green buildings.

First, ***GBA defined its target audience to be progressive-thinking business owners or key decisionmakers.*** It was clear that all sectors of the market could not be reached at once. The sectors that would most readily learn and adopt green building practices, and serve as highly visible spokespersons were targeted. These leaders could then serve to drive other sectors of the market.

Second, ***create a professional image for the organization.*** GBA organization, its staff, offices and materials had to appeal to the target audience. Our image had to be credible to dispel market perceptions of green building advocates as being the "anti-development environmentalists". GBA's executive director was well established in the region as an economic development professional with an extensive network and was not seen as an entrenched environmentalist. The entire GBA staff maintains a high level of professionalism, balancing practical and academic perspectives.

Third, ***form alliances with credible partners.*** No program can succeed in a vacuum; it requires the work and support of many. GBA was fortunate to have several partners beginning with the financial support of Heinz Endowments that funded the organizational start-up. Other partners have included professional organizations, other non-profits, universities, and government. Partners are key to credibility and the ability to reach new audiences.

Fourth, ***establish a consistent and constant message to an expanding audience.*** Confusion and misperception require clear and consistent messages that serve to inform and educate. A critical component is the constant expansion of the audience to avoid a continual "preaching to the choir". Instead, the "choir" of those already knowledgeable can provide a link to organizations and audiences that are not informed about green building. GBA uses printed and electronic materials to reach an expanding and diverse constituency.

Fifth, ***create appropriate programs and evaluate progress.*** GBA did not establish programs until 1 ½ years following its initial start-up. It used this time to understand the market, determine what was the market need, and how to best deliver its message. During the second 1 ½ years, GBA has formalized its programs that include:

- **Education:** sales presentations and materials, professional training workshops, peer exchange forums, university collaborations
- **Resource Center:** web site, newsletter, green library, and research
- **Green Team Builders:** convene and educate project teams, establish green goals for projects, facilitates project implementation, documents results and lessons learned.

Sixth, ***assist highly visible projects with greening, and use them local examples.*** GBA approaches highly visible project decision makers with an aggressive sales pitch on greening their project. GBA provides a range of team education, goal setting and facilitation assistance to several key projects in the region. GBA also matches projects with technical assistance providers and funding to support their greening needs.

Indicators of Success
GBA has several reasons to believe our strategy is working, thanks to the help of its many partners. A few indicators include:

- approximately 2.75 million square foot of green projects are complete or underway in our market area
- GBA workshops draw about 100 attendees, and receive high scores on workshop evaluations
- doubling the number of local design firms that have designated a staff architect to increase the number and quality of green projects for the firm
- 3 of the 12 projects to receive ratings from the LEED™ pilot were in Pennsylvania. (GBA introduced LEED™ to the region in 1998 and sponsored a full day LEED™ workshop in 1999.)

These are just a few examples, more detail is provided on the GBA web site.[iii]

LESSON LEARNED
The ultimate long-term success will depend on the results of improved building operation and the impact on corporate bottom line. Clearly, the client must know what to ask for and how to get it, and the project team must know how to effectively deliver the product. Education must occur on both the demand and supply side. GBA has proven its effectiveness in getting a client in the door and willing to try green practices. Project teams are then trusted to properly deliver the goods and work to avoid bad experiences and results. Based on its market research and direct project assistance, GBA recommends the following components as essential to success of green projects:

- upfront project planning and goal setting
- integrated design approach adopted by all team members
- establish a green champion that reports to the owner
- actively and honestly use a building rating system such as the U.S.GBC LEED™
- utilize computer modeling as a design tool
- include third party commissioning during the design stage

Each of these recommendations has its difficulties. Unfortunately, clients do not want to pay for modeling or commissioning. Design professionals do not want to admit where the project may have fell short of expectations and work to further optimize. The green champion is often overlooked or is placed within the design team and not provided with owner authority. Integrated planning and design are still foreign concepts to most project teams - this is where efficiencies are most likely to be lost if not properly executed. Finally, project schedules seldom allow for proper project planning and implementation.

In addition to the above project team issues, the financial community does not recognize green building. There is a need to educate lenders, appraisers, realtors, insurance industry and chief financial officers on the added value of green building. GBA has included these audiences in its education program, on its board of directors, and in its project education process. Information must be synthesized and disseminated to these audiences if green building is to move from a trendy topic to standard practice, thereby negating the need for the term at all.

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Integrated Design Toward Sustainable Development in a Large Firm

CH2MHILL
Tom Genne, AIA., 2300 NW Walnut Blvd., Corvallis, OR 97330
Skip Fresn, R.A., 2300 NW Walnut Blvd., Corvallis, OR 97330
Hazel Reeves, IIDA and ASID, 2300 NW Walnut Blvd., Corvallis, OR 97330

Sustainable development is critical to the future of our world and is a whole new way of thinking. The goal for all design work is that it be socially, environmentally, and economically sustainable (see Figure 1). Through effort and persistence we can achieve a balance in sustainable development.

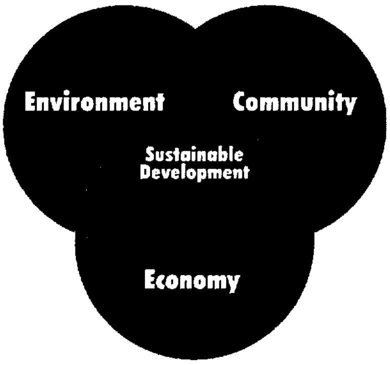

Figure 1
Components of Sustainable Development

Design professionals can no longer apply traditional linear thinking in the design of sustainably-oriented projects. We need to evolve a new way of approaching sustainable development that is more balanced and holistic. This paper addresses the required changes in developing an integrated team and presents ideas for finding the appropriate balance for integrated design with the following topics:

- Integrated Teams
- Appropriate Balance
- Design Process

INTEGRATED TEAMS

In order to design sustainably, it is essential to have truly integrated teams. Yesterday's concept of the master builder is just not workable when requirements are more complicated and sophisticated. Effective teams are larger and more diverse than traditional project teams and require balance and a holistic structure.

A successful integrated design team is a smooth-functioning organism. The linear design approach of one discipline leading other technical disciplines is contrary to integrated design. At CH2M HILL, we promote an integrated design process that encourages the participation of all design areas. To be effective, an integrated team must follow three basic principles.

Include all stakeholders involved in the design and function of the building. This can include the landscape architect, interior designer, building occupants, maintenance and facility crews as well as those who will construct, finance, regulate, or be involved in permitting the building. All are part of the initial chartering process in which everyone agrees to overall project goals and commits to the successful completion of a more sustainable building.

Get the right team members. The persons involved in this process must be open to integrated design and communicate well with other team members. One reluctant stakeholder can impede the chartering process. The design team must be willing to "think out of the box" to solve project challenges. Ideas deserve to be evaluated for social equity, impact to the environment, and

Life Cycle Assessment (LCA vs. life-cycle cost).

The team must respect one another. Respect for everyone's role and contribution to the team is the road to holistic and integrated solutions. Relationships create team synergy.

APPROPRIATE BALANCE

An integrated team does not just balance the social, economic and environmental aspects of the project, it also balances various technical needs. A common image for balance is to have equal parts on both sides of a scale. However, the image that best applies to integrated design projects is that of 25 or more people standing on a large disc that is supported on a fulcrum (see Figure 2). Each time one person moves, several other people have to readjust to maintain balance. When issues arise, balance can be maintained by several team members making adjustments. Much of the success of finding balance for sustainable development issues will be in the fine tuning of each element. This will be like a rheostat, not a toggle switch. The team is not limited to deciding if something should be done but can determine how much or how little of it to do.

Figure 2
Balancing An Integrated Design Team

THE DESIGN PROCESS

At CH2M HILL, we are beginning to apply the process shown in Figure 3 for integrated design. Recently, we have incorporated the concept of an integrated team into some existing design systems. The steps in this design process are discussed below.

Charter the team. This critical step begins by gathering all the stakeholders together and establishing the vision, mission, and goals for the specific project. It is important to discuss the unique features of the project and to establish budgets and schedules. This common understanding is essential to the success of any project.

Do a "fatal flaw" analysis. This review identifies any reason(s) the project cannot be successful. Certain site conditions, unworkable budgets, or flawed economic analysis can all be fatal flaws. Planning or zoning limitations, special interest groups opposed to the development, environmental regulations, or other political considerations can also stop a project.

Benchmark other similar sustainable projects and determine the highest standard reached to date. The state of the art of sustainable design is changing rapidly. With information from the design team, the owner can determine if the standard should be raised another step toward sustainability. It is critical to review and potentially revise the goals of the project at this time in relation to the results of the benchmark study.

Study recent technological developments and assess their potential application. The incorporation of new technological developments allows the team to "raise the bar" and move even closer to sustainability.

Develop the concept design. The concept design is the result of incorporating new technologies and approaches to achieve a new level in sustainability. Once it is developed, the concept design must be reviewed to ensure the vision, mission and goals, and other project criteria are satisfied. The effects of any changes must be understood and endorsed by the team. Continuous team reviews of the design resolve issues in a holistic manner. A project that is well-conceived can fail in this development process if seemingly insignificant changes are made that create a significant impact on the outcome.

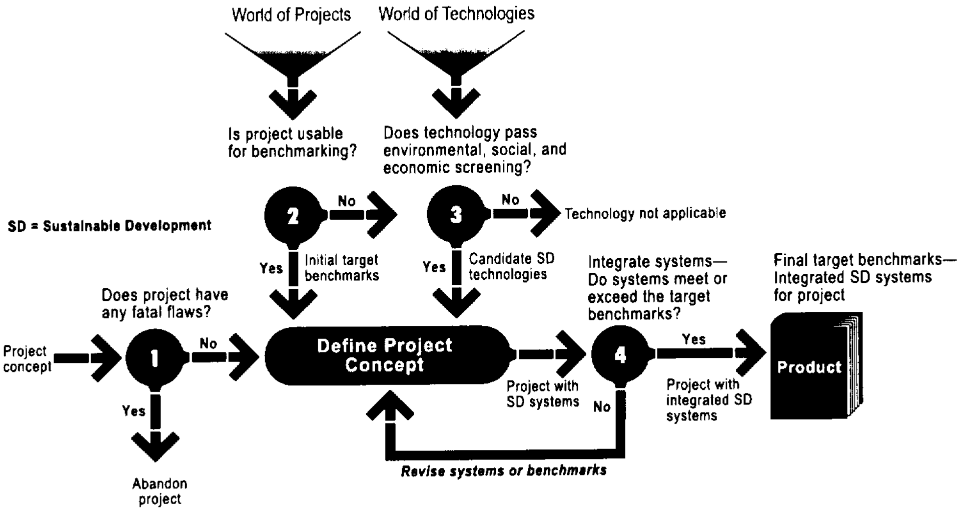

Figure 3
Integrated Design Process Flow Chart

CONCLUSIONS AND RECOMMENDATIONS

We have been dealing with elements of sustainability over the years, but now we must become holistic and balanced in our approach. Critical elements in this process include:

- Create teams that are holistic and share mutual respect
- Charter the project
- Define the process
- Think "out of the box"

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CREDITS

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POLICIES AND STRATEGIES TO ENHANCE SOCIAL BENEFITS DUE TO PRIVATE REHABILITATION OF BUILDINGS

Ivan M. Johnstone
Department of Property, The University of Auckland
Level, 28 Symonds Street, Auckland, New Zealand

INTRODUCTION

Rehabilitation extends the service life of buildings and, in doing so, reduces the replacement rate of the building stock below that which would be required otherwise to sustain a flow of building services. For example, in a recent paper (Johnstone, 2000) I estimate that past and current levels of rehabilitation of New Zealand housing stock have reduced the national annual costs to sustain dwelling services by as much as 30%. Current costs could decrease by a further 9% should additional cycles of rehabilitation extend the service life span of the housing stock from 140 years to 240 years. Social benefits due to undertaking rehabilitation include not only an increase in the consumer surplus, but also a reduction in pollution from manufacturing and construction processes, a reduction in waste from demolition, and a reduction in CO_2 contributions to the atmosphere from activities by the manufacturing and construction industry. This paper outlines a sample of policies and strategies to enable and encourage the undertaking of private rehabilitation.

POLICIES AND STRATEGIES

Buildings codes and the service life of structural systems

The durability of the structural system used by a building ultimately limits the service life of that building and hence the potential for undertaking additional cycles of rehabilitation. The New Zealand building code requires items that contribute to structural stability to have a service life of 50 years. This service life falls well short of the 140 year service life span of the housing stock. Prediction of the long run durability of building components based on accelerated aging is fraught with difficulties. The most reliable predictor of durability is a successful history of performance. Lightweight timber framing, concrete, brick and stone structural systems have already demonstrated an ability to match and exceed a service life of 140 years whereas recent structural systems such as galvanised steel framing and reconstituted wood-fibre sheeting have yet to do so. Building codes should set the service life of structural systems to be no less than that of the current service life span of the building stock otherwise current and future generations will inherit not only the burden of increased costs to sustain services but also increases in pollution, waste products, and CO_2 contributions to the atmosphere.

Tax on unproven structural systems

Innovative structural systems should be encouraged, but until these systems have proven their durability there is the ever-attendant risk of additional social costs in the future. A tax on unproven structural systems would underwrite this risk. Without such a tax, manufacturers of unproven structural systems avoid the costs of underwriting social risk and effectively receive a subsidy instead.

Charges levied on demolition

Most building do not realise their potential service life because it is financially advantageous for the private sector to demolish and replace a building when the value of a new development on a site less the costs of construction less the developer's normal profit exceeds the value of the property in its existing use plus the costs to clear the site. Charges levied on the demolition of buildings would delay the timing of demolition and redevelopment thus extend the service life of buildings and, in the process, encourage recycling of demolition wastage to offset the costs of demolition.

Depreciation allowances based on periodic capital expenditure

In principle, economic depreciation rates of capital assets are based on customary usage and obsolescence in normal circumstances but, in practice, the rates for buildings do not necessarily reflect a true average service life. For example, the straight-line depreciation rate for New Zealand buildings with reinforced concrete framing, steel framing, or timber framing is 3%. Full depreciation occurs in the 33rd year of service life as opposed to the 90 year average service life of dwellings (Johnstone, 1994). Short-term increases or decreases in depreciation allowances for buildings are frequently used as a fiscal instrument to encourage or discourage investment in new buildings. Changes to current depreciation allowances can also encourage rehabilitation.

A renewal of the flow of services provided by buildings can be brought about not only by demolition and replacement but also by periodic cycles of rehabilitation which reverse the decline in the flow of services. Current depreciation allowances for buildings should therefore be revised to fully accommodate periodic capital expenditure. In New Zealand separate depreciation rates apply for buildings and the fit-out of buildings. A building includes the building envelope whereas a fit-out includes demountable and non load-bearing partitions and ancillary plant such as lifts and HVAC. Capital expenditure on fit-out components is subject to higher depreciation rates than that for a building. Because certain building envelopes need to be replaced a number of times over the service life of a building, capital expenditure on such replacement should be included under the category of building fit-out and be subject to a depreciation rate which reflects the service life of the component. The structural systems of buildings should then be subject to depreciation rates that better reflect the average service life of buildings than those rates currently adopted.

Lower depreciation rates are conventionally applied for longer-lived capital assets. Nonetheless, a differential depreciation rate for more durable building structures which is higher than that for less durable structures would provide an incentive to invest in more durable structures. The post-tax net revenue stream of new developments or redevelopments would be greater and any capitalisation effect would increase the value of the development. Complete depreciation of the building structure could occur long before expiry of the full service life of the building. In the long term the total annual tax revenue would be the same irrespective of the depreciation rate which is applied.

Depreciation rates could be set to be progressively greater with each successive rehabilitation cycle so as to encourage building owners to extend the life of existing buildings at the margin. Capital expenditure on structural upgrading to comply with earthquake codes could also be subject to a higher depreciation rate than that applied for the structure of the building. An exemption of General Service Tax (GST) or VAT on rehabilitation and structural upgrading would provide an additional incentive.

Tax on imputed rent

Depreciation allowances apply only when capital expenditure is incurred in the course of the production of gross income. Imputed rent of owner-occupied dwellings in New Zealand is not taxed and owner-occupiers cannot claim deductions of interest on mortgages and expenditure on repairs and maintenance. Owner-occupied dwellings in New Zealand formed over 23% of the total value of New Zealand's capital stock of buildings, infrastructure, plant, and equipment in 1989 (Philpott 1992) and a random survey of 400 New Zealand dwellings has established that deferred maintenance averaged NZ$3,200 per dwelling (Page et al. 1995), or almost three times the average costs of annual maintenance. The opportunity to apply depreciation allowance incentives to undertake rehabilitation is thus not available for a significant proportion of the total building stock and incentives to better maintain the housing stock are needed. If imputed rent from dwellings were taxed, then the incentive to over-invest in housing at the margin would be removed (Bourassa & Hendershott, 1992) and depreciation allowance incentives to undertake rehabilitation would apply to the entire building stock.

Welfare grants and subsidies to undertake rehabilitation

Until recently, the lowest income groups in New Zealand have either rented state owned dwellings at subsidised rents, purchased state owned dwelling with subsidised loans, or purchased new housing with subsidised loans. The process of filtering down has been bypassed, but should take place in the future due to recent changes in governmental policies. Assistance to low income families could take the form of grants to undertake rehabilitation.

Homeowners with limited income are more likely to defer maintenance and not undertake rehabilitation. Home improvement loans could be made available to these low-income homeowners at subsidised interest rates. The elderly could benefit the most from home improvement loans. For many, their home represents their sole store of savings. Rather than allow these houses to sink into disrepair, a loss that is ultimately a national loss, reverse mortgages for the purposes of home improvements should be made readily available to the elderly at subsidised interest rates. Reverse mortgages also fulfil the role of superannuation.

A shift from tax on improvements to tax on land

Property taxes can take the form of a combination of taxes or a single tax on land, a tax on improvements (to land), charges for provision of utilities, and a per capita tax. A tax on improvements discourages rehabilitation as a subsequent reversal in the value of improvements is subject to an additional tax. Any capitalisation effect of a tax on improvements would reduce the value of improvements and thus tend to reduce investment in buildings. On the other hand, taxes on land are capitalised in land values and are therefore neutral with respect to investment decisions (Bourassa & Hendershott, 1992). A tax on land need not be 100% and nor should be otherwise the allocative efficiency role of the price of land would cease.

CONCLUSION

A combination of the above policies and strategies will enable and encourage rehabilitation of buildings. Implementation need not reduce the total tax revenue. However, the effectiveness, efficiency, and equity of each of the above strategies need to be carefully examined before implementation and local circumstances should not be overlooked.

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FROM PRODUCT PROVIDER TO SERVICE PROVIDER
RELEVANT INDUSTRIAL CHANGE FOR SUSTAINABLE BUILDING IMPLEMENTATION

Dr. Tomonari Yashiro
Institute of Industrial Science, University of Tokyo, 4-6-1 Komaba Meguro-ku Tokyo 153-8505, JAPAN

INTRODUCTION

Conventional construction sectors have nature to get revenue by providing 'products' (= constructed building). The nature can be called as 'product supplier'. The paper presents different model of construction sectors termed as 'service provider'. Service providers get their revenue by providing services that include benefits from function, performance and psychological perception embodied with buildings. For service provider, building is a device for supplying service. It does not matter whether the devices are brand new buildings or existing buildings, if the quality of supplied services is acceptable for customer compared with price. A business model of service provider is expected to have potential to improve resource efficiency. The paper discusses need and potential of transition of construction sectors' nature from product provider to service provider, which is essential to extend effectiveness of sustainable building implementation. Then it raises seed for successful precedent model of service provider to disseminate and promote the transition from product providers to service providers in construction related economic activities

WHY SERVICE PROVIDER?

Fig.1 illustrates the difference between product provider and service provider. For product provider, outputs are buildings as products. Components made of natural resources extracted are assembled in site as a building using other resources such as budget, equipment, human resources and information. Prices of outputs are correlated with the quantity of input resources. For product provider, reduction of input natural resources often result in reduction of price. Thus,

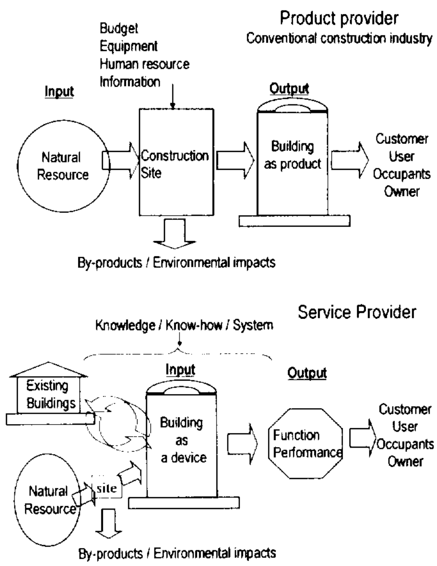

Fig.1 Product provider & Service Provider

product suppliers do not have serious motivation to reduce input natural resource. For product suppliers, efficient assembly of resources has first priority, which give incentive to cause enormous natural resource extraction and waste production by repetition of demolition and new build.
Contrarily for service provider, outputs are services embodied with built environment such as function, performance and psychological perception. Prices of outputs 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, the quantity of resource input to building is a cost for services. Thus, service providers have motivation to reduce the

quantity of input natural resource to reduce cost and to increase profit, because the most effective way to reduce the cost for service provider is the modification of existing building.

RESOURCE EFFICIENCY

Fig. 2 shows the difference in resource efficiency between a set of product providers' activities and that of service providers'. Industrial innovation undergoing in developed countries accelerate the transformation of requirements to built environment, while it is believed that construction sectors are responsible for some 40 % of material use in the globe. If construction sectors should keep the conventional business model as product provider, accelerated transformation of requirements would generate the increase of material use more than 40 %.
Contrarily, for service providers, new emergence of demand tends to promote repetitive use of buildings as devices for supplying services. Thus, increase of demand by rapid transformation of requirements does not result in the increase of the amount of new extraction of resources. Therefore, it can be expected that the transition of construction sectors from product provider to service provider cause great improvement in resource efficiency relating to built environment in global scale.

POTENTIAL NEW BUSINESS MODEL

The transition from product provider to service provider is a set of revolutionary change in technological, social and economic systems relating to construction. Though the changes are expected to be holistic, the creating of successful precedents in specific context has more realistic impacts on conventional systems than the drawing of comprehensive strategy that tend to be too conceptual. The following services seem to be worth to be investigated further as potential seeds for successful precedent models.

Leasing of building components

Contemporary buildings are composed of various off-site made components and equipments. Refurbishment of building is, in

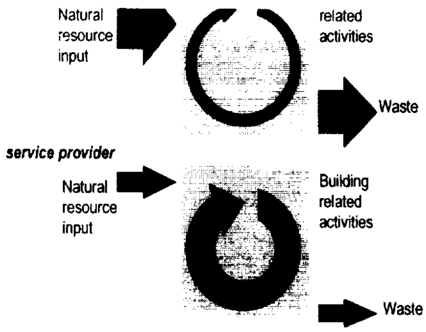

Fig.2 Resource efficiency of product provider & service provider

a sense, a set of replacing these components and equipments by new one that have shorter service life than building structures. In many cases, these components and equipments are replaced before reaching their service lives because of transformed requirements. Conventional fabricators of components and equipments are typical product providers. They only commit until handover their product and are not responsible for removal and disposal procedure, though some of their products are too complicated and hybrid for third parties to dismantle into appropriate pieces for reuse or recycling. Consequently, if more frequently refurbishments be done, more enormous waste and new natural resource input be generated. However, what would happen if off-site made hybrid components and equipments would be supplied as leased devices? Without doubt, end users can enjoy benefits; suppliers assure functions and performance for duration of leasehold, because they are responsible to maintenance and repair of components and equipments. They are also responsible for removal and disposal of components and equipments. Repetitive use of components and equipments with reasonable modification reduce the cost effectively than the disposal of used components and equipments. It gives incentive for suppliers to fabricate demountable and highly durable components and equipments. These incentives result in better resource efficiency with comfortable built environment for users by appropriately frequent replacement of components.
It is notable that leasehold is typical fee-based service providing business.

Life cycle management as continual customization

In the circumstance of decline of new build and rapid transformation of requirements to built environments in developed countries, stakeholders of buildings including owners and users have a need to get integrated services of design, construction, commissioning, operation and refurbishment of building which are tend to be fragmented. The idea of 'life cycle management service as continual customization' may emerge where single party or alliance of experts become a long term partner of stakeholders of buildings to provide continual service to maintain and upgrade the service embodied with building respecting on ever changing requirements and available resources. In continual customization, value management, monitoring and measuring of building performance, information management, life cycle assessment and open building approach should get rightful place in sequential business processes. The amount of fee paid to continual customization are correlated to the quality and quantity of services supplied, not by input resources to building as a device. Thus, continual customization business also has incentive to improve resource efficiency.

CONCLUDING COMMENTS

Sustainable building implementation has limited effect in case construction sectors should keep conventional business model as product provider. The transition to service providers extend the possibility of sustainable building implementation, not only by improvement of resource efficiency but also by paradigms shift of whole industry. Under the new paradigms, various new services will be created that magnify and integrate the benefit of sustainable building implementation. For realizing the transition from product provider to service provider, good and/or best practice approach is essential than theoretical approach. Challenge to cerate successful precedents should be encouraged. Lessons and empirical knowledge from challenges need to be exchanged in global scale.

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THE IMPACT OF FACILITIES/MAINTENANCE MANAGEMENT ON THE LONG TERM SUSTAINABILITY OF THE BUILT ENVIRONMENT: performance indicators at post-construction stage (operation + maintenance phases) of building life cycle

------------ CC GIL, AIA, RIBA.
Sustainable Buildings Research Group, School of Land & Construction Management
University of Greenwich, Dartford Campus, Oakfield lane, DA1 2SZ, UK

It is a well known fact that most of the important decisions affecting the environmental impact of a building are taken at the earliest stages in building conception, and design; and throughout construction. But it is the decisions of the facilities/maintenance manager that will affect the building in-use performance, and eventual long-term sustainability. This paper introduces the broad themes of sustainable development; sustainable construction, sustainable buildings and sustainable design before going further to discuss generally the environmental impact of buildings. Its main focus is on widely recognized benchmarks/performance indicators that facilities/maintenance organizations use to measure or assess the impact of buildings on their environment at the post-construction phase (operation and maintenance) of the building life cycle.

In 1987 the World Commission on Environment and Development (WCED) (1) introduced the idea of sustainable development, *"which states that the needs of the present are met without compromising the ability of future generations to meet their needs"*. The broad theme of sustainability/sustainable development, has over the past decade become a key goal of public policy. This gathering impetus for the quest for sustainability is because it would appear that our survival depends on it. The long-term welfare of the planet and particularly its human inhabitants is now by common consent, threatened by a range of factors, most of which are of human origin. Rising concerns as varied as extinction of species, and scarcity of tropical hardwood, the increasing emissions of Co_2 and all the green house gases, the effect of global warming and the inevitability of climate change are a present day reality. In 1992, nearly 180 countries met at the Earth Summit in Rio de Janeiro, Brazil, to discuss how to achieve sustainable development. They agreed a plan of action, *Agenda 21* (2) and recommended that all countries should produce a national sustainable development strategy. The UK was one of the first countries to publish its strategy for sustainable development early in 1994. But their national government and other tiers of government can not carry out sustainable development alone. At best they should lead the way.

Sustainable development needs to involve every one including civilized society, voluntary organizations and all sectors of construction industry. Sustainable construction is viewed as a way for the building industry to respond to the implications of sustainable development. In 1994 the first ever *CIB International conference on sustainable construction* (4) held in Tampa introduced the following definition of sustainable construction *"the creation and responsible management maintenance of a healthy built environment based on resource efficient and ecological principles (5).* The goal of sustainable construction is to build more efficiently and profitably after adapting responsibly to widespread concerns about waste, pollution, nuisance, quality and user satisfaction. The logical result of sustainable construction is sustainable buildings. Sustainable buildings have been defined as *"buildings which use lightly the earth's resources, and which are expressive also of a way of living that thinks in terms of partnership with nature"*(6). An all embracing opinion is that a sustainable building is a building which (a) consumes a minimum amount of energy/water over its life span (b) makes efficient use of environmentally-friendly, renewable or low-embodied energy materials e.g. clay, stone, etc. (c) generates a minimum amount of waste and pollution throughout its whole life span. (d) uses a minimum amount of land (whether brown or green field) and integrates well with the natural environment. (e) utilizes local recyclable and re-useable materials; avoiding use of composite materials since they can rarely be recycled, because they cannot be separated at the end of the life cycle. (f) meets its users needs now and in future

The bedrock of a sustainable building is a sustainable design. The International Union of Architects (UIA) included in their declaration issued at the UIA World Congress held in Chicago in 1993". *Architects must rediscover what it means to create buildings that have less of an impact on the environment... sustainable designs can significantly reduce adverse human impacts on the natural environment while simultaneously improving quality of life and economic well being"* (7). Sustainable building design starts with the design team. Very serious considerations affecting the environmental impact of a building are taken at the earliest stages in building conception and design. It is also worth noting that sustainable design using daylight and natural ventilation will usually cost less in building energy operating costs, avoid "sick "building syndrome and achieve greater productivity from the people using the building. It is a well-known fact that the built environment affects the natural environment in many ways and because of this will play a major role in achieving a sustainable society. Rodger writing in the UIA newsletter (8) has pointed out *"that the built environment is the principal cause of climatic change"*. It is essential for every one to recognize the contribution of buildings in the quality of our lives, and the extent of our responsibilities in creating a sustainable built environment. There are several benchmarks that facilities/maintenance managers use to assess the impact of buildings on their environment but this paper will concentrate on four key performance indicators (KPIs), namely: (A) energy efficiency and reduction on emissions to the environment (C) creation of less waste (D) improved user comfort and productivity (E) return on investment.

A. Energy efficiency and reduction on emissions to the environment: The focus of all ecologically sound buildings is to reduce the amount of energy used in running buildings. *"This was the approach in the creation of the International Netherlands Group (ING) bank in Amsterdam, which eventually became the second largest bank in the country and one of the most remarkable buildings in the world. It took longer and cost more to design, but less to build. It is largely passively heated, cooled and ventilated. Every room has natural ventilation and the building is so quiet that an acoustic mask has to be designed in"* (9) The building uses less than a tenth the energy of its predecessor and a fifth that of a nearby contemporary bank. The annual energy savings are approximately $2.9 million (1996 US dollars) derived from features that added roughly $700,000 to the construction cost of the building- and were paid back in three months. West et al (10) have determined in the UK that approximately 50% of CO_2 emissions are directly as a result of energy use in buildings and the embodied energy of building materials contributes a further 8% per annum. This is an indication that buildings in their construction and operation dominates our consumption of fossil fuels, and is the principal contributor to the release of CO_2 and other green house gases, and therefore in large measure the cause of atmospheric or climatic change. There is a move towards reduction of CO_2 emissions, the primary greenhouse gas, SO_2 and NO_2 which cause acidic rain by use of renewable energy sources. These include Gas and Solar water heating, wind/hydro-power generation, photovoltaics, and geo-thermal heat exchange systems. Solar energy use is quite popular with completion of such Landmark projects as "the Oxford Solar House" by Dr. Susan Roaf at Oxford. UK.

B. Creation of less waste: *A Better Quality of Life* states among others that the government wishes to agree targets wit h the construction industry for waste minimization, using recycled materials and whole life costing. There is need for housing which, in its operation and maintenance, uses fewer resources, and creates less waste. Better management of resources and associated reduction in waste generation, immediately reduces costs and margins. Meanwhile landfills in many areas are rapidly filling up and solid waste is becoming a real concern. The volume of solid waste generated by a sustainable building can be substantially reduced through source reduction, recycling and composting. Remember that users may pay for waste removal over the building's life. If, on the other hand, it is possible to reduce, re-use, and recycle, then the users of the building may also profit from lowered removal fees and the selling of recycled materials.

C. Improved user comfort and productivity: Improving the lighting, heating, and cooling – measures usually undertaken for energy savings- can make workers more comfortable and productive. A study by Rocky Mountain Institute documents productivity gains of 6 to 16% including decreased absenteeism and improved quality of work have been reported as resulting from energy-efficient designs. Often the gains in productivity are an unexpected bonus. *At the US Post Office mail-processing center in Reno, Nevada, a $300, 000 retrofit was carried out to improve energy efficiency. Calculated energy and maintenance savings came to about $50,000 a year – a calculated six-year payback. But it turned out that the improvements in employee productivity dwarfed savings. With the new energy-efficient lighting, postal worker's output at the mail-sorting machines increased by 6%, while sorting errors dropped to 1% - a rate lower than that of any post office in the western United States. These improvements were worth $400,000 to $500,000 a year. In order words the productivity gains paid for the entire renovations in just seven months.* (11)

D. Return on Investment: Santa Fe developer Robert Zimmer and his partners have built a hotel that would not only embody environmental and social needs and fit into the stylish Santa Fe surroundings, but also be successful financially. The Zimmer Group completed the Inn of the Anasazi in 1991. Located in the heart of Santa Fe's historic Plaza district, it is one of the premier hotels in the United States, rated four stars by Mobil and the American Automobile Association. Water-savings fittings, normal daylight, and energy-efficient artificial light help to make the Inn resource efficient. *"Despite being one of the higher-priced hotels in the area, the Inn leads all others with an 83% average occupancy rate. Hotels rarely begin paying back investors until their third year of operation, yet the inn broke even by the end of its second year and began to pay investors in year three. By the end of year three, return on investment (after debt service) was running at an impressive 13 percent "* **(12)**

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Authors:
F.H. van der Veen, Director-General of the Dutch Government Buildings Agency,
P.O.Box 20952, 2500 EZ The Hague, Netherlands

L.M. Dewever, Government Premises Environment Inspector,
P.O.Box 210, 6800 Arnhem, Netherlands

SUSTAINABLE MANAGEMENT OF LARGE PROPERTY PORTFOLIOS

Presentation by Mr van der Veen, Director-General of the Dutch Government Buildings Agency
The text of the presentation is not final. The article below outlines the backdrop against which Mr van der Veen will be speaking.

Introduction

Maastricht, a beautiful old city, was an excellent choice of venue for the Sustainable Building 2000 conference. The sustainability of buildings is here to see in all its forms. Old buildings, which have been in use for centuries, are models of sustainability. There are also new buildings that, thanks to their exceptional architectural and structural quality, will probably also remain in use for centuries. Maastricht, just like other old cities, is showing us the way to go to achieve sustainability. Structures that have remained from times past were apparently worth maintaining and using, and have therefore been sustainable.
It is, of course, very tempting to complete high-profile new projects (and this must also remain the case!), but the fundamental principle of sustainable building is to be found among the existing stock. The key is to maintain and even enhance the quality of the urban environment that has developed over the centuries. We often see that prestigious new office blocks and shopping complexes lead to existing buildings becoming empty. This leaves us with double the environmental impact: on the one hand the environmental impact of the new buildings and on the other the destruction of a piece of environmental capital because existing buildings fall into disuse as a result of being vacant or being demolished prematurely. We can avoid this by not focusing entirely on new construction projects and at the same time by looking for ways to keep existing buildings functional. This often calls for creative solutions. Sint Annadal is an example of this. It is a former hospital here in Maastricht. The conference programme includes excursions to this building. The excursion on Sunday is general in nature, whereas the excursion on Tuesday will address in more depth the environmental profit generated through the reuse of a building like this. We divided the complex in two. One part was converted into a court building and the other part houses the Teikyo University Holland. There is information about the project available here at the conference. When you see the building, you will appreciate why it is worth going to the trouble to find a new use for it. However, it is not always so clear cut. The crucial question is therefore how we, as management, can address the concept of sustainability in existing buildings. When does it make sense to demolish a building and when is it worthwhile (from the point of view of sustainability) to retain a building? We are developing a decision model for this.

Environmental index

The Dutch Government Buildings Agency is the largest buildings organization in the Netherlands. It provides premises for a large proportion of central government. These are ministries, tax offices, court buildings, laboratories, research institutes, museums, prisons etc.

The Dutch government has expressly selected sustainability as one of the cornerstones of its policy. It therefore goes without saying that it wants to put its aim of sustainability into practice in its own buildings. Consequently sustainable building is a major area of attention for the Dutch Government Buildings Agency. Equally important areas of attention, however, are the functionality of the premises (does the building give the user what he needs?), town planning, preservation of historic buildings, architecture and art. We must also not forget the costs of buildings—both the investment and the operating costs. The challenge is to understand these aspects and the relationships between them, and to reach a satisfactory balance. You cannot separate sustainable building from everything else. As long as the ambition is within bounds, sustainable building measures are as a rule easy to accommodate without conflicts with other interests. If the level of ambition is higher, we need a yardstick for sustainability: an indicator that we can use alongside the other important aspects.

For some years now we have been working with an environmental index. The index shows how much environmental profit has been made compared with the normal situation in 1990 (baseline year in connection with the initiation of sustainable building policy in the Netherlands). If the sustainability of the building is still at the 1990 level, the index is 100. It increases as the sustainability of the building improves. Our current projects have an environmental index of between 150 and 250. An overview of the environmental indices of some twenty buildings will be presented at the conference. There will also be an explanation of how the environmental index is calculated. We will not go into any further detail in this article. In this article we want to show how we propose giving sustainability a place in the total stock of government buildings.

We manage approximately 2.100 buildings. We try to give substance to sustainable building across the entire range of the portfolio. It is of course a good thing if the government now and again explores the boundaries and stimulates the market through an exceptional project (and we like to do this), but we generate the real environmental benefits by moving our large portfolio step by step down the path of sustainability. This is why we do not want to limit ourselves solely to aiming for a high environmental index for individual buildings. We hope that in due course we can also demonstrate that the environmental quality of the whole portfolio of government premises is increasing. The environmental index can be a useful tool in this regard.

Sustainable building is concerned with more than environmentally friendly building materials and the use of renewable energy. Key factors are the useful life of the buildings and the way the buildings are used. Are half the offices empty because staff are somewhere else, or is there hot desking so that the building is utilized intensively? As a result of the rapid changes in organizations we are also seeing that the useful life of buildings is becoming shorter and shorter, and consequently large quantities of environmental assets are being discarded prematurely.

The mobility of the employees is also often a major environmental item. As regards central government, for which we provide premises, mobility is predominantly associated with commuting. Mobility depends on the choice of the location for the premises. The Dutch Government Buildings Agency therefore often opts for locations close to stations, even though land prices are higher.

We consequently need a yardstick that takes all these aspects into account in one way or another. We believe that we have found just such a yardstick by calculating what we call the 'hidden environmental costs'.

Hidden environmental costs

In order to obtain a quantitative picture of the sustainability of our buildings, we calculate the hidden environmental costs by analogy with the normal costs. The hidden environmental costs are the extra costs we have to incur (over and above the costs we already incur for environmental provisions) if we want to make a building 'really sustainable'. These costs are not currently incurred because otherwise the projects would become too expensive and compensating measures go beyond the scale of the project. They are usually not even tabled, and in fact are passed on to other parts of society or later generations. Hence the name *hidden environmental costs*. The hidden environmental costs are calculated in terms of the costs of currently available measures and technologies in order to prevent or compensate for the environmental impact. It goes without saying that development is rapid in this area, as a result of which understanding of the degree to which environmental problems are being passed on is changing. Nevertheless it is worthwhile calculating the hidden environmental costs on the basis of current insight. These calculations give an indication of how great the distance is between current practice and sustainability. The sums involved are usually substantial. The hidden environmental costs of an office building are often of the same order of magnitude as the cost of the building and the land. This means that a project would be approximately twice as expensive if we wanted to build it on the basis of sustainability. It is clear that this cannot be done. It is also clear, however, that we have to look for other, less expensive, solutions as a result of which the hidden environmental costs become lower. By using buildings longer and more intensively, for example, fewer new buildings are needed.

In order to facilitate comparison of the hidden environmental costs of different accommodation solutions or projects, we work with an index. This is the environmental index that I referred to earlier and that is described in the folder available at this conference. The environmental index shows the hidden environmental costs of a project compared with the situation in 1990. In order to do this, calculations are made for a reference project. The reference project reflects how, generally speaking, the building work in the current project would have been carried out in 1990. Timber from forests that were not managed was still being used at that time, for instance. The requirements relating to energy consumption were less stringent. Less account was taken of the proximity of public transport when deciding on a location in order to reduce the use of cars for commuting. There was no office innovation or hot desking. In other words the reference is a building with greater environmental impact than the current project. Consequently the hidden environmental costs of the reference are usually higher.

$$\text{Environmental index} = \frac{\text{Hidden environmental costs of the 1990 reference}}{\text{Hidden environmental costs of the project}} \times 100$$

When working with the environmental index we therefore look at more than the structural aspects of a building. We also consider the way a building will be used. We compare the use of the building (hot desking, multifunctional use of areas, commuting etc.) with the way that buildings were usually used in 1990.

The useful life of the building is also taken into account. This is done by depreciating the hidden environmental costs over the useful life of the building. There is a clear analogy with the way that investments in property are depreciated. But there is also a clear difference. We depreciate the hidden environmental costs over the *technical* useful life of the building, and not over the *economic or functional* useful life, as is customary with property calculations. The underlying idea is that it is desirable from the point of view of sustainability to use buildings as long as possible. Lengthy use means there is less need for new buildings. If a building that is still technically usable is demolished, environmental capital is destroyed, so to speak. Environmental assets are discarded and replaced by new ones, yet technically speaking they could have continued in use for a while. This environmental wastage is revealed by allocating the hidden environmental costs that have not yet been depreciated to the new project.

Future developments

So far the environmental indices of some one hundred buildings have been calculated. The next step is to combine the environmental indices of the buildings to obtain an index for our entire portfolio or for parts of it.

These are very complex calculations. It is therefore important that they are carried out unambiguously and verifiably. The figures must be comparable with one another, irrespective of which organization calculated them. We are therefore formulating strict calculation protocols that will be used by an accountant to verify calculations. A trial has been conducted with a few calculations and the results are encouraging.

It is also possible to calculate the environmental index on an annual basis. The users of the buildings can see from this what the environmental impacts are associated with the utilization of the building. These figures can also be verified by an accountant and then be incorporated in the annual environment report.

Conclusions

1. The biggest opportunities for real sustainable building are to be found in the existing stock. An assessment model is needed in order to compare the environmental impact of redevelopment of the existing stock with new buildings. The equation has to include the structural aspects of the buildings and also the intensity with which the buildings are used and the useful life of the building.
2. As far as major property users, such as government and commercial service providers (banks, insurance companies, firms of accountants etc.), are concerned sustainable building is an issue not just at the level of individual buildings, but above all at portfolio level.
3. The environmental index based on the hidden environmental costs appears to be an attractive management tool for supporting the decision making process. So far nearly one hundred projects have been analyzed using it. .
4. The environmental index can serve as a useful instrument for accounting the environmental impact of a accommodation in the annual environment report.

Reference

List of environmental indices of more than twenty projects, which will be handed out at the conference.
Documentation about Sint Annadal (available at the conference).

DECONSTRUCTION AS AN ESSENTIAL COMPONENT OF SUSTAINABLE CONSTRUCTION

Charles J. Kibert, University of Florida, PO Box 115703, Gainesville, Florida 32611-5703 USA

INTRODUCTION

The demolition of building structures produces enormous amounts of materials that in most countries results in a significant waste stream. In the U.S., demolition waste amounts to 92% of the total construction and demolition (C&D) waste stream of 136 million tonnes annually or about 125 million tonnes of demolition that is for the most part landfilled. In the Netherlands, C&D waste amounts to 15 million tonnes per year; however due to a high degree of environmental awareness and government regulation, over 80% of this waste stream is recycled, mostly into subbase for roads.

Deconstruction of buildings has several advantages over conventional demolition and is also faced with several challenges. The advantages are an (1) increased diversion rate of demolition waste from landfills; (2) potential reuse of building components; (3) increased ease of materials recycling; and (4) enhanced environmental protection, both locally and globally. Deconstruction preserves the invested embodied energy of materials, thus reducing the input of new embodied energy in the reprocessing or remanufacturing of materials. A significant reduction in landfill space can be a consequence. For example, in the U.S. where C&D waste represents about one-third of the volume of materials entering landfills, a diversion rate of 80% as is being experienced in The Netherlands would preserve increasingly scarce land for other optional uses.

The challenges faced by deconstruction are significant but readily overcome if changes in design and policy would occur. These challenges include: (1) existing buildings have not been designed for dismantling; (2) building components have not been designed for disassembly; (3) tools for deconstructing existing buildings often do not exist; (4) disposal costs for demolition waste are frequently low; (5) dismantling of buildings requires additional time; (6) re-certification of used components is not often possible; (7) building codes often do not address the reuse of building components; and (8) the economic and environmental benefits are not well-established. Again, these challenges generally fit into one of two categories: design or policy.

INTERNATIONAL OVERVIEW

The initial meeting of CIB TG39 at the Building Research Establishment (BRE) in Garston, Watford, U.K., was held to assess the status of deconstruction in a variety of countries around the world. Country reports were presented from Australia, Germany, Israel, Japan, The Netherlands, Norway, the U.K., and the U.S. Below is a brief summary of deconstruction in a selection of these countries which represents the differences and commonalities in these locations.

Australia (Philip Crowther, Queensland University of Technology)

The total waste stream in Australia is about 14 million tonnesn of which somewhere between 14% and 40% is C&D waste. Deconstruction of 70 to 100 year old timber houses in Australia is a common practice with about 80% of the materials being recovered and reused for renovation and remodeling of existing homes or in the construction of new, replica housing. Additionally the relocation of houses is a common practice, with 1,000 homes being moved in the Melbourne area each year out of a total housing stock of 800,000 units. For residential structures it is estimated that between 50% and 80% of materials are recovered in the demolition process. The recovery of materials from commercial buildings is significantly lower with a total recovery rate of about 69% (58% reuse and 11% recycled). In Australia up to 80% of concrete is processed to recover the aggregates for reuse in construction. For modern housing, the emergence of new systems of prefabricated buildings allows the potential deconstruction of the housing stock in the future. EcoRecycle Victoria provides guidance for waste minimization in construction and demolition including *Tender Guidelines for Construction and Demolition Projects* and include the consideration of deconstruction as an element of the tendering process (Crowther 2000).

Germany (Frank Schultmann, Deutsch-Französisches Institut für Umweltforschung (DFIU)

The demolition waste stream in Germany is estimated to be about 45 million tonnes per year of which about 25% is concrete and 50% is bricks and stone. Between 1991 and 1999 several case studies on deconstruction were conducted and revealed an exceptionally high recovery rate, in excess of 95% for many structures. Recent studies are looking at deconstruction methods and show that optimized deconstruction combining manual and machine dismantling can reduce the required time by a factor of 2 with a recovery rate of 97%. The Deutsch-Französisches Institut für Umweltforschung (DFIU) in Karlsruhe has several research programs underway that are investigating various aspects of deconstruction. One of these is the process of auditing an existing building for its deconstruction potential for the purpose of predicting the cost of dismantling the building versus the value of the extracted materials. Computer models have been developed to assist in this process and cover both the technical and economic aspects of deconstruction.

The Netherlands (Ton Kowalczyk, J. Kristinsson, and Ch.F. Hendriks, Technical University Delft)

C&D waste in The Netherlands is generated at a rate of 14 million tonnes per year. Strict government regulations ensure that about 80% of these materials are reused in other construction, generally in creating materials for road base. The Dutch Government passed a law on the first of April 1997 which in short states that "...dumping of reusable building waste is prohibited," thus forcing even higher rates of recovery. Reusing components of existing buildings is hampered by two factors. First, the building stock is comprised largely of reinforced concrete structural materials that are difficult to take apart and for disassembly, they must be sawn apart. After disassembly, the recovered component must undergo testing prior to its direct reuse as a slab, column, or beam in a new building. Second, recovered components such as brick are costly to remove and process and are therefore not competitive with new products (Kowalczyk et al. 2000). Efforts are underway to begin the process of informing architects and other actors in the construction industry about the potential for designing buildings for deconstruction.

Norway (Lars Myhre, Norwegian Building Research Institute)

Total C&D waste in Norway is about 1.5 million tonnes per year of which 978,000 tonnes is demolition waste. In the Oslo region, between 25% and 50% of this waste stream is estimated to be recycled or reused. Significant private and public initiatives are underway with a goal of reducing the C&D waste stream by up to 70%. The GAIA group of architects is promoting perhaps the most ambitious plan for including design for deconstruction in planning. They established the "Building System for Reuse" or BfO system which decouples building systems, eliminates the uses of composites, and relies on traditional, locally produced building materials and well-known simple technology. The BfO system includes 88 standard wood and concrete components that can be assembled into a wide variety of configurations. The ability to easily assemble and dismantle the components also allows the capability of easily changing or reconfiguring the building to meet the user's needs over time. A follow on project that takes advantage of the BfO system is called ADISA or Assemble for DIS-Assembly and consists of 45 standardized components with space planning based on a module of 600 mm. Presently a pilot project at the Prestheia eco-village is building 19 dwellings using the ADISA system.

CONCLUSIONS AND RECOMMENDATIONS

As its primary purpose, deconstruction seeks to maintain the highest possible value for materials in existing buildings by dismantling buildings in a manner that will allow the reuse or efficient recycling of the materials that comprise the structure. Deconstruction is emerging as an alternative to demolition around the world. Generally the main problem facing deconstruction today is the fact that architects and builders of the past visualized their creations as being permanent and did not make provisions for their future disassembly. Consequently techniques and tools for dismantling existing structures are under development, research to support deconstruction is ongoing at institutions around the world, and government policy is beginning to address the advantages of deconstruction by increasing disposal costs or in some cases, forbidding the disposal of otherwise useful materials. Designing buildings to build in ease of future deconstruction is beginning to receive attention and architects and other designers are starting to consider this factor for new buildings. CIB TG39 is in the process of conducting a 4 year study of deconstruction and coordinating an exchange of information among research organizations and practitioners around the world.

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ENVIRONMENTAL BENEFITS FROM BUILDING WITH REUSED AND RECYCLED MATERIALS. A CASE STUDY.

Thormark, C.
Lund Institute of Technology, Department of Building Science, Sweden.
e-mail: catarina.thormark@bkl.lth.se.

INTRODUCTION

Recycling building residues is broadly recognised as a means of decreasing environmental impacts. For the Swedish Building Exhibition 1997, a single-family dwelling was built with a large proportion of recycled materials. The project was supported by the Swedish National Board of Housing, Building and Planning in a wish to promote the growth of the reuse of building products.

Aim

Compare environmental impacts from a building with reused materials, REC, to the case with conventionally produced materials, NEW. Analyse how the transport distance effect the environmental benefits from reused brick.

Method

The approach of life cycle assessment was used. The compared systems are presented in Figure 1. The comparison was made as follows: (House built with recycled materials + (Products B – Products A)) compared to (House built with new materials). No allocation was made between the different life times of a product or a component. Global warming, acidification, nutrient enrichment, photochemical ozone formation, the use of natural resources, energy and the waste production were studied. Characterisation factors according to [Hauschild, 1998]. Included building parts were foundation, external and internal walls, floor structures and roof.

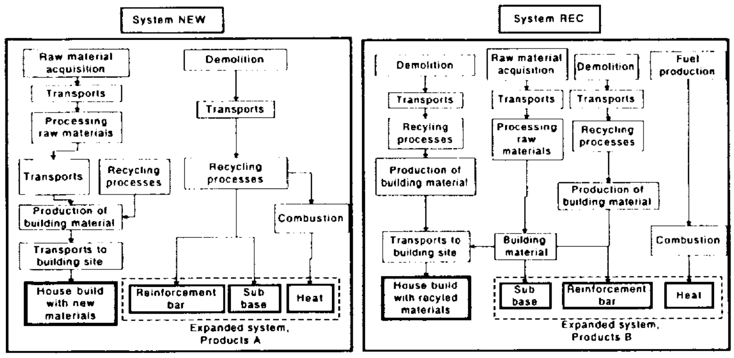

Figure 1. System boundaries of the compared systems.

The building

The building is a one-family dwelling with a net residential floor area of 150 m^2. The foundation is a concrete slab. External walls are a clay brick veneer construction with mineral wool, some parts are of light weight concrete blocks. The roof is a timber structure with clay tiles. Internal walls are mainly of gypsum plasterboard on wooden studs but clay brick walls also occur. Complements of steel structure.

Reused materials were mainly clay brick, roofing tiles, timber, concrete with aggregate partly of crushed concrete, steel structure, wooden panels and wood and brick for floors.

RESULTS

The reused materials accounted for about 30 weight % of all the materials in the studied parts. Of the total requirement of timber, 32% was supplied by reused timber. The total amount of timber was higher in REC due to larger dimensions of the reused structural timber. The requirement of steel was to 70% supplied by reused steel. The energy use, was in REC about 60%, feedstock included, of the energy use in NEW, and 54% feedstock excluded.

The REC caused less use of raw materials for production of building material and a decrease in transports. The main primary raw materials conserved were bedrock, sand, clay and timber which decreased about 30%. The use of fossil resources for energy production decreased about 25%. The use of different chemicals decreased about 80%. As nearly all steel is recycled today, reuse of steel means nearly no change in the amount of used primary raw materials, only decrease of energy use.

In a near future mineral waste and wood will not be put to landfill. This means that the case REC only slightly affected the *amount* of waste put to landfill. However, the high recycling quality decreased the waste from the material production. The environmentally harmful waste decreased about 50% and undefined waste decreased about 30%.

The contribution to the studied impact categories decreased with about 50% for acidification, 30% for global warming potentials and eutrophication and 40% for photochemical ozone creation in REC compared to NEW.

Design aiming at facilitation future efficient recycling

As recycling can considerably contribute to less environmental impacts, recycling aspects are important to consider in the design phase. Possible recycling forms are decided by the assembly. The question is, when is disassembly for *reuse* more important than disassembly for material recycling. Based on analyse of recycled materials and recycling potentials in buildings [Thormark, 1999, 2000], some important a questions for the design process can be formulated. See figure 2.

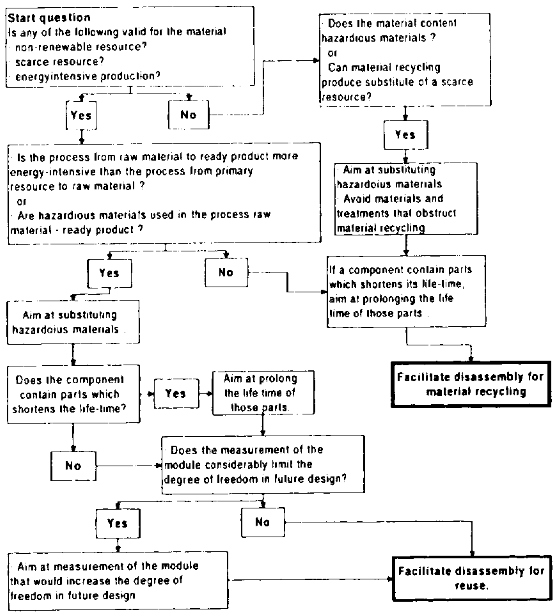

Figure 2. Checklist for design aiming at facilitation of future recycling.

Transports of reused brick

An important question is how long reused materials can be transported before the benefits from reuse disappear. Differences in weight, means of transport and means logistics have to be considered. The contribution to global warming, acidification, nutrient enrichment and photochemical ozone formation, POCP, were analysed. Transport data were from [NTM, 1999]

Long transports offer better logistic possibilities. It was here assumed that the lorry, in transports shorter than 500 km, goes full to the building site and empty in return. At longer distances the lorries were assumed to be filled to 75%.

POCP showed to be the decisive factor and the result are showed in Figure 3.

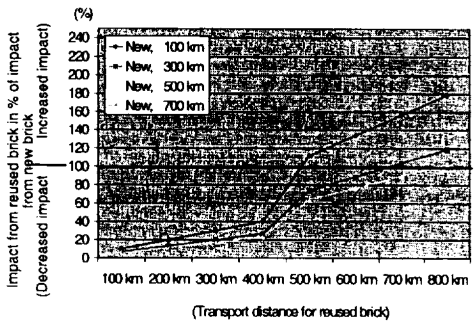

Figure 3. The benefits of reused brick at different transport distances compared to new solid brick.

It should be remembered that reused brick is heavier than new brick and often is bought from places close by while new brick is often bought from producers far away. The figure shows that, regarding the studied impacts, if reused brick is transported 400 km and is substituting new solid brick from a distant of 100 km, the environmental impact decreased to 40%. The benefit is less if reused brick is used as substitute for new hollow brick.

CONCLUSIONS AND RECOMMENDATIONS

Reuse can contribute to a considerable reduction of the impacts from the production of a building. The effect from transport distance on the benefits from recycling must be assessed in each case. Aspects of recycling ought to be integrated already in the design phase of new buildings in order to facilitating efficient future recycling. Simple check-questions can here be of help. The environmental benefits from reuse instead of combustion with energy recovery, is much dependent on the energy source for district heating. If extended *reuse* decrease the amount of waste or not depends on how well developed the waste handling is.

ACKNOWLEDGEMENT

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SUMMARY OF A STUDY ON THE SUITABILITY FOR DESIGNING FOR RECYCLING AND DESIGNING FOR DURABILITY.

Ms. Paola Sassi
Kingston University / Sassi Chamberlain Architects
14 Vicarage Road, Teddington TW11 8EZ, UK
tel +44 (0)20 89774180
fax +44 (0)20 8977 8355
email design@SCAarch.idps.co.uk

Introduction

The UK government waste strategy, as set out in the 1998 Department of the Environment Transport and the Regions consultation paper *Less Waste More Value* (1), promotes a waste hierarchy, which prioritises the reduction of waste followed by reuse of waste, recycling and finally the disposal of waste. Waste minimisation initiatives are well under way in the UK and recycling is now being considered. To enable reuse and recycling in the building industry, buildings should be designed to allow for dismantling of building elements. The ability to dismantle is however sometimes at odds with the principles of designing for durability.

This paper summarises a study that considers the suitability of designing for recycling versus designing for durability based on information collected on the building work actually undertaken to existing buildings.

Waste minimisation and recycling

The UK building industry is increasingly adopting waste minimisation strategies in construction and demolition projects to achieve both environmental and economic benefits. A number of waste minimisation approaches are currently being implemented. In construction, modularization is expected to reduce waste through more efficient use of standard sized materials and prefabrication has been found to minimise waste through the enhanced and more controlled working conditions of a factory environment. In demolition the reuse and recycling of demolition waste has proved to be economically beneficial where the demolition waste can be reused on the same site in lieu of primary materials, be it roof tiles, concrete aggregate or hardcore (2). In both construction and demolition work the segregation of waste has also proved economically beneficial by resulting in reduced disposal costs for the separated waste and the elimination of disposal costs for recyclable materials.

With the evidence of possible economic benefits of recycling, recycling is increasingly being considered as a viable way of reducing the environmental impacts of building. The environmental benefits of recycling materials are extensive. The energy benefits of recovering building elements for reuse or for recycling can be as much as a third of the total energy use of a building (3). Further environmental benefits of recycling and reusing building elements include reduced depletion of natural resources, reduced destruction of natural habitats and the resulting extinction of plant and animal species and reduced waste and pollution generation.

However the scope for recycling building elements and materials in existing buildings is often limited by technical constraints imposed by the construction of the building itself. In order to maximise the potential for recycling in buildings in the future, buildings should be designed to facilitate the reuse and recycling of building elements and components.

But should all elements of a building be designed to enable dismantling and reusing or recycling? Should all buildings be constructed for recycling? Or should certain building elements or building types be designed for maximum durability?

In the UK numerous buildings currently in private and public use are more than 200 years old. The municipal offices in Twickenham (ca. 1650), St.Bartholomew's hospital in London (ca. 1730), numerous London stations built in the early 1800's and a substantial number of the country's dwellings of the same period are some of the many examples of long life buildings. Building for durability still does appear to have a place in today's culture and could have a more targeted practical function in future.

To determine where designing for recycling and designing for durability is most appropriate the nature of building work being carried out to existing buildings in the UK was investigated. A survey was undertaken of UK architects to establish the nature, frequency and motivation for refurbishment, alteration and replacement work to buildings and building elements.

The survey

The work reported as part of the survey was divided in five main different types of work. 1/ Decoration 2/ Internal remodelling (included repositioning of partitions, doors etc. and internal fitouts) 3/ Replacement of services (including heating and ventilation, electrical services etc.) 4/ Replacement of external non-structural elements (including windows, roofing, wall cladding etc.) 5/Conversions and extensions.

None of the work reported included substantial structural work. In most cases the basic building structure was kept fully intact.

The average frequencies of the work (Fig. 1) varied according to the type of work, work to the building interiors occurring more frequently than work to the exterior, and

Category of work	Average frequency of work in years
1/ Decoration	7
2/ internal remodelling	10
3/ replacement of services	13
4/ replacement of external non-structural elements	29
5/ structural alterations, conversions and extensions.	25

Fig. 1 Average frequency of building work

according to the type of building. (Fig. 2) Retail buildings, bars and restaurants were found to have the shortest turnover of internal fitouts and shopfronts and public buildings on the other end of the scale had the longest periods between interventions.

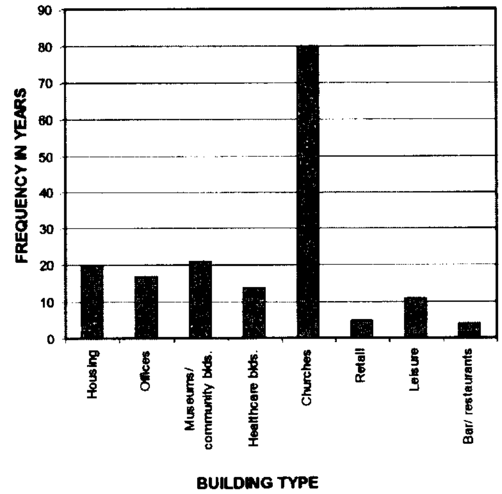

Fig. 2 Frequency of work to building elements of existing buildings

Generally the work frequencies were well below the potential life of most building elements. Internal remodelling would generally involve removing walls with a life expectancy of 30-60 years in plasterboard and 60+ in solid masonry construction (3). A remodelling frequency of 10 years would therefore reduce the life of the building element life to a third or less of its potential. This shortfall could be reduced by either reusing the building element or recycling the material.

What appears significant is the motivation for the building work. Most work to existing buildings was not motivated by requirements for maintenance, but rather by the wish to enhance the appearance, increase space or improve the economic value of the building. The survey results showed only one fifth of the work was regarded as maintenance and another 5% of the work was aimed at upgrading to current technologies (Fig 3).

Motivation for work	%
maintenance	20
Statutory requirements	3
Increase economic value	11
Increase and improved use of space	30
Update to current technologies	5
Improvement of bld. performance	9
Improve appearance	16
Follow fashion, trends	6

Fig 3 Motivation for building work

Reuse, recycling or durability

Reuse is preferable according to the above-mentioned waste hierarchy, but may not always be the appropriate waste solution. Considering the work done in connection with services, we find that services are often removed due to their technological obsolescence and could therefore not be reused, but should be dismantled and the materials recycled. Designing for recycling would therefore seem essential for building elements that have a shorter life than the rest of the building. This would apply to services, but also most finishes in buildings.

Reuse does appear appropriate where building elements have a longer potential life than the time for which they are needed in one location. Internal building elements such as the previously mentioned plasterboard wall are prime examples. Here building technology currently prevents plasterboard walls to be reused. Even recycling of the materials is hampered by the contaminants. However design solutions for reusable partitions exist for offices and similar solutions could be developed for other building types. While the majority of building elements that would benefit from reuse are not reclaimed, there are, in fact, numerous building elements that can and are currently reclaimed and reused, roof tiles, bricks, doors are only a few.

A further point highlighted by the survey was the fact that work to structural elements was minimal. Whether because of an absence of any need to change the structure to achieve the desired results or due to the high cost of structural interventions, the fact remains that it appears possible and very common to work within existing structures. It would therefore seem beneficial to provide durable structures that enable the reuse and recycling of the secondary elements, whereby these durable structures, whether in concrete or steel, are still likely to have recycling potential. Concrete frames can in most cases be reprocessed as aggregate or hardcore and steel can be reprocessed to produce more steel.

Conclusion

As a result of this study the following building format is proposed as a possible way forward for waste minimisation, recycling and reuse in buildings.

The proposed format would provide a durable structure that would allow changes of finishes, secondary building elements and service. It would also be designed to allow changes of building use, which may require the structure to be over-designed in terms of structural loading and sizing (e.g. floor to ceiling dimensions). Internal and external secondary elements should be designed for reuse, many examples are already available on the market. Services should be able to be dismantled and the components reconditioned or recycled. Finishes should be designed for reuse and recycling, possibly following the examples of companies such as Interface, which leases floor coverings and recycles used carpets. The proposed format is not limited in terms of building type.

While some technologies aimed at producing durable buildings preclude the recycling of the same, this is not necessarily always the case. The durability of building elements can in fact contribute to the recyclability of those same elements. The challenge is not to make buildings recyclable rather than durable, but both recyclable and durable.

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New use of a historic warehouse – a life cycle optimised retrofit project

Werner Klaus, Helmut Meyer

TRANSSOLAR Environmental Engineers, Curiestrasse 2, D-70563 Stuttgart, Germany,
☎ +49-711-67976-33, ⊒ +49-711-67976-11, www.transsolar.com, klaus@transsolar.com

Introduction

A warehouse under historical protection in Stuttgart/Germany will be retrofitted and converted into a theatre with 8500 m^2 floor space. Arts and sports are combined within four halls of different size and a sports area.

The building design is focused on the reduction of the building's environmental impacts over the entire future life cycle (assumed as 80 years). On the other hand, modern standards of flexibility and comfort have to be reconciled with the historic construction.

Architects, structural and mechanical engineers in close co-operation with the environmental engineers developed LCA optimised alternatives for construction and the HVAC technology.

LCA methodology

The LCA inventory has been worked out on a level of building materials and processes and energy services by separating all construction processes from the building operation.

	Life - Cycle - Phases		
	Productio	Use	Disposa
Construction	Erection of Building	Maintenance, Refurbishment	Demolition, Disposal/ Recycling
Operation		Lighting Heating Ventilation Refrigeration	

For the construction part it is done with EcoPro - a LCA software tool (developed by ifib, University Karlsruhe) - on base of the architects' cost esti,mation. The inventory for the operation part was deduced from simulation results (thermal building simulation by TRNSYS and CFD with FLUENT). With the help of EcoPro the database of inventories of building materials and energy processes (a consistent database for over 150 building materials developed by HAB Weimar, ifib Karlsruhe and ETH Zurich) the LCA impact assessment results are gained. The following impact categories have been considered:

Resource consumption and waste disposal:
- massflow
- primary energy renewable and non renewable
- land use
- abiotic resource depletion
- hazardous waste and other waste categories
- waste heat

Emission or effect oriented aggregates:
- greenhouse potential
- acidification potential
- eutrophication potential
- ozone layer depletion
- heavy metal emissions
- summer smog winter smog potential
- aquatic ecotoxicity
- terrestric ecotoxicity
- toxicity for humans
- carcinogenic potential

Full aggregates:
- Eco-Indicator 95

As the aim of our investigation was reduction of environmental impacts, we restricted the LCA of that building parts or operation segments where we expected to find design alternatives with the highest reduction potential. Primary optimisation aim is greenhouse and acidification potential reduction. Alternatives favourable under these impact categories have been compared with respect to the other categories.

LCA results for the construction part

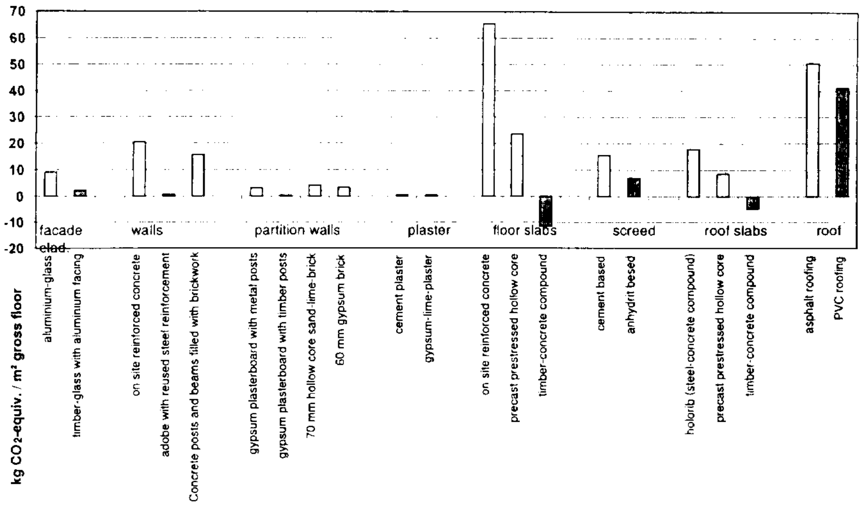
The following building parts have been considered:

- glass facade
- heavy metal emissions
- load bearing walls

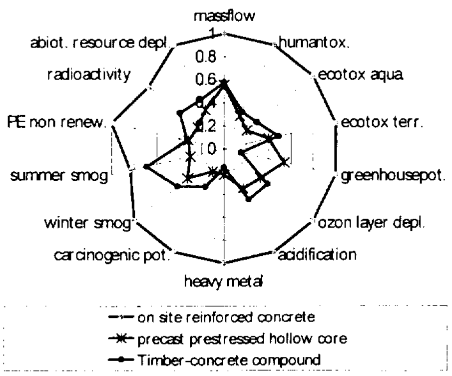
- partition walls
- wall plaster
- floor and roof slabs
- cast plaster floor / screed
- flat roofing system

The following graph shows the results for the absolute greenhouse gas reduction potential of the developed design alternatives. Floor and roof slabs offer the highest reduction potential but the use of timber-concrete compound implies changes in the structural system, which may not be viable for all slabs. The ecological effect of wall plaster is neglectable. The switch from an cement based to an anhydrite based cast plaster floor is in most cases unproblematic. The ecologically favourable adobe wall reinforced with reused steel will unfortunately not fit in the construction time schedule. To build the glass-facade as a timber-glass facade with aluminium cladding seems to be also economically rewarding. A PVC roofing system – with less CO_2 emissions than asphalt – is toxicologically unacceptable. PVC alternatives like polyoloefine membranes might be further alternatives.

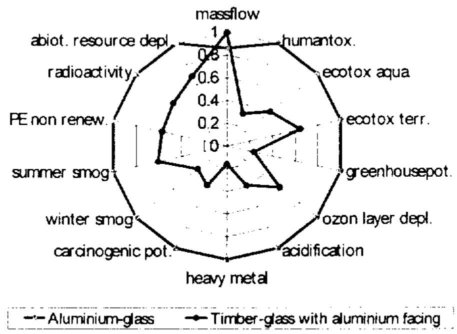
life cycle greenhouse gas emissions: absolute contribution of alternatives



floor slab constructions
environmental impact in relative values



glass facades
environmental impact in relative values

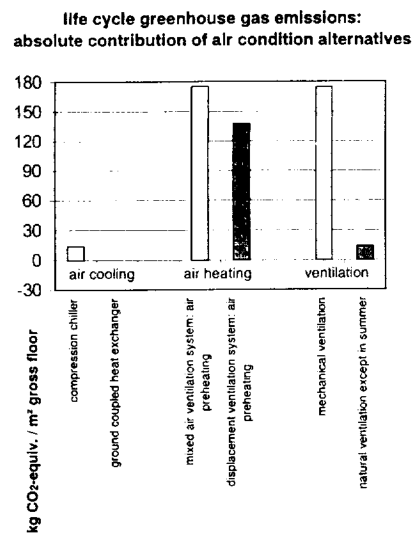


The detailed comparison of floor slab constructions shows that the variant with the least greenhouse potential also is one of the more favourable ones with regard to other environmental impact categories (see left graph on the previous page). We can see almost the same situation for other constructions (e.g. glass facades see right graph on the previous page).

LCA results for the operation part

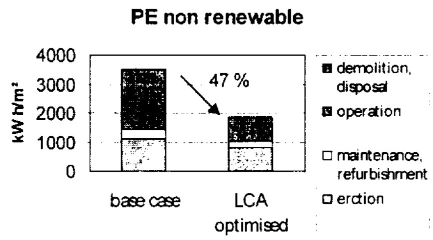
To save energy for the building operation an innovative heating, ventilating and cooling concept was developed through detailed thermal and CFD simulation. Instead of a mechanical air handling unit the building will be equipped with a 30m chimney to use the stack effect for natural ventilation and a ground coupled heat-exchanger for fresh air cooling. Together with a displacement ventilation system the energy demand for ventilation is reduced by about 90%, for fresh air heating by more than 20% and for cooling by 100%.

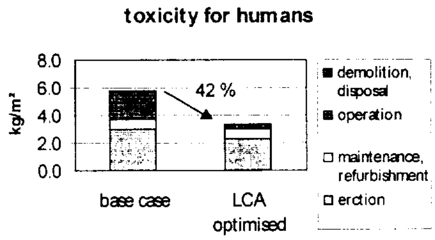
The LCA comparison for the operation part of standard technology with the natural ventilation and cooling components shows similar results (see graph below. Other impact categories like acidification or toxicity differ only little from this picture.)



Conclusions

LCA optimisation of a building design offers a high environmental impact reduction potential. The following figures show the reduction from the base or standard case to a building design which fully integrates the best of the analysed alternatives. The LCA covers all building and operation components that have been considered – not the entire building.





It can be recognised that the main reduction results from operation energy, which is typically even for low energy buildings. Only for ultra-low energy buildings like the 'passivehouse'.

Outlook

An ongoing LCA comparison of the optimised retrofit-project with a hypothetical new building in standard technology in the sane size and on the same site will show the ecological strengths of retrofitting and reusing and also possible weaknesses like the historic facade which is hard to insulate. Some guidelines how to design ecologically optimised retrofits of historic buildings will be an exciting result of this project.

DEVELOPMENT OF A NEW ADAPTABLE AND DEMOUNTABLE STRUCTURAL SYSTEM FOR UTILITY BUILDINGS.

Prof. Ir. Frans van Herwijnen
University of Technology Eindhoven,
Department of structural design,
ABT Adviesbureau voor Bouwtechniek BV
Velp / Delft

INTRODUCTION

The contribution of bearing structures to sustainable building relates to adaptability and demountability. Adaptability means making provisions in the structure for later increase of the bearing capacity and for making holes in the floor system.

Demountability of the structure makes re-use of the long-life components in the future possible.

Based on the philosophy of Industrialised, Flexible and Demountable Building (IFD), a new structural system has been developed for utility buildings (offices, schools, etc.).

The system consists of three standard elements: specially developed TT concrete floor slabs, steel-concrete floor beams and concrete columns. The elements are prefabricated in a concrete factory under controlled conditions in a transportable size. All connections between the elements are demountable.

The system combines the advantages of concrete structures (cheapness, stiffness, sound insulation, heat accumulation, fire resistance) and steel structures (bolted connections, slender dimensions).

PRESENTATION

IFD building

Industrialised and flexible building in itself is not new. However, the combination with demountable building is.

De three elements of IFD building may be defined as follows:

*By **industrial building** in this context we mean the industrially making of building products.*

In building the word 'prefabricated' is often used as a synonym for 'industrial'. In this context prefabrication means to perform in the factory what was originally done on the building site, manufacture here is project specific.

An example of this is prefabricated concrete for columns, facade elements and the like. Besides there are industries that have of old only been able to realise their production in the factory, because the material, the process and the necessary machines require such. Examples are steel construction workshops, but also industries that produce prestressed floor slabs.

***Flexibility** is the quality of a building or building component which allows adjustments according to the demands and wishes of the users.* [1]

Flexibility may relate to two stages:

- the design stage: variability in the composition and the use of material;
- the user stage: flexibility to adjust the composition and the applied building components to the changing demands and/or wishes of the same or varying users while in use.

On the structural level, flexibility in the user stage may be translated into possible adaptability of the floors to higher working loads (the so called extreme live load) and the realisation of recesses for staircases, lift shafts or pipes and ducts. The placing of extra floors or mezzanines and the construction of extensions on ground level must also be counted among these.

***Demountable building** is the construction of a building in such a way that a building component may be removed and possibly re-used or recycled, soiled as little as possible by other materials, and without damaging the surrounding building components.*[1]. *In recycling we do not use the complete product, but only its raw material.*

Demountable building is also a means for the realisation of flexibility, because building components may be easily detached and replaced by other (industrial) building components.

Newly developed and adaptable structural system [2]

The newly developed structural system primarily meets the need for greater column distances and floor span than the 3,6 x 5,4 respectively 3,6 x 7,2 meter of the existing systems: the system starts from a floor span of 9,0 meter (= 5 x 1,8 meter) with a column distance of 5,4 meter (= 3 x 1,8 meter) in the other direction. An immediate consequence is that the floor slabs become too large to be placed directly on columns (as in existing systems), which results in the applying of beams as intermediary.
The structural design conforms to the preconditions of IFD Building, and consists of the following three components:

Floor slabs: (see figure 1)
The system makes use of concrete 'double T' elements with a 9 meter span and a 1,8 meter width. The thickness of the slab is 120 mm in view of sound-proofing requirements and sufficient shear capacity at the support. Concentration of the bearing capacity of the floor in ribs enables the creation of recesses in the (thin) floor between and next to the ribs, without fundamentally reducing the bearing capacity of the floor slab.

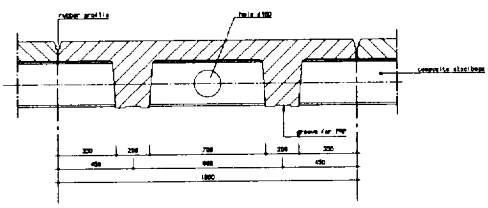


Figure 1 – TT floorslabs

The ribs do not entirely reach the end of the floor slab, which makes the leading through of ducts perpendicular to the ribs at the position of the supports possible.
The floor elements are not prestressed so that upward bending as a result of excentric pre-stressing does not occur. To increase the bearing capacity in the future fiber reinforced polymers (FRP) may be glued in the groove applied at the lower side of the ribs.
To the lower side of the slabs screw blocks are attached for the fastening of installation parts and suspended ceilings.
The connection of the floor slabs to the beams is taken care of by threaded ends which have been welded on the beams and fall into spacious cylindrical holes in the floor slab, which, after having been filled with fine gravel, is covered with a steel plate and pinned with a screw nut. The joints between the floor slabs may remain open (no structural connection is required) or they may be closed air tight by means of rubber profiles.
After mounting the upper side of the floor slabs is covered by a dry finishing floor according to a new system of Van Geel. In the thickness of the finishing floor steel floor gutters are placed for the distribution of data cabling and electrical provisions.

Columns: (see figure 2)
The square columns are made of high strength prefab concrete. By restricting the length tolerance to 2 mm the columns may be piled up as high as three floors without the necessity of having to adjust their height at every new floor.

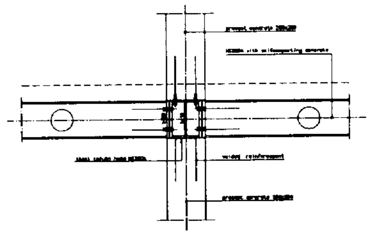


Figure 2 – Connection concrete columns – composite steel beams

Beams: (see figure 3)
As far as beams are concerned a **composite beam** has been designed, put together from a HE-A-280 profile, the chambers having been filled with self compacting (reinforced) concrete in view of fire resistance. The

connection with the concrete column is made by means of bolts that are turned into the anchor bolts hubs on the upper and lower side of the columns. Attainability here is guaranteed by omitting the concrete in the chambers of the steel profile at the position of the support. Fire resistance of the steel profile at the position of the column connection is reached by applying thick steel slabs in the chambers of the steel profile; these also take care of the transference of the column loads along the height of the beam profile.
The standard design of beams has round holes (d = 160 mm; h.o.h. 1800 mm) for the leading through of air ducts.

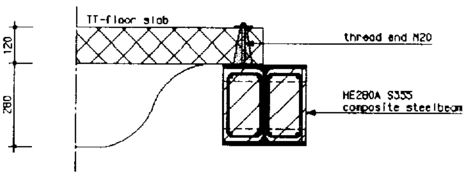


Figure 3 – TT-slab supported by composite steelbeam

Stability:
The stability of the system is guaranteed by added steel stability bracings in two perpendicular directions. The horizontal load from the floors is transferred by slab-beam connections to the beams, which at their turn are connected to the stability bracings.

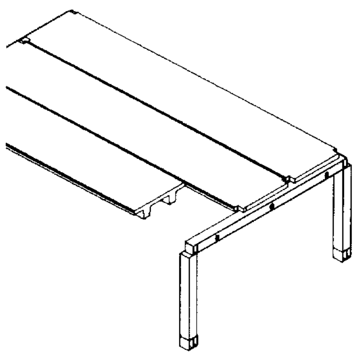


Figure 4 – Perspective of structural system

Conclusions and recommendations
By making use of dry connections between prefabricated elements of concrete and composite steel beams a completely demountable and also adaptable structural system for utility building has been developed, of which all components may be re-used after demounting. By overdesign of the columns, the spare bearing capacity in the beams and the adaptability of the bearing capacity of the floors the system can provide for future needs of higher admissible floor loads.
Besides large recesses may be realised between and next to the ribs of the floor slabs. This creates a great flexibility, which fits into the way of thinking of sustainable building. The system is to be applied to the construction of the office for ABT/Damen Consultants in the Delftechpark in Delft in the course of 2000. This project has been selected as a demonstration project in the programme of IFD-building, a joint initiative of the Ministry of Housing, Spatial planning and Environment (VROM) and the Ministry of Economic Affairs. While realising this project experience and knowledge are acquired, which are important in view of the development of building in demountable concrete structures.

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DESIGN OF A SUSTAINABLE BUILDING USING DISMOUNTABLE LAYERS

Pieter van Hulst, M.Sc.
Michiel Ham, M.Sc.

Eindhoven University of Technology
Group Building Technology
PO Box 513
5600 MB Eindhoven
The Netherlands

INTRODUCTION

The lifespan of a building (aprox. 60 years) is a standard in the traditional way of building. Not all buildingparts are suited to serve for such a long period. Some buildingparts with a short lifespan are to be replaced in the meantime. Other buildingparts serve that period without problems and could easily be used for an other period if only the building were not to be demolished.

Reasons for early demolishion are lack of possibilities for reuse of the structure and a system of services that doesn't allow changes to a sufficient degree. Flexibility is the answer to this problem; if a building is capable of adjusting itself to the changing demands it has a strategy to exist for longer than just one period. A significant property is functional flexibility, the ability of a building to be used for different functions.

THE PROJECT

The aim of this project has been to design a building that delivers improved performances for these two aspects. Solutions have been found using (functional) flexibility of the structure, strategically planning the lifespan of buildingparts and developing a buildingmethod which enables dismountable rebuilding. Reuse of buildingparts is an important issue to enable longer lifespan and better quality for certain buildingparts.

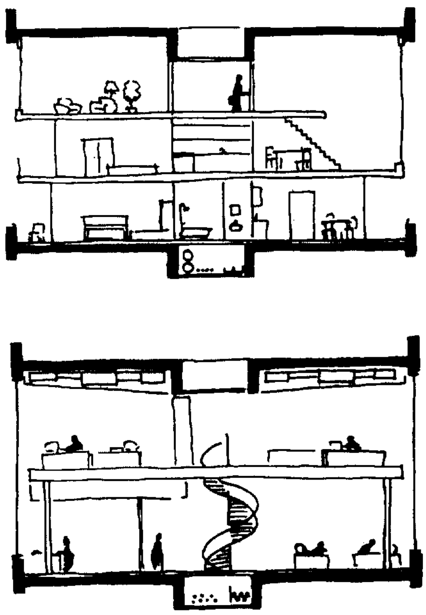

Figure 1. Different functions with different use of space. Above: housing, below: office.

Dividing a building into three layers, each with its own lifetime, and connecting these layers with dismountable joints, both cost of change and waste production can be reduced. Each layer is designed to its own lifetime. The layers are:

- Mainstructure, lifetime > 200 years, flexible, not changeable.
- Substructure, lifetime > 20 years, flexible and changeable.
- Finishing, lifetime > 5 years, changeable, replaceable.

Each layer has its own system of services in order to guarantee the flexibility of the services; they have the same lifespan as the layer they are in. The services are analogous to the layers connected dismountable.

The designs are based on studies on spatial needs of the chosen functions. These functions are offices and houses, the most wanted functions in an urban situation. These studies showed that the mainstructure should have excessive measures in height, depth and maximum floorload to be able to plan different functions in the structure. Designing offices the excessive measures give the possibility of using two stories for large officespaces and three stories for small cells. For dwellings the measures of the mainstructure give the oppotunity to a spatial design.

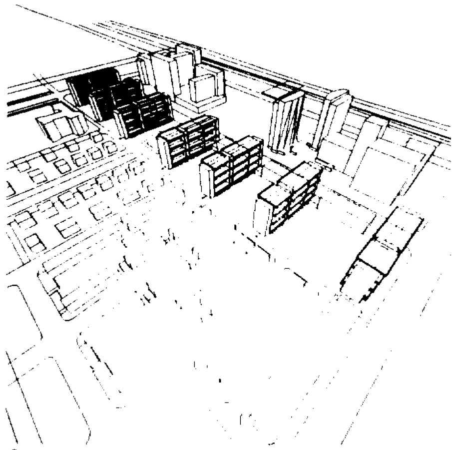

figure 2. Urban situation

The mainstructure is designed in the urban context of the south of Amsterdam. The norht-south positioning is a very important aspect for the amount of daylight inside. The mainstructure offers vertical transport and entrance to big flexible spaces (height, length, depth 9.9m x 22.6m x 19.7m). Services in the layer 'mainstructure' are situated in the middle of the floor between the prestressed beams. They meet in the centre of the building at the mainshaft for services.

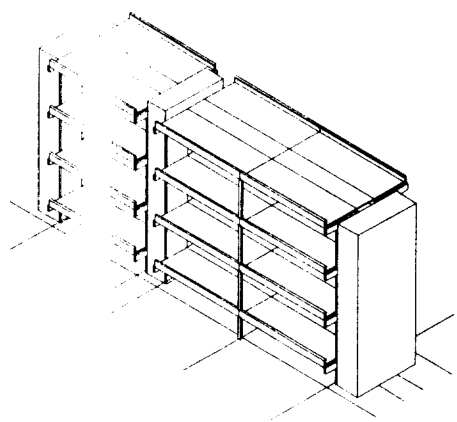

Figure 3. Mainstructure

The substructure is a suspending structure in the mainstructure. It divides the big, flexible spaces into functional units and defines the vertical sections. The design of the substructure focusses on the spatial plan, flexibility, changeablity and reuse of buildingparts. The buildingparts are: suspending columns, beams and floors. Services in the layer 'substructure' are hanging in steel cases.

Building parts in the layer 'finishing' (facades, interior walls, stairs...) are designed to be recycled. Those specific parts are different for each function, and therefore not fit for reuse. Services in this layer are situated in the floors. For this purpose the infra+floor is used. This is a specially devopped product for flexible services. (See reference)

Hanging the substructure in the mainstructure keeps the lower story free from constructive elements. This flexibity is supported by also hanging the services and thus connecting the functions with the mainservice-system above. The services area has been reduced to benefit the flexibility. For example: insulating well and using a so-called 'climatefacade' make it possible to leave out the heatingsystem.

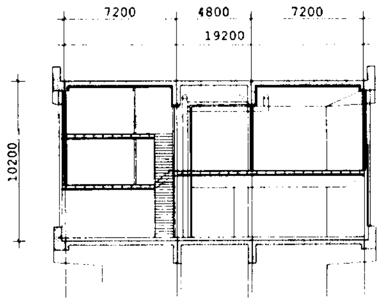

Figure 4. Section mainstructure with substructure and finishing (dimensions in mm).

Due to the flexibility of the building there is to be expected a high rate of change. In order not to hinder other functions while changing one, the vertical transport of building materials is realised trough the midsection of the building. During the rebuild there will not be any transport of material past facades of other functions.

The three layers can make the mangement-structure complex, each layer can be managed by another party. Normally the municipality will be manager of the mainstructure. The spaces in the mainstructure can be let out (empty or built) to companies or housing societies. This of course makes the managingstructure complex, but nevertheless feasible.

CONCLUSION

Drawings of the plan show that the aims are possible. Dividing a building plan into three layers and designing each layer to its specific needs leeds to a better use of environment, time and money. Complicated factors (building management, services) can be dealt with to a sufficient degree.

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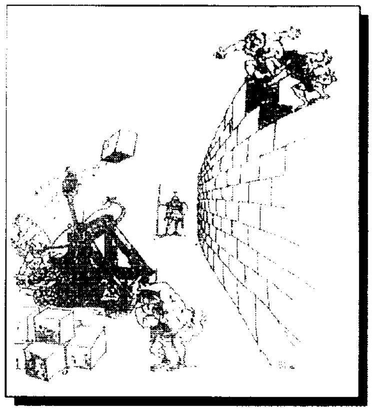
Ifra+floor: Infra+ vloer is a product designed by buro Arch+ in Kelpen in The Netherlands.

THE FUTURE WITH RESOURCE EFFICIENT BUILDING TECHNOLOGIES

Chris Herman Häring, Häring Corp. Ltd., Schlossstrasse 3, 4133 Pratteln, Switzerland

Introduction

The greater prospects of the excellent and multifaceted building material like wood and the lasting utilization of the forests of this earth give us the best opportunities for the survival of the world population.
The regrowth of the wooden biomass on the northern hemisphere is considered to be sustainable.

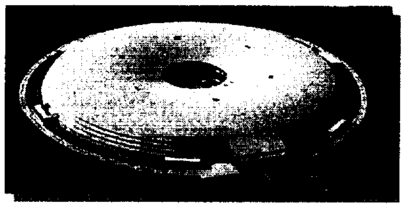


Recognized synergy's in forestry and the building industry lead us to the elements of success of a progressive and lasting economy. In our technologically orientated time we certainly run the danger of "overplanning and overengineering". That means:
"we can't see the forest for the trees".

The pressure of innovation versus old-style construction techniques

It doesn't bother us, that we use old style if not "roman " techniques.

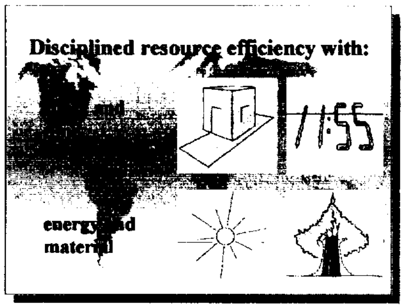
We need new ideas in the European construction industry.



12'000 m^2 of timber roof for the Swiss synchrotron

We need a change in our pattern of behavior to drastically reduce material and energy flows in the economic system. This means we need to massively increase resource productivity.
To raise resource productivity means: we must extract as much services as possible out of a product, a kilogram of material and a kilowatt-hour of energy. The creation of future processes, products and services becomes central.

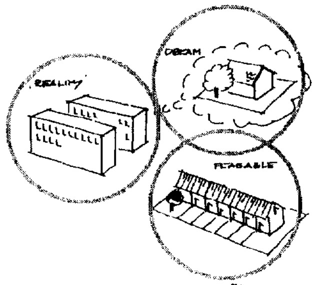
The goal is not only to have a cost effective but also a resource efficient building industry.

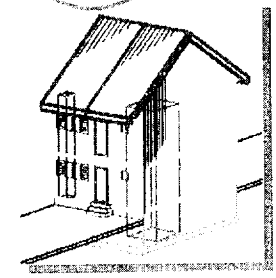


New construction technologies demand a highly disciplined use of the resources:
space and time
energy and material

Space and Concept

The feasible alternative for a human and family friendly society are high density housing estates.
A condition for rational construction is standardization and systematization of building categories. Processed construction systems demand high discipline in the planning stage. The results are intelligent standard-sized modules with a high degree of prefabrication.
Industrially prefabricated large construction modules are made in standardized sizes. They allow architectural freedom of space while enabling dense building. The concept and structure of this technology is convincing and proves to be ecologically wise.
Doubts and constraining regulations regarding sound dampening, fire safety and durability (compared to total building methods) are being solved today with noteworthy technical material developments and are widely being recognized by forward-thinking authorities.





From reality to the feasable dream.

Renewable material

Building with regionally available and renewable materials like wood does not require national high performance production sites. Construction is a regional process with a strong connection to the manufacturing site. Building is low tech. Pragmatically assembled production lines with intelligently linked logistics is very promising. Persistent application of this thinking produces construction systems with wood, which not only save energy, but are also primarily energypoor in their lifecycle.

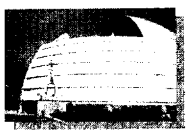
Modular house macro components in NOAH(R) technology

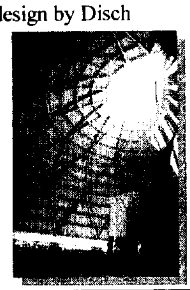
Process time and performance competition

In contrast to the neglect of the resource productivity, the development of higher productivity is in full swing. A real increase in project quality is the result of the reshaping of competition models. These measures will lead to a higher customer satisfaction.

The results of a real performance competition must therefore be the investigation of those projects, which show the best cost benefit ratio taking into consideration investment and operation cost. What we urgently need is not more competition, but more meaningful competition, which provides the owner and the environment with greater benefits.

Modular Solar house, design by Disch





Modular dome structure in Ensphere technolgoy

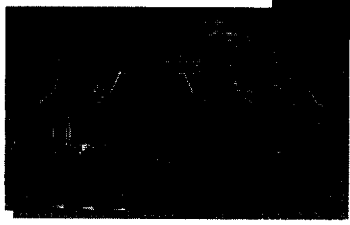
Renewable energy

Our world of tomorrow will still have plenty of energy, if we develop our sustainable resources with foresight, responsibility and respect for the environment.

We are convinced that the heat stored in our globe is the most underrated energy resource accessible to mankind.

In future, geothermal heat will provide clean, reliable, sustainable and economic energy to our society. We are determined to develop geothermal technology in a leading position and contribute substantially to future energy needs.

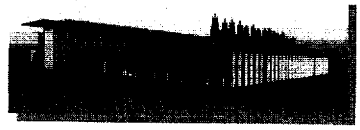
Geothermal energy drilling for low energy estate



Factor 4 rated fast food restaurant

Environmentally – aware construction is not a negation of modern or attractive building.

The shortening of the construction chain combined with resource-friendly technologies provide a leading position. This is the mastery of product and process for total performance.

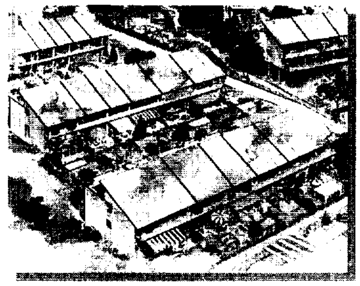


Cartier - jewellery factory in Geneva in timber, under construction

Conclusions

The world markets of tomorrow belong to productions and services created by and using far fewer resources, but retaining more intelligent and pleasurable uses.

Multistory living, industrial, office and school buildings in modern wood construction replace monotonous structures. They take into account the limits of a quality-driven and responsible growth with its' high requirements for sustainable development.
Intelligence, risk-taking and entrepreneur-ship are required.



Solar City in Freiburg (Germany) under construction by Disch

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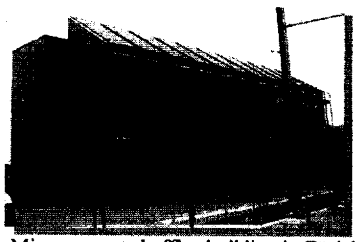


Minergy - rated office building in Zürich

ECO-FLEX HOUSES

ir. M. Kramer, ir. Tj. Deelstra
The International Institute for the Urban Environment, IIUE
Nederlands Instituut voor Duurzame Stedelijke Ontwikkeling, NIDSO
Nickersteeg 5
2611 EK Delft
the Netherlands

INTRODUCTION

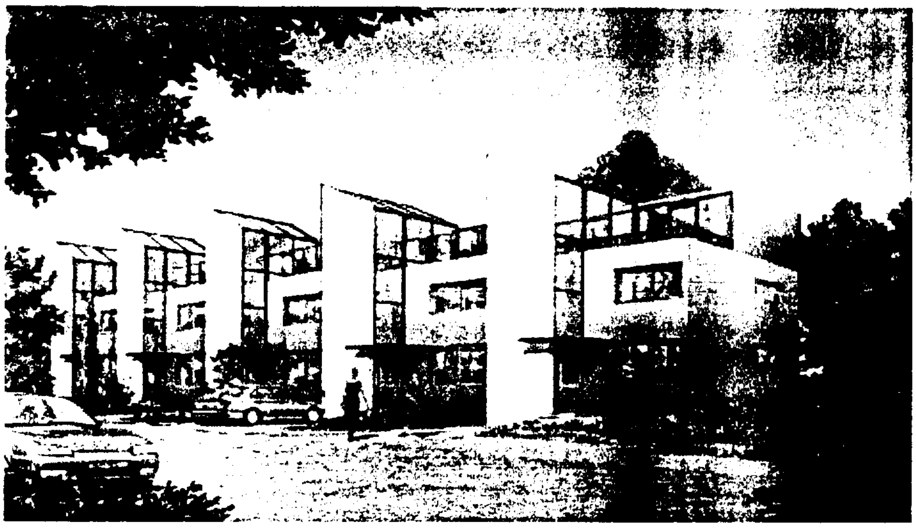
The International Institute for the Urban Environment (IIUE/NIDSO) has designed 14 'Eco-Flex' houses for the town of IJsselstein, near the city of Utrecht in the Netherlands. Project developer is ING property development. The project concept is to create bio-diverse and lifetime-lasting houses. The goal of bio-diverse building means that techniques, systems and materials that are healthy for the residents and the environment are combined to create a healthy indoor-climate and living-environment. Lifetime-lasting building means that the houses are ideally suited to varying lifestyles and circumstances, for example, home-office combination and extended family situations, now and in the future. Building of the houses started in 2000 with completion scheduled for the first half of 2001.

ASPECTS OF THE DESIGN

The idea of the Eco-Flex houses was born out of the experiences of past projects of the IIUE/NIDSO. In several Dutch and other European cities, IIUE/NIDSO undertook projects to create and maintain sustainable housing-areas and improved (urban) environments. In those projects, participation of inhabitants and other users of the city or the specific neighbourhood was very important and valuable. A clear conclusion was that people take more care of their direct environment when they are more involved with its design and maintenance.

In order to create a sustainable social environment in which people want to live for a long time, it is necessary to provide people with the possibility to develop themselves, both in their own house and in their direct living-environment.

In the Eco-Flex project, the parties involved have sought to create a high-quality living environment and houses that can easily be adapted according to the wishes of the inhabitants. In addition, they have aimed to achieve a healthy indoor and outdoor climate.



Healthy Living Environment

The houses are situated on the edge of IJsselstein's new Zenderpark district, in which eventually about 4000 houses will be built. In the immediate vicinity, sufficient possibilities for children of several ages to play are necessary. Near the houses a big playground is planned which, especially for older children, is a perfect place to play football and other games. Children of the whole neighbourhood will come and play here.

In front of the14 houses is a gravel basin for the collection of rainwater from the roofs and the street. Around the basin, a play area for the younger children has been planned.

While each house has a private front and back garden, the architect and developer decided to reduce the individual backyards slightly in size and create extra public space. The municipality will use this space to create a play facility for the youngest children of the area.

Finally, the 14 houses and their surroundings will be enclosed by hedges in which all kinds of small animals can find a place to live.

Flexible and life-time lasting

The goal of lifetime-lasting houses will be achieved by the flexibility offered by the houses.

New inhabitants were given a choice of house type that they wished to buy. They could choose from five types of houses, each with different lay-outs and/or sizes. In addition, the new residents had the opportunity to design their own preferred size and lay-out: only the stairs, the toilet and the location of services were fixed.

The flexibility of the houses also includes the adaptability of the floor plans and sizes in a later phase, achieved through the concept of a 'core building' with detachable facades and an innovative floor system.

The houses consist of two main parts: the core in which the main functions are situated, and the floors with free floor plan possibilities.

In the core the toilet, the stairs and the service pipes are situated. The core's glass facade is situated to the south in order to collect heat from the sun.

The 'free floors' around the core give the residents the possibility to create their own floor plans. Use of detachable internal walls makes it easy to change the lay out of the house at any time. Kitchens and bathrooms can be situated almost anywhere in this free space as on each level there are two places to connect fittings to the pipe systems in the core.

To give the inhabitants even more freedom to make their own lay-out, now and in the future, an innovative floor system is used in which all pipes are directly accessible and can be installed in any direction. This floor makes it easy to change functions later.

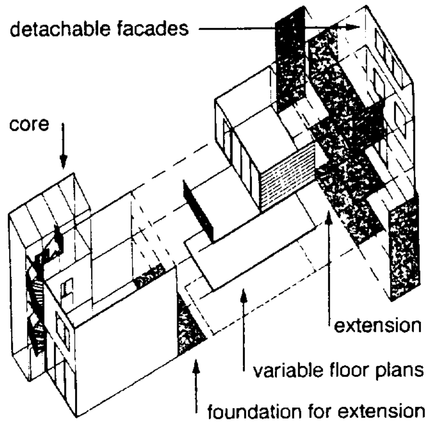
Looking ahead to the longer term, the houses have the possibility to be extended. Foundations for such an extension have been constructed already in the backyard. The rear-facade of the houses is a pre-fabricated element made of wood. In a later phase this element can be detached easily to allow the extension. Afterwards it can simply be re-attached. Future extension of the house will thus use less building materials than normal and because of the re-use of the (pre-fabricated) rear-façade, less building-waste will be produced.

Energy

The houses have natural ventilation. Fresh air will enter directly from outside through air-grates. Part of the fresh air comes in via the core and is heated by the sun. The other part comes directly from outside. Natural ventilation is used to avoid the need for pipes for air-delivery in which bacteria can live and cause negative effects on air quality.

The air is removed mechanically through outlet pipes. This heated waste air passes through a heat exchanger and boiler in which the warmth is re-used to heat water for showering and other household tasks. Part of the electricity for this process is delivered by photovoltaic cells on the roof of the core.

To reduce energy losses, the houses have been insulated to levels higher than required by the Dutch sustainable building standards



CONCLUSION
The building of the houses has not yet been completed, so the experiences of the residents cannot yet be described.
Nonetheless, the process of designing and building preparation teaches us several important lessons. When new, more sustainable building features are included in the design, for example heating techniques or photovoltaic energy, one should be aware of its higher costs. This is especially true in the normal situation in which the developer has to pay the extra costs of these innovations, and is not sure if he will get his investment back. Prices of houses in the Netherlands are still based on the size of the area upon which they are built, and on the surface area and volume of the house and not on the new techniques included. Buyers are willing to pay a little more for such things but when prices become in their view too high because of these features, they will simply choose for a larger house.
It was striking that, in spite of giving the new residents lots of choice in unusual house lay-outs, almost all chose for a 'typical' family house. Depending on their purchasing power, the buyers chose to have either a larger living room at ground floor-level or an extra bedroom on an upper floor. In the same house they could also have chosen a lay-out allowing them to start a company or live upstairs in a two storey living space with a nice view.
The location, a new area in which lots of young families are to live, is the main reason for these choices. Living environments closer to the centre of cities demand more varied houses and floor plans.

Fortunately, these Eco-Flex houses, occupied by people who will change during their lives, and each in another way, can grow and change with their owners.

METHODOLOGIES FOR MAPPING THE PRIORITIES IN BUILDING ENERGY REHABILITATION AT URBAN SCALE

M. Beccali, G. Solaini
DITEC, Politecnico di MilanoVia Bonardi 3, MILANO 20133, ITALY
tel +39-02-23995106, fax +39-02-23995118; e.mail: beccali@mail.polimi.it

The rehabilitation of the building stocks represents a primary task in order to save energy and to reduce pollution connected to energy conversion processes at urban scale. Considering the significant reduction of new building activities, refurbishment has today acquired a crucial importance within the public and private activities concerning housing management. The paper presents part of activities related to the SAVE contract "Energy Rehabilitation Methodology For Buildings Located In Urban Areas" (no. XVII/4.1031/Z/97-113). Aim of this work is to define a methodology that allows to represent on a cartographic base (i.e. to map) the "demand of energy rehabilitation.".

INTRODUCTION

In order to build-up a map of the rehabilitation demand it is at first necessary to operate an analysis of the building stock. The modalities of realisation of such mapping depend obviously on the degree of detail at which the analysis is developed. The methodologies are different according to the scale and then, to the nature and quality of the available information.

The mapping can be developed at different levels of the territorial scale:

- urban scale (or metropolitan area)
- urban scale, but narrowed to a fraction of the park (for instance the stock of the social housing)
- district scale or small groups of buildings

Different scales correspond to different objectives, in terms of analysis and interventions.

Mapping at urban scale corresponds to a preliminary analysis concerning the whole city building stock, with the aim of individuating the most degraded areas. Such analysis is an essential tool in order to promote energy rehabilitation interventions, by using suitable promotion policies and by stipulating agreements with different institutions. Obviously, in this case the deterioration index is necessarily a very general one, mainly based upon statistical remarks.

The reduced urban scale, narrowed to a fraction of the urban building stock, is particularly advisable in the case of a single owner (namely, the Social Housing Authority): actually, this condition allows to have at disposal the data collected by the Authority itself, and therefore to elaborate more specific parameters. The objective of such analysis is to single out the most degraded building groups, when economical resources are available for buildings rehabilitation.

The identification of most degraded building groups allows to further reduce the scale in order to single out, among the identified groups, those which need most urgently rehabilitation interventions. Being, in this case, the number of considered buildings smaller, it is obviously easier to perform a more accurate analysis, which permits to individuate the best available technologies and to perform a cost-benefits analysis.

On then basis of the foregoing remarks we must point out that the urban scale analysis (point 1) is not necessarily targeted and therefore it is not necessarily connected to more detailed surveys (point 2 and 3): this may happen when a particular building stock is identified (for instance, public buildings, or historical ones).

Once data and information have been acquired, it is necessary to proceed to their

elaboration in order to calculate some synthetic indexes allowing a representation on a map of the rehabilitation demand.
In the following a procedure will be described in order to calculate the rehabilitation coefficients, both for the wide urban scale and for a selected stock (i.e. social housing).

URBAN SCALE INDEXES

The knowledge of the data concerning the geometry of the building (volume, heat loss surface, glass/opaque ratio) and its thermophysical characteristics allows the calculation of the global heat loss coefficient (C_g).
The C_g coefficient is defined as follows:

$$C_g = c_{p(air)}\, n + \Sigma_i\, U_i\, S_i\, /V$$

where:
$c_{p(air)}$ is the air heat capacity at constant pressure in Wh/m^3K;
n is the number of the air changes/hour in h^{-1};
Ui, S_i are the U-values and the areas of building envelope elements;
V is the building heated gross volume
The C_g coefficient, measured in W/m^3K, is calculated on the basis of the available U-values, which are generally deduced from the definition of sub-sets of the park according to a consistent differentiation of the construction technologies. The areas of the opaque or glazed closures, as well as those of the roofs and of the on-ground surfaces, can be assessed starting from the values of:

- Average ratio surface/volume (m^2/m^3)
- Heated gross volume (m^3)
- Built surface (m^2) or height (m)
- Average ratio glazed/opaque surfaces

The C_g coefficient represents in a extremely synthetic way the performances of the building in relation to its form and to its constructive characteristics.
An Energy Conservation Opportunities parameter (ECO) can be defined as follows:

$$ECO = 1 - \frac{C_{gref}}{C_g}$$

where C_{gref}: is the C_g value which must comply with law.
Obviously, the higher the C_g value, the higher is ECO: consequently, the ECO highest values refer to cases in which rehabilitation is more urgent and more convenient from the energy point of view.
This value could be adopted as a first-stage index of the rehabilitation demand, in the sense that it is able to highlight the effectiveness, from the energy point of view, of possible refurbishment of the whole building.
Mapping this ratio for an urban area could help decision makers in the choice of most "sensible areas" in the sense of poor energy quality of the buildings.

REDUCED URBAN SCALE INDEXES

It must be clear that C_g does not contain any information related to the estate of maintenance of the building envelope except for the effects related to the degree of insulation that it implies.
As far as a section of the urban building stock is concerned, it is possible to achieve a more detailed information regarding building deterioration.
For this purpose we suggest to use, beside the ECO parameter, two more coefficients:

- BDC: coefficient of deterioration of the building
- PDC: coefficient of deterioration of the plants

both varying from 0 to 100.
The accuracy of the calculation of the coefficients depends on the nature of the available information. We remember that the information related to the buildings are deduced by a statistical analysis or by rapid on-field audits.
In absence of data related to the heating plant the PDC should be assessed directly and subjectively by the auditor. This could lead to significant differences among the judgements and generates a lack of meaning to the index.
In addition to that, technical laws generally state compulsory controls, on the basis of given efficiency standards, on the maintenance of heating plants and this facts implies that technicians are bound to acquire a certain degree of knowledge of the heating plant stock.
Consequently, we suggest to avoid the assessment of PDC except when it can be calculated through a specific audit.

On the other hand, at urban scale it is not possible to achieve information concerning the BDC. At smaller scales it can be calculated by generally available information:

- the level of maintenance of vertical opaque closures
- the level of maintenance of glazed closures
- the level of maintenance of roofs

It is important to state that such index merely concerns the degrade of the structures and of the finishing of the building, independently of its energy performances. It indicates to the decision maker the importance of the degrade in a general sense in order to help him in the selection of the most critical cases.

Calculation of the BDC

As previously stated, the description of the estate of the building is obtained by a synthetic evaluation of the degree of degrade of three main elements of the envelope.

Such evaluation can be expressed through a number, ranging from 1 to 3, to which is associated the following meaning:

code 3: good estate;

code 2: partially degraded;

code 1: strongly compromised

To each of these coefficients a weight must be associated. The "weight design" has been made according to the following considerations:

- each of the three elements has the same importance as the others, in terms of "discomfort" that its degrade could cause to the occupants
- a building with three elements "strongly compromised" must have the maximum BDC (100)
- a building with only one element "strongly compromised" must have a BDC higher than a building with three elements "partially degraded"

Due to the previous statement, it is clear that:

- the weight depends univocally by the degrade of the element and is the same for the three building elements
- the sum of weights associated to the code 2 must be less than a single weight associated to the code 3.
- the sum of the weights of the code 3 must be 100

In conclusion the weights are 0 for the code 3, 10 for the code 2 and 33.3 for the code1.

For each building, the sum of the values corresponding to the evaluation of the three components will be equal to the assessed BDC.

The Building Rehabilitation Need coefficient

Once BDC and ECO have been calculated, it is possible to obtain a synthetic coefficient of the Building Rehabilitation Need (BRN), defined as follows:

$$BRN = [ECO \times 100 + BDC]/2$$

ranging between 0 and 100.

This index will include the expected effectiveness of the "energy-side" rehabilitation together with an assessment of the general deterioration of the building.

Obviously, the highest values refer to cases in which rehabilitation is more urgent and more convenient from both the energy and the rehabilitation point of view.

The representation on a cartographic base of the index BRN will allow to highlight the rehabilitation demand on the geographic area.

However, in order to have the most useful representation of the deterioration problem, it will be useful to produce also two separated maps, one related to ECO, the second one related to BDC.

FINAL REMARKS

The methodology described in this paper represents a very useful and flexible tool, when large stocks of buildings are considered.

Its effectiveness was proved both when the whole city of Palermo and the social housing stock of Milano (about 100,000 flats) have been analysed.

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The Environmental Implications of Building New *versus* Renovating an Existing Structure

Wayne Trusty and Jamie Meil
ATHENA™ Sustainable Materials Institute
P.O. Box 189, Merrickville, Ontario, Canada, K0G 1N0

INTRODUCTION

This case study demonstrates the value of using the ATHENA™ life cycle assessment (LCA) tool during the conceptual design process in two ways:

1. to gauge the environmental implications of retaining the structure and envelope of an existing building instead of replacing it with a new structure; and
2. to help weigh building performance goals against design and material mix choices for a new building.

THE CASE STUDY BUILDING AND METHODS

As the basis for the assessment, our analysis drew upon two versions of an office building design prepared for Natural Resources Canada's C2000 Building performance program. The design basics, common to both versions, include a single basement level and 13 above grade floors with a total gross floor area of 21,740m^2. The two versions of the building, which are characterized in terms of operating energy performance as the ASHRAE 90.1 and C2000[1] versions, differ in their respective fenestration type and area, overall insulation level, and HVAC system efficiency.

Table 1 below outlines both the common and different elements incorporated in the ASHRAE and C2000 designs as well as the operating energy use estimates.

Table 1 — Design/Energy Use Summary: ASHRAE & C2000 Office Building Versions

Building Parameter	ASHRAE 90.1 Design	C2000 Design
Structure	Concrete drop panel system	same
Envelope Exterior cladding	40%Brick/60% curtain wall combination	same
fenestration	22%, double pane, low "E"	37%, triple pane, Low "E"
Insulation level	Approx. R 22	Approx. R27
DOE2 Operating Energy Est.*		
HVAC	102.6 kWh	39.7 kWh
Lighting, plug load, etc.	77.4 kWh	42.3 kWh
Total Operating Energy	180 kWh	82 kWh

Note: * DOE 2 simulation results were provided in the original C2000 program report.

The scope of the environmental LCA undertaken using ATHENA™ was limited to the office building's initial structure, envelope components and related annual operating energy. This limited focus was necessary due to the objectives of the study itself, which did not require study of common elements in the comparative scenarios. The results therefore underestimate the total life cycle environmental impacts of constructing a new building.

ATHENA™, the Institute's environmental life cycle assessment decision support tool, has been under development since the early 90s. The ultimate objective is to assist the building community in making more informed decisions regarding the selection of design and material options that will minimize a building's life cycle environmental impact. The model summarizes results across six key environmental measures covering initial (embodied) energy use; weighted raw resource use; greenhouse gas emissions (both fuel and process generated); measures of air and water pollution; and, solid waste emissions.

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[1] The objective of the C2000 Program is to promote the adoption of leading-edge technologies and building management techniques to attain a very high performance – a 50% improvement in operating energy over the ASHRAE 90.1 standard

RESULTS

Initial New Building Impact (ASHRAE & C2000 Performance Designs)

Tables 2 below summarize the office building environmental life cycle assessment results for the two performance designs by component grouping on both an absolute and per unit of floor area basis. The first year operating (HVAC) energy effects per m^2 are also reported.

Table 2 – Summary: Initial Environmental Impact Profile by Performance Design

Design by Assembly Components	Embodied Energy Gj		Global Warming Potential Eq. CO_2 tonnes		Weighted Resource Use tonnes		Solid Waste tonnes	
	Ashrae	C2000	Ashrae	C2000	Ashrae	C2000	Ashrae	C2000
Structure	25414	25414	6829	6829	25674	25674	1140	1140
Envelope	7873	9032	1132	1369	1501	1623	163	176
Total	33246	34446	7961	8198	26875	26997	1303	1316
Per m^2	1.53	1.58	0.37	0.38	1.23	1.24	0.06	0.06
HVAC Energy (per m^2 per year)	0.39	0.15	0.14	0.03	0.05	0.06	<0.01	<0.01

Note: Global warming and other effects of HVAC operating energy reflect the upstream production and transportation of energy as well as its combustion. Air and water pollution effects, while calculated, are not reported here to save space

Both the ASHRAE and C2000 performance designs share the same structure, which accounts for roughly 75% of the building's initial embodied energy burden. But the C2000 version incorporates about 15% more embodied energy in its envelope materials compared to the ASHRAE design. Overall, then, there is only a 4% difference between the two designs in terms of embodied energy for their respective structure plus envelope materials. For the C2000 design, the modest increase in material use contributes, in combination with increased HVAC efficiencies, to a 2.5 fold improvement in annual operating energy use.

It's notable that as operating energy efficiency improves, the importance of the initial structure and envelope embodied energy increases. In the less efficient ASHRAE design, initial embodied energy is equivalent to about 4 years of HVAC operating energy use, but in the C2000 design, initial embodied energy is equivalent to approximately 10 years of operating energy. The relative importance of embodied energy would be even greater if the estimates covered all of the recurring as well as excluded building elements.

While contrasting the embodied energy of the structural and envelope materials with operating energy is useful, the shear enormity of the total energy involved can easily go unnoticed. To help humanize the results we made a quick calculation which revealed that the energy embodied in the structure and envelope of the ASHRAE design is equal to driving a small car (consuming 8L/100km) a total of 12 million km or 300 times around the earth.

In summary, just building a new square meter of ASHRAE performance level office floor space –

a) requires 1.53 Gj of energy and 1.23 ecologically weighted tonnes of raw resources;
b) produces greenhouse gases equivalent to 370 kg of CO2;
c) requires 19.7 cubic metres of air and 2 cubic metres of water to dilute these pollutants to acceptable levels; and,
d) results in 60 kg of solid waste going to landfill.

This conservative assessment clearly demonstrates the significant environmental impacts related to materials comprising a new building, impacts that become relatively more significant as steps are taken to improve a building's operating energy.

Environmental Impact Avoidance Associated with Renovating

When choosing to renovate, a building's structure is typically retained but the original envelope may or may not be left intact. So environmental impact avoidance scenarios for a major retrofit/renovation involve contrasting a complete demolition and new construction activity with:

a) retention of the structural system only and estimation of the environmental impacts avoided by not demolishing the structure (minimum avoided impact case); and
b) estimation of the impacts avoided by not demolishing either the structural system or the envelope (maximum avoided impact case).

Minimum Avoided Impact Case
The minimum avoided environmental impact case involves saving only the structural system of an existing building, with reconstruction of the rest of the building. The avoided impacts equal the effects of:

demolishing a structural system + rebuilding a comparable structural system.

Here the effects of demolishing the envelope are not avoided and we assume that the environmental cost of rebuilding the envelope on an old building would be the same as constructing the envelope on a new building.

Maximum Avoided Impact Case
This case involves saving the envelope as well as the structure and avoided impacts equal the effects of:

demolishing a structural/envelope system + rebuilding a comparable structural/envelope system.

Table 3 summarizes the energy savings and other avoided environmental impacts for the *maximum* avoided impact case. The results for the minimum avoided impact case, in which only the structural system is retained, can be readily derived from the estimates in Table 3 by simply subtracting the values for constructing the envelope in each impact category.

Table 3 – Results Summary: Environmental Impact Avoidance Scenario

Design by Assembly Components	Embodied Energy Gj	Global Warming Potential Eq. CO_2 tonnes	Weighted Resource Use tonnes	Solid Wastes tonnes
Structure Construction				
Below grade	2183	636	2746	
Above grade	23231	6193	22628	94
Sub-Total	25414	6829	25674	1046
Envelope Construction				
	7873	1132	1501	1140
New Construction Totals				
	33246	7961	26875	163
Per m^2	1.53	0.37	1.23	1303
Demolition Energy[1.]	3073	1848	304	0.06
Total Avoided Impacts				
	36319	9809	27179	831
Per m^2	1.67	0.45	1.25	2134

Note 1: Demolition of cast-in-place structure only; no demolition effects available for envelope materials.

The above table does not consider the eventual operating efficiencies of the new versus renovated buildings, another factor that may have a bearing on the decision to build or renovate. Unfortunately, however, the data is not available to adequately include this aspect.

To put the Table 3 results in perspective, we can compare them to the results for construction and operation of a new C2000 building presented in Table 2. By reusing the structure and envelope of a building and thereby avoiding demolition of these component systems, the total energy saved approaches the energy used to construct the C2000 office building and operate it for a year. Alternatively, the total environmental avoidance is equivalent to 10 years of HVAC operating energy for the C2000 office building design. Either perspective indicates that the avoided environmental impact is indeed, significant.

THERMOPROFIT PLUS – NEW SERVICES FOR THE ECOLOGICAL RENOVATION OF BUILDINGS

Wibke Tritthart (1), Harald Rohracher (1), Christian Gummerer (1), Boris Papousek (2)
(1) Inter-University Research Centre for Technology, Work and Culture (IFF/IFZ), Schloegelgasse 2, Graz, Austria
(2) Graz Energy Agency, Kaiserfeldgasse 13, Graz, Austria

INTRODUCTION

The City of Graz, Austria, is about to set up a programme called "Thermoprofit Plus" to explore the possibilities of new services for the ecological renovation of buildings. "Thermoprofit Plus" is supported by the LIFE-Programme of the European Union and is managed by the Graz Energy Agency. The goal of the programme is to prime-pump a regional market for new building services aiming at a comprehensive ecological retrofitting of the existing building stock. Strategies include model projects; the optimisation of criteria for calls for tenders that will be used by the City of Graz for future construction projects and criteria to assess the different offers. This paper reports results of some background research on possible barriers and opportunities of such a programme.

CURRENT SITUATION

Graz, the capital city of the Austrian province of Styria, is a city of about 240.000 inhabitants living in 103.000 dwellings or 32.000 buildings. Graz has a remarkable and well preserved old town, that recently has been added to the UNESCO cultural world's heritage. Buildings of this part of the city are mostly 80 to 300 years old. Strict preservation requirements must be met. However, beside those historic buildings, the building stock dated from 1961 to 1980 comprises about 10.400 buildings of usually poor thermal standard and therefore is a candidate for renovation.

The establishment of services to promote ecological refurbishment is bound to sufficiently take into account the various actors involved in decisions about renovations, the legal situation as well as the availability of additional funding. When it comes to a decision on renovation, the first important person is the owner. In residential estates that are rented, the tenants also have quite distinct possibilities to determine this decision. Their rent is on a guaranteed level, at least for the dwellings owned by the City of Graz and of co-operative social housing organisations in Graz.

In any case the organisation that is responsible for the housing administration plays a crucial role.

Such organisations decide on minor renovations that are solely maintaining the structure of the building or on renovations that include improvements of the building.

Innovative housing administrations are in the position to propose comprehensive, ecological renovations and to influence the decision on ecological improvements, both in buildings owned by landlords and in those rented out.

Another important factor is the possibility to get subsidies for certain types of renovation. Subsidies are granted by the provincial governments for so called 'comprehensive renovations' that reach a standard according the building code for new buildings. In the majority of cases such renovations focus on the facade, returning a U-value of at least 0,5 kWh/m^2, on the upper ceiling and the heating system (e.g. replacing old coal furnaces with district heating or efficient gas heatings). Subsidies of 25% respectively 50% are given on the rate of the loan, when the amount of money per dwelling exceeds a sum of 7250 Euro respectively 22000 Euro. No extra funding currently is available for "Thermoprofit Plus"-model projects.

Not only the renovation measures itself are subsidised but also the rent in a renovated building – if the tenant fulfils certain social criteria, that is a maximum net income level per year.

ATTITUDES ON ECOLOGICAL RENOVATION

In the course of the EU-SAVE-Project "Ecology of the Rehabilitation of Old Buildings" [1], the owners of single family homes, the tenants and the owners of flats in multi-family homes have been interviewed. Another series of interviews was conducted with professionals in the construction business.

Owners of single-family homes were the only group of persons that showed significantly higher interest in ecological issues of renovation of their home. Specifically, the interest was highest for 30 to 40 year old persons. Retired persons usually didn't want to renovate: "My son/daughter should do this, when he/she moves in.", is a typical answer.

To reach a pro-renovation decision at all, is very difficult in multi-family houses with many owners. Especially those, who have let their flat, are likely to disagree.

Tenants on the other hand often fear they have to move out for some months, when a comprehensive renovation is planned. Only tenants who are suffering from construction-related problems, like thermal bridges, are interested in renovation.

The best arguments – far ahead of healthier living conditions and less energy consumption – are gains in comfort and reduction of operating costs.

Among professionals, plumbers were the group mostly engaged in promoting ecological refurbishments. Subsidies for solar thermal collectors and for biomass heatings have raised demand and created a new market for installers. Moreover, do-it-yourself-markets had a role in directing interest to ecological products, additionally offering some basic planning advice. Builders and construction companies in turn were quite sceptical towards ecological renovation and often would not even give an interview.

Interviews with central actors in Graz are also part of the "Thermoprofit Plus"-Project. The following passages summarise the results of interviews with several officials of the City of Graz (department of housing, department of urban planning, department of building administration) and with authorised persons of five social housing companies. These institutions are in charge of 2/3 of all social housing estates in Graz.

The questions were grouped around following subjects: the process of getting houses renovated: competencies and practice, statements on ecological renovation in general and on various aspects, especially on energy saving measures, barriers for ecological renovations and possible strategies to overcome these problems.

The City of Graz as well as the social housing companies have been writing and announcing calls for tender on their own. Usually those tenders are not functional descriptions with desired specifications, but very detailed descriptions of each task. Functional descriptions would leave it up to the contractors themselves to choose their own best solution, e.g. to reach certain standards of energy consumption or ecology that are required. The problem with the current standard procedure, i.e. detailed specification of sub-tasks is their inflexibility. Those calls are based on the same electronic database called "Standard-Leistungsverzeichnis", which generally does not contain any ecological options. Some social housing companies do also ask for "alternative offers", which – in future – could also be used to ask for "ecological options". To hand over the project to a general contractor is done rather seldom. Apparently the institutions interviewed do not want to loose control over the whole process, justifying it with: "So we can guarantee the best price for our clients."

Interviewees didn't show much fantasy regarding what elements of an ecological renovation could be. The only strategies mentioned were energy saving measures and ecologically sound materials. Speaking about barriers and impediments they started to complain about how difficult it is to achieve a positive decision among tenants or owners of flats. Possible strategies would be to motivate dwellers in meetings, to discuss about energy balances and cost-benefit-calculations, or to give ecological advice. How-

ever, this cannot be covered by social housing companies themselves.
Only a few of the social housing companies are experienced in several different construction techniques including e.g. modern timber-frame construction. Ecological materials often have a negative image as being less durable and requiring more maintenance work. The interviews show that information and model-projects in these fields are still lacking.

SERVICES FOR ECOLOGICAL RENOVATION

Under the brand "Thermoprofit" a performance contracting programme of the City of Graz together with the Graz Energy Agency has been started recently.
A first step has been to initiate a network of companies that offer a complete set of energy saving measures, that range from renewing the heating and heating control system to insulation of the building envelop. "Thermoprofit"-companies are working out (detailed) energy analyses of buildings, they assess the energy saving potentials and guarantee for them, manage and control the implementation of measures planned, sometimes pre-finance the project and take over the permanent optimisation of the renewed technical systems. To get the approval they have to submit a reference project that shows the competence of the company in the fields of planning, construction, operation, maintenance and financing and that fulfils all requirements (reduction in energy consumption, increase in comfort, extensive services). During last year four companies (from the building automation business and energy service suppliers) have got the certification "Thermoprofit"-company.
"Thermoprofit" is a precursor of the "Thermoprofit Plus"-programme that is presented here. The chances and impediments of this service are just being studied and the specifics of this "brand" are still to be defined. "Thermoprofit Plus"-companies should add ecological expertise to their offers. Other ecological indicators, that are based on Green Building Assessment, will be integrated (e.g. environmental loading, reduction of waste and rubble, etc.).
An essential factor of success will be the response of building owners and companies that are offering housing administration and building management services. It is one of the most important tasks of the Graz Energy Agency to stimulate the demand for ecological and for energy saving renovation measures. Until now 12 projects, among them schools, residential buildings and administration buildings, have been established as "Thermoprofit"- projects. The Graz Energy Agency is continuously involved in discussions with owners and their representatives, especially with the City of Graz, with other local authorities in Austria and with social housing companies to spread the ideas of performance contracting and – in future - to show possibilities of sustainable renovation. The three model-projects that will be renovated as a starting point for "Thermoprofit-Plus" within the next two years will play a central role in the acceptance of the idea and the stimulation of follow-up projects.
The ecological measures that will be realised in the first model-project, a multi-family house with about 30 dwellings where only the facade and the common spaces (stairs, loft, cellar) are renovated, comprise: perlite as insulation material for the upper storey (loft), stone wool instead of polystyrol for the facade, mineral instead of synthetic plaster, wooden window frames instead of synthetic ones, halogen-free installation materials, ecologically harmless paintings, besides energy relevant measures like increased thermal insulation, avoiding thermal bridges at the balcony and a (mandatory) switch to district heating.

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The Angus Technopole
Social innovation in the urban redevelopment of a brownsite

Jacques Charest, Société de développement Angus, Montreal, Quebec, Canada
Guy Favreau, Ædifica Architecture + Engineering + Design, Montreal, Quebec, Canada
George Mezzeta, Public Works and Governmental Services Canada, Montreal, Quebec, Canada

The context

For the past eight years, the district of Rosemont, once a prosperous Montreal industrial area, has been and continues to be the stage of a major economic reconversion project. The goal of this project is to create a technological business park in the lot left vacant with the closure of the Angus Shops in 1992, in order to stimulate development within the district and surrounding community. Contrary to classic voluntary reconversion experiments of this type, where the government is the main player, this initiative was set in motion and is directed by a local organization, the Société de développement Angus (SDA).

The Angus Shops were owned by the Canadian Pacific (CP), a major Canadian holding company. Inaugurated in 1904, during the first half of the century, the Angus Shops constituted the most extensive industrial complex in the country, and one of the largest and best equipped construction shops in America. Its main activity was manufacturing rolling stock for the railroad industry. In addition to providing work for nearly 100,000 Montrealers over the course of the century, the Angus Shops were responsible for the rapid urbanization of the neighbouring areas as well as the development of a large number of businesses in the downtown core.

Changes in the Canadian economy during the post-war years had a major impact on the railroad industry. In the mid 1970's, CP was forced to shut down half of the site. The dismantling process continued over the years until January 1992, when the premises was completely and permanently shut down.

The closure of the Angus Shops brought forth the issue of the site's redevelopment. CP planned to transform its remaining 4 650 000 square feet of land into a residential and commercial district. However, whishing to preserve the site as a pillar of the local economy, the community lobbied the local economic development corporation, the CDEC Rosemont-Petite-Patrie, to get the municipal administration to maintain the industrial vocation of the premises.

Negotiations conducted in 1995 led to the signing of an agreement between the CDEC and CP maintaining the industrial vocation of half the site. The CDEC then set up the Société de développement Angus (SDA), a non-profit organization, and entrusted it with the mandate of acquiring and developing the industrial site, which would become the Angus Technopole, in accordance with the principle of community economic development. SDA's main goal was the creation of 2,000 on-site jobs over a ten-year period. The SDA would offer these businesses within the Technopole a wide range of quality support services and would play a pivotal role in the local economy through the realization of projects complying with the social and economic aspects of sustainable development.

In 1998, after receiving the support of various levels of government as well as several private organizations, the SDA launched phase one of the development of the Angus Technopole. A hundred-year old locomotive workshop, the Locoshop, the only remaining building of the former Angus Shops, was modernized and transformed into a multi-functional industrial center.

The Locoshop was inaugurated in June 1999 in the presence of over 1,000 local players, the very ones who had refused to accept the disappearance of their industrial zone in 1992. The project has since received wide acceptance from the community, as well. Apart from having been the subject of numerous articles in both business and architectural press for the integration of ecological criteria in its transformation, the Locoshop was selected to represent Canada at the International Conference Sustainable Building 2000.

Although this initiative is still in the early stages – the process of local revitalization through social innovation of community actors being a long-term process –, the Angus Technopole project is already a great success. Today, only after one year of operations, the 9,300 square meters of the Locoshop are fully occupied, a year earlier than what was initially expected. Almost 200 people are now employed on the premises.

And this is only the beginning. As it moves into the second phase of development, the SDA is endeavouring to attract as many businesses as possible to the Angus Technopole in order to maximize the potential of the site. Construction of new premises in architectural harmony with the Locoshop and which conform to the environmental and social objectives of the SDA are on the drawing table. The SDA's primary objective remains however the job creation for residents of the district and surrounding community. The creation of two hundred additional jobs are anticipated for 2001, leaving about 1,600 for the SDA to meet its goal.

The project

The Rosemont district is located adjacent to the downtown core, well within the heart of Montreal's urban conglomeration. It is extensively built-up, with very few available sites suitable for building, and none the size of this site's overall area. Despite its relatively precarious economic situation, it is, along with its neighbouring Le Plateau and Le Centre-Sud districts, a vibrant an diversified community, lending its own character to the cosmopolitan makeup of Montreal.

Integration to the neighbouring urban fabric in a continuous, seamless way was a major concern throughout the planning phases. The scale and character was to be preserved and reinforced, particular attention was given to the linking of the existing grid system and streetscapes, the diversified land uses, the relatively high density, the proximity of existing and new amenities, and the design of new parks and the greening of the streets.

A century of extensive industrial activity has left its mark on the site. As a result, both buildings and soils were subjected to a thorough environmental analysis. A risk management approach was adopted to the site rehabilitation, which allowed for an efficient, cost-effective method.

Simultaneously, a number of market studies were commissioned and showed that an industrial and business park was feasible but the relative high cost of the land required an innovative approach to building design and land use to keep the overall square meter cost within a comparatively low limits. The public charettes and studies showed that opportunities existed to incorporate sustainable urban and building design into the development of the industrial park.

The objective was to transform the Locoshop into a multifunctional industrial center to house small and medium size businesses emerging in various sectors of the new economy, while preserving the spirit of the place. The Locoshop demonstrates the terms of ecological building, with the incorporation of a number of environmental criteria in all phases of its design development. Among these phases were: the de-allocation and the decontamination of old industrial installations, the reutilization of existing materials, the design of new, more efficient installations in terms of optimizing energy, flexibility of space planning, the use of environmentally friendly materials and state of the art construction techniques.

Many of the typical problems of environmental architecture relate to issues such as the lack of strong social endorsement, the over-emphasizing of the technological advantages, and the undervalue of the social and aesthetic aspects where through community involvement avoided. Costs restricted many of the more exotic technological alternatives; a simple low-tech approach to green buildings was, in many respects, the only cost-effective alternative.

To interpret today's environmental advocacy exclusively in terms of technical hardware, without including the much more interesting sources of visual aesthetics and cultural heritage, is to miss on an extraordinary opportunity. The recycling of existing buildings and structures with an approach to adaptive reuse may well be amongst the most innovative areas of architectural practices in the future. This approach maintains the regional texture and scale of cities, helps keep history alive, and preserves a unique civic identity.

Future trends

The true measure of the success of the Angus Technopole project is in the way it has met the expectations of the local community with respect to sustainable economic development, job creation and quality of life and of the environment. It is a good example of what can be achieved when the various community leaders and the local population cooperate to define the framework for the type of development they want for their future.

The success of the Angus Technopole is also attributable to the cooperative and team integration approach between the various technical stakeholders such as developers, land owners, architects, engineers and construction firms encouraged throughout the life cycle of the project (from design to implementation). Compromises had to be made between environmental, economic and technical constraints but these were made without loosing sight of the basic principles set out for the project. Converting a 100-year-old industrial site in the heart of a major city into a residential, commercial and industrial development geared towards the new economy is quite a unique and motivating experience.

The next challenge to all green design should be the integration of buildings and city planning within their context as a seamless fusion of each other. Connecting buildings and urban planning to the cultural context in an age of globalization is a strong ecological statement, as it offers more cultural diversity with less exclusion and more inclusion.

THE BUILDINGS CLIMATISATION ISSUE IN THE ENERGY MASTER PLAN OF THE CITY OF PALERMO- ITALY

M. Beccali, S. Ferrari
DITEC, Politecnico di Milano, Via Bonardi 3, MILANO 20133, ITALY;
tel +39-02-23995106, fax tel +39-02-23995118, e.mail: beccali@mail.polimi.it

ABSTRACT

In the framework of Energy Master Plan of the City of Palermo, a particular attention has been devoted to the civil sector issue as one of the most relevant item of the energy balance of the city. This paper presents the methodology that has been developed and adopted by the authors for the analysis of the energy offer and for the assessment of the demand for the heating and cooling purposes. Starting from an analysis of the building park that has allowed the implementation of a GIS data-base of the buildings and the definition of a set of characteristic building typologies, energy demands have been assessed either at the urban scale, either at smaller scale with the definition of district energy balances. For each one of the 23 districts it has been also assessed the importance of the currently installed heating and cooling systems typologies. Energy policy interventions has been defined taking into account both trends in the offer side (the growth of the natural gas distribution network) and in the demand side (i.e. the dramatic increase of air-conditioning sales). Each action has been analysed in order to assess its effectiveness in the energy saving and reduction of emission issues. Also economic evaluation, such as Cost of Conserved Energy, have been performed.

INTRODUCTION

In the framework of the Energy Master Plan [1] a great importance has been done to the building energy demand for climatisation. Together with a study of the current consumption levels a forecast of the potential future demand has been performed by the analysis of the existing building stock and heating/cooling equipment. An action plan and a set of scenarios have been developed in order to give to policy makers the information required in order to fulfil energy saving and CO_2 reduction goals.

THE MUNICIPAL ENERGY BALANCE

In the energy balance of the municipality, that has been set up for the most recent years, the energy fluxes were evaluated according to their distribution in four main sectors: industry, domestic and tertiary, agriculture, transportation. Energy consumption of domestic and tertiary sector accounts for the 37% of the total. Its trend in the last years was characterised by a very sharp growth still continuing (about 50% in the decade 1985-1995 in domestic sector only).

Two are the reasons of this expected trend: the scarce diffusion, in the past, of heating systems in the dwellings and the current diffusion of air conditioning units. In fact, nowadays only 50-60% of dwellings are fully heated in winter though conventional systems. The rest is partially heated through LPG or electric stoves.

It can be expected, therefore, a more than doubling energy consumption due to the number of the total dwellings still left to be heated and to the contemporary growth of unit energy consumption for heating. Concerning cooling, it must be noted that the comfort demand is growing, and this trend is confirmed by the sharp rising of the sale of air conditioning units and, consequently, of the electric energy consumption.

THE ASSESSMENT OF CURRENT AND POTENTIAL FUTURE DEMAND FOR HEATING AND COOLING

Palermo Municipality has been provided of a GIS data base containing useful information about the age and the geometry of all buildings in the urban area. Such data base allowed to define the geometry and the physical properties for each one of the about 20,000 buildings of the city

Data from the last census (1991) have been associated to each record. In particular these data allowed to associate to each section a prevalent age of the buildings belonging to it.

An on site survey conduced to a sample of about 90 buildings led to the definition of a "Building Typologies Data Base" containing thermophysical information for each one of the 25 typologies that have been defined considering the age and the localisation of the buildings (somehow related to the quality level of it) [2].

By the means of a simplified semi-stationary energy balance algorithm, it was possible, for each building of the stock to assess the final energy demands for heating and cooling (only the sensible part). These figures represent the potential demand on the hypothesis that the 100% of existing buildings are heated and cooled.

The following table shows the results and their comparison to the current final demand as consequence of the current consumption and the efficiencies of installed heating/cooling systems.

Use/Sector	Current satisfied demand	Future Potential Demand	Current Potential
Ambient Heating/ Residential	1561 TJ	4094 TJ	38,2%
Ambient Heating/ Tertiary	1196 TJ	1611 TJ	74,2%
Cooling/ Residential	38 TJ	1798 TJ*	2,12%
Cooling/tertiary	707 TJ	1471 TJ	48,1%

*Assuming that only the 25% of the total volume is conditioned

It is interesting to note that this assessment confirms the high gap existing through the current demand (related to the assessed consumption) and the potential future one, especially for the residential sector. This fact assumes an hyperbolic dimension for the cooling issue. On the other hand tertiary sector shows higher level of "satisfaction" of both the potential demands.

The final energy demands have been converted in primary energy demands taking into account the conversion efficiencies of the actual heating plant park. Results have been also aggregated at spatial level, according to the administrative subdivision of the municipal territory. For each administrative district the actual energy demand and the potential one, both for heating and cooling have been pointed out.

Assessment of retrofit actions impacts

Three retrofit actions voted to reduce the heating demand have been analysed. Two actions deals with the improvement of energy performances of building envelopes and have been applied only to the suitable buildings typologies: the installation of double-glasses and the insulation of flat roofs.

The third action simulates the effect of the compliance of heating systems efficiency standards stated in the Italian technical rule, that have encountered some difficulty to be applied. The results are shown in the following pictures (fig. 1 and 2).

Also for the cooling issue, electricity consumption in the Business as Usual case and as consequences of retrofit actions have been assessed. A forth action, concerning the installation of shading devices (with an effect similar to the one of traditional "persiane") has been introduced.

Economic performances of retrofit actions have been assessed for each combination of building typologies and heating system and fuel, through the Cost of Conserved Energy index.

Scenarios of Future Potential Demands

The same actions have been applied to the future potential demand items (primary energy and electricity), in order to have an idea of how and if could be possible to

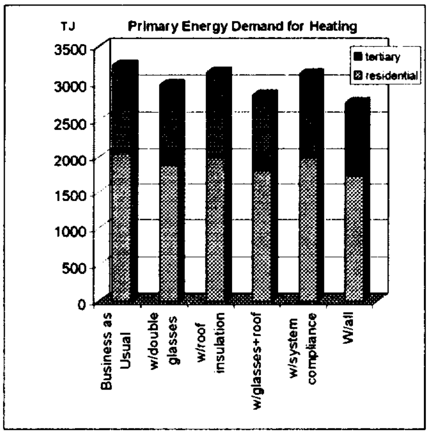

Fig 1

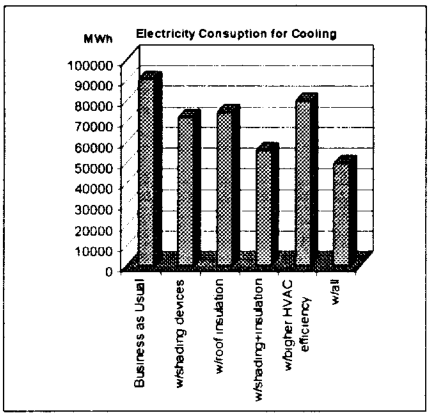

Fig 2

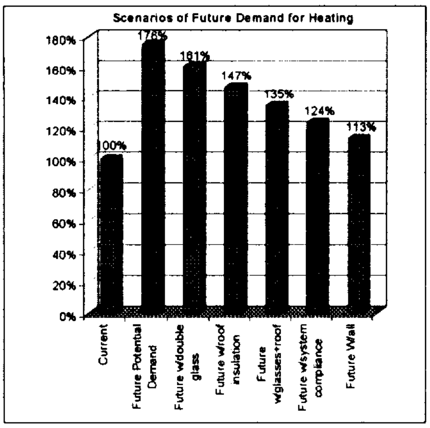

Fig 3

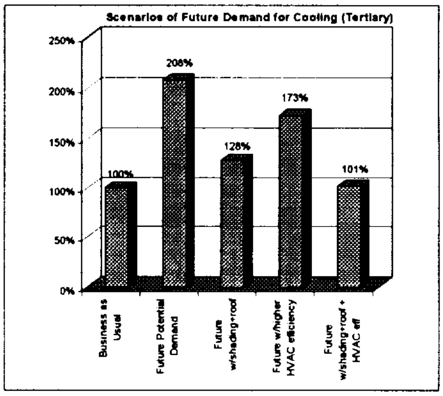

Fig 4

minimise the impact of their expected growth (fig. 3 and 4). It must be noted that the scenarios shown in the following two pictures have been built with the hypothesis that the 100% of the potential demand will be fulfilled with conventional heating/cooling systems (except for the assumption of the use of gas-fired absorption chillers in the tertiary sector for installed powers higher than 100 kW).

CONCLUSIONS

It must be noted that with the aim of a general modellisation of the energy system (in the supply and in the demand sides) the authors of the Master Plan have been able to assess the effects of some actions dealing with two different philosophies: the reduction of the demand growth and the increase of the energy conversion efficiencies. Even if very interesting results can be obtained with such interventions, it is evident that, starting from a situation in which about a half of the heating demand is satisfied (an more less for the cooling one) it is very hard to imagine to reduce current primary energy demands in order to fulfil CO_2 emission reduction goals without considering the diffusion of new and "clean" energy technologies.

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„CO_2 reduction potential for thermomodernized prefabricated concrete panel buildings in Poland during their life cycle”[1]

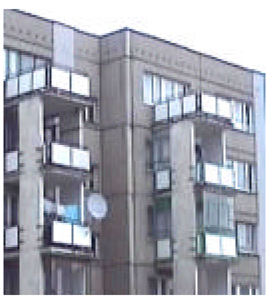
Rafa³ Kropiewnicki M.Sc. [1], Aleksander D. Panek Ph.D. [1,2]

1. National Energy Conservation Agency, ul. Filtrowa 1, 00-611 Warsaw, Poland
2. Warsaw University of Technology, ul.Nowowiejska 20, 00-653 Warsaw, Poland

INTRODUCTION

The aim of the work was determination of emission reduction potential for buildings constructed in concrete prefabricated panel technology. These buildings form a significant share of housing resources in Poland and other Central European countries. Method for estimation of the reduction was based on LCA methodology, which takes into account the whole cycle of building life. Starting point for consideration includes extraction of raw materials from environment, their conversion and transport, operational life of building, its demolition, and waste recycling and disposal.

SAMPLE OF BUILDINGS



Picture 1

Sample of buildings was a group of buildings located in settlement “Imielin” in Warsaw and chosen according to building shape parameter A/V (ratio of building volume to the area of external walls). Buildings were erected in years 1979 – 1982 in prefabricated panel technology W-70 and Wk-70. It is a typical technology within the period. Basic building elements are (picture 1)

- basement walls monolithic or prefabricated,
- internal concrete main walls 15 cm thick,
- ferroconcrete prefabricated floor ceilings of 22 cm thick and 6 m length,
- ventilated prefabricated flat roof,
- external walls of types: multilayer from cellular concrete

WORK SCOPE

First stage of research was survey of materials volume used for building erection; workload of construction process and related to them usage of primary energy. The above volumes have been defined from design documentation. Next, the yearly consumption of primary energy, related to heat, water usage electricity and gas was determined. Subsequent task was estimation of emission level for the volume of primary energy. As a life cycle 50 years period was taken. Finally, the reduction of CO_2 resulted from thermomodernisation of building has been calculated.

CO_2 EMISSION IN CONSTRUCTION PROCESS

Value of this emission has been calculated as a sum of partial emissions from:

- manufacturing of building materials and elements,
- transport of building materials and elements,
- construction process,
- land development process.

CO_2 EMISSION FROM ENERGY CARRIERS USAGE

Emission here is defined as composed from:

- extraction of fuel, its transport and combustion in district co-generation plant,
- transmission of heat and electricity,
- extraction, transmission and consumption of gas for local usage,
- energy for treatment, transmission and consumption of water in buildings.

Table 1

Lp	A/V	A_P	A_G	A_E	$A_{CO,CWU}$	A_W	al
		$kgCO_2/m^2$					
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	0,28	1 326	113,4	3 183	5 388	8,9	**10 019**
2	0,30	1 326	130,7	3 584	5 423	10,1	**10 474**
3	0,32	1 327	97,8	3 398	5 457	9,1	**10 289**
4	0,34	1 327	117,2	3 990	5 480	8,8	**10 923**
5	0,38	1 328	100,6	3 893	5 548	9,7	**10 879**
6	0,42	1 329	99,6	3 906	5 630	8,2	**10 972**
7	0,44	1 330	117,8	4 041	5 659	9,3	**11 157**
8	0,46	1 330	163,0	4 015	5 691	9,3	**11 209**

[1] The article has been prepared for Conference “Sustainable Building 2000”, Maastricht, 23-25 October, the Netherlands.

A_P – emission in construction process; A_G – emission from gas usage; A_E – emission from electricity, A_{COCWU} – heat emission; A_W – water related emission.

THERMOMODERNIZATION OF SAMPLE BUILDINGS

Thermomodernization Act, in force in Poland from 1998, defines scope and form of energy audit, and describes standardised procedure for indication of optimal, from economy point at view, scope of thermomodernization investment. Terms of the Act are as following:

- min 25% of reduction of seasonal consumption for heating and domestic hot water preparation (10% if only internal heating systems is modernised),
- NPV of the investment is positive, r=0,065 and N=15,
- repayment of credit less then 7 years, and payments are equal to savings,
- 25% of credit is forgiven upon payment of 75% of credit amount.

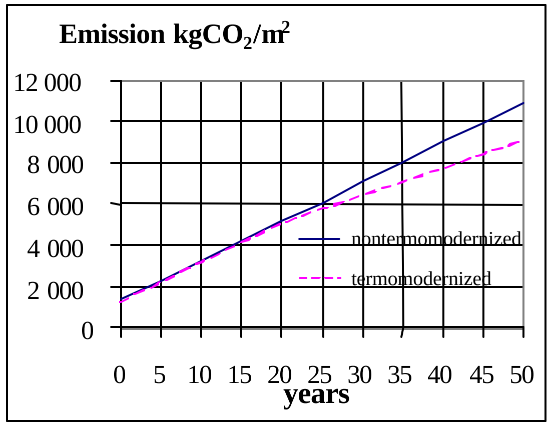
Optimisation of thermomodernization process lead to following recommendation:

- external walls insulation with 14 cm of styrophon,
- flat roof insulation with 14 cm of granulated rock wool,
- basement ceiling insulation with 8 cm of styrophon,
- window replacement U=1,2
- overhaul of internal heating system (two pipe, hydronic open loop system).

Table 2. Emission in 50 years life cycle

Lp.	A/V	before	after	reduction	
		$kgCO_2/m^2$		$\Delta kgCO_2/m^2$	%
1	**2**	**3**	**4**	**5**	**6**
1	0,28	10 019	8 334	1 685	16,8
2	0,30	10 474	8 881	1 593	15,2
3	0,32	10 289	8 465	1 824	17,7
4	0,34	10 923	9 330	1 593	14,6
5	0,38	10 879	9 139	1 741	16,0
6	0,42	10 972	9 041	1 932	17,6
7	0,44	11 157	9 453	1 704	15,3
8	0,46	11 209	9 544	1 664	14,8

Above listed undertakings are resulting in reduction of heat consumption. Table 2 and Fig 1 present relation of thermomodernization process on emission level in life cycle of the building. Value at column 5 in Table 2 have been decreased by the emission related to energy cumulated in materials used in thermomodernization process.



Picture 2. Emission in 50 years life cycle

CONCLUSIONS

The estimation of economically feasible potential of CO_2 reduction in cycle of building life is approximately 16% if the thermomodernization investment will be undertaken

In spite the presented analysis is related to one specific technology, results of survey can be generalised for other prefabricated concrete panel technologies. All the applied technologies were using same set of materials. Architecture styles and shapes of the buildings were very similar.

According to statistics provided by Polish Ministry of Interior and Administration approx. 288 million m^2 of living area have been constructed in prefabricated concrete panel technologies.. It means, in case of Polish fuel balance, reduction of 4945 billion ton of CO_2.

Data taken from constructors offer (1998) shows that reduction cost of $1MgCO_2$ in life cycle of building (in fact for only 25 years remaining) time is 114,15 z³/$MgCO_2$. This is based on Warsaw market prices, which are 20% higher than in other regions The cost of reduction is calculated as simple ratio of: total investment by CO_2 volume. Whereas international institutions to calculate the cost are using different formulas which includes e.g. depreciation period, interest etc. The application of these formulas will result in decrease of CO_2 reduction cost approx. 50% of above. This makes thermomodernization investment attractive not only locally but also internationally when terms of emission trade will be established.

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ECONOMICAL EFFICIENCY OF ENERGY EFFICIENT RETROFITTING SYSTEMS FOR THE EXTERNAL ENVELOPES OF THE EXISTING BUILDINGS IN ISTANBUL

Nil Sahal, Aslıhan Tavil, Cem Altun, Ertan Özkan
1. Istanbul Technical University, Faculty of Architecture, Taskisla, 80191, Taksim, Istanbul, Turkey
2. Istanbul Technical University, Faculty of Architecture, Taskisla, 80191, Taksim, Istanbul, Turkey
3. Istanbul Technical University, Faculty of Architecture, Taskisla, 80191, Taksim, Istanbul, Turkey
4. Beykent University, Faculty of Architecture, Beylikduzu, 34900, Buyukcekmece,Istanbul,Turkey

INTRODUCTION

Since the external envelopes of most of the registered residential buildings and squatter housing in Turkey are either thermally uninsulated or insufficiently insulated to meet the international standards for energy conservation, 35 % of the total energy of Turkey is consumed in buildings. Therefore, a series of preventive measures were taken for the efficient use of energy in buildings. One of the measures was to revise the existing energy conservation values in the national standards and specifications for new buildings. The other one was to rehabilitate the external envelopes of existing residential buildings with energy efficient retrofitting systems.

A research project was set to develop energy efficient retrofitting systems applicable to the external envelopes of the existing residential buildings in Istanbul, [1]. In the research, the thermal performance of the existing external envelopes and each retrofitting systems were evaluated with DOE-2.1E computer program. In this study, the energy efficient retrofitting systems were determined on the basis of the yearly energy consumption values stated in the revised standard. Finally, Life-Cycle Costing model was used to evaluate the economical efficiency of each alternative energy efficient retrofitting systems in order to determine the economical system for the households.

THE EVALUATION OF ENERGY EFFIENCY OF THE RETROFITTED SYSTEMS IN THE SAMPLE BUILDING

In the research, a survey was carried out in Istanbul to determine the typical properties of existing residential buildings. A sample building which represents one of the typical existing buildings in Istanbul is selected for this study. Five storey sample building has a reinforced concrete structure, externally rendered and internally plastered non-load bearing external hollow brick walls of 13.5 cm. thickness, wooden windows with single pane, pitched roof and 1.50 m. cantilevered floors above the ground floor. The total floor area is 1066 m^2 and the normal floor area is 230 m^2. The total exterior wall, the total window, the cantilevered normal floor and the roof areas are 518, 282, 83 and 230 m^2, respectively. The total area of the building for heat losses is 1264 m^2 and the gross volume is 3249 m^3. The transparency ratio for all facades is 35 %.

The retrofitting systems for the opaque components were 3, 5, 8, 10 and 15 cm. thick expanded polystyrene applied as thermal insulation material to the roof, outer or inner surfaces of the walls and cantilevered floors. The thermal conductivity design value of the thermal insulation material was 0.035 W/mK. For the transparent components, single glasses in windows were replaced with clear double glazing or low-e coated double glazing.

The sample building was simulated with a PC version of DOE-2.1E computer program. The hourly weather data of Istanbul and building description input file representing the existing situation and the retrofitting systems for the sample building were prepared for the simulations. The yearly heat loss through the sample building for the existing situation as well as the alternative retrofitting systems were calculated with the computer program. Afterwards, the yearly energy consumption for heating per square meter floor area was calculated with respect to the heat loss of the building, Table 1. It was assumed that the heating system of the sample building had a productivity of 70 %.

RS	IT,cm			GU	ECH,
	W	F	R	W/m²K	kWh/m²
Existing	-	-	-	5.17	213.50
G1				2.81	172.10
G2				1.81	158.52
R3			3	5.17	196.36
R5			5	5.17	192.78
R8			8	5.17	190.02
R10			10	5.17	188.94
R15			15	5.17	187.33
EWF3	3	3		5.17	148.51
EWF5	5	5		5.17	137.79
EWF8	8	8		5.17	129.99
EWF10	10	10		5.17	127.02
EWF15	15	15		5.17	122.69
IW3	3			5.17	174.28
IW5	5			5.17	167.35
IW8	8			5.17	161.98
IW10	10			5.17	159.85
IW15	15			5.17	156.66

Table 1: Retrofitting systems-(RS) for the roof-(R), outer surfaces of the walls-(EW), cantilever floors-(F) and the inner surfaces of the walls-(IW) with thermal insulation material thickness-(IT) from 3 to 15 cm., the thermal transmittance design value-(GU) for glazing systems-(G1, G2) and the yearly energy consumption for heating per square meter floor area -(ECH) before and after retrofitting the sample building.

RS	IT,cm			GU	ECH,
	W	F	R	W/m²K	kWh/m²
F3		3		5.17	205.00
F5		5		5.17	203.59
F8		8		5.17	202.57
F10		10		5.17	202.18
F15		15		5.17	201.62
IWR3	3		3	5.17	157.03
IWR5	5		5	5.17	146.43
IWR8	8		8	5.17	138.31
IWR10	10		10	5.17	135.07
IWR15	15		15	5.17	130.26
IWR3G	3		3	2.81	115.78
IWR5G	5		5	2.81	105.30
IWR8G	8		8	2.81	97.20
IWR10	10		10	2.81	94.00
IWR15	15		15	2.81	89.22
IWR3G	3		3	1.81	102.21
IWR5G	5		5	1.81	91.73
IWR8G	8		8	1.81	83.63

Table 1 cont'd.

RS	IT,cm			GU	ECH,
	W	F	R	W/m²K	kWh/m²
IWR10G2	10		10	1.81	80.34
IWR15G2	15		15	1.81	75.65
EWFR3	3	3	3	5.17	131.90
EWFR5	5	5	5	5.17	117.74
EWFR8	8	8	8	5.17	107.45
EWFR10	10	10	10	5.17	103.51
EWFR15	15	15	15	5.17	97.74
EWR3G1	3	3	3	2.81	90.64
EWR5G1	5	5	5	2.81	76.76
EWR8G1	8	8	8	2.81	66.59
EWR10G1	10	10	10	2.81	62.71
EWR15G1	15	15	15	2.81	57.01
EWR3G2	3	3	3	1.81	77.07
EWR5G2	5	5	5	1.81	63.16
EWR8G2	8	8	8	1.81	52.98
EWR10G2	10	10	10	1.81	49.10
EWR15G2	15	15	15	1.81	43.40

Table 1 cont'd.

The yearly energy consumption for heating was 213.50 kWh/m² for the existing sample building. The yearly required energy for heating was calculated to be 60 kWh/m² for the sample building according to the revised standard, [2]. The energy efficiency of the retrofitting systems were evaluated on the basis of the given value. Consequently, the retrofitting systems where the outer surfaces of the walls, roof slab and the cantilever floors were thermally insulated with 8, 10 and 15 cm. thick expanded polystyrene and the single glasses were replaced with clear double glazing- EWFR8G1, EWFR10G1, EWFR15G1 and the systems-EWFR5G2, EWFR8G2, EWFR10G2, EWFR15G2 were determined as applicable energy efficient retrofitting systems for the rehabilitation of the external envelopes of the residential buildings in Istanbul. The energy conserved by the retrofitting systems- EWFR8G1, EWFR10G1, EWFR15G1, EWFR5G2, EWFR8G2, EWFR10G2, EWFR15G2 are 68,81%, 70,62%, 73,29%, 70,41%, 75,18%, 77,00% and 79,67%, respectively. The least, 68,81%, energy conservation is provided by the retrofitting system- EWFR8G1 where the system- EWFR15G2 has the highest, 79,67%, energy conservation value.

THE ECONOMICAL EFFICIENCY OF ENERGY EFFICIENT RETROFITTING SYSTEMS

Life-Cycle Costing is considered as an appropriate model for the economical analysis of the energy conservation provided with the retrofitting systems. It comprises the yearly monetary savings due to the energy conservation and the initial investment cost of the energy conservation. Pay-back period, the period in which the initial costs are met with the monetary equivalence of energy savings, is an important indicator of the economical efficiency evaluation of the retrofitting systems.

The value of yearly energy conservation were calculated from the yearly energy consumption values before and after retrofitting the sample building. The yearly monetary savings due to the energy conservation was calculated for each energy efficient retrofitting system. The per square meter costs for each energy efficient retrofitting systems were calculated with fixed prices and the initial costs of the investments were determined for the sample building. The minimum pay-back periods of the energy efficient retrofitting systems were calculated with an interest rate of 5 %. The formula is:

$$N: \log[A/(A-P\times I)]/\log(1+I)$$

Where, N: pay-back period, A: monetary equalance of annual energy savings P: the initial capital invested for retrofitting, I: interest rate, considered 5%.

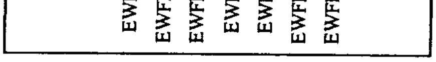

Figure 1: Pay-back periods of energy efficient retrofitting systems

The pay-back periods for each energy efficient retrofitting systems for the sample building are given in Figure 1. In the building; the retrofitting system-EWFR8G2 has the least, 10.1 years, and the system EWFR15G1, has the highest, 11.5 years, pay-back periods.

CONCLUSION

The increase in the thickness of thermal insulation materials results with an increase in energy savings. Besides, the decrease in the thermal transmittance design values of the glazing systems contributes to the energy savings

The energy savings do not increase with the same rate of increase in the thickness of the insulation material, [3]. Besides, the per square meter costs of 5, 8 and 10 cm. thick insulation materials are approximately the same, but, there is a significant difference between the per square meter costs of 15 cm. and 5, 8, 10 cm. thick insulation materials. Therefore, the pay-back periods of the retrofitting systems of 15 cm. thick insulation materials are higher than the other retrofitting systems. 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. Therefore; this system is considered as the most energy and economical efficient retrofitting system for the households in the sample building.

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THE RENOVATION OF RESIDENTIAL BUILDINGS AND THE OPPORTUNITIES FOR CLIMATE PROTECTION AND THE LABOUR MARKET

Holger Wallbaum (holger.wallbaum@wupperinst.org)
Wuppertal Institute for Climate, Environment and Energy (http://www.wupperinst.org)
Eco-efficiency and Sustainable Enterprise Group
Doeppersberg 19, 42103 Wuppertal, Germany, Phone: +49-202-2492-302, Fax: +49-202-2492-138
On behalf of Holger Bartels (Head of the Department for Environment, Energy and Sustainable Development), Trade Union for Building, Forestry, Agriculture and the Environment (IG BAU);
Olof Palme Str. 19, 60437 Frankfurt a. M., Germany, Phone: +49-69-95737-670, europa@igbau.de

Background and target of the project

Sustainable development has been an international aim since the UN Conference on the Environment in Rio de Janeiro in 1992. The central challenges are the maintenance of social security (among others measures to combat unemployment), a sustainable economic development, and the preservation and creation of an intact environment. The building and housing sector is of special importance. Buildings under construction need large amounts of material and surface area and large quantities of final energy for their heating. At the same time, the building trade in particular has been affected by high unemployment in recent years, resulting in social insecurity.

Against this background, the Trade Union for Building, Forestry, Agriculture and the Environment (IG BAU) and Greenpeace have started the initiative "Das Plus für Arbeit und Umwelt" ("The advantage for labour and the environment"). Together with the housing industry, they aim to show that through environmental protection jobs can be created and maintained. As part of this initiative the Wuppertal Institute was commissioned with a study to estimate from the point of view of costs the possible effects that modernisation of residential buildings in Germany to save energy has on jobs, energy and material flows.

Requirements for the quality seal "Das Plus für Arbeit und Umwelt" awarded by Greenpeace and the Bauen-Agrar-Umwelt industrial union

The seal will be awarded to housing enterprises if they commit themselves in future to adopting the following standards on all outstanding renovation measures to save energy:

- After the renovation of a residential building the final energy consumption will be under 100 kilowatt hours per square metre and year ($kWh/m^2 \cdot a$).

In addition, the following points are to be considered when selecting the building materials:

- insulation materials that contain durable additives which are difficult to decompose (e.g. halogenated flame-proofing agents) will not be used;
- Materials comprising CFC's/HCFC's will not be used;
- PVC will not be used;
- Wood from virgin forests will not be used. The use of wood with the FSC certificate is preferred.

Note: the energy-saving target value is always valid for all energy-saving renovation measures to be dealt with. Exceptions are possible for buildings classified as historical monuments and hardship cases. When FSC wood is not available for special applications, indigenous wood is used.

Figure 1: the criteria required by the IG BAU and Greenpeace seal for renovation of a building to save energy. (source: http://www.arbeit-und-umwelt.de)

Results

The assumption underlying the survey is that by this initiative and by further necessary measures, above all on the part of the Federal Government, the number of residential buildings to be renovated in terms of energy-saving measures every year can be increased from around 150,000 today to approximately 330,000 a year. In order to achieve this, around DM 15b will have to be invested annually between 1999 and 2020. This sum corresponds to almost three per cent of the total construction volume of the year 1997. Investments to this extent

- will secure and create on a long-term basis approximately 430,000 jobs, 174,000 of these in the finishing trade alone,
- will decrease energy costs through the reduction of the final energy input by 1,111 PJ (50%) and avoid up to 97.5 m t (58%) of carbon dioxide compared with the reference year 1999
- will also achieve considerable savings of resources (balance of expended and saved material flows), which will reach a scale of around 68 m metric tonnes annually by the year 2020.

This investment plan, which would have to be activated by a support programme among other measures, is facing higher revenues of the state from national insurance and from direct and indirect taxes. At the same time, expenditures for social benefits will decrease because of an improvement in the labour market situation.

Conclusion

The renovation of buildings definitely provides a chance for the climate and the labour market. The study shows that a committed heat insulation scenario can achieve a clear reduction in emissions of CO_2. It clearly has positive effects on jobs and also makes a great contribution to the protection of resources.

This positive tendency corresponds with a number of other scientific surveys which have also tackled the problem of determining the effects of climate and environmental protection measures and energy savings. Differences in the level and the scope of the effects examined result from different assumptions and should be examined more closely afterwards. Further use of resources and increased emissions resulting from economic growth, which might in future be stronger, are naturally not considered. That means in macroeconomic terms that the environmental pollution as a result of renovating old buildings can offset further environmental pollution as a result of economic growth.

The renovation programme examined here can be characterised, from a purely economic perspective with regard to financing, as an investment programme which will be financed by the owners of the residential property. The investments will be financed either from loans or from savings of the owners of the residential property.

The positive effects on the economy are achieved partly by financing of credits but also by the redirection of funds from consumption to building investment. This is because the finishing trade is very labour-intensive but the consumer goods sector is not. The partial financing of credits needed must not be judged critically because it is restricted to the private sector and leads only to a slight increase in interest rate. In addition, it has to be contrasted with a lasting return including an economic and an ecological component: the renovation leads to a sustainable reduction in emissions of CO_2 and in energy costs of the households.

A redirection of money from the government to encourage the renovation of buildings and the passing of an ambitious ecological tax reform would very quickly show that the renovation measures suggested here are economically viable. The monthly financial charge on the rent would either not, or only minimally, make a difference to the tenant because an increase in rent, which might follow because of renovation, would be offset by the reduction in the fuel bill.

RECYCLING CONCRETE AGGREGATES IN SINGAPORE

Mr. Su-Liang Goh

Faculty of Architecture, Building and Planning
The University of Melbourne
Parkville, Victoria 3052
Australia

ABSTRACT

With the rapid pace of economic development and construction activities in Singapore, especially in the past decade, the level of construction waste has increased tremendously. Concrete waste is bulky and it is found in all types of building activities. It could be feasible to support the recycling of concrete aggregates for future construction needs based on current potential to reuse and recycle the material in a land-scarce and non-resource producing environment.

CONSTRUCTION ACTIVITY

The large-scale public housing construction, extensive redevelopment of the central area and rapid expansion of infrastructure in Singapore over the past thirty-odd years has created a demand for basic building materials. A report by Environmental Resources Limited (1980) revealed the most common building materials as reinforced concrete, aluminium, plastics and glass. The report also projected that concrete will become the main constituent of waste. Between 1991 and 1997 demand for granite increased three folds, from 8.2 million tonnes to 23.7 million tonnes (CIDB, 1997).

Current building stock in Singapore includes pre-war buildings as well as post-independence structure. Based on an assumption that if these buildings are either demolished or refurbished, the quantity of concrete debris accounts for approximately thirty-to-forty percent of waste generated (Nathan, 1997). Furthermore, because Singapore relies mostly on foreign import of building materials, as the country has no natural resources, there is a huge potential for recycling and reusing concrete aggregates. The existence of disposal problems due to the lack of land for landfilling points to the recycling of concrete aggregates as economically feasible.

Concrete rubble is probably the most common but cumbersome building waste currently generated from demolition and refurbishment due to its sheer bulk, mass and very widespread use of concrete in our structures (McDonald, 1996). Therefore this material should be diverted from the waste stream and reprocessed for reuse in another form.

Currently in Singapore, a few building contractors are recycling crushed concrete aggregates, to be used mainly on site as temporary road cover for vehicles to achieve better traction on rainy days. Crushed concrete is mainly recovered from wrongly specified or faulty columns or beams. Leftover concrete aggregates from various work processes are used in making road kerbs, as fill material or pathways.

In Britain, Ng (1993) referred to O'Mahony and Milligan (1991), crushed concrete from demolition of concrete structures together with waste from bricks and glass were used as recycled aggregates in the manufacture of new concrete. And in Holland, concrete rubble was used as base materials in road building (Ng, referring to van Winden, et. al. 1991).

POSITIVE EFFECTS OF RECYCLING

As the price of primary resources is very much dependent on the economic factors of supply and demand, it makes sense to recycle especially when material prices are on the rise (CIDB, 1993). The most obvious benefits of recycling concrete aggregates are less atmospheric pollution, slowing down of non-renewable resource depletion as well as the direct monetary savings achieved through transportation, disposal and material recovery.

Transportation

Increased recovery of concrete aggregates has an impact on transport-induced environmental impairment and cost. This is realised through reducing the quantity of materials requiring disposal, reducing transportation of virgin materials if they have to be transported, and reducing vehicle movement which results in less fuel consumption and pollution (Ng, 1993).

Disposal

In Singapore land designated for dumping of waste materials is a premium, so minimising wastage means setting aside less valuable land space for landfills. Current landfill space on the mainland has almost been exhausted. An offshore landfill facility has been built and is currently being used. It is important that bulky construction waste, such as concrete, are recycled so that valuable land is not turned into landfills.

Materials recovery

Consumption of virgin aggregates can be reduced through increased reuse/recycling of demolition material. For example, the use of demolition material as aggregates will reduce demand for virgin aggregates thus reducing environmental damage caused by extraction/blasting, processing and transport.

According to Kibert (1999) the amount saved on recycling most materials compared to extraction from virgin resources is substantial. However, recycling is still a much underuilised means of recovering previously used resources from other applications.

DEVELOPING MARKETS FOR RECYCLED CONCRETE

Recycling is only the initial step in the process that must include reprocessing, marketing and reuse (Peng, Grosskopf and Kibert, 1994). Government supportiveness, legislation and enforcement remain the key to successful recycling of concrete in Singapore.

Consistent and available markets for secondary materials are essential to the success of recycling programmes. There is a need for the building industry to "close the loop" in the recycling programme by purchasing materials recovered from waste. Developers can play a leading role by choosing recycled concrete over products made from virgin materials.

Another useful consideration is to design for deconstruction (DFD) to facilitate recycling (Lawson, 1994) based on reducing the quantity of virgin raw materials needed to be extracted and used or in reducing the need for landfill disposal (Uher and Lawson, 1998).

CONCLUSION

At the present moment, there is no recycling infrastructure in Singapore. There is no pressure to recycle concrete aggregates because recycled products do not work out to be cheaper than virgin products. Contractors, by their own nature of operation, do not have the resources for setting up a recycling plant on site. To ensure recycling is carried out, the government should support the movement and introduce legislation on recycling building materials, especially concrete.

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Recycling of Construction Waste and Demolition Materials in East Sussex

Andrew Miller[1] **and Ian Sweatman**[2]
[1]School of the Environment, University of Brighton, UK
[2]Hanson Waste Management, Newhaven, UK

INTRODUCTION

This paper is based on a research programme undertaken with F.L.Gamble and Sons Ltd. during the development of their construction waste and demolition materials recycling site at Newhaven, East Sussex. The project was funded for a period of two years under the Teaching Company Scheme during which the company gained the approval of the local authorities for the specification and production of a recycled aggregate equivalent to the performance requirements of the nationally accepted Highways Agency 'Type 1' sub-base material.

The research programme established data of the construction and demolition waste arisings within the area of the study and evaluated the energy implications of collection and processing of recycled aggregates.

This paper provides a summary of the major findings of the project and investigates the transportation component of the energy consumed in recycling.

CONSTRUCTION AND DEMOLITION WASTE ARISINGS

Estimates of the total waste arisings from the construction and demolition industry in the UK vary considerably. These estimates are based on different data sets and include different definitions of what is included or excluded from the estimate. Inclusion of material from road widening and improvement works, possibly 25 million tonnes per year, is one element of difference and the inclusion of material recycled within the demolition / construction site is another.

Analysis of two major reports (Arup 1991) and (Humphreys 1994) however identify broad agreement for an estimated total of 70 million tonnes per annum in the UK with perhaps 50 million tonnes per annum if civil engineering road works are excluded.

There are also considerable regional differences in the arisings throughout the UK depending on density of population and activity of the construction industry. An efficient recycling system needs to take account of the location of waste arisings together with the location of recycling plant and the construction sites using the materials.

MATERIAL RECEIVED AT NEWHAVEN

The types of waste being collected are defined as:

- Type A - inert wastes such as concrete, brick and soils.
- Type B - active wastes such as wood, card, plastic and insulation.

Analysis of the material coming into the site during the eight month period between January and August 1998 shows considerable variation month by month but on average the total waste construction and demolition waste intake was 6900 tonnes per month. Of this total an average of 4520 tonnes per month (65%) was type A material with the remainder mixed on arrival. An average of 430 tonnes per month (6%) of wood and rubbish were taken from the site for disposal.

In order to be able to benchmark the quality of the incoming waste it was compared with the specification defined by the Dutch C.R.O.W. organisation (CROW 1990). Its requirements are a minimum of 50% (by weight) of concrete having a minimum density of 2100 kg/m^3, a maximum of 50% (by weight) of brickwork having a minimum density of 1600kg/m^3. It permits a maximum of a further 10% of other stony material of which there is a maximum of 5% tarmac.

The analysis of the incoming waste at Newhaven showed the proportions to be: 72% concrete, 19% brick, 4% stony material and 4% tarmac. It therefore complied with the CROW specification and was appropriate for producing a recycled aggregate suitable for Type 1 road sub-base uses.

The resulting product was tested both in the laboratories of the School of the Environment at the University of Brighton and at independent laboratories approved by the Local Authority. Successful completion of these tests and subsequent on site trials has led to the recycled aggregate produced at the Newhaven site, now trademarked BASECO, being accepted as an alternative to Type 1 aggregates in certain types of road.

The analysis and approval process has increased the potential of construction and demolition waste collected within the region. It has enabled it to be used for higher grade construction than previously and has reduced the demand on virgin aggregates.

In this paper however the transportation energy for collecting the construction waste and demolition materials is evaluated. This is a further component in being able to undertake a full environmental life-cycle analysis of materials and to evaluate the implications of transportation.

TRANSPORTATION

The transportation to and from the Newhaven recycling site was monitored during 1998. All incoming loads were identified for their type of transport, content, origin and route taken. This was important because of the route restrictions in place for heavy vehicles within the surrounding areas.

Table 1 shows the calculated transportation energy for waste being brought to the Newhaven site. It is based on single journeys from collection point to Newhaven and demonstrates widely differing figures for the different types of waste.

	Mass of Material (tonnes)	Energy Consumed (MJ)	MJ/tonne
Type A	53030	1253590	23.6
Type A/B mix	22500	1221950	54.30
TOTAL	75530	2475540	32.77

Table 1 Transportation energy consumption for collection of different types of waste.

Analysis of the type of material collected and the distances travelled are shown in Fig.1.
The figure shows that a large proportion of the material comes from within a 35 km radius, which includes the two major urban areas of Brighton and Eastbourne. It also shows that the total mass of type A material collected within the 35 km radius is greater than for the A/B mix.

Type A waste is generally denser than A/B mix and is generally transported in 12m^3 or 15m^3 lorries. Type A/B waste is generally delivered in skips and 30m^3 roll on / roll off bins and, due to the way they are loaded at the construction site, contain a lot of void space.

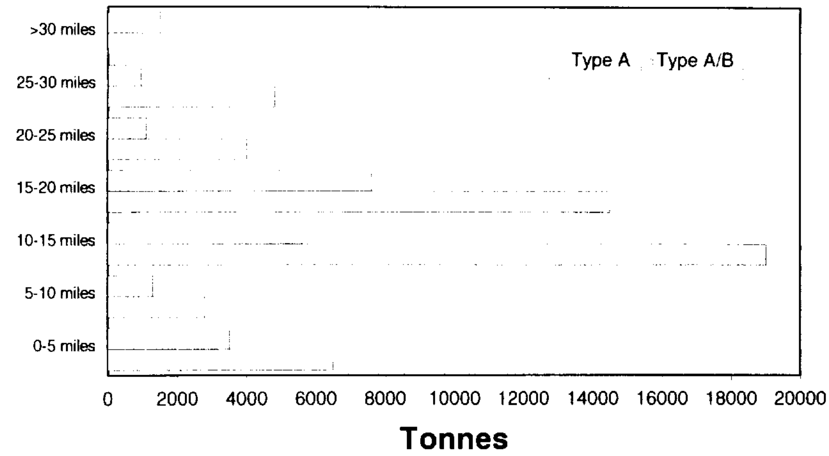

Fig. 1 Distances to Newhaven for Waste types A and A/B mix.

Analysis of the material transported shows a very wide range of weights of material being transported. In the sample taken the average weight of material transported in a $12m^3$ lorry was 9.22 tonnes, only marginally less than the average of 10.57 tonnes in the $30m^3$ bins.

CONCLUSION

The results identify that the energy consumption for transportation of Type A waste to the Newhaven site is 23.6 MJ/tonne. The efficiency of transportation is affected by the size of the container which will be dependent upon road restrictions.

Preliminary analysis of the recycling processes has identified a further 90 - 100 MJ/tonne is consumed in cleaning and crushing the incoming waste to prepare the recycled aggregate. Further transportation is required to the construction site for use.

Continuing research will enable more detailed analysis of these results and enable a better understanding of the total embodied energy impacts of this recycled material.

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Environmental Effects from Recycling Windows. A case study

Professor Bertil Fredlund PhD
Lund Institute of Technology
Dept of Building Science
Box 118
SE-22 100 Lund, Sweden
e-mail: bertil.fredlund@bkl.lth.se

INTRODUCTION

Background

The point of departure for this project is the method, the "Allbäck" method, established 15 years ago by the firm Fönster Hantverkarna AB for the renovation, restoration and maintenance of windows from different epochs. So far the method has been confined to restoring windows to their original state, with the limitations in thermal properties which this involves. In this project the method has been developed so that windows can also be given better thermal properties while retaining their aesthetic values. The project has been commissionned by Fönster Hantverkarna AB at Bjäresjö, Ystad. Finance for the project has been provided by Teknopol in Lund.

The problem

Traditionally, improvement of the U values of windows has entailed replacement of the windows or various methods in which this improvement is achieved by adding an additional pane to the window. These approaches are both expensive and detract from the aesthetic qualities.

A very sympathetic alternative to the established method is to improve the U value in conjunction with renovation by replacing the inner pane by a pane with a low emission coating. One problem in this approach is that the coated panes usually have a least thickness of 4 mm.

This gives rise to two complications. In the first place there is normally no room for a 4 mm pane in the existing glazing rebate which is intended for a 2-3 mm pane. In the second place, the pane is too heavy for the existing frame.

During discussions with Pilkington Floatglas AB it was found that the firm can supply coated glass of only 3 mm thickness at no extra cost or longer delivery times (Ref Tomas Grange). This makes it possible for a simple and aesthetically attractive solution to be applied in practice for upgrading the thermal properties of windows.

The aim

The aim of the project was to investigate and document improvement of the U value of renovated windows where the inner pane is replaced by a pane with low emission coating of the hard type. The test method and evaluation of measured values complied with the Swedish Standards applicable to new production of windows, so that the results may be used for analysis and comparison with the alternative where the window is replaced by a new one, and also that an assessment may be made of the effect that renovation and upgrading of the existing window has on energy use compared with the case that the window receives no remedial treatment.

PRESENTATION

Method

In order to achieve this aim, tests were made on unrenovated, renovated and upgraded windows in which the inner pane had been replaced by one with a low emission coating. Tests were made by the hot box method in accordance with Swedish Standard 02 42 12 (SIS, 1981). Evaluation conforms to the guidelines set out in Swedish Standard SS 02 42 13 (SIS, 1987).

Three windows were selected for the tests in consultation with Fönster Hantverkarna AB. These windows are constructions typical of the periods 1880, 1930 and 1980. The outside frame dimensions of the windows in the test series are ca 1.2 x 1.2 m. The properties of other window sizes were obtained by calculations with the program Frameplus (Frameplus Toolkit, 1995).

The windows selected for testing were carefully documented with regard to their condition prior to renovation. All action taken during renovation was also documented in detail. This work was performed by Fönster Hantverkarna AB.

Description of the test objects

The test series contained three windows from different periods. These are briefly described below.

Window No 1 was initially a four-light window from ca 1880 which was too large for our test equipment. A suitable specimen size was obtained after the two smaller upper lights had been cut away. Window No 1 is thus a "two-light window" for testing purposes, with two single panes, one in the outer casement and one in the removable inner casement. The glass thickness is 2 mm and the distance between the panes is 90 mm.

Window No 2 is a two-pane window from ca 1930. It has coupled casements in which the distance between the panes is 31 mm. Glass thickness is 3 mm.

Window No 3 is a product from the firm SP Windows. It was made in 1982. The window is fitted with a sealed unit consisting of three 4 mm panes, with 12 mm air gaps between the panes.

The frames and casements of all windows are made of pine.

Measurements on the two older windows, Nos 1 and 2, were made both in their original states and after renovation, i.e. among other things removal of paint, adjustment of the fit between casement and frame, and fitting of new sealing strips. The windows were finally upgraded which means that the inner pane was replaced by one with a low emission coating, in this case Pilkington Kappa Energi Float.

In the case of Window No 1, the influence of two horizontal glazing bars per light was also tested.

Measurements on the more recent window were made only with the window in its original state since it was fitted with a sealed unit that could not be taken apart.

Evaluation of tests

In order that a direct comparison of these three windows may be possible, the test results must be corrected with respect to differences in window size. This correction was effected using the program Frameplus (Frameplus Toolkit, 1995). Calculations can be divided into three types. The first step is to perform calculations on the windows concerned in order to gain an idea of the accuracy of the program. In a second step the effect of reducing or increasing the window size by varying height and width by 10% is studied. Finally, the U value is calculated for Windows Nos 2 and 3 when their height and width are put equal to those of Window No 1, i.e. 1200 x 1200 mm. The theoretical relative difference between the actual window size and the basic case, 1200 x 1200 mm, is then used as the correction factor for the measured U values.

The maximum difference between the calculated and measured U values is 10%. This is the expected accuracy in calculations. This implies that Frameplus has adequate calculation accuracy for it to be used in correcting the measured U values with respect to variations in window size.

Results of measurements

The U values ($W/m^2,°C$) of the three windows as measured in our laboratory (Fredlund, 1999) are set out in Table 1.

Table 1. Final results of tests and evaluation of U values (W/m^2,°C) for older windows

Measure	Window type/year of manufacture		
	1880	1930	1982
Existing state	2.44	2.56	1.83
Renovated	2.07	2.26	
One new LE pane	1.60	1.77	

As will be seen from the table, the U values (heat losses) for the older windows after upgrading are in actual fact lower than that for the three pane window from 1982. The almost 120 year old window has the lowest losses.

It is further seen from the investigation that the effect of the glazing bar is relatively marginal. It makes no difference whether the glazing bar is fitted in only the outer casement or in both the outer and inner casements. For the 1880 window the U value deteriorated by 3—5% when the window was fitted with a glazing bar

CONCLUSION AND RECOMMENDATIONS

The study shows that heat losses through older windows can be reduced by ca 35% without any negative effects on the original architecture.

The method of upgrading is based on replacing the window pane, preferably in the inner casement, by a new type of glass with a low emission coating that is available in the market today. Pilkington manufactures this type of glass in 3 mm thickness which both suits existing glazing rebates and does not place too much load on the existing casement. A thicker glass may be too heavy. This type of glass marketed by Pilkington Floatglas AB is called Kappa Energi Float. The emission coat on the glass is a very thin metallic deposit. This metallic deposit is of a very neutral colour and daylight is reduced by only a few per cent. Because of this it is very difficult to distinguish these panes of glass from ordinary clear glass.

The effect of renovating and replacing the glass in the old window from 1880 is that this becomes much more competitive than when the old window is replaced by a new one. Heat losses are of the same order as in modern windows from 1980 to the 1990s. Since the low emission glass is not appreciably more expensive than ordinary window glass, there is great potential for improving existing windows at a relatively modest cost.

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THE RECYCLING POTENTIAL OF BUILDING PRODUCTS AND BUILDINGS

Dr. Ing. Thomas Lützkendorf

Bauhaus-Universität Weimar, Institut für ressourcenschonendes Bauen, Lehrstuhl Bauklimatik
D-99421 Weimar, Germany (office: Bauhausstrasse 7b, D-99423 Weimar, Germany)
Tel: 0049 (0) 3643/58 3435; Fax: /58 3438; Email: thomas.luetzkendorf@archit.uni weimar.de

PROBLEM DESCRIPTION AND GOALS

One possibility to reduce demand on resources, energy expenditure and environmental impact connected with the construction and use of buildings lies in the use of recycled building materials and construction elements. This is applicable both in the construction of new buildings utilising recycled building materials, as well as during the service life of a building and/or its demolition through the transfer of removed building materials and construction elements to recycling processes. Questions regarding recycling potential very often centre on practical issue such as the clarification of technological, constructional and regulatory problems, as well as at a highly theoretical level in the establishment of agreed rules for the calculation and evaluation of ecological impact.

This paper attempts to address questions and possible solutions connected with recycling from the viewpoint of the planning professional. Planners have a direct influence on the type, range and use of recycling materials in the design of buildings. Through the selection of particular combinations of building materials and connection methods, planners also affect the disposal and recycling characteristics of buildings at the end of their period of use. They therefore require information and aids which make the ecological and economical effects of planning decisions (here in connection with recycling) identifiable and quantifiable.

ANALYSIS AND SOLUTION PROPOSALS

Buildings, in contrast to consumer goods, have a long lifetime and service life. Solutions are required which address questions regarding the course of decisions and the effects of decisions within the life-cycle analysis, in particular when these are connected with the evaluation of recycling effects.

The life-cycle analysis of products very often takes the view that when determining 'total expenditure' of resources and energy during their service life, a portion thereof can be 'recovered' (in the sense of a credit) through the re-use and/or thermal use of the product at the end of its lifespan, and should be taken into consideration. This results in the production, operational and disposal expenditure being offset against a recovered portion. This approach can be appropriate for short-lived consumer goods.

The transfer of this approach to products with a longer lifetime (in this case constructions/buildings) leads, in the view of the author, to an inadmissible neglect of the factors of space and time. The longevity of buildings, due to the larger timespans involved, leads to the fact that a later recycling does not have a concurrent reducing effect on the initial environmental expenditure. In particular, the offsetting of savings resulting from recycling against the initial production expenditure during the investigation and evaluation of individual buildings, dramatically falsifies the real and temporal energy and mass flow. Energy and resource expenditure and/or savings cannot be meaningfully transferred to other time-periods, as is possible with monetary units through interest calculations.

Questions regarding the consideration of recycling effects from point of view of the planner, will be illustrated and discussed using the example of a new building currently in the planning phase.

Proportion and effect of recycling products on initial construction expenditure

As part of the evaluation of a proposal from an ecological viewpoint, it is desirable to represent the proportion of recycled products within the total mass balance and the effect of this proportion on the energy and mass flow for the manufacture and construction of the building. A planner's decision favouring the use of recycled products directly affects the demand on resources and environmental impact at that point in time. Whether through the conscious choice of recycled products or the unconscious use of products with a high recycled content, considerable energy and resource savings can be realised as well as a reduced environmental impact, made possible both through previous recycling processes and the proportionate reduction in new production and manufacturing.

As a result, data detailing the energy and mass flow for building products (and recycled products) are required which additionally describe their 'prehistory' as a basis for making planning decisions. The following cases arise:

a) Energy and mass flow data for building products and construction elements are available which represent the momentary national mean expenditure for their manufacture. They therefore already contain the current national recycling quota automatically. The recycling proportion therefore favourably influences the mean ecological balance. This effect is, however, not apparent to the planner – the evaluation of the 'recycling effect' is not readily calculable.

b) Specific energy and mass flow data for building products and construction elements are available which detail not only 'new manufacture' but also 'recycling product' and/or 'product with x% recycling proportion'. The advantages of an increased utilisation of recycled products can be identified and assessed by the planner when evaluating alternative solutions.

At present case a) is typical. The use of mean values is, in the author's opinion, still appropriate for decisions within the earlier planning phases. In later planning phases and in particular during specific product selection, the procedure b) can be more meaningful to demonstrate the ecological advantages of the use of recycled products. A prerequisite for this is however the availability of product-specific information.

Effects and potential of recycling processes for demolition and disposal

The planner's decisions during the design phase also have an effect during the service life of the building. Although the planner rarely has an active role during this period (excepting the planning of maintenance, modernisation and/or clearing measures) he/she, through the choice of particular products and construction methods, has an effect on the building's characteristics, for instance it's longevity and/or 'maintenance-friendliness'. With this in mind, it would be desirable to be able to assess the 'recycling-friendliness' of a specific design proposal at the design stage. This should facilitate evaluation of the selection of the type and connection method of a building product and whether this makes a possible later dismantling, separation or re-use easier or more difficult. This evaluation, when undertaken at all, has up until now been more or less qualitative in nature. In order to facilitate a meaningful quantitative evaluation, the author suggests the determination and evaluation of a '**recycling potential**'.

Although the planner does not influence whether a demolition, dismantling or re-use at the end of the building's service life actually takes place, he/she can nevertheless create essential favourable conditions for it – a potential. The direct use (i.e. advantageous effect) of the recycling processes only occurs in the future and if these are actually realised. For this reason the author is opposed to the offsetting of future recycling effects against the initial production and construction expenditure. The introduction of a recycling potential however, represents a possibility of transferring information about possible (potential) recycling effects which come about at a later date into the current planning phase and of evaluating them. The recycling potential should be understood as additional information and should be declared as such. The following aspects are prerequisites for the recyling potential:

a) on the level of the building product

The life-path of a building product is affected, among other things, by the kind and location of its use in the building. A variety of scenarios are conceivable for a single product and must therefore be simulated in the planning on the basis of assumptions. Aside from the provision of data regarding energy and mass flow for the product's manufacture, additional information describing its properties in a number of different possibilities (further use, re-use, thermal utilisation, disposal etc.) is required. In [SÖR 97] for example, a portion (KEA_{BONUS}), recoverable through recycling and/or thermal utilisation, is offset against the cumulative energy expenditure (primary energy) for the production (KEA_H) as additional information.

Insulation material	KEA_H in kWh/m³	KEA_{BONUS} in kWh/m³
Wood fibre	700 - 900	480
Polyurethane Foam	750 - 1030	210
Extruded Polystyrene 15	390 - 525	237
Expanded Polystyrene	570 - 1180	311

Table 1 : Example for the additional declaration of the recoverable proportion of energy expenditure through re-use and/or thermal utilisation [SÖR 97]

b) on the level of the construction unit (element)

For constructional elements, typically consisting of several building products, the type of material combination and combination/connection method needs to be examined and described as to how they influence the recycling characteristics of the construction element as a whole and/or of its individual constituents.

Additionally it is suggested in element catalogues to indicate separately the demolition/disposal properties and the separation/recycling properties.

c) on the level of the building

The calculation and assessment of a recycling potential for an entire building requires not only the presence of suitable data (see a) and b)) but also the choice of suitable scenarios (e.g. separation and recycling) when establishing the energy balance in the life-cycle analysis of a building.

PERSPECTIVES

With the introduction of a recycling potential it is hoped to be able to contribute both to the reduction of misunderstandings and errors in calculating ecological balances, and to a quantification of the 'recycling-friendliness' of buildings.

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APPLICATION OF RECYCLED AGGREGATES IN THE EUROPEAN CONCRETE INDUSTRY – ITS CURRENT STATUS AND FUTURE OUTLOOK -

Hans S. Pietersen

Delft Technical University, Faculty of Civil Engineering and Geosciences, Subfaculty of Civil Engineering, Materials Science Engineering Section, Stevinweg 1, 2628 CN DELFT, The Netherlands. E-mail: H.Pietersen@CT.TUDelft.NL

INTRODUCTION

CDW recycling and sustainable development

Mankind's universal mission for the next century could be summarised as to "feed double the number of people, provide them with energy and materials, let them live according to the requirements of a developed society and do not pollute the earth nor change the climate" [1]. In essence, this should be the clear objective for a "sustainable society". The concept of "sustainable development" was put on the international agenda with the UNO-report " Our Common Future", also known as the "Brundtland Report", which was published in 1987 [2]. This report stated – simply put - that problems which occur due to human actions should not be passed on to future generations. In the present paper the "problem" of waste recycling, and in particular the recycling of construction and demolition (C&D) waste, will be addressed. It is estimated that the amount of construction and demolition (C&D) waste produced in Europe ranges between 220-335 million tons annually, approximately 0.6-0.9 ton per capita. As a comparison, this is roughly twice the amount of municipal solid waste produced per inhabitant. It will be clear that C&D waste should be considered as a major waste stream. The progress achieved in Europe will highlighted and documented, including the progress obtained within the recently established European Thematic Network on "Use of Recycled Materials as Aggregates in the Construction Industry"[4]. The presentation will be concluded with a vision on how large-scale application of recycled aggregates in the (concrete) construction industry may gradually be obtained.

CURRENT STATUS OF CDW RECYCLING

EC Directive on waste

In Europe some ideas derived from the Brundtland report became part of the EC Directive 91/156/EEC on waste, formally adopted in March 1991. This directive intends to force EC Member States to stimulate, a/o:

- the prevention and reduction of waste through the development of clean technologies as well as products that can be re-used or recycled;
- the recycling and recovery of waste, and its conversion into secondary materials; and
- the recovery and disposal of waste without endangering human health or the environment.

Based on this directive, waste management plans are currently in the process of implementation on a European Community level, as well as on a Member States level. And because one of the major waste streams in the European Union consists of construction and demolition waste (C&D waste), the EU-construction industry is closely involved in setting up and implementing these management plans.

European CDW

Table 1 summarises EU official data on C&D waste on a European country by country basis [o.a. 3]. Presently, these data are not believed to be entirely correct [ongoing discussion in 4], mainly due to a lack of proper definitions for C&D waste fractions, and a lack of sound EU monitoring programs. However, from table 1 some trends may clearly be derived. It is clear that notably the more densely populated countries, such as Belgium, Denmark and the Netherlands are progressing relatively well with respect to CDW recycling. Running up are Finland, France, Germany and the UK. In the other countries CDW recycling still seems to be restricted to larger urban agglomerations.

Table 1. Generation of C&D waste in EU member countries [4]. Data between brackets were derived from reference [5].

EU Country	Population (Million)	C&D waste (Mton)	C&D waste (kg/capita/year)	Percentage Recycled [3]	Domestic waste (kg/capita/year)
Belgium	10	7,5-8 (7)	700-800	87	350
Denmark	5,2	2,3-5 (3)	460-1000	81	460
Finland	5	1,6 (1)	320	45	620
France	56	20-25 (24)	340-450	15	460
Greece	10	Unknown (2)	- (500)	<5	300
Netherlands	15	13-14 (11)	870-930	>90	500
Ireland	3,5	2,5 (1)	710	<5	310
Italy	58	35-40 (20)	600-690	9	350
Luxembourg	0,4	2,7 (0)	6670 (?)	(?)	450
Portugal	10	Unknown (3)	- (330)	<5	300
Spain	39	11-22 (13)	280-560	<5	320
United Kingdom	57	50-70 (30)	880-1220	45	350
Sweden	8,5	1,2 (2)	140	21	370
Germany	79	52-120 (59)	840-1900	17	360
Austria	7,7	22	2860 (?)	41	430
EU-total (est.)	*364*	*221-334 (180)*	*607-918*	*28*	*390*

Current applications of C&D waste

Most of the EU stony C&D waste is currently still applied for road foundations. Wood is recycled mainly for the wood-chip industry or use as energy source for e.g. power plants, metals are also recycled as raw material in the steelwork industry, and plastics are generally combusted, due to the current lack of economically interesting applications. What remains are asphalt granulates and stony aggregates. If the Netherlands are taken as an example, asphalt granulates may be reused relatively easily for new or renovated roads. It is a waste fraction, which also becomes available as a more or less uniform material, and it is not recommended to mix asphalt granulates with entirely stony aggregates; any future separation, for whatever reason, is bound to be much more difficult than the process of mixing it up.

Applications of recycled aggregates into concrete currently remain restricted to pilot and demonstration projects. Results are definitely promising. A practical problem is logistics. For that reason, there are currently only few concrete(-products) manufacturers in Europe who supply (and apply) concrete with recycled aggregates on a regular basis into their products (e.g. are concrete street- and pavement blocks, pre-fabricated walls for housing projects).

Applications for recycled stony aggregates

Stony aggregates are, according to the recommendations of the CEN 154 “ad hoc group on recycled aggregates” [6] to be divided into three main classes. These classes also reflect the fact that in Europe houses and other constructions are made of concrete, clay bricks or natural stone. Gypsum plaster and gypsum blocks are also generally applied for indoor walls and indoor wall finishing or decoration. Relatively small quantities of lightweight concrete and sand-limestone bricks remain in certain EU countries. In table 2, an overview of the three above-mentioned recycled aggregate classes is provided.

Table 2. Classification criteria for recycled aggregates [6].

Requirement	Type I	Type II	Type III	Test method
Minimum dry particle density (kg/m^3)	1500	2000	2400	prEN 1097-6
Maximum wt.% with SSD < 2200 kg/m^3	-	10	10	prEN 1744-1 section 13.2
Maximum wt.% with SSD < 1800 kg/m^3	10	1	1	modified as ASTM C123
Maximum wt.% with SSD < 1000 kg/m^3	1	0.5	0.5	
Maximum wt.% of foreign materials (metals, glass, plastic, wood, paper, tar, crushed asphalt, etc.)	5	1	1	Test by visual separation as in prEN 933-7

Note 1: prEN 1744-1 section 13.2 as currently drafted separates materials only at a density of 2000 kg/m^3; prEN 933-7 is a sorting method, limited to the determination of shell content.

Type I aggregate are implicitly understood to originate primarily from masonry rubble, while type II aggregates are implicitly understood to originate from concrete rubble. Finally, type III aggregates are implicitly understood to consist of a blend of recycled aggregates (with a maximum of 20%) and natural aggregates, with a mandatory minimum of 80%. The maximum content of Type I aggregates in a blend is intended to be 10% (i.e. 50/50 masonry/concrete mixtures may be used for blending with natural aggregate). In some documents of CEN a type of recycled natural stone masonry is foreseen with almost the same specifications as for Type III. These categories may be related to an increased level of performance, Type III resulting in concrete with a performance essentially unchanged by the content of recycled material.

The properties of concrete with recycled aggregates may differ from concrete with only natural aggregates. Because of this preference is given to concrete in which only part of the aggregate consists of recycled material. RILEM [6;7] concluded that the property variations within concrete with up to 20% (m/m) recycled concrete aggregates or up to 10% (m/m) recycled masonry aggregate are negligible. Depending on a specific application, higher replacement levels may result in slight property deviations. As an example, ongoing studies at the TU-Delft [8;9;10] point out that recycled concrete and recycled mixed aggregates may be applied for concrete with a design strength of 35 MPa and an environmental class of 3 up to replacement levels of 100% for the course 4/22(32) fraction. According to the same study, recycled fine aggregates may be recycled up to replacement levels of 50% in concrete with the above specification, a result that has also been reported by Van der Wegen and Haverkort [11]. Recent large inventories carried out by the Dutch CUR organisation suggest that concrete with recycled mixed aggregates is very well applicable for concrete with 28-strengths up to 25-35 MPa, and environmental classes up to 2 (W/C ratio 0,55) [12].

Standardisation, quality control and legislation

As already mentioned, standardisation procedures are well developed in most EU countries [see 7], and discussion networks are steadily being extended. An example of the latter is the recently started European Thematic Network on Use of Recycled materials in Construction [see 4]. Quality control is a different issue, which should be addressed as soon as there is an agreement over draft standards. It should be realised that the construction industry will NEVER apply recycled materials if their quality can not be guaranteed. Finally, national and regional public bodies and governments, e.g. those responsible for regulation and legislation, play a crucial role. It is well established that in The Netherlands, application of recycled aggregates was stimulated greatly by a ban on the landfilling of recyclable C&D waste, effective from 1997 onwards. Currently, gate fees have to be paid “at the gate” of recycling plants, depending on the C&D quality (or recycling potential). Only if these three aspects are well covered, and in the proper order, the recycling industry should be expected to invest in the large scale processing of C&D waste.

FUTURE OUTLOOK OF CDW RECYCLING

From “waste management” towards “chain management”

Currently, in some European countries (notably The Netherlands), a trend has started to investigate the possibilities to recycle stony building materials into the materials where they were originally derived from. The driving force is the producer’s responsibility to provide for “sustainable” as well as “durable” building materials, potentially lasting centuries. The implication is that concrete should preferentially recycled back into new concrete, and e.g. sand-limestone bricks into sand-limestone bricks. For concrete this seems to be relatively easy, for clay-bricks it will be far more complicated. Even reuse at the construction element level is looked at. The latter aspect requires new solutions in the fields of construction (mounting and demounting of elements), quality control and logistics, and does not seem that easy. Realistic quality control procedures, and the willingness to work accordingly, are essential for an unreserved application of recycled aggregates in the building industry [see e.g.13].

Economical aspects

From an economical point of view, recycling of building materials is only attractive when the recycled product is competitive with natural resources in relation to cost, quality and quantity [3]. Mainly due to several additional procedures and possibly slightly more complicated processing, necessary for the manufacturing of good quality concrete with recycled aggregates, the costs to produce the recycled aggregates for concrete will be at a higher level than in road construction. Even in the Netherlands, where there is a ban on landfilling building- and demolition waste, applications in concrete have not started on a really large scale yet. The main reason here is also that road-construction still has sufficient capacity. However, the general expectation is that in future the application in concrete will increase, especially since the bulk of demolished concrete is growing rapidly. Other solutions, such as those mentioned earlier on in the text, have to be ready by that time [13].

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THE RECYCLED BUILDING PROJECT

Dr Mark Gorgolewski
The Steel Construction Institute, Silwood Park Ascot, Berks, SL5 7QN, UK.

INTRODUCTION

The use of recycled materials and reused components in construction can lead to lower environmental impacts and a reduction in material disposed to landfill. However, the practical, environmental and economic aspects of using these construction materials are often not properly understood within the construction industry. This project aims to quantify these aspects and thereby raise understanding and awareness among designers, materials producers and other parties involved in construction of the opportunities and benefits offered by the use of recycled materials

The objective of this project was to evaluate the cost and environmental impacts of reusing construction products or using products that contain a high proportion of recycled or waste material. The project provides an quantitative environmental and cost assessment of a typical office building with various primary and recycled specifications. The environmental burdens, in terms of embodied energy and carbon dioxide emissions, and the cost implications of the changes in specification are assessed. It was originally intended to include a quantitative assessment of resource consumption and waste generation, however, there was found to be a lack of data for these environmental burdens, particularly for recycled materials.

The information derived from the quantitative assessments was used to provide practical guidance for designers, materials producers and other parties involved in construction, about the opportunities and benefits offered by the use of such materials.

METHODOLOGY

The project was undertaken in three phases:

1. The collection of cost and environmental data for a list of conventional materials such as timber, primary concrete and new bricks; recycled materials such as cellulose insulation, steel and glass wool; and reused components such as second hand bricks, used roof slates and steel piles extracted from a previous site. Data was collected from a variety of sources including BRE[i], IISI[ii], product manufacturers and Ecobillan[iii]. A methodology was developed for calculating environmental and cost data for reused components where little information currently exists[iv].

2. The above data was used to calculate and compare the cost and environmental impacts of a variety of specifications for a square metre of wall and roof assembly, including conventional specifications and those that feature reused and recycled materials. The cost data and the masses of material used to calculate the environmental impacts was supplied by Davis Langdon and Everest (DL&E).

3. Finally the data was assembled to provide an assessment of the overall environmental impact and cost of a typical medium-rise office building with a primary steel frame. Five alternative specifications were assessed for the building include standard and low cost specifications and those that minimise environmental impact or maximise the use of recycled materials. The specifications of the walls, roof and substructure were varied from conventional (primary) materials to recycled and reused materials. Figure 1 shows the total cost and environment impact for the five alternative specifications considered. This illustrates that there is an additional cost of about 4.5% when choosing the environmentally friendly specifications but that a 15% saving can be achieved in embodied carbon dioxide emissions by careful material selection.

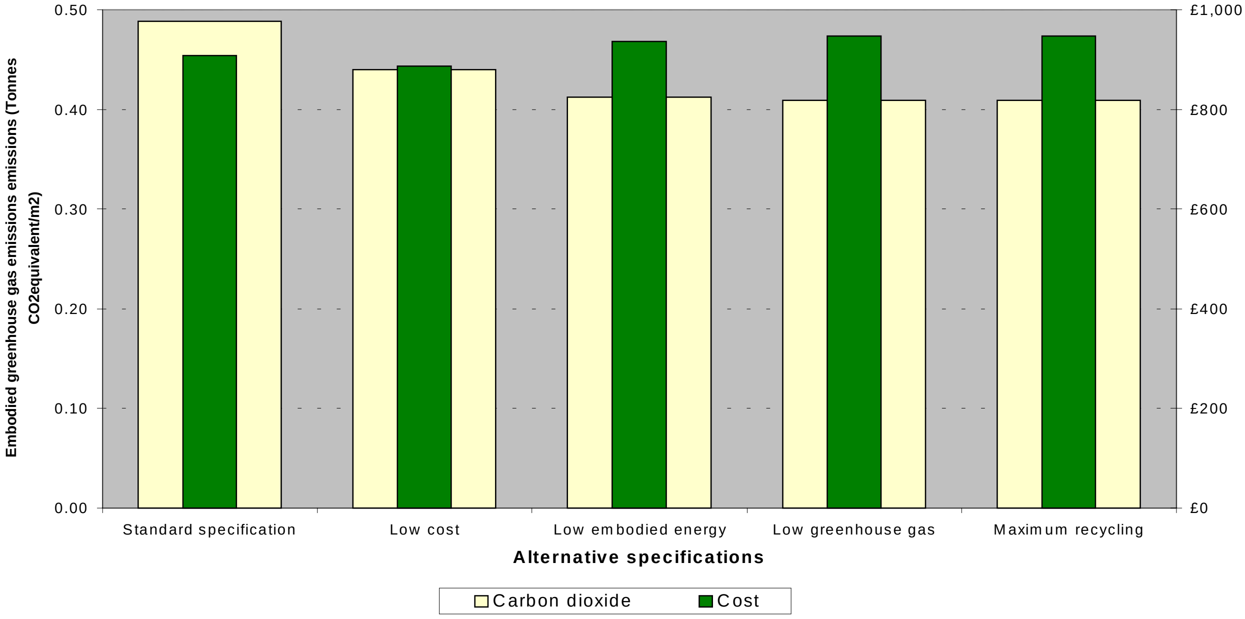

Figure 1 *Comparison of the CO_2 emissions and costs for alternative building specifications.*

ECONOMIC ISSUES

Based on the experience of collecting cost data during this project and on information from other sources, it became apparent that the cost of using recycled and in particular reused products and materials can often attract a price premium. Furthermore, the prices of such products are highly variable reflecting the state of the market local to the project and on a number of project-specific factors. It is important to point out however, that this is the current situation which can be expected to change as the market grows (invoking economies of scale) and as primary material prices rise (enhanced by taxation such as the landfill and primary aggregates taxes).

Project-specific factors to take into account when costing for recycled materials include:

- Distance of the site from a guaranteed supply of the materials (and hence transport costs).
- The need for advance purchase (and perhaps storage) of materials to guarantee a supply.
- Regional variations in market conditions.
- The costs involved in testing.

It may also be appropriate to consider the commercial and marketing benefits to the client when developing a project which features recycled materials. Surveys have shown that some clients are prepared to pay a premium for reclaimed and recycled materials (up to 10% has been quoted).

CONCLUSIONS AND DESIGN GUIDANCE

The following guidance has been developed based on the quantitative assessments carried out during this study. It is important to bear in mind that it was not possible to assess resource depletion and waste generation when interpreting this guidance.

- The largest environmental benefits are achieved when using reused components. Specifying these leads to significant reductions in greenhouse gas emissions and embodied energy. However, due to the inconsistency in the supply chain, there is a premium to be paid for the use of reused materials. This is due to the variable supply at present, and suggests that the larger environmental benefits gained by using reused components may have some cost penalty.
- The environmental impact of the external walls is dominated by the external cladding material. There are several reused options such as second hand bricks or recycled options such as steel

cladding or bricks with recycled content that can significantly reduce the environmental impact of external walls. It is worth the designer focusing on the specification for the wall cladding.

- The environmental impact of the roof is dominated by the roof structure and cladding. Recycled options such as steel cladding or tiles made from slate dust or reused options such as used concrete or clay tiles can generate significant environmental benefits. Using steel as the roof structure can also reduce the overall environmental impacts of the roof.
- The availability of reused components such as second hand bricks and roof tiles is limited and it may be difficult to secure sufficient quantities from one source. Approaching demolition contractors directly may be the best option. Otherwise salvage yards will need as much notice as possible to source larger batches.
- The correlation between cost and environmental impact is complex. Although the most environmentally beneficial options, particularly reused components, are more expensive, by careful choice it is possible to make cost effective choices that can significantly reduce environmental impact. Many of the materials that feature some recycled material, such as glass wool or cellulose insulation are competitive in terms of their costs.
- The correlation between environmental impact and the recycled content is complex. Many materials such as cellulose insulation with a high recycled content have a low environmental impact, but this is not the case for all product. Where materials have a partly recycled content, such as steel, generally the environmental burdens are reduced as recycled content increases.
- For most materials there is a strong correlation between the environmental indicators greenhouse gas emissions and embodied energy. However, there are some variations and, in particular, the situation for timber is complex. For timber the carbon sequestered during growth is offset by the carbon dioxide and methane generated when it is disposed. The overall result is that although embodied energy is relatively low, greenhouse gas emissions are more significant.
- Standardisation of components would greatly enhance the match between those retrieved from old buildings and those required for new buildings Many architects would like to reuse old elements but find it difficult to locate suitable supplies. Equally many demolition contractors would like to sell whole building elements for re-use, but the timing of the demolition contract rarely coincides with demand for those elements. Supply and demand of recycled construction products is currently too erratic for a stable market in re-used elements to exist. However this barrier is not insurmountable and with a certain amount of 'pump-priming' from the construction industry and the imposition of 'green' taxes on primary construction materials, the supply and demands should be better matched in future.
- The elements assessed in this study (external wall, roof and substructure) form only about 20% to 25% of the environmental impact of the whole building. The study has shown that it is possible to reduce the environmental impact of these elements by up to about 50% by careful specification, particularly of reused components. There are less options for using recycled materials for other elements, and it is unlikely that savings on this scale could be made.
- When set in the context of a 60 year lifetime (including the emissions from operating energy use) the embodied greenhouse gas emissions represent between 15% and 18% of lifetime greenhouse gas emissions. This is the equivalent of between 9 and 11 years of emissions from operating the building. By careful specification of reused components and recycled materials about 3% of lifetime emissions can be saved.

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FROM GRAVE TO CRADLE:
REINCARNATION OF BUILDING MATERIALS

Bart J.H. te Dorsthorst[1], Ton Kowalczyk[2], Charles F. Hendriks[1] and Jón Kristinsson[2]
Delft University of Technology, Delft, The Netherlands
[1] DIOC-DGO The Ecological City, Rotterdamseweg 139A, 2628 AL Delft
[2] Faculty of Architecture, Environmental Technical Design, PO Box 5043, 2600 GA Delft

INTRODUCTION

One of the possible contributions to sustainable building is to keep the building materials as long in their own cycle as possible (figure 1). This can be done on two occasions: during the design-stage or demolition-stage. In the design-stage a dismantable building system can be chosen, where all the elements and components can easily and directly be re-used after dismantling a building. This building system is called Design For Dismantling (DFD). Design For Recycling (DFR) is an other building system where during the design-stage reckoning is given with the fact what to do with the building materials after demolition. The materials are easy to separate during the demolition process and after further processing (e.g. crushing) they can be used as a raw material for the production of building materials.

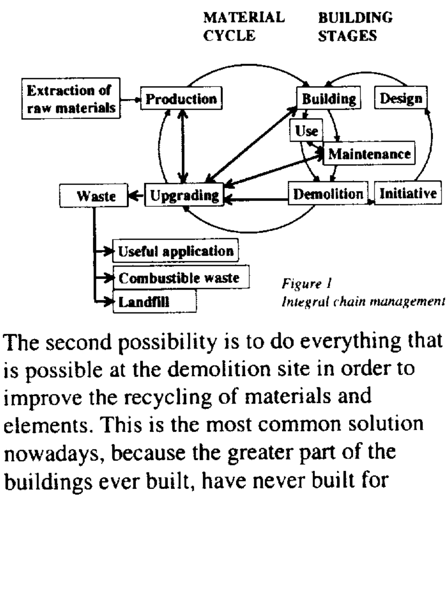

Figure 1
Integral chain management

The second possibility is to do everything that is possible at the demolition site in order to improve the recycling of materials and elements. This is the most common solution nowadays, because the greater part of the buildings ever built, have never built for dismantling. So the present emphasis lies on the demolition process.

The Netherlands produces 16 million tons of Demolition and Construction Waste (DCW) a year, for example: this quantity can be used for a road basement for a 250 km, six lane speedway, 20 meters wide and 2 meters thick. 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 four possible solutions. Firstly, all new buildings can be built and assembled with reusable elements (DFD) and materials (DFR). Secondly, existing buildings can be upgraded if possible. Thirdly, if upgrading is not an option then buildings should be dismantled into elements and components when possible and finally buildings should be demolished (selectively) and the materials can be re-used at material level.

DELFT LADDER

In 1980 the Dutch government published an order for waste treatment (1) this order was called the Ladder of Lansink. This order was a fixed top-down approach. Since 1980 more waste treatment options were developed, therefor the Ladder of Lansink has been extended with three new options. This new order, called Delft Ladder (2), becomes flexible thanks to the results of calculation methods like Life Cycle Assessment and Eco-cost Value Ratio (3). The options of the Delft Ladder are: prevention, object renovation,

element re-use, material re-use, useful application, immobilisation with or without useful application, incineration with or without energy recovery and landfill.
The first option of the Delft Ladder tries to prevent the production of waste. This step must be taken before a building is demolished, it must be taken into account in the design and building stage (DFR). This can be done twofold: by using a dismantable building system like LEGO, or by using recyclable or renewable materials which are easy to separate and can be used in their own material cycle. The 2nd until 5th option will be discussed later on.
Immobilisation with or without useful application is the next waste treatment options. Hazardous waste can be used as a construction material. By incineration with energy recovery energy is gained out of the burning of waste. The incineration of materials in a cement-kiln is an example of this option. By incineration without energy recovery the material is just burned. The last step is to landfill the materials.

OBJECT RENOVATION

When a construction is at its end of life, it will not be demolished, but the construction will be renovated. After the renovation the function may be changed. This can be done with all buildings, but with constructions that are designed to be adapted, it will be much easier. There are a lot of examples; two of the most famous are "de Kop van Zuid" in Rotterdam and "Entrepotdok" in Amsterdam, two warehouses built in the 17th century and renovated in the 1980's. Now they serve as houses and shops.
Newly built construction can also be designed to be adapted. An example of such a construction is a building in Schijndel. In this building there are a school (ground floor and first floor) and apartments (second floor). In about 20 years, the school will need less space, and the rooms at the first floor can easily be changed into apartments. Another example of object renovation, which will be discussed further on, is the case in Maassluis.

DISMANTLING

Dismantling a building is easier said than done, especially when it has not been built with the intention of regaining the used elements and components. The first thing to do is to establish the building method and the matching details. With this information in hand and the knowledge of the dismantling techniques you can determine the success of disassembling the building into elements or components.
One of the greatest bottlenecks mentioned before is that most of the buildings are never meant to be dismantled into reusable elements or components. This means that the thoughts about the utilised building method and details were only concerned with how is a building put together and not how it can be dismantled. A reinforced concrete structure with every joint well fixed, is hard to dismantle. A possible technique could be by sawing the construction. Another disadvantage of this method is that the reinforcing steel will be exposed to the air, which could lead to the decay of concrete. A disadvantage could be that the gained element smaller is then the original one, but this could be overcome by redesigning the gained element.
On the other hand dismantling a building is not quite the same, as the opposite of building, but the same safety measures have to be taken. During the building-stage, when a construction reaches its strength the safety support structure can be removed. During dismantling, the first thing is to build up the safety support before a construction can be dismantled.
For demolishing a building a contractor can choose from a range of methods, such as: balling, impact breakers, hydraulic shears, explosives, gas expansion and solid expansion. They all result in breaking the building into smaller pieces, but not in reusable elements or components (4).
For dismantling a building, methods have to be found which don't damage the element or component and which will lead to a successful re-use of the element or component. Usable methods could be mechanical cutting and grinding, thermal

cutting, water jet cutting and laser cutting. These methods make a cut of a few millimetres to a few centimetres at most, so a small part of the construction is gone without damaging the rest, and if dismantling a building is no problem, accessibility of the location could be one. The accessibility of the location (residential area) could limit the size of the trucks, and as a result the elements couldn't be transported. The size of the elements could be made smaller but could also decrease chances of successful re-use.

BUILDING REGULATIONS AND MATERIAL REQUIREMENTS

The elements or components that are deemed reusable have been built in an earlier period. In that period there were other building regulations and material requirements effective. For example: in the 1950's there were no insulation regulations, and in the 80's a standard double glazed window had a k-value of 3.5 W/m²K. Nowadays the insulation regulations for elements or components are redundant because of the Energy Performance Coefficient (EPC). This EPC calculates for a certain building the usage of energy and how that will be accomplished is up to the architect, it can be realised by using single glazed windows and heavily insulated walls. Or the deflection of a structure: can the structure still be re-used when it is a certain age and can it still fulfil the deflection requirements?

So after an element or component is dismantled it still has to undergo a few examinations before the decision can be made for direct re-use. If the element or component won't meet the requirements and building regulations, than upgrading could be an option. Not only requirements and building regulations play a part in the decision for reusing, the architectonic view or even the colour can also be a deciding factor.

In the Netherlands the building regulations are summed up in the Building Decree. This means that every element or component must be certified and so must every secondary element or component be certified. If a secondary element or component lacks a certification it will not find its path to the construction site.

Two of the problems of the certification of a secondary element or component are: how will it be done and who is going to do it? Starting with whom is going to do it, an independent institute should do the job. Concerning the manner of how is it done: is every element or component examined or will a representative sample be taken and examined? An aspect of these problems is the cost associated with such a process? When a secondary element or component completes this process, then the next step will be the determination of the costs and environmental impact.

MATERIAL RE-USE

Re-use of materials is common practice now in the Netherlands. Over 90% of the DCW is re-used nowadays, almost all in the road building industry. Before the DCW, the stony part, can be used as a road base material or as a secondary aggregate in concrete it has to be crushed. This crushing can be done on site, with a mobile crushing plant, or at a fixed crushing plant. At the crushing plant the material will be cleaned from iron, wood, paper and so on. And after crushing the material into the proper size, the material will be sieved in order to get the right fractions. The crushing companies in the Netherlands have their own certified product, named 'Korrelmix'.

CASE MAASSLUIS

Currently there is a re-use project going on in Maassluis, the Netherlands. It is a project where six apartment buildings of four floors high will be re-used. Two apartment buildings have been renovated and a fifth floor has been added. Of three apartment buildings, the two top floors have been removed and the remaining part of the building will be redesigned to become single-family dwellings (figure 2). The sixth apartment building has been demolished, only the foundation will be re-used for single-family dwellings.

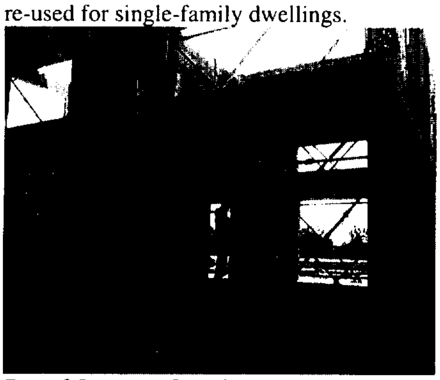

Figure 2 Remaining floors for a single-family dwelling

One of the first and most important problems encountered during dismantling is that the apartment building is not quite built as it was designed. During the building the contractor changed the details without giving any notice of it, which came across when the dismantling started. Firstly, when the project was just in the initiative-stage, the idea was to dismantle the third and fourth floor. These elements would be used to build single-family dwellings just across the street, and in this stage it wasn't clear whether the elements were reusable, so the second thought was to dismantle the two upper floors and store them on a nearby location to catalogue and test them. Realisation of this idea was not possible; two things went wrong during this process. Firstly there wasn't enough time and knowledge available and secondly the government wasn't intending to subsidise the project so all the risk was for the housing association and the contractor.
The used building method is a precast building system where the connections between the floors and walls should have been filled up with a mixture of sand-cement. During the construction a much stronger mixture was used, there is no need to say that this made it more difficult to dismantle the construction. Reusing the construction instead of building totally new houses gave a profit for the smaller dwellings of $2.250 and for the bigger $5.500. So far, for the first apartment building the extra costs were about $45.000, that is per dwelling $2.800.
This project is the first in its kind in the Netherlands and so it is a learning project. About 2 million of these apartments have been built during the period 1946-1980, and nowadays a lot of these apartments cannot meet the standards of today. Because the housing association, the principal in this project, owns 2.500 of these same type apartments in the same condition as this project, it can be expected that more of these projects will follow in the future.

CONCLUSIONS

Nowadays almost all DCW in the Netherlands ends up as a road base-material (grave) what is not necessary the best reuse option. Technically a rebirth of these materials is possible but economical and environmental aspects determine how this will be done and in which step of the Delft Ladder (object renovation, element re-use or material re-use). We seek for the best environmental and economical option for closing the material cycle, so after demolition building materials end up in the cradle ready for a new life.

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Environmental impact of recycling PVCu

Flanagan L and Miller A J
University of Brighton, The School of the Environment, Cockcroft, Brighton, Sussex, England BN2 4GJ.
Email L.Flanagan @Bton.ac.uk

Introduction

The desire to quantify the impacts associated with the use and enduse of polyvinyl chloride (PVC) products has gained increased emphasis over recent years [Plinke et al 2000]. Primary research conducted by the University of Brighton has investigated the use of PVCu joinery profiles using a methodology based on accepted LCA practices. The resultant eco-profile identifies the process specific burdens attributed to polymer formation, use and enduse. A key research consideration was the development of a computer program in order to investigate the complex interactions experienced during the profile's life-cycle. The completed Systems Model enables the environmental impact of differing reuse and recycling scenarios to be assessed.

Model design

The System Model, as illustrated in figure 1, addresses five criteria: 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 materials and material efficiency – related to the amount of waste produced. A schematic representation of the processes investigated readily identifies each sub-system and its relationship within the life-cycle. The System Model displays both process specific and cumulative value of material, energy and transportation requirements. Cumulative emissions, in the form of eight primary pollutants, further illustrate the eco-profile's total burden. Variation in process impact due to fuel mix, conversion and process efficiency of each sub-system may also be modelled. The model consequently provides the opportunity to review critically the embodied energy requirement, transportation impact and the energy mix employed within each sub-system as well as the life-cycle as a whole.

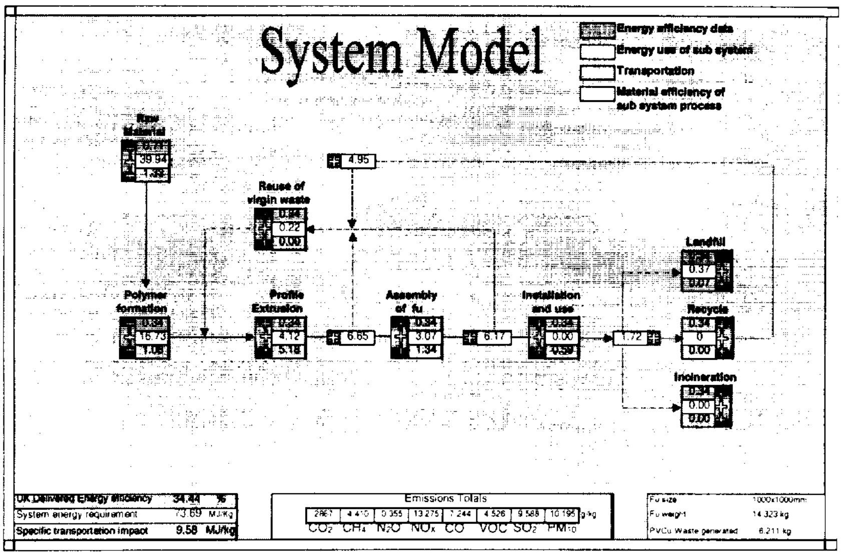


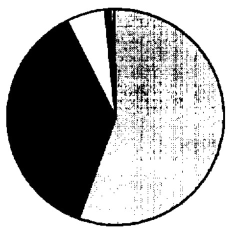
Figure 1: System Model Review sheet

Figure 1 identifies the process specific impacts associated with the formation output of 1kg mass balanced unit from each sub-system. *Profile extrusion* for example requires 4.12 MJ/kg in process energy. An additional 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 electricity from differing geographical regions is also provided. *Raw Material* formation in Norway therefore records a conversion efficiency of 71 per cent due to the use of hydropower.

Discussion

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 PVCu joinery profiles. The energy consumption of each sub-system in isolation and the cumulative impact within the complete life-cycle is identified in Figure 2. The life-cycle embodied energy (EE) impact of the fu (functional unit) is calculated to be 83.27 MJ/kg when the enduse scenario is landfill.

Delivered embodied energy impact of fu PVCu window joinery



Fu : 1000x1000mm full size casement PVCu window frame
PVCu material weight: 14.323 kg

Sub-system	Process energy use (MJ/kg)	Transport energy use (MJ/kg)	Sub-system 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	6.07	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	2072 g/kg	795 g/kg	2867 g/kg	

Figure 2: Eco-profile delivered embodied energy impact of PVCu window joinery

The formation and transportation of the PVCu polymer accommodates 80 per cent of the eco-profile's delivered energy consumption. The energy intensive activities of chlorine production, the thermal cracking of naphtha and conversion to ethylene dichloride for processing into VCM subsequently have a significant impact on the life-cycle of the eco-profile. This high value is nevertheless partly attributed to the cumulative impact of waste from downstream processes, which increase the process energy use by 13 per cent. Transportation impact is also increased.

Conversion of the PVCu powder into joinery profiles and their subsequent assembly into a casement window utilise 13.71 MJ/kg and represents in the region of 18 percent of total life-cycle energy consumption. Moreover nearly half of this energy impact is attributed to the carriage of PVCu goods between *Profile extrusion* and *Assembly* operations sub-systems.

The transportation distance recorded 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. The delivery of profile lengths to the assembly site subsequently displays a four-fold increase in energy consumption over bulk transportation of polymer powder. Empty vehicles on return routes further adds to the inefficiency of regional distribution.

Conclusion

The cumulative impact of material waste from profile extrusion and assembly operations has a significant impact on upstream processes. Inefficient use of transportation further increases the life-cycle impact of the material. Reduction in the process energy of all sub-systems may however be attained by exploring the reuse of virgin PVCu waste generated and transportation of goods between each sub-system. The ability to model and critically review the data sets of each sub-system targeted subsequently offers guidance on the impact of contrasting reuse and recycling scenarios. For example the reintroduction of differing rates of PVCu scrap up to 10 per cent as allowed by BS 7722 [1994] using the existing transportation system would enable the following cumulative savings to be made, as detailed in Figure 3.

Scenario	Recyclate percentage		Process Energy (MJ/kg)	Transportation energy (MJ/kg/kg)	Total energy Use (MJ/kg)	Transport distance (km)	Process CO_2 (g/kg)	Transport CO_2 (g/kg)	Total CO_2 (g/kg)
	input	loss							
FU	-	-	73.69	9.58	83.27	5493	1435	795	2220
One	5	5	70.37	9.58	79.95	5493	1385	795	2180
Two	5	10	68.31	9.52	77.83	5493	1213	843	2056

Figure 3: Reduction in EE via reuse of virgin waste

Scenario One records the reintroduction of five per cent "in-house" PVCu waste generated during the extrusion of the fu profiles. The reuse sub-system incurs its own energy use of 0.22 MJ/kg and experiences a five per cent recyclate loss. The reintroduction of the recyclate attains a revised cumulative energy consumption of 79.95 MJ/kg. This is primarily due to reductions in upstream processing and transportation. Carbon dioxide emissions are also reduced accordingly. Scenario Two explores the life-cycle impact of further improving the previous proposition by returning assembly waste to the extrusion site via the existing transportation system in place. Cumulative process energy reduces to 68.31 MJ/kg - a seven per cent energy saving over the FU eco-profile. Combined airborne emissions also reduce proportionally due to the reduction in process energy use cancelling the six per cent rise in vehicle emissions.

The relationship between reuse and the environment is governed by the reduction in the use of all primary resources against all impacts associated with reprocessing. True reuse and recycling therefore remains concerned with saving energy and materials. The reapplication of scrap material into new profile systems consequently negates the burdens associated with upstream polymer formation. The environmental impact of the specification and use of PVCu joinery can thus be reduced by co-ordination of all sub-system processes of the material's life-cycle.

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AIMING FOR WASTE MANAGEMENT FROM CONSTRUCTION SITE PERSONNEL TO ACHIEVE SUSTAINABLE CONSTRUCTION: A TARGET FOR SINGAPORE

Mr. Su-Liang Goh

Faculty of Architecture, Building and Planning
The University of Melbourne
Parkville, Victoria 3052
Australia

ABSTRACT

Building related work from new constructions, renovations and the final demolition produces waste. Waste causes environmentally unsustainable issues such as pollution and resource depletion. The issues related to environmental unsustainability from construction are serious and have consequential effects to the future of human kind. The urgent challenge now is to reconcile continued economic growth with the constraints of a shrinking pool of resources and an increase in the degraded environment. This can be achieved by minimizing and managing building waste. Any company who is looking for the competitive edge that will keep them competitive in today's construction industry has to manage their waste in a sustainable manner.

LOCAL CONSTRUCTION WASTE SCENARIO

Construction and Demolition (C&D) waste is found in all types of building work. It creates a disposal problem for land scarce Singapore; and leads to the unnecessary consumption of natural building resources. This creates unsustainable use of natural resources and pollution to the environment.

At present construction debris is estimated to constitute about 7 per cent of the municipal solid waste (ENV, 1997). While the Environment Ministry estimated the recycling rate of construction debris to be about 60%, an independent research carried out by the researcher found the actual recycling rate for construction debris to be only 25%. The remaining 75% were assumed to be disposed of in designated landfills. The high disposal rate is attributed to the poor attitude of most building contractors who felt environmental issues are currently not a high priority on their agenda, or it is not their concern. The contractors agreed that everyone had a part to play in order to conserve the world's natural resources and environment. Only a hand full has started to sort their waste in an environmentally conscious manner by engaging specialist waste contractors to remove it for recycling.

Reducing, reusing and recycling building materials would reduce dependence on the environment for natural resources. Furthermore it will reduce energy consumption in the production of materials.

Reducing waste at source by not generating it is the most resource conserving method because less raw materials are used while manufacturing the product; and extending the product life reduces the quantity of waste to be disposed of. Reuse is the second most resource conserving approach. Recycling is the third in line; it generally conserves less virgin materials and creates less pollution than manufacturing using virgin materials. Land disposal is the last resort because it neither recovers energy or materials.

Singapore is not endowed with natural resources to produce its own building materials, therefore building construction using non-renewable resources is fundamentally unsustainable.

A case study research was conducted to identify factors that can support and increase effective waste management in the Singapore construction industry in general. An interview was conducted only on managerial personnel on site because commitment to waste management is perceived to start at the managerial level before site operatives can be told to manage waste at their operating level. Potential financial and ecological benefits can be achieved from proper utilisation of waste.

CASE STUDY RESULTS

The level of understanding of solid waste management was moderately high. Solid waste management was viewed as:

A method of controlling solid waste produced in the construction process so that the quantity of waste can be minimized. Otherwise the unwanted and non-hazardous waste that was generated should be collected and disposed off site in containers as soon as possible. By managing solid waste well, cost benefits can be achieved.

The site supervisors expressed the strongest commitment to solid construction waste management, followed closely by the project manager, architect and site engineers. The project director was the least committed. This could be due to his over-riding responsibility to ensure that the project is completed within time, cost and quality.

The site supervisors were involved in waste management by providing guidelines on managing waste and designating waste collection areas on site. The site engineers contributed by setting up a waste management manual or procedure to manage construction waste such as collecting, storing and reusing the waste for other purposes.

Both project managers and site supervisors felt very strongly that waste management is important irrespective of the cost of doing it. The site engineer and environmental and quality service manager felt otherwise. The disagreement could be because of practical or economical constraints that affect the feasibility of recycling or reusing the waste.

The main issues that can positively encourage managing waste are source separation and reuse, education and information sharing, rewards and project cost benefits.

Source separation and reuse

Source separation is the preferred method over the traditional method that relies on the participation by construction workers to physically pick and separate the waste. The traditional separation method can be time consuming as well as labour intensive. It is also unproductive.

The company's waste management policy is put in place by their ISO 14000 accreditation. It involves the segregation of waste to enable its reuse on the same site or on another project where feasible. Re-usable waste such as bricks and concrete are used as hardcore. Steel formwork was used in the project in favour over timber, because it was highly reusable. Reusing steel formwork minimizes the need to exploit diminishing natural resources and in the process reduces environmental pollution.

Developers and architects were frequently encouraged to use environmentally friendly materials and reuse non-renewable materials.

The importance of proper waste management was frequently stressed during meetings. Further improvements to work methods were also frequently discussed so that waste can be reduced.

Education and Information sharing

The company uses in-house exhibitions, as their current education and information sharing method, to bring across their commitment to solid waste management. These exhibitions are conducted frequently to increase the level of awareness of site personnel on reusing unwanted material and reducing wastage. Positive team effort has encouraged the entire project team to work towards producing less waste.

Rewards

The company rewards those who act to effectively manage waste. Reducing defective work, especially in the structure, saved materials and time. Monetary savings from reducing the cost of purchasing materials and quicker construction time was put back into the employees' bonus system as a form of reward.

Cost benefits

Overall cost benefits to the project was gained through reduced tipping fees and purchase of common building materials. Solid waste management also contributed to a reduction in operating costs through less abortive work. A small cost saving was achieved by selling steel bars to another user or back to the manufacturer for recycling or reprocessing.

CONCLUSIONS

Site managerial staffs adopt a positive attitude towards minimizing and managing waste. Reduction, followed by reuse of waste is currently the company's priority on waste management. If more waste contractors are set up, site operations could improve in tandem and source-separating the wasted materials could be viable. A dedicated contractor to handle C&D waste is necessary to spearhead any recycling initiative on site.

Overall, site respondents felt that there is a lack of information on the principles and procedures of managing solid construction waste on site.

Monetary reward is mainly geared towards management staff as a form of incentive to work towards waste minimization. Such incentive could motivate employees in the area of waste management, and at the same time, demonstrate management commitment towards waste management.

Most site staff perceived waste management as cost effective irrespective of the initial cost outlay in infrastructure and training. In direct relation to cost, managing waste on site hasten construction time.

Currently recycling building materials is low because there is no recycling infrastructure, or supporting industry. Furthermore, there is no pressure to recycle most types of building materials at the moment because recycled products do not work out to be cheaper than virgin products. To ensure recycling is carried out, the government should support and introduce some mandatory requirements equivalent to ISO standards for quality work.

The case study showed that for the organisation who was looking for the competitive edge that will keep them competitive in today's industry, they have to manage their waste in a sustainable manner.

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THE RECYCLING OF DEMOLITION CONCRETE, WITH PARTICULAR REFERENCE TO THE EFFECT OF PLASTER CONTAMINATION.

John Sturges[1] and Colin Whyte[2].
1. Centre for the Built Environment, Leeds Metropolitan University, UK.
2. St. George plc, UK.

Introduction.
Concrete is the most widely used of all construction materials, and it therefore forms a large proportion of demolition waste. In the UK about 70 million tonnes of demolition and construction waste are produced each year (Humphrey, 1994). Only 4% of demolition concrete is properly recycled, 29% goes for low level uses and 67% goes into landfill (Golton *et al.*, 1995) and attention has been devoted to the possibility of recycling this material. However, contamination is always a problem, and even with good demolition practice, concrete rubble is likely to contain some metals and plaster, for example. Metal can be separated but plaster cannot easily be removed. It was decided to carry out a small experimental programme to examine the quality of concrete made from recycled material, including concrete contaminated with some gypsum (Whyte, 1999).

Methodology.
Demolition concrete taken from two points on a construction site at Kingston-on-Thames, UK, was used in this work. Material was taken from a basement retaining wall and also from a cast *in situ* floor slab from a demolished shop. The two samples were kept separate and transported to the Mining Department at Leeds University, where they were put through a jaw crusher. The jaws were set between 24mm and 30mm apart to produce aggregate of appropriate size (Hansen, 1992).

The crushed concrete was subject to a sieve analysis, graded and then used as the coarse aggregate in this work. River sand was used as fine aggregate.

Three mix designs were used, these followed the designs of De Larrard (1992), for Normal strength, High strength and Very High strength concrete. The first mix was made using virgin aggregate to act as a control. The second and third batches of concrete made included the recycled aggregate material as replacement for the coarse (6mm to 20mm) virgin aggregate. Finally, the third batch of concrete was contaminated with 4% by weight of unhydrated gypsum.

In each case 100mm × 100mm × 100mm test cubes were made. After setting overnight the cubes were transferred to a curing tank. The cubes were tested at 7 days, 14 days and 28 days using an Avery Denison cube tester.

Results.
The results obtained from the three mixes are shown in figures 1 to 3, and it can be seen that all three show typical strength gain behaviour with time. In addition, all three sets of curves

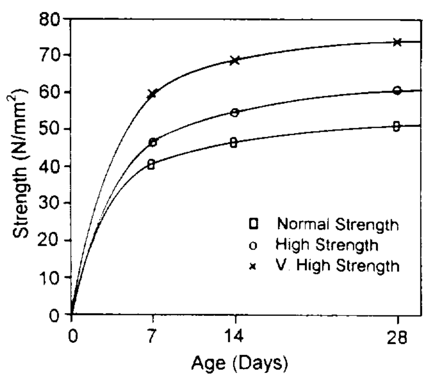

Fig. 1. Control Mix Results.

consistently show a modest increase in strength between the normal and high strength mixes, and a larger increase between the high strength and very high strength mixes. As would be expected, the control set achieved the highest strengths, with 28-day strengths of 51.85 N/mm^2, 60.87 N/mm^2 and 74.44 N/mm^2 respectively for the normal, high and very high strength mixes.

These values were somewhat lower than those achieved by de Larrard (1992), but since the same methodology was applied to all three batches of material, this was not seen as a real problem. The control mix was the benchmark against which the others were compared.

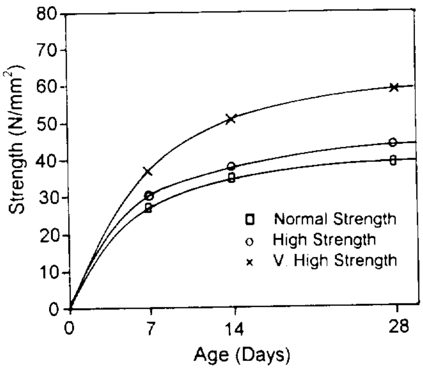

Fig. 2. Recycled Aggregate Concrete Results.

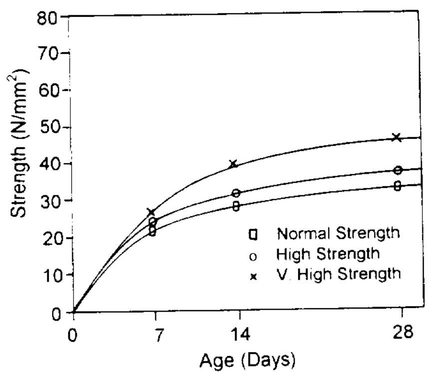

Fig. 3. Recycled Aggregate with 4% Gypsum contamination.

The 28-day strengths of the mixes made with recycled concrete were 39.13 N/mm^2, 43.39 N/mm^2 and 57.60 N/mm^2 for the normal, high and very high strength mixes (Figure 2).

Finally, the corresponding 28-day strengths of concrete made with plaster contaminated, recycled materials were 31.95 N/mm^2, 36.33 N/mm^2 and 46.39 N/mm^2 for normal, high and very high strength mixes (Figure 3).

The reductions in strength compared with the control mixes ranged between 22.5% and 27.8% for the recycled aggregate, and between 37.6% and 40.3% for the plaster contaminated, recycled aggregate.

Discussion.

The experimental work showed that concrete made using recycled aggregate exhibited orderly strength gain behaviour similar to that made with virgin aggregate. The strength values obtained compared very favourably with those reported by other investigators (e.g. Collins, 1997).

One of the principal problems with recycling of any material is obtaining supplies of scrap material of consistent quality, free from contamination. When buildings come to the end of their useful lives, they are usually demolished by the quickest method and this gives rise to demolition rubble contaminated with timber, plaster, metals plastics, paper, etc. Such mixed material cannot be recycled without some separation process, and often, this is not economic.

However, the results reported above, show that concrete may be successfully recycled, provided that contamination is of limited extent. These results are very encouraging, and suggest that for many applications, recycled material could be more than adequate in strength terms. Obviously, there will be many applications where other considerations come into play that would rule out the use of such material. A major problem in construction is the large amount of material (67% reported by Golton *et al.* 1995, above) that is not recycled. The UK needs to increase this, and the UK Landfill Tax, which came into force in October 1996, represents an initial step towards achieving increased recycling.

The production of concrete using recycled aggregates is governed by similar principles to concrete making with virgin aggregates, in that supplies of consistent quality are essential. The demolition and recycling of large concrete structures may provide aggregates of consistent quality. However, the stockpiling of demolition material from a variety of sources might also provide adequate material by an 'averaging out' process.

An infrastructure for collecting and processing demolition waste does not really exist in the UK. To help achieve this, buildings would need to be designed so that they could be dismantled at the end of their useful lives, improved labelling/recording of materials would be needed, as well as machinery for crushing and grading concrete rubble on-site. Developments are ongoing in all of these areas.

A major barrier to increasing use of recycled material lies in the areas of specification and risk. Compliance with BS 5328 for concrete does not prevent the use of recycled material. However, contract specifications which require compliance with BS882 (Natural aggregates for concrete) do preclude the use of recycled aggregates. Blast furnace slag (BS1047) and Lightweight aggregates (BS3797) are the only regular exceptions to this. Non-compliance with BS822 places the risks consequent on its use on the specifier, and this is nearly always unacceptable to those specifying concrete. Measures to increase confidence in the use of recycled materials would include more demonstration projects such as the one carried out at BRE in the UK (Collins, 1997).

Conclusion

i) The results obtained showed consistent patterns of behaviour; very important when concrete is being produced for large projects.

ii) Demolition concrete can be crushed, graded and used to make recycled concrete with very good strength properties.

iii) The presence of gypsum plaster in the demolition concrete caused a further decrease in the strengths achieved. However, for many applications, demolition concrete could safely be used in place of virgin aggregates.

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Architecture of the Future

by
Prof. Kazuo Iwamura
Architect/JIA, Musashi Institute of Technology

1. UIA Chicago Congress (1993)

In 1993, the 18th Congress of International Union of Architects (UIA) was held in Chicago, right a year after the Rio's "Earth Summit". To this congress ca.14,000 architects from 80 countries have gathered to discuss about the architects' professional responsibilities related to the sustainable development, which emerged as a global key-word for the upcoming 21st century from Rio. The results of the congress have crystallized in Chicago Declaration (Declaration of Interdependence for a Sustainable Future: 18-21 June 1993) as follows;

We commit ourselves, as member of the world's architectural and building-design professions, individually and through our professional organizations, to:

1) Place environmental and social sustainability at the core of our practices and professional responsibilities.
2) Develop and continually improve practices, procedures, products, curricula, services, and standards that will enable the implementation of sustainable design.
3) Educate our fellow professionals, the building industry, clients, students, and the general public about the critical importance and substantial opportunities of sustainable design.
4) Establish policies, regulations, and practices in government and business that ensure sustainable design become normal practice.
5) Bring all existing and future elements of the built environment - in their design, production, use, and eventual reuse - up to sustainable design standards.

2. UIA Beijing Congress(1999) and Architecture of the Future (AOF)

Scheduled to convene in Beijing last year, the first venue in Asia, the 20th UIA congress was organized under the theme **"Architecture of the 21st Century"**. Back in 1994, when this theme was first conceived, "Architecture of the Future / UIA Work Programme (AOF-WP hereinafter)" was established under the auspices of the Japan Institute of Architects (JIA). Since then, the AOF-WP's activities have evolved greatly due to the participation of 60 UIA member architects from 14 countries.

The backbone of these activities is the sprit of the Chicago Declaration itself. Accordingly, architecture is no longer allowed to remain a field isolated from its society. Nor is it allowed blindly serve solely for profit-oriented egoism. Occasional natural calamities, such as the earthquakes in Kobe, near Istanbul and in Taiwan, reveal and remind us of these ethics. Rather it can only be permitted to cope with society, and the economy and environment, being the matrix of our daily life. It is this prospect which directly mandates the basic assignment for architects.

3. GLOCAL Approach

Since 1994, periodical meetings and symposia have been organized for AOF-WP. Through these opportunities, more and more specific direction was brought to light. That direction is to seek out and establish those goals that architects and architectures must attain in order to contribute to the creation of a "sustainable" society, taking into consideration both global issues and local matters. In other words, architects must adopt a "GLOBAL" vision regarding the effects of their architecture on energy, natural resources, the economy and the environment. Even more importantly, they must develop beautiful solutions. And furthermore, not only must their solutions be compatible with the "LOCAL" characteristics of the building site, but compatible with the human and socio-cultural environment as well.

While these two elements are often considered to be opposing in principle, the holistic view of sustainability requires the integration of both in terms of time, space, and humanity- which can best be expressed by the term: "GLOCAL (GLOBAL + LOCAL) Approach" (cf. Fig.1, P4). In developing this vision, AOF member architects have thoroughly communicated their viewpoints through their own thoughts and practices.

The purpose of this direction is to enlighten the case practices under these conditions and the methods of architects approaching them, as well as to facilitate the exchange of arguments regarding the common issues of these particular diversities.

4. The quality of life and the environmental pressures

By the way, all industry represents the form of our activities fulfilling human needs. People produce goods and place them into circulation, generate and distribute information, and provide society with dreams and services. However, regardless of the kind and style of

industry, energy and natural resources are consumed by all these human activities, bought and sold as a matter of course in a society of market economy. Buyers and sellers are striving to change their roles with each other, and it is through this process that both local and global markets are formed. For many years, we have believed that the surest way to improve the quality of our lives was to allow these activities to continue unabated.

But due to the rapid globalization of transportation system, and electronic information networks, we have gradually become aware of a sorrowful contradiction attributed to all mankind; that is, unchecked commercial and industrial development in tremendous scale, while serving to enhance the quality of life, will eventually damage the very foundation that serves as the basis of all living things, including human beings.

For most of the second half of the 20th century, we have lived without being conscious of this contradiction, or even if being vaguely aware of it, we pretended not to be. The present trend of a changing global paradigm is motivated out of vivid human desire to face and overcome this contradiction for the sake of future generations. The UIA Chicago Declaration was based upon such awareness, and referred to the related task of architect and architecture of the future.

5. The degree of satisfaction

Needless to say, the "quality of life" is relative, and the standard used to measure it depends upon the level of satisfaction enjoyed by each individual member of society. The degree of satisfaction is also influenced by the careers of these individuals, the volume of information that they have and the balance between substantial and spiritual elements in their lives. We all know that substantial satisfaction does not always bring us spiritual satisfaction. Accordingly, when we macroscopically talk about "sustainability", we first need to understand the scale upon which the "degree of satisfaction" is measured, and address the improvement of sustainability within its relevant developing stage.

Without these considerations, any technical or spiritual discussions do not contribute to the improvement of our society. Particularly, the relationship between "environment" and "economy", which clearly illustrates these points, seems to have seldom been put on the table for practical and detailed examination during most of architectural and management process.

6. Four Design Approaches towards Sustainability

The AOF-WP activities have been based upon four categories of design approach, as follows; 1**Ecological Design Approach 2Technological Design Approach 3regenerative Design Approach 4 Socio-Cultural Design Approach**

7. AOF GLOCAL Document 2000

In order to record many of these efforts mostly made during the last decade, JIA has compiled a document entitled "AOF GLOCAL Document 2000 (cf. P10~13)" under my supervision. This includes 22 case practices from 7 countries, which have been selected and classified according to the four design approaches sharing the sustainable concept of being "GLOCAL". Also included are the outstanding executed examples of urban scale, as well as

Glancing at all these works in this document, you would recognize that there arises a movement with strong and clear will as a paradigm of architectural and urban design. And again, we can discover the joy of architectural diversity characterized by the national, regional and local contexts.

8. Design Process for Sustainable Architecture

At the same time, the design process itself has more important meanings. Including the design assessment such as GBC or BREAM, architectural design of the future shall be more open, comprehensive and cyclic, rather than closed, specialized and open-ended, to accommodate the development of a sustainable society. Such design process could be illustrated as shown in Fig.2 (**Pre-Design Design Post-Design**), which implies us the future role of architects and other stakeholders.

At the end, as stated in the Chicago Declaration, I hope also such sustainable design becomes "normal" practice in near future.

ECONOMIC AND ECOLOGICAL OPTIMISATION OF THE CONSTRUCTION AND RENOVATION OF BUILDINGS: THE OPTIMAL INVESTMENT PATH METHOD

Johan Coolen, Master in Science of Economy, Industrial Engineer
Address: Mens en Ruimte&Groep Planning, Waterloolaan 90, 1000 Brussels, Belgium
tel. 00-32-2-512 70 11, fax. 00-32-2-512 31 90, Email: mrnv@mensenruimte.be

INTRODUCTION

For the purpose of an economic and ecological optimisation of the renovation of buildings, the Belgian architecture-engineering group Groep Planning constructed, in collaboration with her daughter company Mens en Ruimte, a special calculation model which is capable of finding the optimal mix of saving measures by means of the 'optimal investment path' method. The procedure followed by the model is illustrated in this paper by means of the energy audit of the administrative centre 'Gentbrugge' of the city of Ghent (Belgium). This energy-audit was ordered by the City of Ghent and performed by Groep Planning together with three specialised partners.

ANALYSIS OF THE BUILDING

The administrative centre 'Gentbrugge' is a multifunctional building with a floor surface of 6.300 m^2. The building contains a police office, administrative services, a festivity hall, an exposition space and a wedding hall. The building was constructed in 1969, thus before the oil crisis, and the energy consumption is more then double the current standards in Belgium for new administrative buildings.

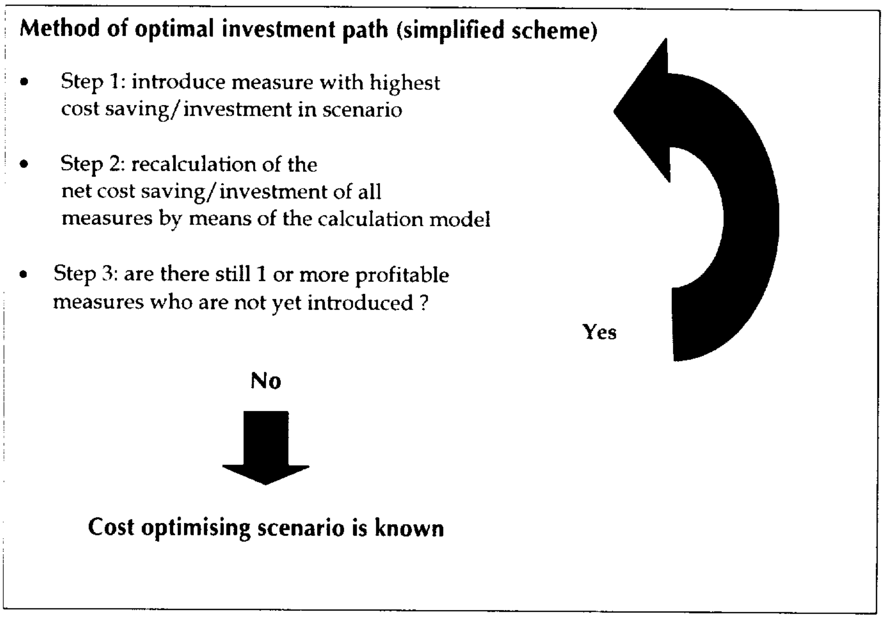
In the first phase of the audit, the existing situation was thoroughly analysed. It was observed that, due to the limited subdivision of the building in separate thermal zones, the heating and ventilation of the spaces were not compatible with the real needs of heating and ventilation in particular spaces: e.g. the long opening hours of the police office implied that large parts of the building were unnecessarily heated and ventilated during a large part of the week. The users complained furthermore in a comfort-inquiry about the difficulty of regulating the heating installation. This complaint could be explained by the fact that the distribution system of the central heating installation was so heavily polluted that the water could not pass sufficiently well through the narrowing convectors.

EVALUATION OF MEASURES

We can distinguish in the administrative centre 63 building components (e.g. glazing at the south façade, the heating boilers,...) for which on average 3 measures could be formulated. In total, almost 190 (= ± 63 x 3) measures had to be evaluated. By combining these different measures, 3^{63} (= 1.000.000.000.000.000.000.000.000.000.000) scenarios can be created with each scenario having a different investment and cost-saving. In order to find the financial optimal scenario, theoretically all the possible scenario's have to be calculated and the scenario with the highest cost saving, which still respects the available investment budget, is the optimal scenario. This optimisation procedure is, as can be easily understood, not feasible in practice. For this reason, Groep Planning developed an other optimisation procedure which we call 'the method of the optimal investment path'.

The core idea of this procedure can be summarised in the following steps (see also scheme):

- in Step 1, the measure with the highest ratio 'net cost saving/investment', this is the most profitable measure, is introduced. The net cost saving of a measure is the sum of the investment, maintenance, energy and water costs over the life span of the investment 'actualised' to the present. The net cost saving calculated by the model includes the direct but also the indirect effects of the measure:
  e.g. for an insulation measure, besides the energy savings, the investment savings of heating production and distribution equipment and the savings in maintenance of this equipment are also calculated.



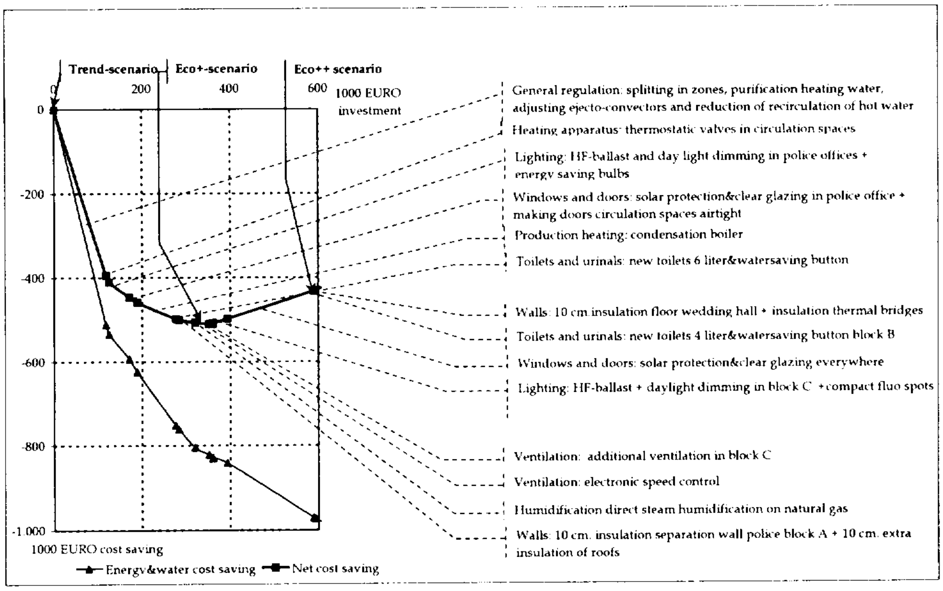
- in Step 2, the model recalculates automatically for all the possible measures the ratio 'net cost saving/investment'. This is necessary because the introduction of a measure changes the profitability of other measures: e.g. the introduction of a high efficiency boiler decreases the financial profitability of insulation measures.
- in Step 3, the model checks if there are still profitable investments left. If yes, Step 1 is performed again. If not, the optimal mix of saving measures is found.

RESULTS OF THE METHOD FOR THE ADMINISTRATIVE CENTRE 'GENTBRUGGE'

In the following graph, the optimal investment path is presented graphically for the previously mentioned office 'Gentbrugge'. In the X-axis the investment cost over 40 years is presented and in the Y-axis the cost savings over the same period. The thin line presents the energy- and water cost savings and the thick line is the net cost savings. The cost savings in the graph are calculated using current water- and energy prices. We make the following remarks:

- the **Trend-scenario** is the continuation of the existing situation. The Eco+-scenario is the financial optimal scenario if we assume current energy- and water prices. The Eco++-scenario is the financial optimal scenario if the existing prices would be increased with external (environmental) costs
- on the basis of the graph, we can conclude that by investing 360.000 Euro (=**Eco+-scenario**) the city could save an 'actualised' sum of 830.000 Euro energy&water costs (lower thin line on the graph) and 40.000 Euro maintenance costs (not shown on the graph). This results in a net cost saving of more then 500.000 Euro (lowest point of the thick line). This remarkable cost saving is mainly a result of an investment in a better regulation of the heating of the building, with among others splitting up the building into thermal zones which can heated and ventilated separately and purification of the heating distribution system.
- In the **Eco++-scenario**, the total investment is increased to 600.000 Euro. By investing more, we can see on the one hand that the energy&water cost savings are growing but on the other also that the slope of the curb, thus the energy&water savings per invested Euro, is decreasing. Given the current energy&water prices, the net cost savings are decreasing slightly when investing more than the Eco+-scenario prescribes. However, if we add external costs to the existing energy&water prices and make a graph of it, we see that the net cost savings would further increase and the net cost savings would be optimal in the Eco++ scenario.

Optimal investment path for the administrative centre 'Gentbrugge'



ENVIRONMENTAL ASSESSMENT DURING THE DESIGN PROCESS – AN OVERVIEW

Dr.-Ing. Thomas Lützkendorf, Dipl.-Ing. Karsten Tanz
Bauhaus-Universität Weimar, Lehrstuhl Bauklimatik, Bauhausstrasse 7b; D-99421 Weimar
BBS-Ingenieurbüro Gronau + Partner, Thomas-Müntzer-Str. 6, D-99423 Weimar

PROBLEM DESCRIPTION UND GOALS

To realise the goal of sustainable development within the building sector necessitates the integration of measures for conserving resources and for health and environmental protection within the planning and decision-making process. The effects of planning decisions on health and the environment need to be described, evaluated and influenced already at the initial design stage. To achieve this suitable evaluation methods and planning aids are required. However the building sector encompasses a range of different objects of evaluation, different participants in the process as well as different protective aims to be achieved, and the information requiring evaluation is available in a differing degrees of detail.

Clearly not only evaluation methods but also planning aids need to be and are adapted to fit each specific situation, which explains the current multiplicity of approaches in use internationally. As a result the need arises to arrange both evaluation methods and planning aids according to a systematic structure. These need to be made accessible in the appropriate form to the relevant participants, and the participants involvement must be structured so as to ensure the necessary depth and complexity through the overlapping of different aspects.

ANALYSIS

To usefully analyse and systematise evaluation methods and planning aids, it is necessary to first examine the different participants, the objects of evaluation and protective aims individually.

Participants or 'actors'

The actors are those who participate in the building process. Strictly speaking this means the investor, owner, user, planner, builder, manager etc. The individual actors require only specific information related very often to their specific motives and their role and influence in the decision-making process. Whilst the planner must be able to determine and evaluate the effects of his or her decisions at the design stage, the investor and/or user are more interested in already collated descriptions of evaluation results and quality levels achieved. This in turn influences the choice and suitability of planning aids.

Objects of evaluation

The need and preparation of appropriate ecologically relevant information within the building sector ranges from the building material through building product, an individual building to building stock. It is both necessary and possible to examine the life cycle in its entirety as well as differentiated according to individual phases. It should be noted that the different objects of evaluation are interdependent. Information about the building material or product is 'inherited' in the buildings characteristics, and the service life of the building in turn determines the lifetime of the building product.

Protective aims

Protective aims are wide and varied ranging from conservation of resources, maintaining biodiversity, conservation of the natural landscape, general and individual health protection, soil, air, and water cleanliness etc. The development and application of evaluation methods must take account of both the specifics and complex interactions of different protective aims.

Evaluation methods

Developments in the last couple of years have produced a multiplicity of approaches that are suited to differing degrees and in different ways to address particular protective aims, and to illustrate and evaluate the effects on health and the environment. Examples of quantifiable measures are:

- mass flow input	= cumulative mass flow
- mass flow output	= waste produce
- mass flow total	= MIPS (Material Intensity Per Service unit)
- energy expenditure	= cumulative primary energy expenditure KEA
- cumulative surface area deployment	= ecological footprint
- General health	= DALYs (disability-adjusted life years)
- environmental effects	= effect-oriented criteria (z.B. global warming potential)
- personal comfort	= PPD (predicted percentage of dissatisfied)

Qualitative aspects (for example environmental hazards and health risks) are also necessary to address the 'gaps' between the areas covered by quantitative aspects. However, the subsequent, typically computer-aided, processing of information at the next higher level presents problems, for example the transfer of information from individual component to the building. A structured process is proposed to cover the different information requirements. Quantitative information (energy and mass flow) can be cumulated or aggregated, qualitative information, such as hazards and risks, primarily localised.

A full aggregation can follow based either on quantitative scientifically justified considerations (scale of environmental pollution, ECO-indicator etc.) or qualitative approaches using valuation and weighting of criteria.

Planning aids

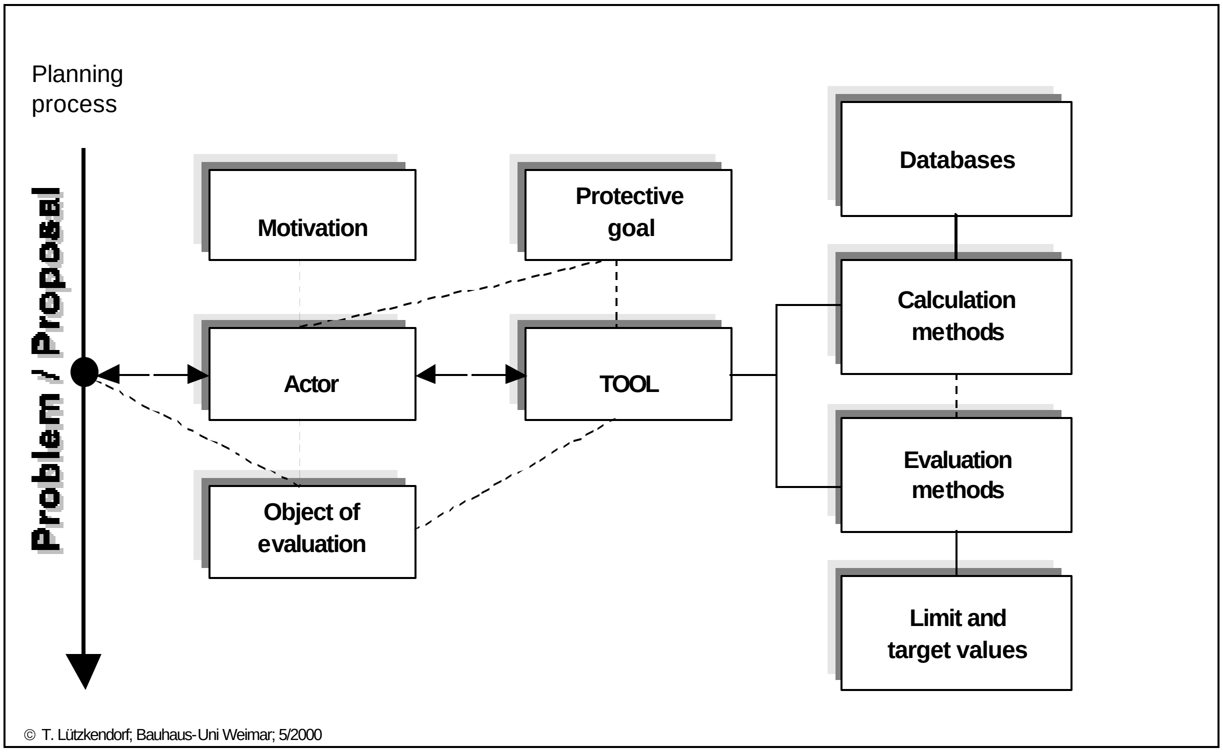
Within the context of integrating ecological aspects into the planning process, it is important to use available tools and aids in the appropriate situation, based on already existing information and to answer specific questions. They are closely related to evaluation methods and very often are the means by which the methods and/or their results are made available to the planner. Currently available planning aids can be grouped as follows:

- law, regulations, conventions
- recommendations, case studies
- limit and target values
- positive / negative lists and recommendation / exclusion lists
- environmental labelling, quality marks
- ecologically oriented specification texts
- object documentation, building pass, energy passport
- checklists
- partial declaration / full declaration / declaration scheme
- building product databases, pollutant information systems
- Element catalogues
- balances, eco-inventary, eco-balance
- Complex planning and evaluation tools.

Of these, the last – complex planning and evaluation tools – is the only planning aid that can interactively inform the planning and design process. The groups are, of course, interdependent: a planning tool can on the one hand reference databases and/or element catalogues, and is at the same time the instrument used to generate building documentation and/or the values for an energy passport.

SOLUTION PROPOSALS

The analysis demonstrates the need to develop a systematic categorisation of the different evaluation methods and planning tools. In the author's opinion, this should be oriented on the problems and issues that arise during the planning process and the resulting decisions that need to be made. Each solution and decision is undertaken by a particular actor, whose judgement is influenced both by personal motives and individual and/or social protective aims. Depending upon the problem to be solved, an object of evaluation needs to be chosen. The actor must be able to access suitable planning aids, adapted to suit both the current stage of planning as well as the protective aim(s) and object of evaluation in question. Complex and interactive tools very often additionally involve calculation and evaluation methods. The following diagram illustrates the interdependencies. More detailed information is contained in [IEA 2000].



FUTURE PERSPECTIVES

The author, in co-operation with professional colleagues from Holland, Austria and Switzerland, intends to develop a systematic categorisation of existing planning tools with a view to improving their availability and suitability to the planner. The research is oriented amongst others on [KBOB 2000]. At present the topic is being pursued as part of the scientific research project 'optimisation of solar energy use in large buildings', part of TASK 23 of the IEA.

LITERATURE:

[IEA 2000] Results of IEA-Annex 31 "energy related environmental impact of buildings" http://www.uni-weimar.de/ANNEX31

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Moving Towards a Green Building Design Process

Nils Larsson MRAIC
C-2000 Program Manager
Natural Resources Canada
Larsson@greenbuilding.ca

The Relevance of the Design Process

Researchers and designers are becoming increasingly aware that the potential performance of a building is largely determined in the early phases of design, or even in the pre-design phase. Conversely, it can easily be demonstrated that the grafting of advanced technologies onto a design that is well advanced can lead to minimal performance improvements. Although the philosophy is well accepted, traditional ways of working, especially the separation of tasks by discipline and fee structures, prevent this goal from being reached in most projects. Recent experience in Canada indicates that measures can be implemented to minimize the effects of such barriers.

The C-2000 Program

The experience of the NRCan C-2000 demonstration program for advanced commercial buildings may be useful in highlighting some of the approaches that support design teams in their attempts to reach high levels of performance.

The program was launched in 1994 to demonstrate to Canadian industry that high levels of performance, centered on energy and emissions, could be achieved without substantial penalties in cost of design time. The initial target performance level for operating energy consumption was set at 50% of conventional performance levels for office buildings, and at 55% for apartment buildings, normalized for regional climatic conditions.

Even though C-2000 was aimed at a select group of clients known to have an interest in high performance, it was assumed that some level of financial incentive would be required to make the program a success. However, the extent of incentives required and the best point of intervention within the project development process was very much open to question.

C-2000 technical requirements covered energy performance[1], environmental impacts, indoor environment, functionality and a range of other related parameters[2]. It was therefore expected that incremental costs for design and construction would be substantial. After a preliminary analysis of current project costs and an informal survey of designers, provision was made for support of incremental costs in both the design and construction phase. Contributions were provided according to a sliding scale ranging from 7% in large projects to 12% in small projects.

The first two C-2000 projects received support according to this formula in the range of CAD $400,000 to $750,000, and funding of this order of magnitude was also planned for subsequent projects. However, after the first six projects were designed and two had been completed, it was found that that incremental capital costs were less than expected, partly due to the fact that designers used less sophisticated and expensive technologies than anticipated[3]. Investigation of the first two C-2000 projects actually constructed, Crestwood 8[4] and Green on the Grand[5], indicated that the marginal costs for both projects, including design and construction phases, was 7%-8%

more than a conventional building, a rather modest increase. Even more interesting, the designers all agreed that application of the integrated design process required by the C-2000 program was the main reason why high levels of performance could still be reached[6]. It also appeared that most of the benefit of intervention was achieved during the design process.

This turn of events led to changes in the C-2000 Program, so that financial and technical assistance was henceforth only provided for the design process, to cover costs such as the provision of a design facilitator and subject experts, energy simulations, and extra design time for the core design team. Specifically, the following C-2000 requirements have proven to be important and are now collectively referred to as the Integrated Design Process or IDP:

- Inter-disciplinary work between architects, engineers and operations people right from the beginning of the design process;
- Discussion of the relative importance of various performance issues and the establishment of a consensus on this matter between client and designers;
- The provision of a Design Facilitator, to raise performance issues throughout the process and to bring specialized knowledge to the table;
- A clear articulation of performance targets and strategies, to be updated throughout the process;
- The use of energy simulations to provide relatively objective information on a key aspect of performance
- Documentation of major steps and issues raised in the process.

Simple software design support tools have been produced to help design teams enrolled in the C-2000 program. One outlines generic design steps and provides a simple way for designers to record their performance targets and strategies; another helps the design team reach a consensus on the relative importance of various issues.

The Commercial Buildings Incentive Program (CBIP)

In 1997, it was decided to launch a larger national program to move the industry towards energy efficiency. Based on the lessons learned in C-2000, it was decided to focus the financial incentives of new CBIP program on providing incremental costs for the design process. However, several changes in approach were necessary for a program that was intended to be delivered to a large number of clients on a "hands-off" basis. This meant primarily that the program had to be simplified so that customized support would not be necessary. Specifically, this resulted in a narrowing of objectives of CBIP to energy only and a reduction of required performance threshold to a 25% improvement over the MNECB, rather than the 50% required for C-2000. However, the philosophy of placing emphasis on supporting the design process only was retained[7].

The funding available for the CBIP Program was established as two times the predicted annual energy costs, with a maximum incentive level of $80,000. An analysis of preliminary results in the CBIP Program presented in *Advanced Buildings Newsletter*[8], showed that, as of the Fall of 1998, typical CBIP projects were receiving funding in the range of $35,000, because their performance and/or size did not enable them to reach the maximum amount. The incentive has now been increased to three times the predicted annual energy cost to provide a greater incentive for smaller projects, but the $80,000 cap remains.

It should also be noted that the C-2000 and CBIP Programs are now being combined, so that almost all new C-2000 Projects also participate in the CBIP Program. The combination of programs results in customized support and a total maximum available financial support of up to $100,000 for a small number of projects each year.

A Stand-Alone Integrated Design Process

The C-2000 and CBIP experience are leading the program managers to separate the IDP process from the achievement of required performance levels. In recent major projects, the design process starts with a design workshop to discuss key performance issues and is followed, in those projects opting for the C-2000 path, by continuing support. Most of the resulting designs will reach the 25% improvement target (CBIP), a few will reach the C-2000 50% level, while a still unknown proportion may reach intermediate levels of performance. It appears that, at least in the Canadian context, an energy performance improvement level of about 35% is achievable without heroic measures. And, while efficient and modern technologies are required, most of the improvement appears to be due to the system synergies achieved very early in the design process, while incremental construction costs are reported to be no more than 5%. While it is still more of an art than a science, the IDP approach is a clear success.

The interest in the IDP process is not confined to Canada. A working group of the International Energy Agency, Task 23, is in the midst of a program to develop a generic international IDP process, based on C-2000 and other similar initiatives in other countries[9]. This work should bear fruit in the form of draft guidelines by 2001.

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1 At the time, the energy requirement was 50% better than the ASHRAE 90.1 standard (the benchmark is now the Model National Energy Code for Buildings, MNECB). Both are North American standards for good practice.

2 *C-2000 Program Requirements*, N. Larsson Editor; Natural Resources Canada; Ottawa, October 1993, updated April 1996.

3 The conservative preferences of designers is based primarily on their perception that they might face legal liability problems if they use exotic and unproven technologies.

4 *Technical Report on Bentall Corporation Crestwood 8 C-2000 Building*, April 1996, CETC, Natural Resources Canada.

5 *Technical Report on Green on the Grand C-2000 Building*, April 1996, CETC, Natural Resources Canada.

6 Briefly, the process involves the use of inter-disciplinary teams from the outset of the design process, the use of a Design Facilitator, the availability of technical specialists for quick advice, and the frequent use of energy simulations during the design process.

7 *Energy Efficiency Programs for Commercial Buildings: Summary of Discussions*, for Natural Resources Canada, by Ron Robinson, ARC Applied Research Consultants, October 1997, Natural Resources Canada, NG096

8 Preliminary Survey of the Commercial Buildings Incentive Program, Rich Janecky and Nils Larsson, *Advanced Buildings Newsletter*, pp. 8-15, Number 22, September 1999, Green Building Information Council, Ottawa.

9 Coordinator of the group is Anne Grete Hestnes of the Norwegian University of Science and Technology; contact at AnneGrete.Hestnes@ark.ntnu.no

LIFE CYCLE ASSESSMENT OF BUILDINGS IN EARLY DESIGN PHASES – A CASE STUDY

Annick Lalive d'Epinay [1)]
Safety and Environmental Technology Group, ETH Zentrum, UNL D3, 8092 Zurich
[1)] corresponding address: Basler & Hofmann, Engineers and Planers SA, Forchstrasse 395, CH-8029 Zürich

INTRODUCTION

Environmental aspects have to be considered already in the design of buildings, when aiming for an environmental friendly living. These aspects must determine the design like technique, function, form, aesthetic and costs. One method to assess the environmental impact of buildings is the method of life cycle assessment (LCA) [1]. This method has the advantage of optimising simultaneously energy and material related environmental impacts.
The aim of the study [2] was to analyse the ability of LCA to be used in the early design phase of a building project. Therefore a detailed LCA was performed and several decision situations were simulated.

Method

To guarantee for transparency and for a detailed analysis of the methodology a new tool called EcoCheck was developed. The tool allows a detailed modelling of the building and of each calculation parameter. The tool is structured in three parts: The database, including the inventory data for all processes and materials [3, 4, 5]. The "building" part, where all building components and the energy consumption have to be specified. The third part contains the evaluation part, where the link between the database and the building specific inputs is made.
The lifetime of the building, the lifetime of the materials and the way of demolition and disposal at the end of the buildings life have to be defined. No refurbishment or change of use during the lifetime of the building is considered. The system boundaries include all materials and processes except the transports of the materials to and from the building site, some of the finishing material (metals and paints) and some installations like cables and radiators. The functional unit is the building "Stahlrain" with a lifetime of 80 years in use.

The Case Study Building "Stahlrain"

The case study building is an office building located in Brugg, Switzerland. It was constructed in the nineties and corresponds to a modern, well-designed architecture. It is located in a triangular rest piece of land between an urban road on the west side, the railway line from Zurich to Basle in the south and a small road leading to a housing zone in the east. In Table 1 some of the relevant information about the building is listed.

Table 1 List of materials of the main building components

Specific areas	
Total volume	13'726 m^3
Area of energy consumption	3088 m^2
Typical building occupancy	100 persons
Materials	
Main structure	reinforced concrete
Walls	concrete or brick
Facade	fiber cement, glass wool and plaster
Windows	wooden frames, insulated glazing
Energy consumption	
Specific consumption of thermal energy	175 MJ/m^2a (85% gas, 12% oil and 3% sun panel)
Specific consumption of electrical energy	117 MJ/m^2a (10% photovoltaics)

The office building is a long and simple volume, which longs the railway in a curved line. The base is made of reinforced concrete, the façade of the upper floor is a lightweight construction with Eternit overlapped boarding. Three window-ranges long the whole northern and southern façade. A café on the roof of the building provokes a dynamic aspect and uses the roof as terrace.

DECISIONS IN THE DESIGN PHASE

First Simulation

One of the first steps in the design is to find the best shape of the building for a specific site and function. The ratio between envelope surface and volume (S/V) can be an indicator expressing the shape of the building. It was the aim to check, if the ratio S/V can – with the help of inventories – be an indicator for the environmental burdens of a building.
A constant volume in five different shapes was defined (1: 9x12x50; 2: 3x12x150; 3: 27x14.1x14.1; 4: 18x17.3x17.3; 5: 9x25x25 with a small court of 6x6). In a first step a constant u-value for the whole envelope was defined and the total energy flow through the envelope was calculated. In a second step the u-value of the roof was improved.
The results are represented in Figure 1. The u-values of the components influence the result more significantly than the simple S/V.

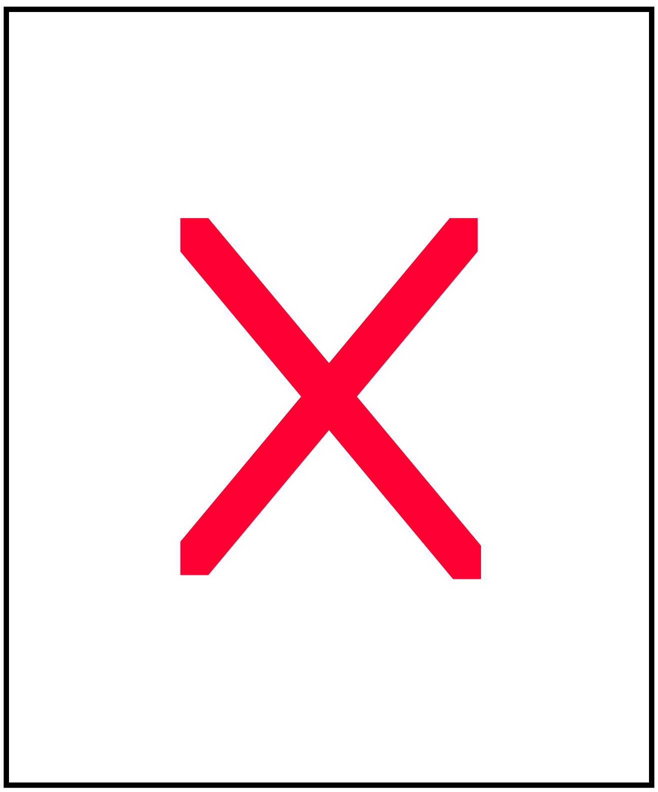

Figure 1 *Results. Energy use in the use phase for the first simulation (upper line) and for the adapted simulation with variable u-values for the different envelope components. The lower figure shows the part S/V = 0.3175 m^2/m^3 to S/V = 0.3200 m^2/m^3.*

Second Simulation

A next decision step in the design process is the material choice of the main building components. To simulate this decision situation the building “Stahlrain” was re-constructed in wood. It was analysed, if simple assumptions concerning the amount and composition of material used (depending on the way of construction) are sufficient to assess the environmental impact of the

The results show for simple constructions like reinforced concrete frames a very good approximation using simple assumptions concerning the amount and composition of the construction element. For more complex constructions like the wooden one, the assumptions are much more difficult to make. There is a need for approved characteristic values.

Third Simulation

In a later phase in the design process the envelope of the building is defined. Is there an optimal insulation thickness of the envelope regarding the total environmental impact of energy use and material use of the building?
Six cases were defined, where the thickness of insulation over the whole building envelope was varied with factor 0.5, 1, 1.5, 2, 5, and 10. The energy use was calculated among SIA 380/1 [6] and the environmental impact of the material and energy use was calculated using inventory data. Figure 2 shows the results, where an optimum (for this case only) can be seen close to a factor 1 to 2.

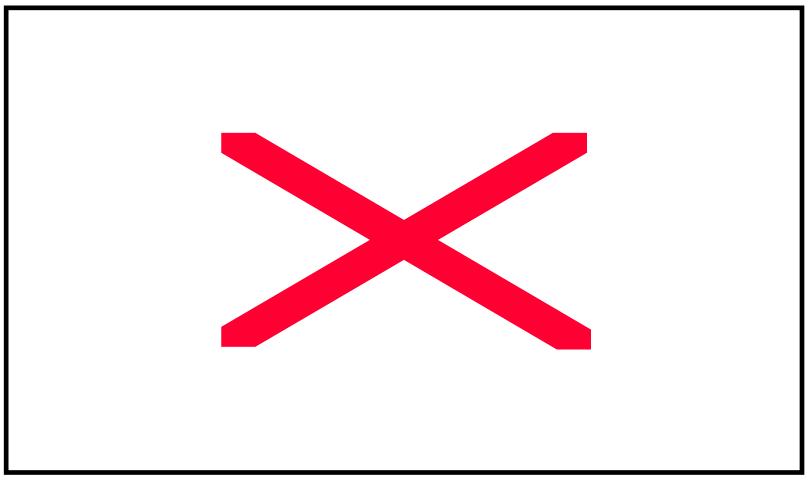

Figure 2 *Results expressed in Eco-Indicator 95. The point with factor 1 corresponds to the original "Stahlrain".*
: material related env. impact *: energy related env. impact*
: total environmental impact

CONCLUSIONS AND RECOMMENDATIONS

LCA is a useful method to assess the environmental impact of buildings. The bottom-up approach is very time-expensive and the uncertainties are big. The simultaneous optimisation of material and energy related impacts is important and LCA is very suited to provide this information. To use LCA in early design phases qualified characteristic values (for whole construction principles) are needed. The first simulation showed that for very early design phases the environmental impact of buildings is better represented using simple energy balances or other, e.g. urbanisation-related criteria, because no information about the material is available.

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RAISING THE PROFILE OF LIFE CYCLE ASSESSMENT

Marc Buridard, Scott T. Chubbs, Louis G. Brimacombe
International Iron & Steel Institute, Rue Colonel Bourg 120, B-1140 Brussels, Belgium
American Iron & Steel Institute, 1101 17th Street NW- Suite 1300, Washington DC 20036, United States
Corus R,D & T, Moorgate, Rotherham S60 3AR, United Kingdom

INTRODUCTION

The growing interest in the concept of sustainability emphasizes the importance of life cycle assessment (LCA) for the materials industries and particularly for users who require reliable data, related information and guidance to make sound decisions on sustainable applications.

THE IISI POLICY STATEMENT ON LCA

The policy statement that was agreed by the Board of Directors of the Institute in 1995 sets out the steel industry's support for the use of LCA in the context of sustainable development but cautions against simplistic and partial analysis that undermine the potential of the whole analytical approach.

Therefore the policy statement calls for the highest standards to be adopted in both the undertaking and reporting of LCA studies, especially when comparative assertions are made.

The policy also supports the development of standards for LCA. Both IISI staff and several representatives from individual steel companies have been closely involved in the development of the ISO 14040 series of standards.

These ISO standards helped to disseminate good practices for LCA studies. There are undoubtedly still many aspects to improve, both concerning the availability of reliable data and the methodology used. Notably, it is observed that some indices are commonly used for impact assessment that are either highly unreliable or not scientifically valid. These indices have been widely spread by software packages and tend to be used as "black-box models".

A first category of these indices that are potentially misleading concerns the impact categories heavily influenced by spatial and temporal variances or by concentration effects, such as toxicity. As an example, Figure 1 shows the large differences between different characterization models currently used in LCA studies for ecotoxicity (logarithmic scale).

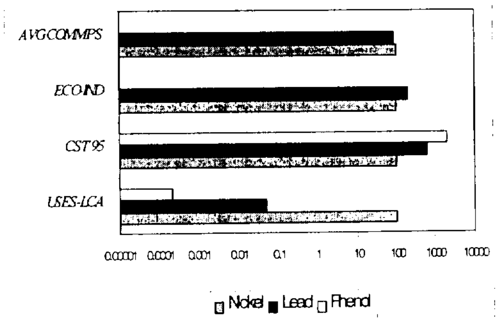

Figure 1: Results of different eco-toxicity characterization models for water releases of nickel, lead and phenol (normalised to nickel), courtesy of Ecobalance Inc.

It is therefore important to question the ability of the current LCA techniques to address environmental impacts other than the global ones, namely global warming, natural resources depletion and possibly ozone layer depletion. Data quality is also a key factor in the integrity of LCA applications. Even when a rigorous approach has been used, as in the IISI LCI study described below, there are still data gaps in key input categories. Further research and testing of impact assessment methodologies is necessary to overcome deficiencies, particularly with local and regional impacts, in order to progress towards widely accepted methods.

There are still more problems to aggregate indices for different impact categories, or even worse with price indicators, into a single figure. The development of single score methods has been driven by the legitimate demand of designers for simple tools compatible with their operational constraints. However, those single score methods are by nature dominated by subjective judgements. It is therefore not surprising that results from different single score methods applied to the same LCI never agree, which makes them of little practical use. More seriously, when such a method is used without regard or knowledge of its limitations, the result may lead to wrong decisions.

The IISI Policy Statement on LCA also supports the collection and dissemination of sound data for LCA and especially life cycle inventory (LCI) data. Accordingly, the IISI's LCI study was undertaken to produce LCI data for a wide range of steel products. This study and its outcome are presented below.

THE WORLDWIDE IISI LCI STUDY FOR STEEL PRODUCTS

General Description

This LCI project was launched in late 1995. The primary goals were to develop a common worldwide methodology for cradle to gate steel product LCIs and to produce corresponding data as requested by stakeholders.

There had been many attempts to carry out LCA studies of steel products, but the use of different methodologies and, in some cases, a lack of transparency gave rise to some confusion. Also studies that had been carried out by third parties alone (consultant, universities) suffered from a lack of understanding of our industrial processes.

The project was commissioned to an independent consultant (Ecobilan) who worked in close partnership with a group of steel industry experts. From the early stages, the study underwent a continuous and constructive critical review process by a panel of independent experts. Their report is freely available in its entirety.

A notable feature of the study is a detailed modeling of the steel industry processes including the establishment of a common nomenclature for the many inputs and outputs at each unit process level. Based on this exercise, an electronic questionnaire for site data collection was developed. This questionnaire and a user guide allowed for a consistent approach to data collection and verification, especially at the site level. The tools developed for the project are currently adopted by several other metal industries.

Fifty-five sites participated, located in Europe, North America, Japan, Korea, India and Brazil. The study covered both the ore and scrap based blast furnace route and the scrap based electric arc furnace route. Twelve types of products were covered, including steel products used in construction such as rebar, bloom and plate (intermediate products to make structural steels), galvanized and painted sheets.

Provision of data

Communication of the LCI study methodology and results was key to achieving an effective outcome of the work. IISI and its member companies initiated a two-point approach with regard to the provision of LCI data. First, steel representatives participate in life cycle initiatives with steel customers, providing data and technical assistance. Second, since May 1998 organizations are invited to request LCI data through the IISI web site and personal communications. LCI data are provided to external audiences by a network of contact persons belonging to member organizations who respond to requests in their respective countries. The contact persons are advised to verify if the studies conform to ISO standards before provision of any data. When data are provided, further assistance is also encouraged, such as for the selection of the relevant product categories or on the recycling aspects. The user of the data is also invited to give a feedback on the study results, so as to help the industry to set priorities for environmental improvements.

Limitations and Further Improvement

As for any LCA studies of this magnitude, there is still large further scope to improve the database.

This includes the recurrent problem of acquiring data for the operations external to the steel plants. Concerning the steel plants, diffuse emissions such as some particulates emissions are difficult to quantify even though they can be significant. Water consumptions and water borne emissions are difficult to allocate to each individual product. For water emissions specifically, care must be taken to subtract the background pollution (for some sites located downstream of urban and industrial areas, the outflow water is purer than the intake). Many data categories are highly variable across steel plants and the statistics which accompany the LCI average data help to interpret their use in LCA calculations. The LCI results are sometimes sensitive to the detailed specification of the products. Finally, the database would also benefit from a larger number of participating sites for certain products.

Consequently, a large programme of work has been set up involving IISI and the participating steel companies to continue improving and updating the database.

Considering the equivalent level of complexity of many other industrial systems, it would be surprising if the accuracy of other common LCI data sets were not also affected by similar problems and sometimes by other problems specific to the industries concerned.

CONCLUSION

In the six years since IISI began its work on LCA, initiatives have been undertaken to develop the steel industry's LCA capability. The initiatives presented here, the policy statement, the LCI study, communications, and benchmarking, are important first steps, building the base for continuing work.

For LCA to be used as a reliable tool for decision making high quality data, sound methodology and transparent reporting are essential. The LCA activities by IISI members are aimed at enhancing these standards and the industry intends to continue and encourage this trend in its future programme of work.

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RENEWABLE ENERGY BASED CARAVAN SARAI'S ON TRAVELLING ROUTES IN CENTRAL ASIAN HIGHLANDS AND TIBET

Author- SANJAY EKTATE Co-Author- ANJALI EKTATE
No 323 ,above CGHS dispensary, sector C, CGS colony, Bhandup (E), Bombay, 400 042 , India

Ancient travelling routes are still the main arteries of communication, connecting isolated pockets of human habitation in the desolate and sparsely populated Central Asian Highlands and Tibet. While most of the routes are East to west like the Traditional Silk Routes, parallel to the major mountain ranges like the Himalayas, Tien Shan, Kun Lun ,Pamirs , some routes also traverse the Asian Highlands from the North to South across the Himalayas. These routes, are dotted with traditional Traveller Resting camps, spaced apart at an approximately 6 hours travel time by foot or camels or yaks or 2 hrs to 6 hrs by motorised vehicals. These tented camps, are dependant exclusively on external supplies even for essential commodities like fuel and food, and just provide subsistance shelter, during emergency like blocked route due to avalanche, landslide, terrorism or rebellion. It is essential to replace these makeshift and Energy wasting camps with **Self Sustaining and Permanent , Renewable Energy (Green House) based South -Sunward Sloping CARAVAN SARAIs** with permanent residences, ranging from economical to luxurious, and heated and powered with Solar energy, Sewage Recycling with Biogas, biomass, ground water replenishment, Water power and Wind Energy. **Sarai means Travellers Lodge.**

Idealized Salient Features of a Self Sustaining CARAVAN SARAI

Location- Near the Northern extremity and at the Wintertime focus of a "South Sun Facing Fan Shaped Valley, Surrounded by Snow Covered Concave Parabolic Hillside" which focuses Solar Energy on the Caravan Sarai during the very cold winter months. In Summer, less Solar Energy is concentrated at the Caravan Sarai, due to shifted focus of the high Sun and less snow cover resulting in less reflectance from the brownish mountainside. Caravan Sarai should be near the confluence of small mountain streams, but should be away from and on a hump at higher elevation than flash flood ,avalanche or landslide prone zones. Less ideal locations, in order of preferance are (1) North slope of a wide East-West valley, (2) Wide fan Shaped SouthWest/ Westfacing valleys and (3) Wide fan shaped SouthEast / East facing valleys.

Basic Amenities- a) Permanent Residences, b) Temporary Residences -Tents and Instant Shelters , c) Storage and Godowns, d) Shops- mainly Essential and Provision, e) Enclosed Parking /Stables / external parking, f) Greenhouse, g) Heliport / VTOL / STOL Airstrip, h) Machinary, automobile repair garage and fuel dump ,i) Emergency Services- Fire fighting, Medical, towing, excavating machines, wireless, UG water tank, Security, j) Kitchen, k) Entertainment, l) Tourist / Trekking Center, m) Biogas , Solar, Wind energy, Water Power centers ,n) Miscellaneous including Farm , Animals , Pasture, Dairy management , Computer and Information Center cum Office.

A. Permanent Residences- These will range from very economical large dormitories to middle range single and double bedrooms to comparitively luxurious water cooled and solar heated family suites. In a traveller dominated SARAI, dormitories will predominate, while in a tourist Dominated SARAI, family suites will predominate and will be located on the Sunward South sloping face behind the deciduous plantation of the Greenhouse.

B.Temporary Residences- There will be provision for storing and erecting Tents and other prefab temporary or seasonal accomodation, during emergencies like blocked road or refugee exodus, tourist season or festivals. Location will be South of sunlight reflecting Greenhouse.

C. Storage Spaces and Godowns- Food and Grain Coldstorage and Material Godown ,with Low operating cost due to Dry -Cold weather, will serve CARAVANSARAI and its hinterland and also an approchable Urban Resource Center like a remote mine, as a longtime Grain or Corrodable Material like Steel, holding center and will be located in the Basement and the Sunless Northern portion of the Sarai, which normally face the coldest Blizzards.

D. Shopping- Essential and Provision- Shopping will consist mainly of essential Items like medicines, weatherproof clothing, shoes, pure water and will be located in the very interior of the

Caravan Sarai and separated from the Sunlit face by rows of greenhouse residences and from the cold north face and basement by the storage and godowns.

E. Enclosed Parking/ External Temporary Parking/ Stables for Camels/ Ponies / Yaks- Parking for essential and vulnerable vehicals (Ambulances) may be located in the basement or between rear of Sarai and hillside. Reasonable flat space may be provided near Sarai for parking travellers / tourist vehicals , buses , trucks and for semiprotected tented Stables for pack animals like Camels, Horses, Yaks, Ponies , preferably near the Biogas plant (animal dung) and with provision to shift the animals to the parking areas or some shielded zone ,Caves or between hills and the rear of the Sarai ,temporarily during severe storms or bad weather.

F. Greenhouses- Entire Sun facing Southside frontage of the Caravan Sarai will have Greenhouse with Deciduous Plants between two transparent walls of fibre reinforced plastics or reinforced glass, at multilevels, infront of residences and common Lounge. Hardy Deciduous Plants ,which can regenerate easily after a period of severe bad weather and which "Shed Leaves during Winter, therby allow the Sunlight to Enter and heat the Sarai in cold Winter months and filter very bright Sunlight due to blockage of Sunlight by regenerated Spring Leaves in Summer and provide the vital insulation buffer between the external extreme envionment and make the Microclimate in the Interior of the Sarai milder."

G. Heliport / VTOL/ STOL Airport- located at a safe approchable distance from the Caravan Sarai in less windy flatlands area, not prone to any crosswind. Heliport should be adjecent to the Caravan Sarai and, the optional V- STOL Airstrip is an long and flat piece of firm ground .

H. Machinary and Automobile Repair Garages and Fuel Dumps- LPG , Petrol, Diesel and Aviation Fuels should be stored in cavelike or underground Dumps, adjacent to the Sarai with adequate fire fighting equipment and antipilferage measures. Machinary and Automobile repair garages should be located partly in basement , for locked machinary and partly outside or in caves or adjacent to the external parking., where the actual repair job will be done .

I. Emergency Services- Firefighting measures and equipment with an underground static tank located at a nearby higher elevation, will be provided with Evacuation plan and alternative emergency shelters (caves), as long exposure at these altitudes means death. Primary Medical Aid together with High Altitude Medical Aid shall be available in the form of Oxygen or Pressurised air suits. Excavating, Road and Snow Clearing Machinary for clearing landslides, avalanches, road diversions, caves, with some facility for building a Temporary bridge and some equipment for fjording a river or flooded area. Suitable Wireless telecommunication sets and Satellite communication dish antennas to be available. High elevation UG Water tank with another UG tank near Sarai with suitable filtering aids to be provided for daily consumption of water, apart from the static tank for FireFighting.Barrages made of rocks with wiremesh will be useful for controlling flash flood and also for additional water storage. Security measures and Security Guards alternating as Mounted emergency Police petrol , are necessary for maitaining law and order in Sarai .

J. Kitchen- should preferably be detached from Sarai, connected by covered passage and should be adjacent to foodstore. Only a cooked or ready food pantry with heating facillity should be located in Sarai. Kitchen should have facility for packaging food for journeys.

K. Entertainment- Being remote, recreation facilities like outdoor and indoor sports, Video Games and if possible TV, with dish antenna and restricted gambling should be provided.

L.Tourist/ Trekking Center- Sarais will be a favourite place for starting Expeditions to remote areas and peaks. Adequate camping and Mountaineering Equipment with trained guides and emergency rescue measures will make the Sarais, a profitable tourist attractions.

M. Biogas /Solar /Wind Energy/ Water Power centers- During peak Tourist Summer season ,the Solar and Water Power , due to swollen meltwater of glaciers, are at their maximum. Solar Photo Voltaic Collectors, for greater efficiency, cooled by cold glacier water flowing through structural tubes on the backside of the Photo Voltaic Cells, act as Composite Photo Electric and heating Solar collector, as cooling water gets heated and shall be located on Sunlit roof , canopies of Caravan

Sarai and on major Sunlit surfaces of structurally sound permanent structures and stable slopes. Windmill Electricity generators can be on ridges of hills and on Sarai using its structures for support. Mini- Hydro Electricity Generators can be suitably located at nearby major streams. Cold meltwater from glaciers, whose level rises with rising temperature, can be used to cool Sarai as the water rises above the gatelevel of cooling canal if temperature exceeds 80F . BioGas plant, will use Human Sewage from Sarai, Animal dung from stables and fallen leaves from Green House and will be located exactly south of Sarai, to use reflected Sunlight from Green house glass with direct Sunlight to heat Biogas plant and should be covered by two glass layers for Green house effect, because warmer temperature is needed to sustain Biogas bacteria. The treated waste and sewage water from Sarai will irrigate Crops and Pastures and Recharge ground water table .

N. Miscellaneous- P.C.s with floppy library for records and information will keep track of daily travellers' provisions, finances ,other activities and act as an office. Agricultural Farms irrigated by organic matter rich treated sewage from Biogas plant and covered by polymer film green house to retain moisture and heat, will provide atleast subsistance food supply, apart from stored supplies, during road blockages. Farm Polyhouses will be surrounded by animal pastures to make the best use of plentiful water seeping out from the peripheries of film covered farms. Hardy Yaks will be the preferred Dairy animals for a modern dairy located in the basement of the Sarai. Mountain Goats and Endangered species of high altitude animals may be deliberately bred for promoting wildlife tourism on the protected pastures. Suitable veternary medicines and trained persons will be permanently available for all the animals including local and pack animals

Referances- No specific references. We have camped and travelled in Ladakh, adjacent to Tibet.
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Paper presented at the International Conference Sustainable Building 2000, 22-25 October 2000, MECC Maastricht, The Netherlands

MULTI-CRITERIA DECISION-MAKING IN GREEN BUILDING DESIGN

Inger Andresen, Ph.D.
Department of Building Technology, Faculty of Architecture, Planning and Fine Arts, Norwegian University of Science and Technology, N-7496 Trondheim, Norway.

INTRODUCTION

In the design of "green" or sustainable buildings, the criteria that the decision-makers need to address are often conflicting and may appear incommensurate. Usually, both qualitative and quantitative performance criteria are present, e.g. aesthetics, energy consumption, economics, comfort, etc. In order to holistically evaluate the "goodness" of a design, expertise from a range of different fields need to be integrated. In this complex decision-making context, there seems to be a need for a structured approach that can formalize the evaluation process and make the value judgements consistent and transparent.

This paper presents some results from a Ph.D. study that has investigated the use of Multi-Criteria Decision-Making (MCDM) methods in building design. The principle aim of MCDM methods is to help decision-makers organize and synthesize conflicting and complex information in a way that leads them to feel comfortable about making a decision. In addition, the methods intend to help decision-makers learn about the problem they face and to learn about their own and other parties' value systems. Thus, an MCDM approach seems to be well suited to facilitate integrated green building design. This paper includes a summary of some approaches for MCDM, evaluated with respect to their potential use and adaptation into building design.

MULTI-CRITERIA DECISION-MAKING (MCDM) METHODS

MCDM methods include Multiple Objective Decision Making (MODM) methods and Multiple Attribute Decision Making (MADM) methods. *MODM* methods are concerned with the identification of a preferred alternative from a potentially infinite set of alternatives. Options are not defined explicitly, but implicitly by a set of constraints. By far the majority of MODM approaches use mathematical programming in some way. MADM methodology is designed for problems that are concerned with the evaluation of, and possibly choice between, discretely defined alternatives. The MODM methods do not easily fit into a practical building design framework. This is partly due to their rather complicated mathematical form. The use of computers may facilitate this, but still it is important that the users understand the theory behind the methods in order to use them correctly. Also, the MODM methods require explicit formulation of constraints and objectives as equations prior to their application. This is difficult to obtain in the case of building design. Moreover, they require a large amount of time to collect data that in the early design phase will have a questionable accuracy. MADM methods are much easier to understand and apply, and since building design is very much about evaluating different design options, they seem most appropriate. Thus, the rest of the discussion will be devoted to MADM approaches only.

There are numerous MADM methods, ranging from relatively simple and straightforward models to advanced mathematical approaches. However, all MADM problems share some common characteristics (Yoon and Hwang 1995):

- *Alternatives:* A finite number of alternatives are screened, prioritized, selected and/or ranked.
- *Multiple Attributes:* Each problem has multiple attributes. The number of attributes depends on the nature of the problem. For

example, to evaluate cars, one may use the attributes “price”, “gas mileage”, “safety”, “warranty period”, and “style”.
- *Incommensurable Units:* The attributes may have different units of measurement.
- *Criteria Weights:* Almost all MADM methods require information regarding the relative importance of each criterion.

According to Valerie Belton (Belton 1990), the MADM approaches can be separated into two major, distinct categories, plus a few individual, fringe approaches. The two distinct categories are the *aggregate value function approaches*, principally developed and applied in the USA, and the *outranking approaches*, principally developed in France and Belgium.

The most simple and straight forward of the value function approaches is the Simple Additive Weighting method (SAW). Also, the Analytical Hierarchy Process (AHP) is gaining attention. The Simple Additive Weighting method uses all attribute values of an alternative and applies regular arithmetical operation of multiplication and addition. Therefore, the attribute values must be numerical and comparable. Also, for the method to be strictly valid, the criteria should satisfy the conditions known as *preference independence* and *utility independence*. Preference independence states that the tradeoffs a decision-maker is willing to accept between any two criteria are not dependent on any other criteria. For example, given three criteria: “minimum environmental loading”, “minimum cost”, and “good aesthetics”. If a decision maker is willing to accept a 10% increase in building costs given that he will get 20% lower environmental loading, this should be the case for any implications on aesthetics. Utility independence means that criteria are neither *complementary* nor *substitutes*. Criteria are complementary if excellence with respect to one attribute enhances the utility of excellence with respect to another. Criteria are substitutes if excellence with respect to one attribute reduces the utility gain associates with excellence with respect to other attributes. The verification of these two conditions depends upon the confidence one can attach to trade-offs among criteria at hypothetical levels. These types of questions may not be easy to pose to the decision-makers in manageable practical ways. Row and Pierce (Rowe and Pierce 1982) argue that those who are asked to describe indifference levels or trade-offs may not have great confidence in their ability to make the necessary judgements.

The AHP (Saaty 1990) has become quite popular, and has found applications in a wide number of fields. The most important drawback of the AHP for use in building design is that the pairwise comparisons may lead the decision-maker to feel that he looses the overview of the problem. The decision maker focuses on small parts of the problem at a time, and when the overall result is presented, the details of the cause-effect relationship are difficult to see. If the decision-maker does not understand this relationship, the result might be hard to accept. Another problem may arise when there are many attributes, because the number of pairwise comparisons becomes large. For example, if there are 10 attributes, there will be 45 pairwise comparisons. The advantage of the AHP is first of all that it offers a formal and logical way of including qualitative values in the analysis. The consistency check may help uncover biases and inconsistencies in judgements. Also, the hierarchical way of structuring the problem may help the understanding of the problem and the value system.

The ELECTRE methods represent the most common of the outranking approaches. Bernard Roy (Roy 1977) developed ELECTRE because he was critical to the utility function and value function methods on the grounds that they require all options to be comparable. Roy describes the ELECTRE methods as providing weaker, poorer models than a value function, built with less effort, and fewer hypotheses, but not always allowing a conclusion to be drawn. However, Roy and Bouyssou (1986) admits that ELECTRE “*has no axiomatic basis, and consequently it is often difficult to interpret certain parameters in it*”. They add, “*only considerations based on common sense allow the decision-maker and the analyst to give them a numerical value*”. By using outranking methods, some incomparable actions become comparable because realistic information exists, but other actions remain, nevertheless, incomparable.

The most serious drawback of the outranking methods in relation to use in building design, is that they are very difficult to understand for people that are not experts in the field. The value function approaches are much more intuitive and simple. However, these too are fraught with difficulties. The aggregation of impacts across a wide range of variables may be worrying to decision-makers. Some argue that the worth of a particular plan is not a simple additive function of the worth of the various components or even a readily identifiable multiplicative function, for that matter. This is stressed in a paper by Roy and Bouyssou (Roy and Bouyssou 1986). Some even argue that no multi-attribute formulation can ever capture the subtlety and delicacy of the human mind's ability to compare holistic alternatives (Duckstein, Kisiel et al. 1975; Goicoechea, Hanson et al. 1982). One the other hand, there seems to be a lack of empirical support for this view (French 1988). Also, it has been showed that holistic assessments in practice give weight to fewer attributes than a guided multi-attribute approach (Slovic and Lichtenstein 1977; Fischer 1979). While the legitimacy of using simple additive weighting methods may be contested, it is a fact that they are the most commonly used of the MADM methods. This is due to their simplicity and intuitive appeal. Also, theory, simulation computations, and experience all suggest that the SAW method yields extremely close approximations to very much more complicated non-linear forms, while remaining far easier to understand (Hwang and Yoon 1981).

CONCLUSIONS

An important advantage of multicriteria methods is that they make subjectivity and judgements explicit. Multicriteria methods allow one to take into account conflictual, multidimensional and incommensurable effects of decisions in a formal way. They may help to uncover and discover values and aspects that would otherwise have been forgotten. A good MCDM approach may stimulate discussion among team participants and promote a common understanding of the design problem. In this way they seem to fit perfectly into the framework of green bulding design. However, the methods may appear very complex and "foreign" to building designers. Also, the reliability of the methods is questionable, especially when used by someone inexperienced. However, in building design, one can't expect to find *the one and only right answer* in any case. Therefore, the most important feature of the methods is that they can produce deeper understanding of complicated green building design issues. Thus, as long as the users understand the logics and shortcomings of the methodology, some aspects of MCDM approaches may be useful in a green building design framework.

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ENVIRONMENTAL AND ARCHITECTURAL IMPACTS OF THE 'BIOCLIMATIC' HIGHRISES IN THE TROPICS

Kenneth Ip PhD MSc MCIBSE CEng, Puteri Shireen Jahnkassim MSc BSc
University of Brighton, School of the Environment, Cockcroft Building, Lewes Road, Brighton, BN2 4GJ

INTRODUCTION

Malaysian architect Kenneth Yeang has developed a 'bioclimatic' highrise offices design strategy that seeks to minimise energy use while not sacrificing thermal comfort expectations in tropical working environments. The design integrates sky courts, the peripheral positioning of service cores as 'solar buffers' and the use of natural ventilation in transitional areas - such as the lift and ground floor lobbies. These 'bioclimatic' forms also use vertical landscaping/vegetation and vertical sun shading to minimise heat gain and integrate roof forms for future photovoltaic electricity generation.

A field study of two of Yeang's 'bioclimatic' highrises (Kassim & Wolff, 1999) - Mesiniaga and UMNO- revealed that there was inadequate shading on the western 'curvature' of the UMNO building while an occupant survey (Kassim & Ip, 2000) revealed that due to the impact of afternoon sun of the western facades of the Mesiniaga, both thermal and visual comfort level were unsatisfactory. In both highrise offices, undesirable glazed openings had to be provided on the western facades for visual amenity and scenic views due to site conditions. This paper investigates the compromise involved in regional 'typology' of bioclimatic buildings through the study of energy performance of Yeang's 'bioclimatic' design and the 'ideal' climatic configuration.

METHODOLOGY

An equatorial climate (latitude 3.12°N for Malaysia) consists of year-round high temperatures and high humidity. The combined high intensity of the direct solar radiation and air temperature in the afternoons resulted in high sol-air temperatures on the western facade. Noori (1989) has emphasised the importance of shading any glazed openings on the western facade to minimise energy usage in a highrise building in Malaysia and hence a bioclimatic model would have to take this into account. The integration of 'landscaped' balconies to act as shading devices presents an effective way of alleviating the impact of heat gain on the west facade. Taking into account the sunpath and solar intensity in a tropical climate, an 'improved' model for Mesiniaga building was designed which uses the balconies as shading systems to minimise heat gain at the entire western curvature as shown in figure 7. Similarly for the UMNO Tower, the balconies were designed to 'wrap' around the western curvature (Fig. 5) where there is a maximum impact of direct radiation in the afternoon.

The energy performance of these 'improved' models were compared with Yeang's design for both Mesiniaga and UMNO (Fig. 1, 4 & 6) and with typical 'Modernist' glazed towers represented by base-case models (Fig. 2). These 'improved' models represent ideal 'bioclimatic' configurations in the tropics and their performance is compared to Yeang's regionalist inspired design for both towers.

THERMAL ANALYSIS

Using thermal simulation software APACHE, the thermal performance of Mesiniaga and UMNO buildings were compared with two base models of typical modern air-conditioned homogenous buildings. The regionalist 'bioclimatic' models were also compared to the improved 'bioclimatic' models. Potential savings with photovoltaic panels deployed on the roof forms and the use of daylight controls were also analysed.

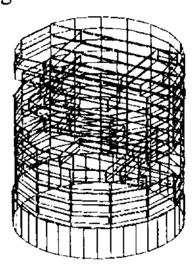


Fig. 1 Mesiniaga Tower - original model with landscaped balconies 'spiralling' around a cylindrical base

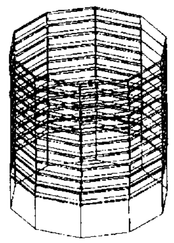


Fig. 2 Mesiniaga Tower Base-case model with central core all air-conditioned

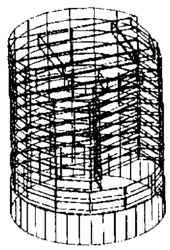


Fig 3. Improved model where size and position of balconies are 'optimised' to maximise shading effects

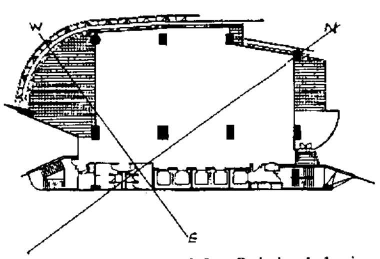


Fig 4 UMNO- Level 9 - Original design

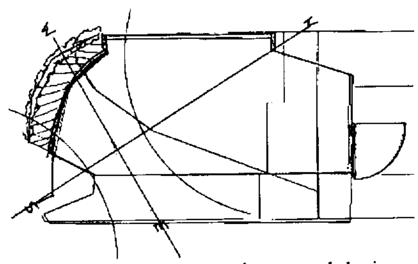


Fig 5 UMNO Tower - improved design

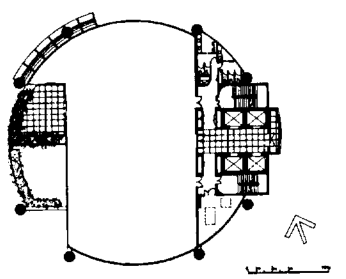


Fig 6 Mesiniaga - Level 3 - Original design

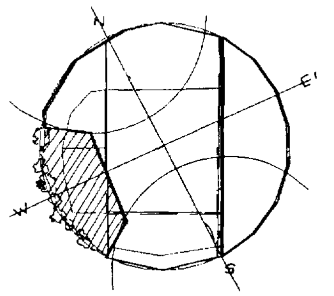


Fig 7 Mesiniaga - improved design

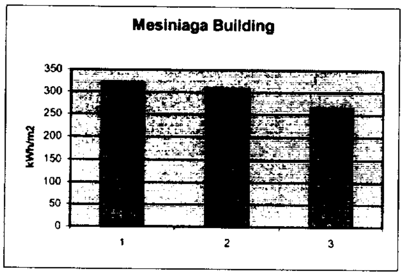
RESULTS

Simulation results (Fig. 8) show that for the Mesiniaga Tower, Yeang's 'bioclimatic' model saves 4% energy use when compared to the base-case model. However the improved model saves 17% compared to the base-case models. Using daylight controls saves a further 10% and integrating photovoltaic in the roof systems would save a further 4 % of energy consumption.

In the UMNO Tower, Yeang's 'bioclimatic' model saves 31% of energy use from the base case model. However the 'improved climatic' model shows a saving of 63% compared to base-case model. Using controlled daylight would further save 6 %; and additional 4% can be saved with the use of photovoltaic panels on the roof.

CONCLUSIONS

The results showed energy savings can be achieved by Yeang's 'bioclimatic' models when compared to typical modern sealed homogenous highrise models, in particular the UMNO Tower which is partially naturally ventilated. But more significant savings can be achieved by adopting the improved 'bioclimatic' model. An overall energy reduction of 73% in the 'ideal' UMNO building when daylight control and photovoltaic panels are included is feasible.



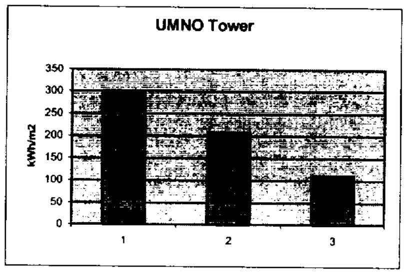


Figure 8 Simulation results
1. Base model
2. 'Bioclimatic' model
3. Improved 'bioclimatic' model

Yeang's design is derived in the context of generating a regionalist 'typology' for tall buildings in a tropical climate. Such design attempts to move away from the 'monolithic' block in order to develop a 'tropical Far Eastern hybrid form' (Richards, 1993). Yeang's philosophy sees the building envelope not only acts as a climatic sieving enclosure (Yeang 1985), but also its overall form is an abstraction from the traditional cultural context. Mesiniaga has since gained international recognition (awarded the Aga khan award) due to its 'symbolic cultural contribution and architectural response to a rapidly developing environment in the East' (Abel, 1997), also its 'organitech' form due to the integration of its 'organic' spiralling balconies and advanced-technology.

The current study highlights the level of compromise involved in responding to such a 'cultural' context, indicative from the difference between energy performance of Yeang's 'bioclimatic' design and the more ideal climatic configuration. In a rapidly developing world, the necessity of 'cultural' forms becomes a priority due to the increasing pre-dominance of 'Western-type' forms of glass, curtain-walls and homogenous designs in corporate office buildings.

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The Sound Sustainable Building

Jonas Honoré, Morten Elle. Technical University of Denmark, Department of Planning, Urban Ecology. Building 115, 2800 Lyngby, Denmark.
jh@ivtb.dtu.dk - me@ivtb.dtu.dk - http://www.domus-logos.dk

In the future your house might be smarter than you.

INTRODUCTION

The ideas and results presented in this paper are based on a report on sound sustainable building and the results from an ongoing Ph.D.-project.

What is sustainability? In this paper the term sustainability is based on the definition by the Brundtland Commission:
"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainable building and sound homes are becoming an increasing imperative and must be built in the best way possible. But too often engineers, architects and other professionals forget the importance of involving the (future) residents of the building when choosing the most efficient technology.
It is well known that the residents have an impact on the actual sustainability of a household that easily equals that of the implemented environmental technologies.

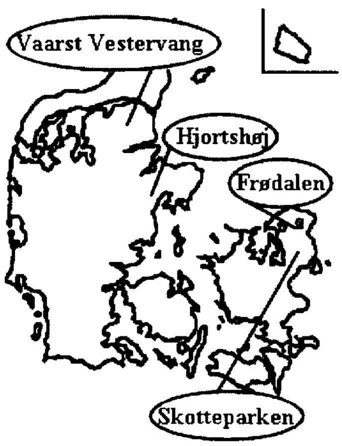
This paper will demonstrate the importance of involving residents in sustainable building and point to methods and technologies that will facilitate this in the home of the future.

PRESENTATION

An analysis of 4 recently erected Danish sustainable dwellings was conducted to determine the importance of resident participation and tried to seek out areas where further development of the actual involvement of the residents is necessary.

All of the 4 dwellings were chosen because of the use of environmental techniques in the buildings – specifically the wide range of environmental issues that had been taken into consideration in each of the dwellings.
2 of the 4 dwellings are public housing, 1 consists of private homes and 1 is a co-operative dwelling. The dwellings are:

- *Skotteparken*, 14 km west of Copenhagen, 100 apartments, focus on energy-savings
- *Froedalen*, 40 km north of Copenhagen, 95 apartments, focus on life-cycle economy
- *Andelssamfundet i Hjortshoej*, 15 km north of Aarhus, 5 houses, focus on building materials and social bonds
- *Vaarst Vestervang*, 20 km south of Aalborg (in the north of Jutland), 16 houses, focus on heating and indoor climate



Frame of Analysis and Method

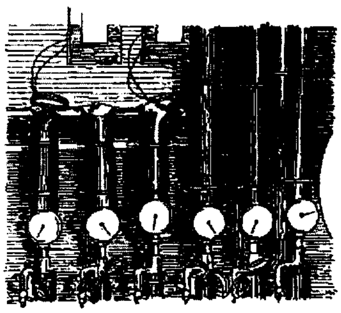
The analysis of the dwellings was performed on the basis of a basic model, involving 4 layers of actors:

- Consultants
- Public administration
- Building professionals
- Residents

and 3 geographic layers:

- The building
- The building site
- The surroundings

The analysis was primarily based on in-depth interviews with representatives from all groups of actors. Since the consultants are architects, engineers and other building professionals it was necessary to perform several interviews in this group of actors for each building. A procedure that was repeated for the residents, who has very different opinions on the environmental products installed in their homes. All in all more than 30 interviews were conducted for the 4 dwellings. Furthermore reports and construction plans were taken into account.



Active Residents – Active Technology
Having collected data for the 4 dwellings a pattern emerged. A rough division into two types of dwellings is possible.

- Dwellings with *active residents* - *Vaarst Vestervang* and *Hjortshoej*
- Dwellings with *active technology* - *Skotteparken* and *Froedalen*

The dwellings with *active residents* were initiated by the residents themselves, which gives the residents a strong insight into the sustainable techniques used in the buildings as well as an understanding of why these specific techniques were chosen. Furthermore the technology in these dwellings seemed to be of a more basic if not low-tech nature compared to the sustainable technology of the dwellings with *active technology*. In the latter type of dwellings the technology was chosen by engineers and other professionals. This shifted the criteria from low/easy-maintenance to technology with the greatest resource- and cost-saving potential.

One of the primary reasons for this difference is that in the *active residents* dwellings the residents take care of the buildings while in the *active technology* buildings most of the work related to maintaining the dwelling is done by caretakers.

The outcome of the analysis illustrates that dwellings with a strong involvement of the residents have the lowest negative environmental impact. Furthermore the residents are generally very satisfied with their homes including aspects, such as the disposition and size of the home, the indoor climate and the materials - but they are also looking for ways to further improve the sustainability of their homes.

Use of resources
What is the price for involving the residents in the process of choosing technology and thereby having to use less environmentally-efficient products? Actually there is no price to pay - on the contrary it seems that the *active resident*-dwellings are more sustainable.

Dwelling\Ressource	Heating kWh/occupant/year	Electricity kWh/occupant/year	Water M^3/occupant/year	Solid waste Kg/occupant/year
Skotteparken	3593	1400	41	206
Froedalen	4500	1200	38	247
Hjortshoej	2057	777	20	48
Vaarst Vestervang	3786	1080	31	105 (54)*
Danish average	7974	1821	59	305
"Environmental space" 2030	3141	718	32	-

* 54 kg/occupant not counting the solid waste that is incinerated.

The numbers clearly indicate that the dwellings with active residents have a lower average use of resources than the dwellings with active technology. Assuming that the active technology actually is more efficient than the technology used in the active residents' dwellings, it must be concluded that it is more important that the residents are motivated and aware of the environmental issues than it is to implement the most efficient techniques.

Conclusions and Recommendations

The sound sustainable building requires that the focus is shifted to the residents and that all aspects of the building and the process of building sound sustainable dwellings must be related to the residents' needs and wishes.

Unfortunately it is not feasible that all or just a larger part of residents will have the opportunity to be involved in designing their homes like the residents of Hjortshoej and Vaarst Vestervang.

Therefore alternative methods to activate residents must be developed. This is the aim of the ongoing Ph.D.-project concerning the learning house.

The fact that the most sustainable dwellings are not using the theoretically most efficient/sustainable technology points to a potential for reducing the environmental impact even further. This potential could be implemented by developing intelligent building-systems which on the one hand help the residents to understand the functionality of their homes, and on the other hand educates the residents to a higher level of awareness that hopefully involves them in sustainable living. In other words a system that would combine *active technology* and *active residents*.

Furthermore the house should adapt to the residents' needs and habits as well as providing the residents with the right information at the right time. The right information has to do with the environmental impact of the household. In its most basic version this an alert function, that will inform the residents to be aware if certain limits have been reached. A passive sustainable sentinel so to speak.

A more advanced version dynamically incorporates the state of the house and the current activities. On the basis of these data the system will be programmed to do certain tasks and respond to situations that are unwanted. For instance the system could shut off the heating if windows are opened.

The system might also help co-ordinate daily routines such as the best time to do the laundry or other energy demanding activities. It might even adjust the indoor temperature to the clothing and activities of the residents.

However it is important that all tasks are not automated and taken care of by machines and technology, leaving the residents with no involvement in the sustainability of their home. To avoid this situation some of the building components must require the residents to participate in the daily routines. This is probably the most difficult part to implement, since tiresome tasks involved with maintaining the household have brought on a steady evolution of technologies to eliminate manual labour.

The specific mix of technologies that respectively activate and inform the residents depends on the local conditions and infrastructure and last but absolutely not least the residents.

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Greening of An Office Building

Sang-Dong Park, Kee-Shik Shin, Soo Cho, Jong-Jin Kim
1,2,3. Korea Institute of Energy Research, 71-2 Jang-Dong Yusong-Ku, Taejon, Korea
4. University of Michigan, Ann Arbor, Michigan, U.S.A.

INTRODUCTION

The high demand for buildings imposed significant pressure on major cities as well as small rural towns and villages to sprawl into suburban areas. As a result, a boom in building construction became noticeable throughout the country. While the construction of new buildings contributed to the local and national economy, they have been a significant burden on the environment. While construction activities were stimulated by government policies, proper regulations or guidelines for reducing the negative impact of buildings on the environment and the quality of life of people were not sufficiently established. As such, after the four-decades of economic development, the ever-increasing building construction activities have emerged as a major threat to the natural environment, to the quality of life of the present generation and to the well being of future generations.

BUILDING FUNCTIONS AND DESIGN CRITERIA

General Goals and Objectives

As the first "green office building" in Korea, this building will serve three primary functions :

- As a *headquarters building* that houses administrative and research offices of the Korean Institute of Energy Research.
- As a *demonstration project* that showcases various energy-conscious and environmentally friendly building design features to educate building professionals as well as the general public.
- As a *laboratory*, in which various methods of sustainable design and construction can be experimented with in a real-world setting.

In the process of designing and constructing this building, it was hoped that this building will provide a useful experience that can be applied to other buildings in the future.

The greenness of this building was manifested in three ways : energy efficiency, resource efficiency and the provision of a healthy and productive work environment. The energy and resource efficiencies were approached with the life cycle assessment method. Under these general goals, a set of design criteria were developed :

- Provide spatial flexibility to occupants.
- Create comfortable and healthy work environments.
- Create comfortable and visually pleasing outdoor spaces.
- Provide facilities for bicyclists such as shower rooms, bicycle racks and lockers.
- Develop methods of reducing or protecting noise from automobile traffic and building equipment.
- Building location should be determined considering energy savings and existing vegetation.
- Utilize passive solar, daylighting and natural ventilation systems in building design.
- Develop building envelope systems that reduce cooling load.
- Building systems must be designed for easy maintenance and replacement.
- Develop an integrated pest management scheme.

Development of Design and Construction Guidelines

After the building proposal was approved, one of the first tasks conducted was to establish guidelines that ensure the design and construction of the building are executed in environmentally friendly manners. A set of guidelines were developed encompassing factors to be considered during the entire life cycle of the building ranging from project planning, schematic design, design development, construction, commissioning to operation after occupancy. It was intended to develop the guidelines as detailed and comprehensive as possible so that they can serve as a tool that assists the designer and the contractor in the design and construction processes.

The guidelines consist of two types: mandatory and recommended guidelines. The recommended guidelines were encouraged to be applied after evaluating their technical and economic feasibility.

DESIGN FEATURES

Site

Landscaping and outdoor space design are important features of the greening of the building. While the primary purpose of conventional landscaping is to create visual quality, the buildings outdoor spaces were designed to perform multiple functions including energy conservation, rain water collection, shading, acoustic buffer and outdoor rest-area for people and wildlife.

To minimize traffic noise, the building was located a sufficient distance away from the northern approach road, and the outdoor space between the building and the road was allocated as a parking area and a green area.

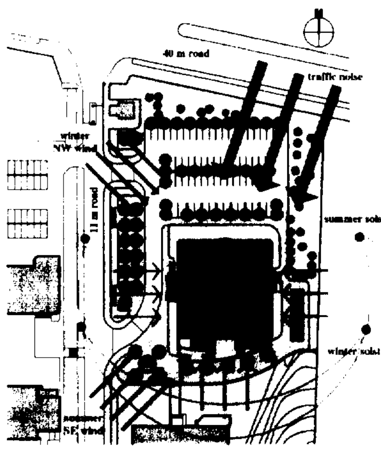

Fig. 1. Site plan

The parking area was planted with deciduous trees that will provide shading in summer.

Fig.1 shows the site plan.

The Buildig

Building system synopsis

This six story, 6184m^2 building incorporates various energy-conscious and environmentally friendly features including :

a double-envelope on the south facade,

an atrium for daylighting and natural ventilation,

movable shading devices on the west facade,

rainwater collection and gray-water recycling system,

energy-efficient HVAC system,

specification of environmentally friendly building products,

solar collectors on the roof and

solar cells

The building mass is elongated in the east-west direction to the maximum extent for exposure to the sun. Because the buildable area is narrow in this direction, it resulted in a square-shape floor plan. To reduce heat loss in winter, the north wall was highly insulated, and windows on this facade were either avoided or made small if necessary

Facade design

Two different concepts, dynamic and energy producing facades, were applied to the facade design. For the east and west facades, a concept of dynamic facades was applied, and movable shading devices were designed to dynamically reduce solar heat gain according to the suns position in the summer. The application of moveable shading devices on the east and west facades was intended to not only effectively block solar heat gain but also to provide the maximum view outside from within the building while preventing solar heat gain.

A concept of an energy-producing facade was applied to the south facade. The south facade, starting above the ground level, was constructed with a double-skin envelope (See Fig. 2). The double-skin envelope consists of two layers of glazing, an air space in between the two glazing layers, and air inlets and outlets at the bottom and top of the air space respectively. In winter, the air space is, in essence, an air-based solar collector. It traps solar radiation and heats up the air coming through the inlets. The heated air is then supplied to the mechanical heating systems through a duct that connects the air space and mechanical room. As such, the double skin functions as a pre-heater for HVAC systems. In summer, on the other hand, with its lower air inlets and upper outlets opened, the double-skin envelope functions as a solar chimney which draws outdoor air into its air space creating natural ventilation.

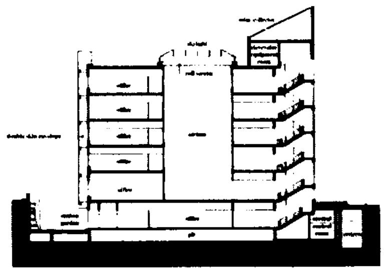

Fig. 2. Section illustrating double skin envelope

Water conservation

Experimenting with and demonstrating water conservation techniques is one key feature of the green building. Various water-conserving devices and systems were implemented. The green area to the south of the building was sloped to create a natural swale, and rainwater falling in this area is collected in ponds. Rainwater collected on the roofs of the green building and an adjacent building is channeled to cisterns in the basement. The collected rainwater will be used for plant irrigation and toilet flushing. In addition, water-conserving faucets were installed in the shower room and restrooms. The sink water faucets and toilets were installed with infrared sensors. To reduce water consumption in air-conditioning, the cooling towers of HVAC systems were installed with a device that prevents evaporated moisture from escaping to the outside.

Building products and materials

The use of building materials and products that are environmentally friendly is another important aspect of green buildings. Green building materials can be defined as one made of the following :

- recycled materials
- natural or organic materials
- materials with low embodied energy
- non-toxic materials
- local materials
- materials or products that conserve water consumption
- materials or products that conserve energy consumption
- materials having long-life

Before the materials and products were specified for the building, a survey of building product manufactures was conducted. Through the survey, it was realized that there are only a few environmentally friendly materials available on the market. Nevertheless, careful considerations were made in the selection of the building materials and products.

Economic feasibility study

The building is designed to consume 210Mcal/m^2· y comparing with total average consumption 300Mcal/ m^2· y in the Institute. Therefore the tangible energy saving is expected as 90Mcal/ m^2· y(₩25,000,000 annually). The intangible savings are presumed as 30% annual decrease of GHG emission and ₩200,000,000 of annual productivity improvement.

Other uncountable national benefits are resources saving, prevention of water and air pollution, promotion of employees' health and so on. So, the payback period is anticipated as 3 years at maximum and this building has economical propriety.

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IS THERE ANY GREEN BUILDING ? AN ASIAN PERSPECTIVE

Prof. Santosh Ghosh
President
Centre for Built Environment
2/5, Sarat Bose Road, Calcutta 700 020, India

INTRODUCTION

Urbanisation in Asia is still 35% but it has more large cities out of 42 cities in the world, each having a population of 5 million and above, Asia has 23 of them in 2000 while in 2015 there will be 70 such cities of which 40 will be in Asia (UNCHS, 1996). Such a city is often an oasis in the desert of rural poverty. About 30 to 40 percent people live in slums and squatter coloneys and build their houses without much basic services and with waste materials, cheap building materials and often they are lcoated near drainage basins, hazardous industries or garbage dumps, and many of them without electricity. Environmental improvement becomes more important than a good building. To these millions sustainability means survival.

A building is part of the system – physical and non-physical. In Asian cities non-sustainable energy intensive and resource exploitive urban development projects are everywherethe high-rise buildings at the centre and sprawl at the periphery of cities. A large number of people construct their houses with cheap materials, or often houses remain incomplete. John Nortan advocates indigenous construction and says that sustainable architecture is a process which can be repeated (Norton, 1999).

PRESENTATION

Green buildings are sustainable buildings but a building cannot be green by adding greenery. It is dependant on environmental measures. Green building concept refers to global interest to reduce the adverse environmental impacts of buildings and to develop a global standard for building performance assessment and lebelling. The Green Building Challenge (GBC) is now adopted in 17 countries and it includes a number of factors including transportation, resource consumption etc. (Larsson, 2000).

From the perspective of environmental health, cities in the north perform much better for the people than the south while from perspectives of resource utilisation, the cities of the South perform better.

The sustainability factor is being incorporated in policies and plans by various developed countries. The European thinking about sustainability is a broader concept than environmental protection. It concerns social, economic, physical and ecological issues. It emphasises a range of tools for formulating, integrating and implementing local environmental polices (EC, 1994).

To the Asian cities, urban environment management is more important as it benefits millions of poor people. Various programmes and projects with the support of the United Nations, the World Bank and others have been taken up –Urban Environmental Management Programme, Healthy cities plan, Sustainable Cities programme etc. with rising consciousness for environment and ecology, ecovillage developments etc. have taken place and 'Recycle, reuse repair, reintegrate, etc' are becoming the new order.

In the Netherlands, the Green Investment Scheme provided a stimulus for sustainable building but its acceptance was slow (SEV, 1999). In India incentives have been given for utilisation of solar energy in buildings, but architects have not taken advantage of this.

Anke Van Hal in the research studies on sustainable building supported by Novem and others in some European countries has shown that only a few paid attention to sustainable building while some environmental measures have been implemented on a large scale in some coutnries without sustainable building in political Agenda (Hal, 1999).

In 1996 a survey of sustainable housing in 24 European countries showed that many countries did not have specific policies. Some measures have however been taken on energy, traffic, water, materials, health, flora, fauna and soil (Sustainable building, 1997) CIB has also issued guidelines for sustainable construction (CIB, 1998).

Environmental management systems (EMS) are growing. Two main initiatives – Economic Management and Audit Scheme (EMAS) and International Organisation for Standardization (ISO 14001). Despite various merits in quality control, it does not provide any guarantee of higher environmental performance neither it is accountable to the people. On the other hand the UN Zero Emissions Research Initiative (ZERI) is better as all wastes are used in production and it is used to create value by other industries (Robins and Kumar, 1999).

Obviously environmental goal in developing countries is different despite globalisation. Sustainability is a holistic concept and integrated with socio-economic issues. Wolfagang Sachs et al suggest ecological tax reforms in marketing green products and adopting environmental measures. (Sachs et al, 1998). Sustainability has gender aspect and the women's views of environment in building are overlooked.

The World Watch Institute has predicted that by 2030 the principal source of materials for industry will be from recycling. At present in Europe only about 5% of building material are recyclled and it should be possible to recycle about 75% and this figure, may be 40% in Australia (Maf Smith et al, 1998). Asian cities have taken up programmes but environmental improvement of buildings for low income people can be started with recycled materials instead of putting emphasis on sophisticated green building guidelines.

The concept of environmentally sustainable develoment starts with recycling of wastes of all kinds. With increasing cost of new building materials and problems of environment, recycled mateial will be used more in future construction – flyash bricks and blocks for walls, door and window frames and shutters from wastes, roofing tiles and other elements can be from indigenous materials. Intermediate technology plays vital role. An ecological community can be designed out of total waste recycling. The ecological sanitation with natural composing may provide vegetable farming and recycling of waste water may and produce fish pond, and there will be fruit trees. Energy will be supplied by biogas and biomass. Such development will preserve bio-diversity and nature. The city edge will also be green with more oxygen. (Ghosh, 1999).

CONCLUSION

(1) There cannot be sustainable building unless the cities are sustainable. Built form and environment relations are to be established in townplanning and building regulations and environmental guidelines.
(2) Considering the housing of the poor in the Asian cities, 'Green building' guidelines should start with them in order to improve the life of the millions.
(3) Waste should be considered as wealth and recycling of waste into eco-friendly building materials, and other productions are necessary.
(4) Education and training of architects, building engineers and city planners are to be reoriented towards these, including intermediate technology and indigenous materials application.

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Architectural Quality in Sustainable Building Assessment

Mr. Stephen Pope
Stephen F. Pope Architect
68 Clegg Street
Ottawa ON K1S 0H8 Canada
Tel./ Fax + 1 (613) 231 5681
E-mail: sfpope@cyberus.ca

Introduction

The argument that a whole building assessment system needed to include a measurement of "architectural quality" was premised on the observation that those who pay for the design and construction of buildings will chose a "better looking" building over one that has a better performance rating. Accordingly, if aesthetics are not given a formal place in an assessment, an ad hoc aesthetic judgement may unduly influence the outcome of the assessment process. Maintaining the integrity of the assessment process requires a method by which one could account for the subjective elements of aesthetic preference.

Presentation

There are difficulties with this statement of the problem. The "look" of a building can be taken to mean the sum of a large range of experiential qualities, or it can be a literal reference to visual style or the qualities of the finishing materials. In the former case, without enumerating and assessing the component elements in their context, the use of the term is excessively vague and the value of the assessment uncertain. In the latter case, the assessment of visual style or finish materials alone misses many of the key architectural decisions that produce the desired image, and so the assessment is trivial.

The implied equation of overall architectural quality with architectural aesthetics or style is problematic due to its limited scope. From the perspective of a North American architectural practitioner, it is the result of a gross failure of architectural criticism affecting the North American public and profession alike. The Green Building Challenge process offers a strategic opportunity to address this failure. An assessment of architectural quality in the GBC framework would improve the appreciation of building design, while avoiding involvement with the claims of superiority made by one aesthetic ideal against all others.

In the void left by the failure of criticism, discussion of architectural quality in North America has been colonized by the propaganda of the early period of the Modern Movement in architecture in Europe. At the beginning of the last century the association of building styles with social reform movements introduced moral notions to the broader ideas of architectural quality. In this regard the 1908 polemical manifesto by Viennese architect Adolf Loos entitled "Ornament and Crime" comes quickly to mind. Previous to Loos however, the English art critic and educator John Ruskin had linked the artistic and architectural production of the gothic periods in Europe and England with an idealized image of a productive and healthy society.

The result of this ideological overlay was that visual style became shorthand for a full set of cultural assumptions regarding hygiene, productive social order and equity. Especially in post war North America, Modern style was taught with a religious overtone such that to disobey the stylistic canon was not just to produce work of poor quality, but to demonstrate moral degeneracy. The linkage of aesthetics and morality was, and remains, highly problematic in that it prevents critical discussion of how aesthetic structures operate, substituting a list of approved forms for a critically developed expression of the values inherent in a project.

The official dominance of the Modernist aesthetic produced a dichotomy in public discussion of architecture where “the educated” held out one version of quality, and the public users were, in all but very rare cases, better satisfied by something different. The design dogma provided an aesthetic gloss and theoretical legitimacy to a North American architecture of expediency where the concerns of the professional were commonly reduced to speed of construction and reduction of cost.

To displace the dogma and initiate a meaningful discussion of architectural quality we must return to a discussion of how buildings are produced. The process of architectural design involves the establishment of the spatial, visual and material characteristics of a building based on the interpretation of a program of use, provided by or developed with a client. The interpretation of the program is the starting point of architectural quality. The design team may develop concepts for a number of approaches each of which demonstrates in built form the client’s internal social relationships and relationships to the society in which the client lives. Generally, the more complete and convincing the character of the design, the better the architectural quality will be.

At a panel discussion held for the year 2000 conference of the Royal Architectural Institute of Canada, Chief Architect of the US General Services Administration Edward Feiner, suggested that one proof of good architecture was when the community refurbished a building at the end of its initial program life. This judgement of time suggests the experience of the building has been positive enough to have its owners and users invest in it both emotional value and maintenance funds. Accordingly, one might define architectural quality as the built character that contributes, over time, to the recognition of a building as part of the cultural heritage of the community.

The GBC framework currently reviews a number of elements that contribute to architectural quality under the “Indoor Environmental Quality” and “Quality of Service” sections. These elements cover building performance criteria such as air quality, thermal comfort, illumination, and noise control that individual users would require satisfied to have good working or living conditions. On a building owners scale the framework addresses the flexibility of the planning, the maintenance of performance, and the quality of site and amenities. The framework also assesses the urban context of the project with special attention to the richness of the area’s cultural character.

The treatment of architectural scale, the use of architectural elements and materials for wayfinding, and the communication of differences between public and private spaces in a building, are also elements which support the activities of the user and contribute to the perception of quality in the project. Related to the concept of scale are perceptions of the level of detail needed to support the experience of place. These architectural elements, and others like them, need integration with the framework to complete the qualitative evaluation.

Examples of whole building approach to architectural quality can be found in the case studies provided in the Rocky Mountain Institute’s Green Development handbook. The projects presented are considered good examples of profitable real estate development where the overall quality is comprised of part quality of space, part ease of use (flexibility & adaptability), part air and light quality, part context (history, cultural presence), part scale, and part coherence of visual composition. This type of description unifies all the elements of the experience of a building, rather than attempting to isolate a particular source of "beauty."

An architectural review of these successful projects reveals a richness in the handling of space, usually integrating height and volume in addition to varieties in plan. Connections between the interior and exterior are well articulated, whether through access to daylight from working areas or exterior spaces from public entrances and collective spaces.

Conclusions and Recommendations

A measurement of architectural quality represents the manner by which the building assists the day to day activities of the occupants, makes them aware of the connection to their fellows, and at best provides moments of inspiration. The diversity of interior volumes, with interconnections between spaces of differing scales is an important means of making visible the connection of an individual to the larger group. Diversity in scale of space is necessary to respond to the different nature of activities undertaken with different sizes of occupant groups. Consistency of architectural detailing can both reflect the differences between large group activities and small group or individual activities and indicate the continuity of the context.

The inclusion of architectural quality in the GBC assessment framework will integrate physical elements that impact the social abilities of the user community. The following list is presented as a starting point. I suggest that the following list is both neutral enough to be coherent in any regional style, while remaining specific enough to form the basis of a ranking scheme.

1) Architectural quality
   a) Diversity of spaces;
      i) In plan;
      ii) In interior / exterior volume;
   b) Use of scale in space and detail;
      i) Scale of project in relation to neighbourhood; Complementary / Contrasting
      ii) Variety of scales from large public spaces to intimate personal ones;
      iii) Cascade of scales: capability of unifying different scales – providing an internally coherent identity while supporting the existence of other separate identities;
   c) Connection to the exterior
      i) Access to daylight / views
      ii) Access to "outdoor rooms"
      iii) Relationship between interior spaces and exterior landscaping / exterior urban amenity.
   d) Articulation of thresholds: inside / outside; public / private
   e) Consistency and coherence of stylistic approach.
      i) Use of regional / local styles;
      ii) Level of complementarity / contrast of non-regional styles if applied.
   f) Appropriate level of finish with respect to neighbourhood context;
      i) Complementarity / contrast of material texture
      ii) Complementarity / contrast of colour

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TOWARDS SUSTAINABLE ARCHITECTURE: THE RELEVANCE OF DESIGN IN EVALUATION METHODS.

Silvia de Schiller
Research Centre Habitat and Energy, Faculty of Architecture, Design and Urbanism
University of Buenos Aires
Pabellón 3, Piso 4, Ciudad Universitaria (1428) Capital Federal, Argentina
schiller@fadu.uba.ar / 98034255@brookes.ac.uk

INTRODUCTION

In the last decade, a number of valuable initiatives for promoting sustainable architecture have been developed, based on the need for explicit and replicable evaluation methods. These initiative raise a number of issues at different scales and stages of project development, from urban design to construction specifications, and encompassing themes ranging from global warming concerns to local impacts on occupants [1]. The methods also reflect the evolving issues of energy, health and global sustainability.

These efforts have not yet attracted adequate attention from architects, urban designers and planners. The lack of commitment from the producers of the built environment should be tackled within their own fields of interest, practising skills and relevance to spatial dimensions. A widening gap between designers and scientists developing evaluation methods is increasingly evident and a factor of concern.

Stress on life-time efficiency and operational costs, essential issues in sustainability, are often of little concern in project development.

Interaction of building and context, analysing environmental influences at the micro urban scale, is another key area for evaluation.

Especial efforts should be paid therefore to study how design issues can be successfully integrated into the evaluation methods.

PRESENTATION

Although the quality of architectural design is undoubtedly related to each of these issues, themes and focuses, the difficulty of evaluating the implications of design decisions in the built environment and in specific buildings is still very considerable [2]. The risk of segregate design issues under the consideration of being subjective' and 'aesthetic' may also contribute to increase the gap between designers and scientists within the process of introducing and developing evaluation methods in current practice. Some of the design aspects affecting 'sustainability' may be overlooked and underdeveloped in existing evaluation methods and procedures.

The use of these procedures and attempts to apply them in the specific local situation of Buenos Aires give rise to the following reflections:

Globalisation: The globalisation process of technology and design may ignore specific local cultural and geographic requirements. There is also an increased danger that the superficial image of well-publicised 'green buildings' from a different context is copied rather than the substance behind the physical appearance.

Climate: Methods for building evaluation, which have been prepared primarily in developed countries as a result of climate change and CO_2 emissions concern, should be evaluated and adjusted before implementation in different environmental context found in hot and warm climates.

Development: Regions with hot dry and warm humid climates are also related to the .under develop belt' of the tropics; therefore attention should be paid to differing and specific comfort requirements and life styles together with the internationalisation of technology and spatial configurations. Changing patterns in behaviour constitute a 'moving target' in the performance of the built environment, where market forces strongly influence social expectations and user demands. The trend supporting these factors leads to the adoption of certain building typologies, related to demonstrating status and following patterns of consumption. These parameters will then affect the factors to be included and the balance required in the evaluation process to achieve improved levels of sustainability.

Change: The rapid evolution of focuses and dimensions of 'greenness' has produced significant variations in the structure and content of evaluation procedures over the last years, not always following architectural fashions, which are also changing fast. Therefore, evaluation methods should recognise that the targets are moving and changing over time, while what is targeted is also in the process of definition.

SPECIFIC FACTORS

The following specific factors exemplify the general reflections mentioned in the previous section:

Bioclimatic design: The relevance of bioclimatic design strategies for natural conditioning of buildings may have a different emphasis in subtropical climates where the energy demand can be reduced to very low levels with appropriate design. The criteria for evaluation of the building's response to climate may be the subjective thermal quality rather than the control of energy consumption. Nicol [3] has shown that thermal comfort preferences in warm climates vary from air conditioned buildings to natural conditioned buildings.

Embodied energy: In naturally conditioned buildings with low energy use over the life of the building, the environmental impact of the embodied energy may be proportionally more important than in the colder climates of the developed world.

Outdoor space: The microclimatic quality and design of usable outdoor space is of greater importance in climates where conditions in these spaces are closer to comfort levels. Outdoor and intermediate spaces in traditional housing of warmer climates, such as patios, verandas, loggias, etc., provide additional living area. With simple elements such as shade trees and pergolas, etc., usable space of very low impact and adequate comfort levels can be created. On the other hand, in cold climates, outdoor space has different intensity of use and levels of benefits for the occupants.

Sustainable materials: The traditional materials used in the developing world were by their very nature more sustainable than most modem materials. Renewable or very widely available raw materials were used without elaborate or energy consuming processes, though frequent labour intensive maintenance. was required. Modem materials often imply greater environmental impact, without necessarily assuring better environmental quality. This raises the problems of comparing and assessing different types of variables [4].

Development and dependency: In first world countries, the origin of raw materials, the industrial processes, transportation and the technology used in the production of the built environment can be evaluated in terms of embodied energy, environmental impact of production and impact on internal air quality, etc. It can be argued that, in the context of regions under different development stages, promotion of local employment, reduction of technological and economic dependence, etc., are also vital to promote 'sustainable development'. It is also important to estimate the dependence of future generations to support excessive operating and maintenance costs due to building inadequacy or short lifetime cycles.

DESIGN FACTORS

In both developing and developed countries, the design quality of buildings, though difficult to evaluate, may have a vital impact on 'effective sustainability'. Functional relationships and the external appearance of buildings can have a profound influence on the users, affecting the sense of belonging and the consequent social behaviour.

Many large-scale housing projects around the world, with carefully developed designs and well planned social programmes, have experienced catastrophic both social and construction problems that have required major renovation, redevelopment, partial or even total demolition before the planned lifetime of the buildings have been reached.

The globalisation of design at different scales is running fast and the fragmentation of the urban tissue seen in many developing regions shows it's impact due to the increasing number of free standing high rise buildings, not only in central areas but also in new developments and small towns. This pattern, resulting from design alterations, is producing considerable changes in the urban environment, affecting building quality with immediate and long time effects [5]. This is another example of the need to qualify and quantify design decisions.

CONCLUSIONS

There are general and specific factors found in less developed countries that require adjustments to the evaluation system, both in the variables included (or excluded) and the relative values of each variable.

The explicit incorporation of design factors and variables, though complex and often implying more subjective evaluation criteria can help to bridge the gap between environmental evaluation and guidance for the designer.

Evaluation of buildings, as a new discipline in the production of the built environment, may also contribute to modify decision making within the design process.

ACKNOWLEDGEMENTS

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Environmental Education for the Building Industry: An Internet Resource

Caroline Mackley[1], Paul MacLennan[1], Andrew Miller[2] and Steve Curwell[3]
[1]Massey University at Wellington, New Zealand
[2]University of Brighton, UK
[3] Salford University, UK

INTRODUCTION

This paper is based on the work of the CIB W100 sub-committee on education and communication.

The aim of the sub-committee is *"to integrate Environmental Performance Assessment Systems into the educative process so that awareness of environmental issues becomes second nature to current and future generations of Built Environment students and practitioners alike"*, (Mackley, 1999).

The work of the sub-committee commenced with the establishment of a database of people and organisations throughout the world with an interest in best practice environmental education. The focus to date has been university based, however we are seeking to expand this in acknowledgement that education is a life long process and is applicable equally at all stages of professional development. In addition, funding was raised to undertake a survey to collect data from key industry groups of the built environment in relation to needs and attitudes towards the environment and the impacts of buildings. This was completed with a particular emphasis on the concept of Environmental Performance Assessment (EPA) methods. The purpose of which was to determine the potential of the Internet to as a vehicle to provide resources to develop an understanding of environmental performance assessment of developments to the built environment.

There was a clear expression of interest from industry for access to self-education in relation to environmental issues and a perception that the Internet was the most appropriate vehicle for this due to its increasingly all pervading nature and "real-time" capabilities. Moreover, results achieved to date appear to support the international consensus that there is a need to provide improved industry education with respect to environmental issues. In addition, a distinct "gap" in basic environmental awareness is identified, which presents a barrier to the implementation of environmental assessment methods and applications.

The major barriers to implementation of EPA measures are environmental awareness, cost of and accessibility to suitable information resources. These barriers appear to be regionally consistent.

In Australia and New Zealand material exists, at the tertiary level, which address the proposals of the New Zealand Natural Heritage Foundation (NZNHF, 1998) and Australian Environmental Education Network (AEEN, 1999), in relation to the incorporation of Sustainable Development concepts into curriculum to better promote the understanding of the interaction of man and the environment. However, these are aimed more at resource management issues as opposed to the built environment, are only available at universities and are without industry integration. Research and development in the area of user needs relating to environmental education, specific to the built environment is lacking. As a result a gap exists in the availability of co-ordinated, comprehensive industry specific environmental educational materials.

A total of 43 major organisations have been surveyed to date. This number is increasing continually. Data was collected by way of a structured interview applied either in person or via the telephone. Question categories related to:- ***Awareness*** of the impact of buildings on the environment, ***Relevance*** of this issue for respondents own specific industry activities, ***Interest*** in access to a single comprehensive information resource, ***Needs*** in relation to the nature of potential education, ***Perception*** of value of a resource such as this in relation to benefit, sponsorship and accessibility, ***Responsibility*** for the development and management of a central information resource, ***Potential Use*** of the proposed resource.

KEY FINDINGS - ISSUES

Awareness of Environment and EPA,

- 98% of respondents stated that they were aware that buildings have a range of impacts on humans and the environment and believe that this is relevant to their activities. However, when broken down and analysed by sub-category, results suggest that awareness pertain to a narrow range of impacts.
- The issues most frequently identified were (in ascending order of frequency); Energy [70% of total responses], Indoor Air Quality [67%], Material use [65%], Thermal Quality [65%], Day lighting [65%], Physical impact of buildings [58%], Global warming [54%] and Waste generation [54%].
- Only 42% of respondents were able to identify specific EPA methodologies. Of those identified, the BREEAM method enjoyed the greatest level of recognition at 24%.
- The major conclusion that can be drawn from the awareness and implementation findings is that accessibility to specific information provides a key barrier to accelerated take up and application of EPA within industry.

Implementation of Tools and Methods,

- Only 33% of respondents have ever been involved in projects where EPA tools had been applied. Interestingly, there was unanimous agreement that their application had proved to be beneficial to the project outcomes.
- Over 80% of the organisations surveyed to date believed that their understanding of the tools available and the benefits that they provide, was below average. The same 80% expressed a desire to learn more about EPA tools and methods.
- Of those seeking to implement EPA, the most commonly identified reasons for doing so included; Client request [72%]; Government policy [61%]; Cost savings [47%]; Environmental Commitment and Competition [44%].
- Interestingly, in relation to the reasons identified above, there was a 100% response rate from the UK organisations.

Access to Information and Resources

- Only 37% of respondents identified that they had attempted to source information for projects. Of this total, only 31% felt that the information that found or attempted to find was either easy to access or in a form readily applicable to their specific needs.
- 88% of respondents expressed an interest in having access to a single point internet resource aimed at developing an understanding of EPA.
- These same respondents were of the view that the Internet was the most appropriate vehicle for information of this nature due to its real-time and all pervading nature. However, there was concern expressed in relation to equity in the case of low access to Internet facilities.
- Interestingly, 57% of New Zealand respondents felt that the information should be exclusively regional in focus compared to only 26% of UK participants. This perhaps reflects that geographic isolation provides a barrier to implementation.

Barriers to Implementation

- The main barriers identified included; Limited awareness of environmental impacts; A lack of access to hard data; Balancing economic imperatives with environmentally sound practices; Limited awareness of the cost/benefit implications of EPA; Poor performance by relevant authorities in terms of developing; implementing and enforcing regulations and Attaining and acting on information is perceived as costly.

The overwhelming theme that emerged from the data appeared to be that people only change when it is forced upon them, or when there are clear benefits for individuals in the market.

- Most respondents felt that this area is currently poorly serviced and that a comprehensive educational resource would assist in advancing environmental sustainability objectives. This view is supported by the finding that 88% of respondents reported interest in using an Internet based information and education resource for EPA, and 80% of respondents felt there was value in a central information resource.

CONCLUSIONS

There is a range of challenges that will need to be overcome if the resource is to achieve its full potential. In particular, issues of audience variation, promotion, funding and management will need to be addressed. It appears that industry has limited understanding of EPA and the range of positive cost-benefits associated with it. The development, promotion and content of any final resource must take this into account.

Despite a moderate awareness of building impact issues and EPA, the New Zealand industry as a whole appears to have little in-depth understanding of this area and its cost-benefit implications and consequently place little value on it. Results suggest that the economic benefits that flow from the use of EPA tools become self evident to users.

The challenge is to communicate this to people who have not already had some involvement with EPA. It appears that there is a gap between the development of tools, their implementation and the communication of the benefits that flow from their application.

The committee will continue to determine the needs of the construction industry with respect to knowledge and application of Environmental Performance Assessment Systems and to work towards the development of these resources.

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HOW SHOULD ENGINEERS HELP DELIVER SUSTAINABLE CONSTRUCTION?

Dr Bill Addis
Buro Happold, 17 Newman Street, London W1

INTRODUCTION

Issues of sustainability are, at present, generally incorporated into the design process for buildings in *qualitative* terms. It is still rare to encounter a *quantitative* specification for the 'sustainability performance' of a building or structure in the way we already use specifications for performance relating to strength, safety, temperature, humidity, running costs (in terms of energy or cost), durability and so on.

There are three main reasons: first there are few mathematical models of sustainable behaviour (as we can call it, by analogy with structural and environmental behaviour); there is also wide disagreement about an objective means of comparing data relating to sustainability (of which there is a great deal). Finally, there is the all-important question as to who will pay for the additional work needed to consider sustainability.

The result is an impasse - an apparent barrier to incorporating sustainability issues in design decisions and project evaluation in the day-to-day work of engineers. But engineers are known for their ability to break vicious circles and to act when there is too little, too much or conflicting data. Engineers are pragmatists.

THE ROLE OF CONSULTING ENGINEERS

At a technical level, engineers have much the same to contribute as they have done in the past:

Minimum weight was always the goal of builders of long-span roofs and bridges and, in this century, builders of aircraft. But the most profound study of minimum weight as a design philosophy was by a biologist looking at natural structures - d'Arcy Thompson in 1917. Out of this philosophy came the ideas of specific stiffness and specific strength - the amount of stiffness you get per kilogram of material [1]. The logical progression from d'Arcy Thompson's work has been to consider energy rather than weight – the energy – and, hence, fuel resources - needed to produce a kilogram of a material – the embodied energy. It is a short step to consider the amount of structural utility you could get for a certain amount of embodied energy – an energy-based equivalent to specific stiffness [2]. On this scale timber generally rates well, steel and aluminium less well.

Building services engineers have long been devising ways of reducing the energy buildings need during their life. Now this can be very low indeed, so low it can be provided from renewable sources (e.g. Bavarian Environmental Protection Agency, Augsburg).

The challenge is now for engineers move on both to broaden their approach and to increase the influence they have on buildings by becoming more influential at earlier stages of their projects. This can be difficult, not only because clients and architects are not used to seeking such input, but also because many engineers are not used to looking at the broad picture before designs have become precise enough to calculate their engineering performance.

Nevertheless, engineers have already begun to make this transition and can

THE DUTCH NATIONAL PACKAGES FOR SUSTAINABLE BUILDING: A FIRST STEP TOWARDS A SUSTAINABLE BUILT ENVIRONMENT

Ellen van Bueren, Ellen van Keeken
Delft University of Technology, DIOC-DGO The Ecological City
Rotterdamseweg 139A; 2628 AL Delft; the Netherlands
E-mail: ellenb@sepa.tudelft.nl; e.p.h.vankeeken@citg.tudelft.nl

INTRODUCTION

The Dutch 'National Packages for Sustainable Building' (Packages) contain sustainable building measures, ranging from concrete *do's* and *don'ts* to more abstract principles for the planning and design of buildings and the built environment. The emphasis, however, is on concrete measures to be applied in the realisation stage of the building process. Different Packages exist for the building and management of dwellings, utility buildings, urban planning and (rail)road constructions and waterworks [1a-d]. The Packages were introduced between 1996 and 1999 and are updated periodically. The Packages are becoming the standard for sustainable building for many actors in the Dutch building sector. The Packages and revisions are produced by the actors in the building sector and are supported by national and local governments.

The National Packages for Sustainable Building were the subject of a case study carried out by the Delft Interdisciplinary Research Centre DIOC-DGO, The Ecological City. A research team from this centre analysed the extent to which these Packages are useful ingredients to use to compose an image of the ecological city. The central research question was: *To what extent do the Dutch National Packages for Sustainable Building contribute to a sustainable built environment and to what extent present the Packages a coherent view on sustainable building?*
The conclusions of this case study will be presented and discussed in this paper.

RESEARCH APPROACH

An operationalisation of the sustainability concept was needed to answer this question. The Ecopolis Strategy offers such an operationalisation. Three decision fields concerning the sustainability of the built environment are distinguished in the Ecopolis Strategy: actors, areas, and flows [2]. Sustainability should be addressed in all three decision fields, and co-ordination is required between the multiple decisions taken in these decision fields.
The three decision fields aim at various qualities of decision making processes: process quality (actors), spatial quality (area's) and environmental quality (flows). The extent to which the Packages contribute to these three qualities is discussed in the following paragraphs.

PROCESS QUALITY

Process quality refers to the contribution of the Packages to the quality of the decision making processes concerning the design, realisation, use, and management and maintenance of the built environment. The evaluation of this contribution can be operationalised in two ways in our perception:

- as goal rationality: do the Packages contribute to the goals they were supposed to meet?
- as a learning process: do the Packages contribute to learning processes about the sustainability of the built environment?

The Packages were introduced to harmonise the wide variety in checklists for sustainable building that were spontaneously developed by local governments and environmental organisations at the beginning of the 1990's. Construction companies complained about the legal inequality between various municipalities as a result of these initiatives. The Dutch Ministry of Housing, Spatial Planning and the Environment therefore stated in its policy plans for sustainable building that harmonisation of these

checklists was required [3]. The building and construction sector was made responsible for the development of these Packages. This was in accordance with the large role of the private sector in the development and implementation of sustainable building policies.
This market approach resulted in Packages for each building sector. The Packages for dwellings were published in 1996, for utility buildings in 1998 and for (rail)road constructions and waterworks and for urban planning in 1999. The conclusions in the next paragraphs of this section are based on the experiences with the Packages for dwellings and utility buildings.

The Packages are widely known among the potential users. The Package for dwellings, which was the first Package to be introduced, is widely used: 61% of the building permits for new dwellings adopt some measures from this Package in 1998, and the Ministry of Housing expects this percentage to rise to 80% in the year 2000 [4]. The contribution of the Packages to a sustainable built environment are successful from a goal rationality perspective. The building sector has succeeded in harmonising the sustainable building measures presented in these Packages. The responsibility of the building sector for the Packages and their contents is an important explanation for the wide support and use of the Packages.

The contribution of the Packages to learning processes on sustainable building however, is less positive. The decisions as to which measures should be part of the Packages are based on consensus. The measures reflect common sustainable building practice and their technical and economic feasibility is beyond doubt. The effect of this consensus based decision making is that the sustainability ambitions of the measures are lowered until all actors involved agree. The state of the art of sustainable building is more or less frozen at the level of the measures presented in the Packages. The annual updating of the Packages cannot prevent this. Changes in the updated versions are restricted to slight modifications of the measures. The Packages are becoming synonymous with sustainable building for many actors. Incentives to develop measures reflecting higher ambitions are lacking. The learning processes are stagnating.
The evaluation of the contribution of the Packages to process quality results in two different conclusions. From a goal rational perspective, the Packages are a major success story. From a learning perspective, the Packages do not stimulate further developments in knowledge on sustainable building.

SPATIAL QUALITY

From the Ecopolis *areas* perspective, the National Packages on Sustainable Building should also contribute to spatial quality to achieve a sustainable built environment. Spatial quality can be measured with the following three criteria: use value and perceived value, and future value [5].
Use value has different names on different spatial levels: for buildings it is called comfort, for neighbourhoods liveability. The use value of the built environment is set by its users and occupants. Perceived value is of a more subjective nature: it refers to the value as perceived by the users. Future value refers to the flexibility and adaptability of the built environment to future changes in needs of the users.

In the Packages for dwellings and utility buildings the emphasis is put on the indoor environment, i.e. on comfort, and the environment directly surrounding the building. The focus is on both physical and psychological health to improve comfort in dwellings and utility buildings. Measures with positive effects on thermal comfort, air quality, sound, (day)light, privacy, view, aesthetic quality and individual control are suggested.

Use value and perceived value are part of the subject 'living environment' in the Package for (rail)road constructions and waterworks. The measures in this Package focus on avoidance of hindrance and safety risks.

The Package on sustainable urban planning pays more attention to use value and perceived value than the other packages, especially in the themes transport and liveability. Use value is approached as a *conditio sine qua non* for sustainable building in this Package. In the other Packages, use value is approached more as part of sustainable building. The influence of users and occupants on the built environment are important aspects in the themes water, nature and ecology and energy.

The Packages for (rail)road constructions and waterworks and for urban planning also pay attention to use value for plants and animals, i.e. the possibilities that are created to enlarge biodiversity of species and ecosystems, but do not give a general framework to which can be referred for criteria and evaluation, such as the concept of the meta-populations. The proposed measures do not refer to private green property: the gardens.

The contribution of the Packages to spatial quality is thus specifically aimed at the improvement of the use value and perceived value of the built environment for today's users, both homo sapiens and the flora and fauna of the Netherlands. Future changes in the possible needs of users do not receive much attention in the Packages.

ENVIRONMENTAL QUALITY

The contribution to environmental quality made by the measures contained in the Packages was analysed for three important flows in the built environment: construction materials, including resources and waste, water and energy. These flows are important points of action to reduce the environmental load caused by the design, realisation, use, and management and maintenance of the built environment.

Part of the flow analysis investigates the ambition reflected in the measures. These ambitions can be grouped as follows.

1. Reduce unnecessary use
2. Choose finite resources consciously and use them efficiently
3. Use sustainable resources and reuse components

These three kinds of measures are distinguished in the Dutch National Environmental Policy Plans [6]. Most measures presented in the Packages refer to these first two steps. The third step, the most ambitious one, is hardly addressed.

Materials, energy and water are recurring themes in the measures presented in the various Packages. Many of these measures, however, lack indicators to monitor and measure the effectiveness of these measures, especially quantitative criteria or methods are missing. The actual contribution of the measures to the reduction of the environmental load therefore cannot be determined. The interaction between measures addressing different flows also lacks attention. Potential trade-offs and synergies are not, or not clearly, indicated in the description of the measures. The measures are mainly concerned with short term environmental gains. Most measures are not concerned with creating conditions to achieve sustainability goals in the future.

The contribution of the Packages to the environmental quality of the built environment is difficult to assess. Most measures in the Packages concern a reduction in use of finite resources and the increase of efficient use of these resources. Indicators and monitoring systems, however, are lacking, which makes it impossible to determine the actual reduction in the environmental load.

CONCLUSIONS AND RECOMMENDATIONS

The Dutch National Packages on Sustainable Building are expected to reach their goals: harmonisation of the measures presented in the four Packages, increased support for sustainable building, diffusion of knowledge among the actors in the various building sectors, and environmental and spatial qualities are addressed in the Packages.

The sustainability ambitions reflected in the measures, however, are modest. Explicit tuning between the various measures in the four Packages is lacking. This concerns the tuning of flow measures and spatial quality measures. Explanations for these results can be found in the way the Packages came into existence: measures have to be supported by all (market) parties involved and have to be technically and economically feasible. In addition, as a consequence of the sectoral development of the Packages, the potential for trade-offs and synergies between measures in the various Packages are not addressed.

The Packages are analysed in this paper from a normative point of view: the contribution of the Packages to a sustainable built environment as well as the coherence of all the measures within the Packages. The Packages are a first big step towards a sustainable built environment. The challenge in the near future is still to start and continue the sustainable building learning processes: to identify the issues on which major sustainability gains are to be expected; to address those actors who can make significant contributions to the sustainability of the built environment; to specify measures with indicators and measuring systems; to develop measures from a lifecycle approach; to create flexibility and adaptability of the built environment to be able to accommodate changes in needs; to tune the various measures to each other, both in space and time; and to shift to the use of sustainable resources. Policies and instruments should be developed to stimulate these actions. The Packages can be important instruments in the learning process on the sustainable built environment by laying down common practice.

ACKNOWLEDGEMENTS

We thank the case study team – Machiel van Dorst, Bart te Dorsthorst, Maaike Kaiser, Hans Pietersen, Evert de Ruiter, Robin Seijdel, Mario Willems, and especially Kees Canters – for their help in analysing the contents of the Dutch National Packages on Sustainable Building.

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THE MINNESOTA SUSTAINABLE DESIGN GUIDE: A WEB-BASED DESIGN DECISION SUPPORT SYSTEM

John Carmody, Mary Guzowski, and James Wise
College of Architecture and Landscape Architecture
University of Minnesota
1425 University Avenue SE, Suite 220
Minneapolis, MN 55455
USA

INTRODUCTION

The *Minnesota Sustainable Design Guide* is a web-based tool to learn about sustainability, manage design decisions, and integrate sustainable design into the building design and operation processes for new and renovated facilities. It can be used to define sustainable design priorities and goals; to develop appropriate sustainable design strategies; and to determine performance standards to guide the design decision-making process. Although the *Design Guide* builds on other rating systems, including LEED, Green Building Challenge '98, and BREEAM, it is unique in providing ecological resources and a step-by-step process to implement sustainable design practices. Now in use by several public agencies in Minnesota, case study information is continually added to create an evolving knowledge base.

The first phase of the project (completed in 1998) involved development of the structure and content for the *Minnesota Sustainable Design Guide*. The second phase of the project included the development of resource materials and an educational program to assist designers in the implementation of the system. The third phase includes the development of an electronic library of case studies focussing on particular strategies and materials. The *Design Guide* has been pilot-tested on projects for Hennepin County and the Minnesota Department of Natural Resources. In addition, the guide is currently being applied to projects for Ramsey and Carver Counties as well as the University of Minnesota.

A DECISION SUPPORT TOOL

The overall goal of the *Minnesota Sustainable Design Guide* is to create an effective design decision support system. While there is a considerable amount of information on sustainable building design, those in the building delivery process are overwhelmed and lack a framework in which to make decisions. They also lack critical information when they need it to make decisions. The key to developing an effective decision support tool is to provide several types of mutually supportive information woven together into a easily accessible form. Giving a designer a list of strategies is not sufficient without key resources at hand so the strategies can be achieved. Similarly, a clear process and system for measuring performance do not ensure that owners and architects will be convinced to commit to sustainable principles in their projects. Examples of case studies and reports on others experiences are often the critical factor when decisions are made. To provide such a framework, the *Design Guide* is organized into four interrelated components: Process, Strategies, Documents, and Case Studies (Figure 1).

Process

This section leads the user through step by step instructions for each phase of the building life cycle. The *Minnesota Sustainable Design Guide* is structured to inform decision-making and design-thinking during the Predesign, Design, and Construction Phases and to guide building operations during the Occupancy Phase. The major phases and sub-phases include: 1) Predesign (Project Initiation, Programming, and Site Selection); 2) Design (Schematic Design, Design Development, and Construction Documents and Specifications); 3) Construction (Bidding and Award, Construction, and Commissioning); and 4) Occupancy (Start-up, Operations and Maintenance, and Next Use).

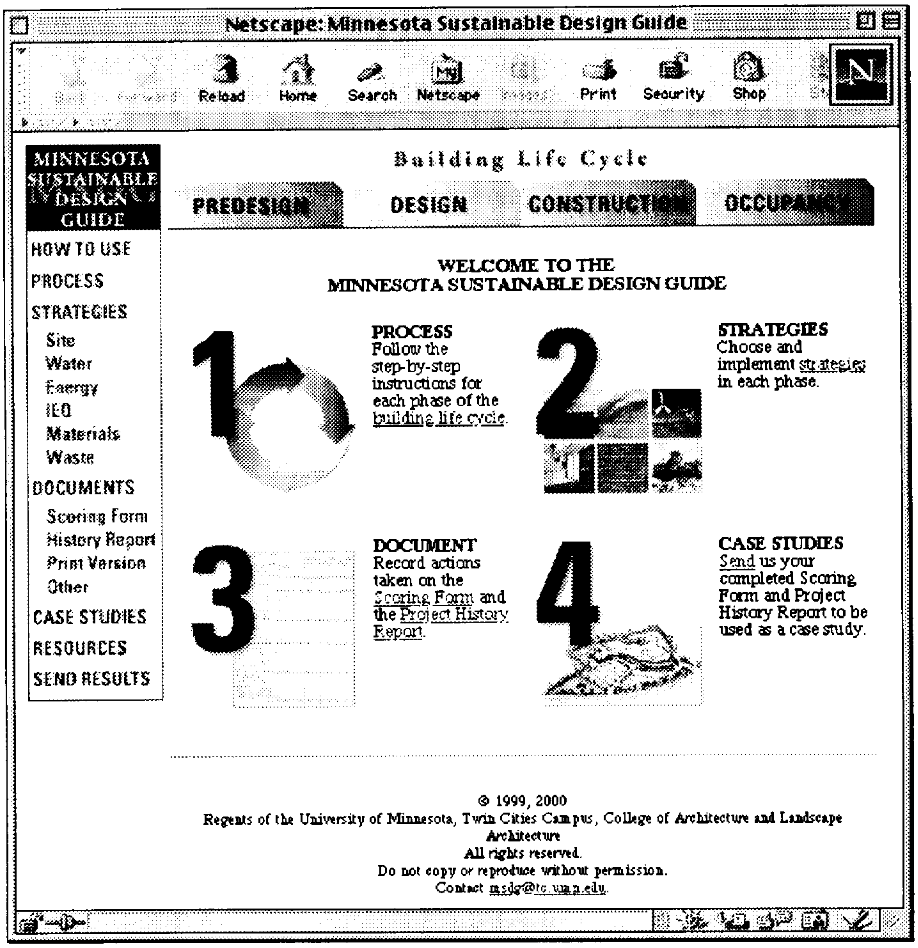
Strategies

During the building delivery process, the team must first choose and then implement appropriate strategies. The *Design Guide* provides approximately 50 strategies that are organized according to six environmental design topics – site, water, energy, indoor environment, materials, and waste. Each topic contains a series of design strategies that address the related sustainable design issues. In addition, each strategy has performance indicators, which set the minimum efforts (or benchmarks) that must be met in order to obtain credit for the strategy. Quantifiable performance indicators are used whenever possible; however, less tangible, immeasurable, and even developing areas of sustainable design are also rewarded. Resource materials and supporting information are provided for each strategy and performance indicator to guide design implementation.

Documents

During the pilot studies, it became clear that a formal method for tracking and recording the strategies kept the team focussed and created useful data for future projects. The *Project*

Figure 1. Minnesota Sustainable Design Guide Web Site Contents (www.sustainabledesignguide.umn.edu)



History and *Scoring Form* evolved from this experience. (Both of these documents can be downloaded from the web site.) Since the decision-making process is recorded through the different stages of the project there is an ability to identify critical problems and obstacles throughout the design and construction process.

The *Scoring Form* tracks the score throughout the project. Each strategy is awarded points based on specific performance indicators. One hundred points are distributed among the strategies according to the perceived environmental and human impacts as well as regional considerations. This particular weighting system reflects the priorities of a regional advisory group. The design team for an individual project will determine a "target score" based on the building type, site, and other characteristics. The target score represents a feasible, yet ambitious, design goal. Since some strategies apply only to certain projects (i.e. renovations versus new construction, urban versus rural sites, etc.) it is important that the "target score" can be tailored to reflect the opportunities and constraints of the project.

Experience with the pilot studies clarified that establishing an absolute scoring system was not as important as creating a tool where the users can adjust the priorities based on the project or agency mission. This experience led to the evolution of the project from a "rating system" into a more versatile design guide and management tool. The team members were very responsive to the fact that the system was flexible and they were empowered to make choices and decisions within the framework

Case Studies

Case studies and examples of previous successful experiences with products, materials, and specifications are invaluable in giving the architect and client the confidence to deviate from conventional practice. For this reason, a knowledge base of case studies is being developed from the project histories that will be fed back into the *Design Guide*. The case studies will be able to record lessons in the context of various projects based on building type, region, and setting. The *Design Guide* will encourage the contribution of *Scoring Forms* and *Project Histories* to the evolving knowledge base. Professional organizations are assisting in the development and eventual maintenance of the database.

FUTURE DIRECTIONS

The future directions for the *Minnesota Sustainable Design Guide* are:

- Development of case study material on individual strategies as well as whole projects.
- Continuation of more detailed pilot projects and the development of a protocol for applying the system.
- Identification of "design integration patterns" where a combination of strategies produces effects greater than the impact of the individual strategies applied separately.
- Conducting training workshops for architects and building industry professionals.
- Further development of the web site to become more interactive and transparent to users.

ACKNOWLEDGMENTS

This project has been developed with the support of the Minnesota Office of Environmental Assistance, Hennepin County, and the University of Minnesota Design Institute. The *Design Guide* has been developed from the contributions of numerous University of Minnesota faculty and other collaborators.

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SYSTEMATIC APPROACH TO DESIGN OF BUILDING'S TRANSFORMATION

Ph.D. Student Elma Durmisevic, Prof. Ir.Jan Brouwer
Delft University of Technology, Faculty of Architecture, Department of Building Technology – research group OBOM
De Vries van Heystplantsoen 2,2628 RZ Delft, The Netherlands

INTRODUCTION

Traditionally design has concentrated on the construction phase, optimizing construction costs and short-term performance. However new circumstances such as changing economies, customization of building industry and environmental consciousness are asking for different design approaches and application of new building methods. In order to stimulate the development of new innovative ideas that will help to bridge the gap between traditional and new building concept the Dutch government has started the project called "IFD" (industrial, flexible and dismantled buildings). This concept should stimulate further industrialization of building process by systematization of building; extend the life cycle of building by adding the aspects of flexibility and extend the life cycle of building components by dismantling building components. IFD concept is basic for this research project which is focused on D (dismantling). Disassembly is precondition for easy transformation on building level and exchangeability, reuse, repair and recycling on product and material level. Dismantling is not related only to the longer life of the building and waste reduction but further more it has to do with: simplified and faster construction and reconstruction processes; reduction of noise and dust; less use of row materials, easier quality control; and finally less use of energy which leads to lower greenhouse effect.

PRESENTATION

State of the art

Environmental conciseness

Building operation and construction consume large quantities of materials and energy and contributes significant solid liquid and gaseous emissions to the local and global environment. In Brundtland Report it was stated that the building industry is the greatest consumer of worlds natural resources and energy as well as the greatest waste producer [DIOC96]. For example 50% of material resources taken from nature are building related; over 50% of national waste production comes from the building sector; 40% of the energy consumption in Europe is building related [Anink96]

In dens populated country, as the Netherlands the yearly waste production of 14 million tones is no option any more. Therefor in order to improve the efficiency of the building industry the way we will construct and transform our buildings in the future has to be fundamentally different focusing on material saving, energy saving and clean construction and reconstruction process.

Market requirements

In the past decades the technical and functional service life of buildings was approximately 50 years. Today it happens that buildings with an age of 15 years are demolished to give way to new construction while most of their components still have technical life cycle of 50-75 years. This has to do with market-oriented economy, life stile changes and changing businesses. For that reason average functional service life is becoming shorter and forces a return-on-investments to come quicker. Within this context the reduction of the technical service life is no option, because this would in fact be destruction of capital investment.

Design

In order to keep buildings and their components in their life cycle as long as possible, we must consider how we can access and replace parts of existing building systems, and accordingly how we can design and integrate building systems in order to be able to replace them later on.

This is asking for more systematic approach to the design (the first phase of building life cycle) where the greatest potential exist to influence the building properties in all life cycle phases.

Such development provides a framework for the multidisciplinary teamwork (concurrent engineering) that can influence the building design for cost effective and high performance buildings.

Strategies for design of transformable structures

Dismantable building can be a good strategy to bring the technical, functional and economic life span of building in line. Such buildings could be efficiently exploited and remain a high standard of quality for use, which in return contributes to the quality of the built environment.(figure 1 left). Moreover such buildings stimulate conscious handling of row materials, which is an important element of sustainable development in the building industry.

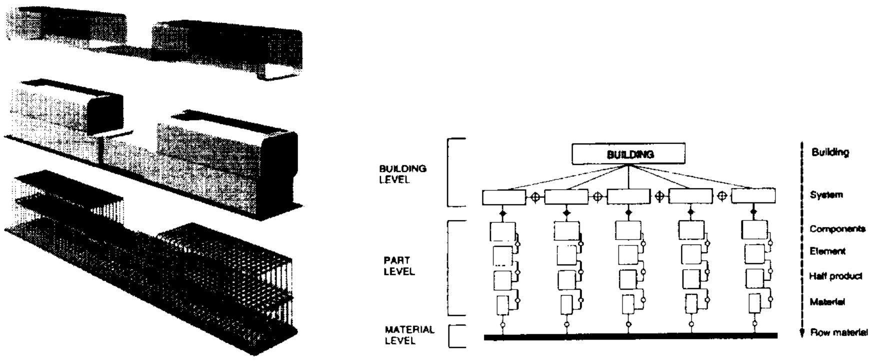

Figure 1: "A+markt" IFD building project in Amsterdam (left), shearing levels of change within the building (right)

When designing a dynamic structure whose parts could be dismantled back into components than the aspects which are related to the process of making and use of building materials have to be integrated from the beginning of design process. In table below the key aspects of sustainable design are defined per life cycle phase.(figure 2). Design for disassembly is considered to be successful integral design concept which aims at optimization of building properties in each of its life cycle phases for longer life of building and its components.

Life cycle phase	Strategy per L.C. phase	Relevance
Design	• Development of scenarios for building use • Optimization of the building in each of its life cycle phases • Concurrent engineering	Flexible building Environmental burdens Timely and correct decision making Construction time
Manufacturing	• Use of material saving process • Use of recyclable or reusable materials • Use of low weight materials • Use of less energy intensive materials	Resource depletion Energy use Environmental burdens Resource depletion
Transport	• Low weight / volume	Environmental burdens
Assembly	• Dry assembly • Parallel assembly	Construction process Resource depletion Environmental burdens
Exploitation	• Low energy use • Design for maintenance/long life	Resource depletion Environmental burdens Resource depletion
Dismantling	• Design for disassembly	Resource depletion Environmental burdens

Figure 2: aspects of sustainable design per life cycle phase

The major obstacles in design for disassembly are "shearing layers of change"(Stewart Brand) that create constant temporal tension in building. Design Life of modern building is 75 years, yet their service life is unpredictable because their major parts were out at different rates complicating replacement and repair schedules. Faster cycling components such as Space Plan elements are in conflict with slower elements such as structure and site(Kibert00). When considering the potential for closed loop materials cycle for the built environment it becomes clear that the main problem lays in dependent integration of components with different lifetime and functional expectances at connections. Therefor the first step towards managing the temporal tension in building is through decoupling of slow (fixed) and fast (changeable) components (Kibert00).

In relation to that the design strategy should be focused on defining the hierarchical order which is suitable for maintenance and replaceability of changeable components and accordingly on design of dismantlebel interfaces to insure reuse and recycling. Such design strategy should be applied on all three levels: building level, product level and material level.Dismantling on building level would provide transformable building structure which can be easily adopted to the new requirements, dismantling on product level would provides reuse of components, elements and half products, while dismantling on material level would provide material recycling.

In accordance with that some design principles are listed bellow:

- Provide separation between the fixed and the flexible parts of the building

- Create separation between the elements within different functional and life time expectances by using separate construction systems
- Provide accessibility to the elements with shorter life cycle
- Use open in stand of closed systems to allow easy alteration in the future
- Design building connections optimizing the type of material, its performance, life cycle and assembly sequence
- Use a minimal number of connections to allow easy disassembly
- Keep all components separated avoiding the penetration into another components or systems
- Dry jointing technique should be used in construction.
- Parallel assembly should replace sequential assembly in order to allow disassembly of single part without disruption to other parts.

Case study in the Netherlands

Recently built family "smart houses" in the Netherlands could be used as example where above-mentioned principles were applied. Dutch government has subsidized this project as one of IFD projects.

Strategy -flexibility

The load bearing structure of the "Smarthouse" is made of steel scelet. Façade, roof, floor and separation walls are sequentially assembled into structure and each system could be replaced without interference to others. Installations are distributed through the hollow floor what makes functional flexibility possible.

According to above-mentioned principles smart house has following flexibility aspects: exchangeability of façade, roof, partitioning walls, installations, extendibility of the structure, and spatial flexibility.

Dismantling

The weight of Smart house is 25.000 kg including the weight of load bearing structure (5000-8000kg). This is one fifth of one conventional house.(Winkel99) Having in mind that the components are made in factories and than transported to the assembly sites, it would be possible to transport whole building at once since its weight does not reach the maximal weight that could be transported on one truck (max. weight is 35.000 kg.). All parts of the smart house could be dismantled to the single component.(figure 3) The possibility of bringing the components back into production and building process is being considered.

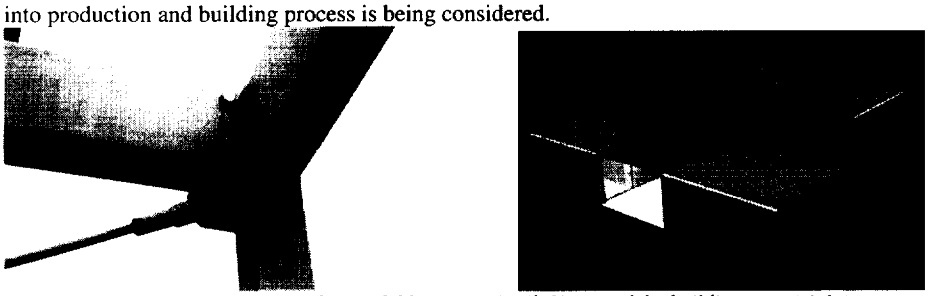

Figure 3: Smart house – dismantleble connection(left), one of the building types(right)

Recycling

Most of the steel components could be easily brought back into the building process as a half product. Comparing with the material recycling half product reuse saves much more energy. The partitioning walls are constructed with gypsum boards that are made of old papers and rest products. All boards will be brought back to the production process.

CONCLUSIONS AND RECOMMENDATIONS

Modern buildings are not designed to be dismantled, building products are not designed for disassembly and the materials comprising building products are often composites that makes recycling extremity difficult. Buildings can experience different phases in building use and they frequently undergo renovations and modernization. In each case the inability to easily remove and replace components results in significant energy inputs to building systems and larger quantities of waste. The aim of this research is to provide a Decision Support Model (DSM) for design for disassembly. The DSM will provide a recommendation for design and application of building systems being a part of dynamic building structures. Therefore the research addresses the interaction between various building components, considering various determinants such as functionality, durability and demountability. The aim of this project is to develop a decision support model which will help to make a balanced considerations when designing a building that can be easily transformed and whose parts could be reused or recycled.

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Sustainable Buildings Programme in Upper Austria

Christiane Egger, Christine Öhlinger

O.Ö. Energiesparverband
Landstrasse 45, A-4020 Linz/Austria
T: +43-732-6584-4380, F: +43-732-6584-4383
E: office@esv.or.at, I: www.esv.or.at

Introduction

In the region of Upper Austria a comprehensive building programme has cut energy consumption in 95 % of all new single-family houses by more than 30 % since 1993. This was done through an innovative programme which combines a financial soft loan with an information element (energy advice session). This programme is operated by O.Ö. Energiesparverband, the regional energy agency.

Programme Elements

In Austria, public support is provided for the construction of new housing and for retrofitting older dwellings, usually in the form of soft loans (called "Wohnbauförderung") for a large percentage of all buildings. The amount of this soft loan varies from region to region, in the region of Upper Austria it is between 40,000 and 70,000 for a single family house.

Step 1: Sustainable buildings programme for new buildings ("energy efficient housing")

In 1993, the government of Upper Austria decided to introduce an "energy efficiency criteria" into the housing programme for new single/double family houses.

The criteria to be met are:

- An overall energy index for the whole building (at the moment: 65 kWh/m^2 "useful heating factor", this factor was already decreased twice: January 1993-July 1995: 75 kWh/m^2, August 1995 - December 1996: 70 kWh/m^2). This energy index is reached mainly by additional insulation and smart windows.
- Participation in an obligatory, individual energy advice session; each future home owner spends one hour with a trained energy advisor discussing his/her individual house and the possibilities to save energy in addition to the a.m. requirements.
- For every house owner an "Energieausweis" (energy label) is issued. The energy label for buildings is using the same lay-out than that for household appliances.

If the criteria are met, the house owner receives an additional loan of about 3,500 .

Parallel programmes for energy efficiency criteria and building labels connected to financial support exist for multi-family housing.

Step 2: Sustainable buildings programme for low energy houses

Due to the success of this programme, it was extended to "low energy buildings" in 1999. The same procedure (energy labelling, energy advice session) is applied but the amount of money granted is increased to 7,200 if the energy co-efficient is below 50 kWh/m^2a.

Sustainable buildings programme for retrofitting of single-family houses

Based on the programme for new buildings, in 1998 the region of Upper Austria introduced "energy efficiency criteria" into the programme for retrofitting single/double family houses. In order to be eligible for this programme, a number of criteria have to be met, among others the following:

- the building permit has to be older than 25 years
- the annual income of the homeowner has be under a certain (quite high) level, more than 90 % of all homeowners are below this threshold
- an overall energy index (or co-efficient) for the building shell of 65 kWh/m^2, a which is calculated based on the transmission losses through external surfaces (walls and roofs), solar gains, internal thermal gains, climate factors, ventilation losses and the heated surface of the buildings
- participation in an obligatory, individual energy advice session (normally 1.5 hrs), usually held on-spot in the relevant house.

If the energy criteria are met, a support payment is given, both for re-paying the loan and for the interest (35 % of the annual annuity instead of 25 %). For a 38,000 Euro loan (based on the 1998 interest rate and a 15 year period for repaying the loan), the capitalised support payment is 5,300 Euro. That means, over a period of 15 years the homeowner has to pay back less than 38,000 because the support payment covers interest and compound interest.

What is special about this programme is, that the energy advice session takes place at the respective building site, which ensures that the advice service is well directed towards the needs of the building owners.

Energy advice session

Both programmes, for new buildings and for retrofitting, combine the financial incentive with a strong informational aspect. In addition to this housing programme, energy advice services are offered to private households that are on the point of making a decision about an investment, e.g. installation of a new heating system, insulation or electric household appliances. Annually more than 10,000 energy audits for private households are conducted.

Supplementary to energy advice for households and building owners, other consumer groups have the opportunity to get a free energy advice session once a year too.

Results

The sustainable buildings programme had the following results between 1993 and 1999:

Number of single/double houses:	20,000 houses
Influenced building space:	3,530,000 m^2
Energy savings:	95 million kWh/year
CO_2 reduction:	19 million kg/year
Total programme expenditure:	83 M

Additionally the information aspect led to numerous supplementary investment in energy efficiency (e.g. household appliances) and renewable energy sources (e.g. heating system, hot water supply).

The main monitoring mechanisms for this programme are on-site controls by the relevant government offices. In addition to that, the energy label issued encourages monitoring of the own energy consumption.

The programme is financed by the regional government of Upper Austria and implemented by O.Ö. Energiesparverband and the relevant government offices.

Conclusions and Recommendations

The sustainable buildings programme so far showed very promising results, but it is necessary to continuously "keep the programme going" and adapt it to recent building trends. That is why it has been extended recently to low energy houses and is also continuously evaluated. Besides that the energy criteria has already been decreased several times (the programme started in 1993 with 75 kWh/m^2,a and now holds by 50 kWh/m^2,a!).

Although financial incentives are a good method to direct investment, the combination with a energy advice session proved to be very effective and raised the overall energy efficiency achievements. Besides written and electronic information tools, personal contact during an energy advice session and the possibility for home owners to discuss "their individual housing dream" with a trained expert who does not necessarily want to sell anything, is one of the key elements of success.

THE DECIDUOUS ROOF: A PERFORMANCE PREDICTION MODEL

Jim S Evans, Kenneth Ip & Andrew J Miller
School of the Environment, University of Brighton, Cockcroft Building, Lewes Road, Brighton, BN1 4UT, United Kingdom

Introduction

The use of plant canopies to reduce solar gain in buildings is commonplace throughout the World. Typically ivy type varieties are encouraged to climb external walls. For millennia gardeners have supported vines on frames to provide shade in outside areas.

The deciduous roof reduces solar gain on a horizontal surface by means of vines suspended on lattice frameworks inclined to intercept the maximum direct sunlight. An arrangement of east-west oriented rows allows for routine maintenance of the roof and plants, whilst ensuring that the entire surface will be cast into shade by a full canopy, as shown in figure 1.

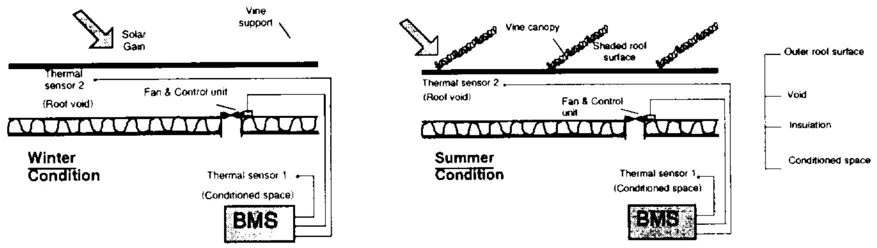

Figure 1 Schematic representation of the deciduous roof in winter and in summer. The research programme at the University of Brighton is primarily concerned with the summer condition, in which heat gain, and hence cooling load, is reduced by the presence of the canopy.

A pilot study (Evans & Miller, 1994) predicted an overall reduction in cooling load of 43%, across the cooling period for a standard commercial building at Kew, London. A programme of research is nearing completion at the University of Brighton, in which a deciduous roof has been built and field data has been collected. The experiment and initial findings have been discussed in a previous paper (Evans & Miller, 1997). The data has now been used to produce a mathematical model of the shading performance of the canopy, with respect to solar irradiance. It is intended that this design tool may be used by architects to compare the energy performance of target or proposed buildings, by means of computer simulation.

The model is based on the assumption that the canopy will reduce the intensity of global irradiance (I_G) by a quantifiable proportion. The coefficient of reduction (R_t) is the factor by which the incident irradiance is reduced. It has been shown that the value of R_t is dependent on the canopy leaf area, the solar angle of incidence to the canopy and the intensity of direct irradiance. The model approaches each component of solar irradiance separately.

Direct Irradiance

The coefficient of reduction for direct irradiance (R_{I_D}) was found to be dependent on the canopy cover (c) and the angle of incidence between the sun and the normal to the plane of the canopy (i_c). The model uses the following function to generate a mean value for the coefficient ($\overline{R}_{I_D}$) for the range : $i_c < 48°$ (am) and $i_c < 67°$ (pm).

$$\overline{R}_{I_D} = 0.24\cos\left(\frac{18i_c}{13}\right).c + 0.45\ \sin(i_c$$

The instantaneous intensity of direct irradiance under the canopy (I'_D) is given by the expression:

$$I'_D = I_D(1 - R_{I_D})$$

Where I_D is the intensity of direct solar irradiance above the canopy. The model therefore produces an approximation to the intensity under the canopy with the expression:

$$\overline{I}'_D = I_D\left\{1 - \left[0.24\cos\left(\frac{18i_c}{13}\right)\cdot c + 0.45\sin(i_c)\right]\right\}$$

The overall error in $\overline{I}'_D$ over the whole cooling period is -0.33%. The rms error for instantaneous values however, is considerably higher because the penetration of the canopy by direct sunlight is sporadic rather than continuous.

Diffuse irradiance

The coefficient of reduction for diffuse irradiance (R_{I_d}) was found to be dependent on the canopy cover (c) and the intensity of incoming direct irradiance above the canopy in Wm^{-2} (I_d). The model uses this function to generate a mean value for the coefficient ($\overline{R}_{I_d}$) thus:

$$\overline{R}_{I_d} = (15c + 11)\times 10^{-1} - 5cI_D \times 10^{-4}$$

The instantaneous intensity of diffuse irradiance under the canopy (I'_d) is given by the expression:

$$I'_d = I_d(1 - R_{I_d})$$

Where I_d is the intensity of diffuse solar irradiance above the canopy. The model therefore produces an approximation to the intensity under the canopy with the expression:

$$\overline{I}'_d = I_d\left\{- \left[(15c + 11)\times 10^{-1} - 5cI_D \times 10^{-4}\right]\right.$$

The overall error over the cooling period is +0.16 %. The rms error is approximately half that for $\overline{I}'_D$.

Conclusion and recommendations

The model produces the result shown in the graph in figure 2.

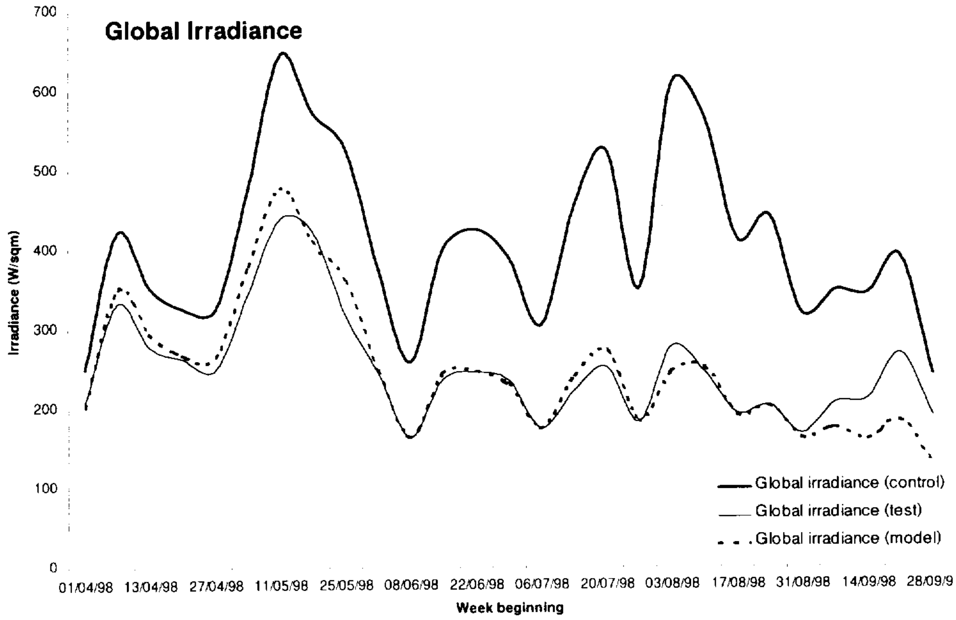

Figure 2 Comparison of the actual and predicted values of global irradiance under the canopy. The overall error in energy collected at the roof surface is -0.12%.

The total energy received at the roof surface during the cooling period was reduced by 39%. The value of the canopy in terms of energy consumption during the cooling period must be determined by means of computer simulation. The viability of a deciduous roof can only be determined by a function of the climate, the building's characteristics, energy costs and maintenance costs. Three of these are inclined to vary over time.

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ENVIRONMENTAL DESIGN STRATEGIES – LEARNING FROM BUILDINGS

Paula Femenías, architect, PhD student
Department of Built Environment and Sustainable Development (and MISTRA Sustainable Building), Chalmers University of Technology, S-412 96 Gothenburg, Sweden
Tel: +46 31 772 24 58, Fax: +46 31 772 23 71, e-mail: femenias@arch.chalmers.se

INTRODUCTION

This doctoral project is about learning processes in the building sector and sustainable development. The approach is to study the practical situation: how sustainable issues are handled in building projects, how the building sector learns by doing, and how and what people outside the project can learn by studying built examples of sustainable design.

Model-projects play an important role in the development of sustainable building and environmental design. Built examples serve as inspiration and as a source of information. Many model-projects of sustainable design are initiated and built today, but unfortunately, few are evaluated. This means that important information is lost. A model-project can be a teaching example but is not automatically a "best practice". For this, an evaluation is needed and a consensus on what best practice is.

Even less successful model-projects can be valuable for the development of sustainable design. As model-projects tend to age quickly when new techniques develop and the conditions for implementation hopefully get better as the market gets more receptive to sustainable design, it might not be the technical solution or the product, the building itself, which is the most important lesson in these model-projects, but the knowledge gained by actors involved.

In this project we aim at contributing to the development of a framework for discussing how knowledge can be gained from model-projects and how this knowledge can be presented in order to be useful. A qualitative case study of a building project with the aim of building more sustainable than in a normal situation is the empirical basis in this tentative approach to reach appropriate research questions. Parallel to the empirical work, a theoretical conceptualisation of the interrelation of buildings, nature, and society has been started. From a longer perspective, the doctoral project aims at formulating environmental design principles by using experiences and feedback from built projects of sustainable design. Results will be directed mainly to developers and architects to be used in the early programmatic and strategic phases of a project in which important long-term decisions are made.

PRESENTATION

The approach in the doctoral project has been a tentative search for appropriate scope and research questions based on empirical studies using qualitative methods. A case study of a recently built area with multi-family housing, called GWL-terrain in Amsterdam, the Netherlands, was initiated at an early stage of the project. [1] The use of a Dutch case is defended by a lack of appropriate cases in Sweden at the time, but is also a way to broaden the perspective and get input from another European country. Few cases of sustainable housing were constructed in recent years in Sweden due to a negative trend in the building industry. In the Netherlands, many projects with sustainable and environmental ambitions have been constructed in the late 1990s as a result of a broad initiative to accelerate the development of sustainable building. The Dutch case was chosen after scanning the field of sustainable building in the Netherlands. [2]

Carrying through the case study

Building projects can be considered as unique and not able to be repeated exactly. A building is a highly complex product, and the modern building process is equally complex involving many actors from different disciplines, and can be characterised as a relay race in which one actor hands one phase over to a new actor. An appropriate way to learn about building projects is through a case study in which both the product, the building itself and the process behind its realisation are studied simultaneously in order to clarify what is special in the project, and what could be generally applicable. To understand the building, the time, the place and the context should be considered.

The qualitative case study in this project has been made in three steps: 1) an over-all description in order to describe the product, the building itself, and to identify and reconstruct the process behind the realisation of the project; 2) an evaluation and structuring of the information using mainly methods from evaluation research; 3) a synthesis and discussion relating to existing theories.

So far a preliminary evaluation of the case has been made. A qualitative discussion about the environmental profile of the result is a part of this evaluation. Both product and process have been evaluated regarding: ambition and goals, efforts made, prerequisites and hindrances, fulfilment of goals and result. Further, the motivation of the actors for conducting the project has been discussed, as well as the internal effect of the project, like knowledge gain, among actors. The external effect of the project, the relevance of this project for the development of sustainable building in a particular city, region or nation will be the focus of further analysis of the case.

Preliminary result

The studied project, GWL-terrain, is planned and realised in a systematic and ambitious way where the environmental issues have had an important role from the beginning. Detailed programs explaining the environmental ambitions, the engagement of an external environmental advisor through the whole process, together with a motivated developer and political support in the city district have been ways to secure the environmental goals and ambitions.

In GWL-terrain, extra effort has been made to fulfil the environmental ambitions as far as possible. Still some hindrances have obstructed a full implementation of these ambitions. A hindrance found is time-pressure, both during the design and construction phases for different reasons. There seems also to have been a miscalculation between the set ambitions and the financial situation, which resulted in more effort made in the beginning than in later stages of the project. The overall impression is that most effort concerning environmental issues has been made in the programmatic and early phases.

A few years after the project has been completed, an external firm has done an evaluation. The evaluation has been made regarding fulfilment of national measures for sustainable building on a voluntary basis (The National Package), and also as regarding the process. The actual environmental load from the project in relation to the "normal" Dutch situation has not been monitored. So far rather little knowledge from the project has been made explicit for a larger public, even if actors involved will certainly make use of personal experiences in new planning situations.

CONCLUSIONS AND FUTURE WORK

Conducting a case study, and trying to make an evaluation of the result, can be a difficult task for a person outside the project. A few years after the project is finished, documents and knowledge tend to get spread among actors as the project organisation is dissolved. It can be difficult for the actors involved to remember the specific planning and design situation. It is also hard to get facts about what was, in fact, implemented in the project. Further, monitored data from, for example, energy and water use can be almost impossible to get if no such measurements have been planned from the beginning. The specific flow can be mixed with others, or actors can be unwilling to give away data due to the risk of a negative interpretation of these.

Results from this first part of the project have provided some conclusions and have revealed some areas that will be further studied in the continued work:

- Evaluations of model-projects of environmental design should be made to a larger extent. There is a need for feedback mechanisms that can provide useful and meaningful knowledge as an aid in programmatic phases of new projects, and in the management of other existing projects. It can be of interest to study the projects some years after they have been in use, in order to study the line from ambitions, through the process and finally the result. Several evaluations made with an interval of a few years would be ideal.
- The evaluation should be planned and budgeted for already in the planning phase. But, who should conduct the evaluation is not clear. If the actors involved make the evaluation, the result might not be objective or facts might be left out.
- Two kinds of knowledge can be found in building projects: the generally transmittable and the knowledge gained by involved actors. Is there a way to make the knowledge made by actors involved explicit and useful for people outside the project? The tacit knowledge gained by architects and practitioners through their work can be difficult to spread through books, pictures, internet etc. Is there a way to teach or inform actors in new planning and design situations how to work with environmental issues in building projects? Or is the best way to engage an environmental advisor? The use of an external environmental advisor in building projects has so far not been that common in Sweden as it has been in the Netherlands.
- The feedback and knowledge from existing projects should be made useful for the actors in their actual working situation. This could be in the form of self-leading indicators that make it possible to get a response to how the particular program or design situation is connected to global environmental issues. The indicators should also be tools to support communication among actors involved in the process. New forms for the building process might be needed.
- Building design is a prediction of future use of the building. But, as often with predictions, the building design is bound to be wrong. [3] Flexibility in design and in the organisation of projects can be seen as a valuable potential for change. The initial strategic phases are of importance. In these stages, important decisions from a long-term perspective will be made. It is also usually found easier to make good decisions in these stages rather than try to correct bad ones later in the process.

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INTEGRATED SIMULATION FOR (SUSTAINABLE) BUILDING DESIGN: STATE-OF-THE-ART ILLUSTRATION

J L M Hensen[1] and J A Clarke[2]
[1]Centre for Innovation in Buildings TNO-TU/e, Technische Universiteit Eindhoven, Netherlands
[2]Energy Systems Research Unit, University of Strathclyde, Glasgow, Scotland

The state-of-the-art in integrated building simulation is illustrated by means of a sustainable building design study.

Background

Many buildings are still constructed or remodelled without consideration of energy conserving strategies or other sustainability aspects. To provide substantial improvements in energy consumption and comfort levels, there is a need to treat buildings as complete optimised entities not as the sum of a number of separately optimised components.

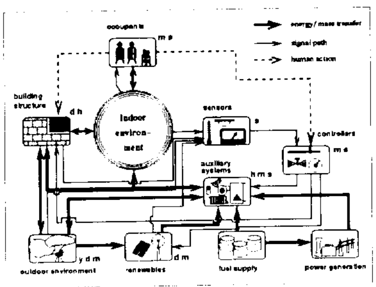

Figure 1 The building as an integration of energy systems.

Simulation is ideal for this because it is not restricted to the building structure itself but can include the indoor environment, while simultaneously taking into account the outdoor environment, mechanical, electrical or structural systems, and traditional and renewable energy supply systems. By assessing equipment and system integration ideas, it can aid building analysis and design in order to achieve a good indoor environment in a sustainable manner, and in that sense to care for people now and in the future.

Although most practitioners will be aware of the emerging building simulation technologies, few as yet are able to claim expertise in its application. This situation is poised to change with the advent of: performance based standards; societies dedicated to the effective deployment of simulation - such as IBPSA[1] ; appropriate training and continuing education; and the growth in small-to-medium sized practices offering simulation-based services.

One thing is clear: as the technology becomes more widely applied, the demands on simulation programs will grow. While this is welcome, in that demand fuels development, it is also problematic because the underlying issues are highly complex. Although contemporary programs are able to deliver an impressive array of performance assessments, there are many barriers to their routine application in practice, mainly, in the areas of quality assurance, program interoperability, and task sharing in program development.

An example state-of-the-art system

The ESP-r system (Clarke 1985) has been the subject of sustained developments since 1974. The aim, now as always, has been to permit an emulation of building performance in a manner that a) corresponds to the reality, b) supports early-through-detailed design stage application and c) enables integrated performance assessments in which no single issue is unduly prominent.

ESP-r comprises a central Project Manager (PM) around which is arranged support databases, a simulator (consisting of specialised concurrent solvers for domains such as heat flow, fluid flow, power flow,

1 IBPSA: International Building Performance Simulation Association - http://www.ibpsa.org

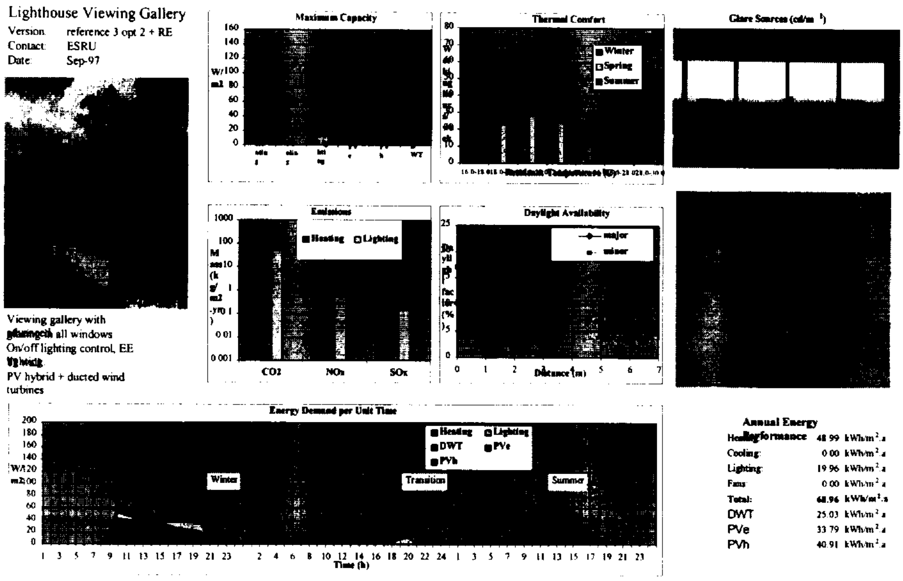

Figure 3: Integrated Performance Appraisal with Passive and Active RE Systems Applied

Figure 3 summarises the final performance results in the form of an "integrated performance view" as produced by ESP-r.

The combination of ducted wind turbines and PV components proved to be a successful matching of renewable energy systems to meet the seasonal energy demands. The wind turbines produce electricity predominately during the winter period when the PV components can contribute little. Conversely, the PV components supply power predominately during the summer period when the winds are light. The combination of the two systems gives rise to an embedded renewable energy approach that is well suited to the climate of Glasgow.

Conclusions

This paper has elaborated and demonstrated the state-of-the-art in integrated building simulation and it's value when used early in design. This paper has also argued the importance of this technology and how it will benefit in an economical and environmental context. Since many people in the field are not yet aware of this, there is a need for an organisation such as IBPSA. It's main role is to alleviate the above problem and thus moving the technology in everyday practice of engineers and architects.

Acknowledgements

The ESP-r system has evolved to its present form over 25 years. Throughout this period many individuals have made substantial contributions. In particular, we would like to acknowledge the contributions of some of our ESRU colleagues: Jon Hand, Milan Janak, Cameron Johnstone, Nick Kelly, Iain Macdonald, John McQueen, Abdul Nakhi, Cezar Negrao and Paul Strachan. Our hope is that the many other contributors, too numerous to mention, will be content with collective thanks.

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control, etc.), performance assessment tools and a variety of third party applications for CAD, visualisation, report generation, etc. (Figure 2). The PM's function is to co-ordinate problem definition and give/receive the data model to/from the support applications. Most importantly, the PM supports an incremental evolution of designs as required by the nature of the design process.

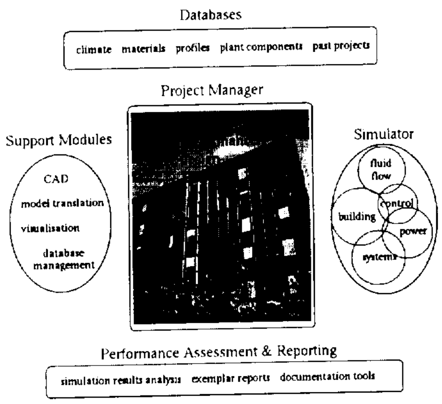

Figure 2 Main architecture of ESP-r.

Case study: embedded energy systems

The Lighthouse Building, designed by Charles Rennie Mackintosh, is the centrepiece of Glasgow's celebrations as UK City of Architecture and Design 1999. This refurbished city centre building is of major architectural significance. A specially configured portion of the building serves as a showcase for state-of-the-art technologies that demonstrate the integration of complementary passive and active renewable energy components at the urban scale.
While a more complete description can be found in (Clarke et al. 1999), the following outlines the design process undertaken.

Implementation of renewable energy systems at the local level can be fraught with technical problems. When undertaking such tasks within an urban environment adds additional problems to a project such as impact on building aesthetics and most importantly, planning requirements which impair system performance. After careful consideration, the renewable energy systems chosen for this demonstration were categorised as: type (i) are those that reduce energy demands and type (ii) are those that generate electricity to meet some of these demands.
The 3 passive (type i) components were:

- advanced glazings, including a triple glazed, double low-e coated, argon filled component, a light redirecting component and a variable transmission component;
- daylight utilisation through illuminance based luminaire control; and
- transparent insulation with integral shading.

The 2 active systems (type ii) consisted of:

- facade-integrated photovoltaic (PV) cells with heat recovery; and
- roof mounted, ducted wind turbines with integral photovoltaic aerofoils.

Evaluation methodology

The evaluation procedures adopted adheres to a standard performance assessment method whereby computer simulation is used to determine the multivariate performance of an initial model of the building (in this case corresponding to current best practice design). The multivariate performance data are then presented in the form of an integrated performance view such as shown in Figure 3. The model is then modified by incorporating one of the renewable technologies and re-assessed. In this way, the contribution of both passive and active renewable technologies, applied separately or jointly, may be assessed and the different possible permutations compared.

Results

In comparison with the initial design hypothesis, the cumulative effect of advanced glazing, a fast response, critically controlled, convective heating system, high efficacy lamps and luminairs, lighting control and transparent insulation facade resulted in a 58% reduction in annual heating energy demand, a 67% reduction in heating plant capacity, an 80% reduction in lighting energy demand and a 68% reduction in overall energy demand.

UK BUILDING ENERGY AND ENVIRONMENTAL PERFORMANCE: BREAKING THE VICIOUS CIRCLE

Andrew Horsley [1&2], Chris France [1], Barry Quatermass [2]
1. Centre for Environmental Strategy, University of Surrey, Guildford, GU2 5XH, UK.
2. Carillion Building Special Projects, 24 Birch St, Wolverhampton, WV1 4HY, UK.

INTRODUCTION

A wide range of environmental impacts occur over the life cycles of buildings as a function of component production, their construction, use and eventual demolition. Of all these impacts, it is usually the energy consumed during the building's operative life which has the most profound environmental burden.

The energy performance of UK buildings lags behind much of Europe, and almost 50% of the UK's energy consumption and CO_2 emissions can be attributed to the operation of the built environment (see figure 1 below).

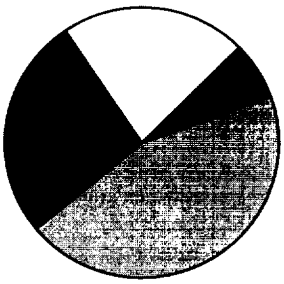

Figure 1: Energy use in the UK by sector (adapted from Parrot, 1998)

Across Europe the total area of the built environment, is increasing, forming an upward trend in energy consumption within the sector. Rather more concerningly, the consumption per unit area is also increasing, and in the UK the combination of these two factors has led to a 250% increase in building energy consumption since 1980 (EIBI, 2000)

There is some evidence to suggest that it is market conditions which are hampering the drive towards more efficient buildings. The UK Construction Confederation describes this as a "vicious circle of blame" in which all parties within the building delivery chain (designer, contractor, developer, financier, and occupier) blame other members for poor environmental performance. There is a common misconception within the marketplace that low energy, environmentally sound design is expensive. However, there is an accumulating body of evidence to suggest that low energy design can reduce both capital and operative costs, and increase occupant satisfaction.

Attempts to increase the energy efficiency in buildings including the review of the Part L of the UK Building Regulations is projected to have a positive, but relatively small effect on overall energy efficiency, despite the fact that both new and current buildings are targeted.

Significant energy efficiency gains will only be possible though a fundamental shift in the way operative and energy performance is viewed throughout the procurement and design process. This may be realised through a relatively new UK government procurement route known as the Private Finance Initiative (PFI). PFI encapsulates not only the design and construction of buildings, but also a period of operation, in the order of 25 years.

Whilst PFI may represent an appropriate route to demonstrate the long term approach to the design and procurement of buildings, there exists a need for a new procedure to manage energy related aspects of the design, to demonstrate the environmental benefits of particular strategies, and illustrate the financial implications.

PROCEDURES TO IMPROVE BUILDING ENERGY EFFICIENCY

Energy performance is not currently an intrinsic part of the building design process. As operative energy performance contributes as much as 90% of the total life cycle environmental impact of a building over a 60 year life (Smith, 1997), this component clearly demands serious and urgent attention.

Building energy performance is a function of three interrelated factors, demonstrated by figure 2 below.

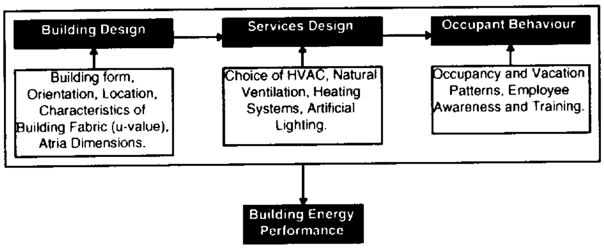

Figure 2: Components of Building Energy Efficiency (adapted from Baker 1998)

The finite period over which these factors can be influenced, means that consideration of energy performance needs to begin at the earliest stages of the design process, and in particular during the inception, concept and outline design stages. The procedure which facilitates this is illustrated in figure 3 and in the following discussion.

Basic building parameters such as plan, configuration, location and orientation, are some of the first areas of the design to be established, and are essentially permanent features over the operative life of the building. The central requirement during these outline design stages is a comparative assessment of the predicted energy performance of a number of solutions to the brief. This information, although clearly only one of the many factors influencing the design at this stage, is an important environmental performance indicator. The effect of these parameters on overall energy performance is being assessed using the *LT method* (Baker, 1998).

In later stages of the design process, when more detailed information about the building parameters becomes available, a more predictive, and absolute assessment of energy performance is required. At this stage a number of energy efficiency scenarios are applied to the building design in strategies for

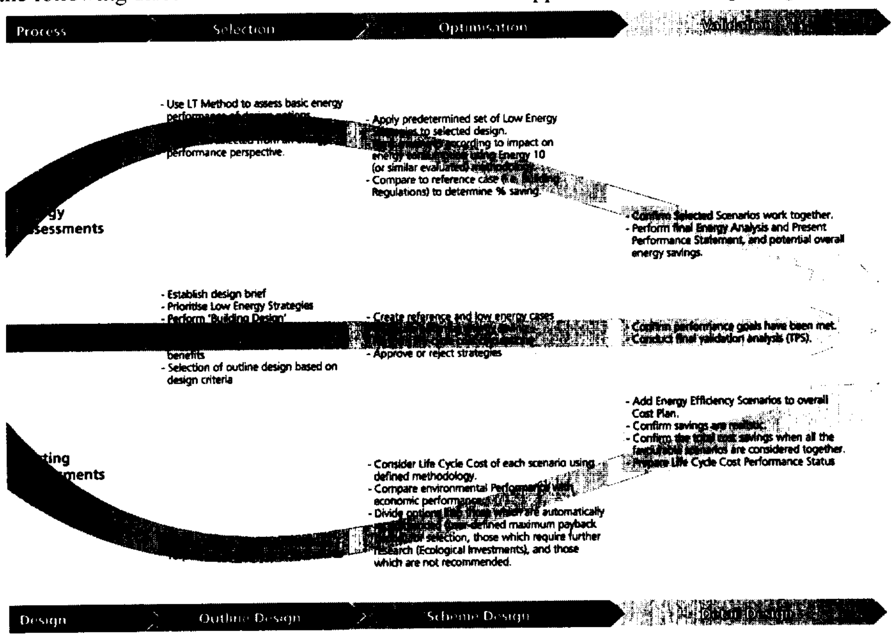

Figure 3: The overall energy efficiency assessment procedure detailing the design stages and the energy and costing assessments which inform the decision process.

reducing lighting, heating and cooling loads. These scenarios are selected according to their general suitability to work with the characteristics of the building (size, occupancy patterns etc.), and guidance is given through a decision tree.

The selected scenarios are assessed as to their effect on whole-building energy performance. A comparison is made against a reference scenario which is based on either building regulations, or accepted standard practice. The performance of both the reference, and low energy options is assessed using the software tool *Energy 10* (SBIC, 1999).

The decision to either reject or accept each strategy is made through an environmental/cost model illustrating the relative performance of the low energy and reference cases, which are essentially two alternative systems providing the same service. This model details the environmental impacts arising from the energy consumption of each option, and also the capital and operating costs of the components upon which the two systems depend. The period over which these factors are modelled is usually in line with the contract period, as defined by the PFI contract, but can be adjusted to reflect other situations.

The life cycle costs of the two options are considered as a function of their capital, energy, maintenance and replacement costs. A financial comparison is made through a discounted cash flow methodology, which reflects the fact that there is a time-value to money, and offers an objective means of comparing alternative systems, where life-cycle expenditure occurs over different timescales.

The building components included in the life cycle cost assessment are all those which are affected by the decision to select a particular energy efficiency scenario. For example when considering the optimal levels of insulation for the building, it is not sufficient to consider simply the costs of insulative material. Additional supportwork may be required, and increased insulation may reduce plant requirements. Hence a low energy option should be considered as a combination of both additional and avoided costs.

CONCLUSIONS

Energy performance of buildings is a vital link in achieving a more environmentally sustainable built environment. It remains the largest environmental challenge facing the industry. The sector, contributing such a large component of national energy use and CO_2 emissions, must be looked upon to deliver equally significant reductions. The 60% reduction in CO_2 emissions, put forward by the IPCC (Houghton et. al. 1990) as the level of reduction required to stabilise climate change, suggests that future improvements in energy performance will need to be dramatic.

The procedure recognises the potential environmental and economic benefits of low energy building design. It offers a level of control and influence during the crucial stages of the building design process where significant components of both environmental and economic performance are determined.

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MANAGING SUSTAINABLE BUILDING DESIGN

Group Manager Pekka Huovila
pekka.huovila@vtt.fi, VTT Building Technology, PO Box 1801, 02044 VTT, Finland

INTRODUCTION

In building design various aspects are analysed, compared and compromised. Selecting final solutions between alternative systems and products requires good understanding on the owner's and end users' needs and operations affecting the life-cycle behaviour of the facility. In current practice the source information for design is often imperfect and the desired performance is not properly understood. Hence the decision-making is based on insufficient knowledge. Lack of information may cause inadequate decisions concerning alternative design solutions and result in sub-optimisation that conflicts with the life-cycle objectives. Striving for the best design options in the present building process takes extra time, which is not always found, to analyse the consequences of ambivalent decisions. The proper decision support mechanism and tools have not been fully applied to ensure the efficiency of the design phase.

This paper describes experiences from development and implementation of a decision-making procedure supported by a requirements management tool, EcoProP. The tool is based on a generic classification of building properties, VTT ProP, developed at VTT Building Technology. The tool supports documentation of requirements in a form of values or classes so that their conformity in design can be verified. Its intended use is to produce the design brief and to serve as a guide for designers. The decision-making procedure with EcoProP is transparent and the well-documented objectives can be revisited in need of change. The tool is currently implemented in live projects of different building types.

MANAGING THE BUILDING PERFORMANCE

Control over the properties of building and its components is a prerequisite for successful management of building performance. Various lists or classifications of requirements have been produced during the past decades to serve users' needs to control these characteristics.

Table 1 - Checklists of building properties or requirements.

ISO 6241 User Requirements	CIB Master List of Properties	EC Essential Requirements	Green Building Challenge GBC '98
• stability • fire safety • safety in use • tightness • hygrothermal • air purity • acoustical • visual • tactile • dynamic • hygiene • suitability of spaces • durability • economic	• capacity, consumption • structural, mechanical • fire • gaseous, liquid, solid • biological • thermal • optical • acoustic • electric, magnetic • resistance to attack • service life, reliability	• mechanical resistance, stability • safety in case of fire • hygiene, health and environment • safety in use • protection against noise • energy economy and heat retention	• resource consumption • environmental loadings • quality of indoor environment • longevity • process • contextual factors

In spite of the international status of CIB Master Lists (1993) and ISO 6241 (1984) standards they have not been widely taken into practice by practitioners. The EC Essential requirements (1989) partly replace ISO6241, but does not reach details. GBC (1998) seems to become a process that will contribute to a common set of properties for buildings. In the meanwhile a compatible classification is developed and tested at VTT Building Technology supporting the following approach. For details, see (Huovila 1999, Leinonen et al. 2000) or (Foliente 1999) in regard with performance models.

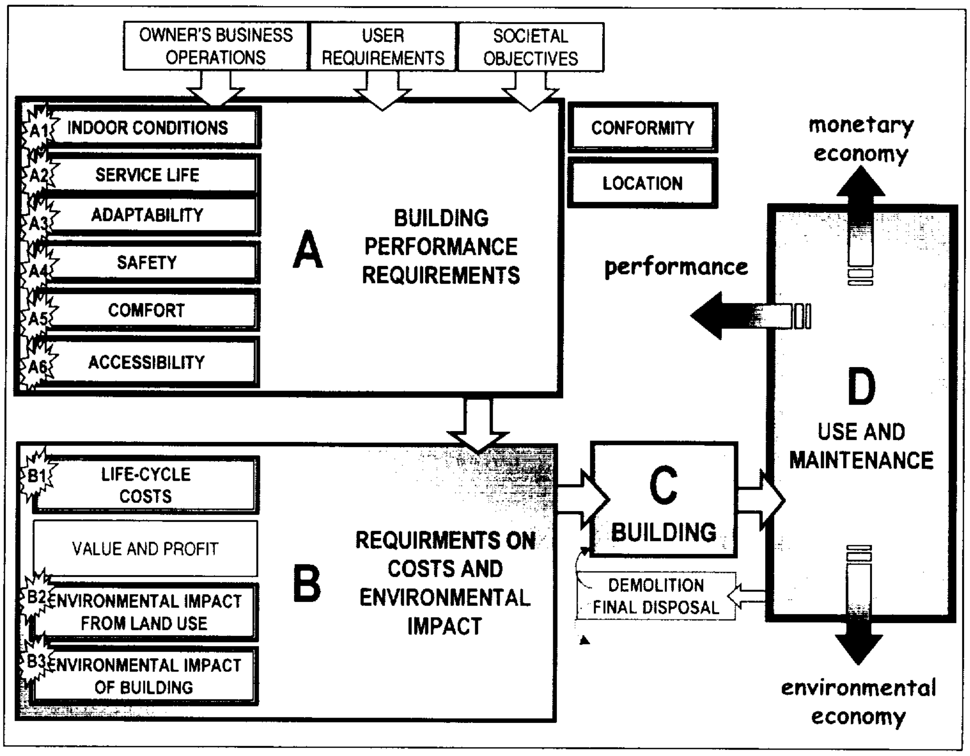

Figure 1. The approach for managing the performance of buildings.

Buildings should meet the needs of their clients, who are mainly owners and users. Users often change and the owners have an interest of varying duration towards their buildings. The investment life cycle is normally far shorter than the life cycle of the building and most of its systems. One client who has always a long-term interest on the constructed building stock and the built environment is the society. Construction and use of buildings consume nature's resources affecting there also by emissions and by changes to the biodiversity. Therefore the nature should be considered as a client, too.

The interests of different stakeholders may have different priorities. For the owner, life cycle costs may be number one, for the users indoor conditions and comfort certainly have a role, whereas the society takes care of issues like safety, land use and accessibility. The most important aspects for the nature are environmental burdens, adaptability and service life. The mentioned characteristics are partly linked with each other. What is common to all stakeholders is value over time. It consists of building performance components that deal with quality issues. It has also economic components that affect the monetary world, and that of nature's resources.

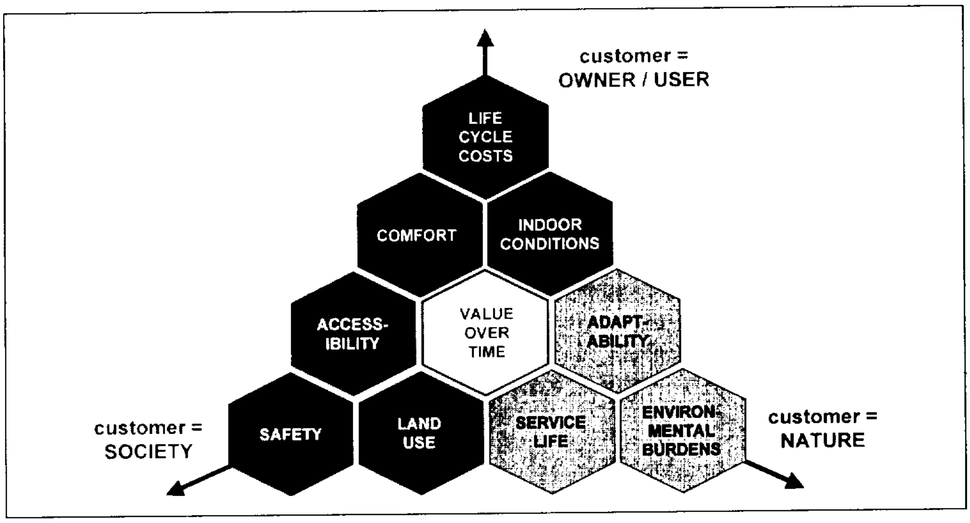

Figure 2. Different clients with different priorities.

A requirements management tool, EcoProP, has been developed at VTT Building Technology. The tool is based on the described building properties classification VTT ProP. It supports documentation of requirements in a form of values or classes so that their conformity in design can be verified. It's used to produce the design brief. The decision-making procedure with EcoProP is transparent and the well-documented objectives can be revisited in need of change. The tool is currently implemented in live sustainable construction projects of different building types with the emphasis in indoor conditions, adaptability, service life and environmental burdens. The procedure supports the performance approach and leaves the user control over decisions. It does not give automatic solutions, answers or labels, but forces different stakeholders to think over the life cycle performance early in the process when changes can still be done.

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DEFINING UK DWELLING PERFORMANCE STANDARDS FOR 2005: THE ST. NICHOLAS COURT FIELD TRIAL.

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Robert Lowe[1], Malcolm Bell[1], Phil Bixby[2] & David Roberts[1]

[1]Centre for the Built Environment
Leeds Metropolitan University
Brunswick Building
Leeds, UK

[2]Constructive Individuals
Holgate
York, UK

INTRODUCTION

The construction of new houses with very low space and water heating requirements can make a substantial contribution to the lowering of CO_2 emissions. Technology for achieving such standards has been available for over twenty years and forms the basis for regulatory standards in a number of countries (Swedish Board for Housing Building & Planning 1995). Lowe & Bell (1998) suggest that the implementation of regulations similar to the 1995 Swedish regulations could reduce space heating in new UK dwellings by 80% compared with those built to current standards. The implementation of such standards would also guarantee affordable warmth and effectively eliminate fuel poverty in new housing. Lowe & Bell (1998) have argued that such standards should be considered in the current review of the UK Building Regulations (DETR 2000) and could form the basis for regulation from 2005. The implementation of such regulations faces a number of barriers. The construction industry needs to be convinced that the regulations are workable, that costs are proportionate to the objectives and that the risk of building failures and defects is acceptable. Equally, Government must be satisfied that health, safety and comfort will not be compromised. A number of schemes in the UK have already demonstrated the technical feasibility of achieving large improvements in energy and environmental performance in new housing (Olivier & Willoughby, 1996; DETR, 1998). However, very few of these schemes have been subjected to comprehensive monitoring, either of energy performance or of procurement process, and dissemination has been poor. It is likely that these factors have contributed to the limited overall impact of these schemes.

The St Nicholas Court field trial was set up in 1999, with funding from the Joseph Rowntree Foundation, the Housing Corporation and from the DETR under the Partners in Innovation Programme, to address these issues. The project seeks to comprehensively evaluate the impact of an enhanced energy performance standard (Table 1) designed for possible incorporation into the UK Building Regulations in or after 2005. The project is based on a development of 24 houses to be built at St Nicholas Court for York Housing Association (YHA) by Wates Construction Ltd.

Table 1a **Limiting U values**	
exposed walls	0.25
roofs	0.15
floors	0.25
windows, glazed outer doors & roof-lights	1.3 or window energy rating ≥ 70 (Lowe *et al*, 1999)
opaque outer doors & hatches	0.6

Table 1b **Air leakage & heating system performance**	
air leakage rate (m/hr at 50 Pa)	3.0
carbon intensity of heating (kg/GJ)	70

The purpose of this project is not to push the boundaries of technical performance, but to explore ways of making significant improvements in the energy and environmental performance of mainstream house building and to assess the implications of doing so. This paper reports on the objectives, methodology and dissemination strategy of the project and offers a brief review of some initial insights from work in progress.

METHODOLOGY

Technology in its deepest sense consists of the knowledge and understanding possessed by individuals and organisations and of the relationships between them, as much as of the physical products of those individuals and organisations. Understanding technological change therefore requires the application of an array of methods and research techniques, drawn from the human as well as physical sciences.

Accordingly the project is being conducted within an Action Research framework. AR has been defined as "the search for understanding in the company of friends" (Stringer, 1996), and has proved to be one of the most useful tools for the investigation of organisational change (Greenwood et al 1993). It is well matched to the demands of design and construction, particularly in the context of the partnering approach established by YHA at the outset. The merging roles of the researcher and the researched encourages all participants to articulate their ideas and ensure that they are expressed clearly. This approach should allow us to reveal the fullest picture of the implications of the enhanced energy performance standard for the designer, the client, the contractor, the suppliers, the workforce, building control and the dwelling occupant.

The principal issues for evaluation will be the environmental performance achieved, the costs of achieving it in practice and the impact of the proposed standards on all participants and processes. Impacts of the enhanced energy performance standard will be evaluated using qualitative and quantitative measures. Qualitative evaluation will be based on participant observation, focus group and individual interviews and will provide insights into the attitudes, concerns and problems faced by all participants in the project, including the dwelling occupants. Quantitative evaluation will be based on cost and physical assessments of the dwellings. During construction and on completion, the dwellings will be subjected to infra-red thermography, co-heating and pressurisation tests. Energy use, thermal comfort and indoor environmental quality (based on CO and CO_2 measurements, humidity levels and fungal spore and dust mite concentrations) will be monitored during occupation.

DISSEMINATION

Results will be disseminated directly through papers, a web site and a conference. In addition, an Advisory Board which will include representatives of BRECSU, CITB, and NHBC as well as our funders and industrial partners, will review all results and consider their potential implications for the UK construction industry. The Board's task will be to identify the information needs of all players in the procurement process and to devise programmes of dissemination and training to satisfy those needs, in advance of any revision of the Building Regulations. The objective is to make the maximum use of existing organisations with a responsibility for provision of information and training to the construction industry, to ensure the most effective dissemination of the results from the project.

PROGRESS TO DATE

The project began with an initial innovations brief from YHA which was influenced by the Egan Report (Construction Industry Task Force 1998). The intention was to commission a sustainable housing scheme using integrative construction management (partnering). The main objectives of this brief were:

- to use building products that conformed to sustainability objectives;
- to increase predictability of construction in order to achieve zero defects;
- to extend the partnering to include the supply chain;
- to use standard components where possible to reduce site re-work and waste; and
- to achieve low space heating and hot water use and low energy bills.

The housing scheme is based on timber frame construction. This decision was taken very early in the process, prior to the selection of the constructing partner and before the involvement of the research team. The choice was influenced by the perceived sustainability of timber and the fact that timber framed construction lends itself to prefabrication (a strong theme of Egan). It was also a form with which the architect was familiar. The omission of masonry construction from the project is however significant, given its current predominance in UK housing.

Design of the dwellings is now almost complete. Construction is expected to begin towards the end of 2000 and occupation is from the middle of 2001. The design process has been informed by a series of briefings, dealing with solar water heating, water consumption, passive solar measures, potential for summer overheating, airtightness, thermal bridging and design integration. Technical support for these briefings has been provided by LMU, the Design Advisory Service, Energy Advisory Associates and BRE.

Two of the most interesting issues identified and explored during the design process have been the design of the wall to minimise thermal bridging and the use of pre-fabricated timber I-beams in a warm-roof. The original wall design made use of pre-fabricated storey-height panels constructed with 195 mm deep solid timber studs. A number of alternatives were proposed and explored. The solution that has eventually been adopted uses a 100 mm deep timber frame, clad externally with 50 mm of expanded polystyrene. The main reasons for this, rather than a timber I-beam solution were the unfamiliarity of the timber frame supplier, Oregon, with the latter, and the additional costs of importing I-beams from the US or Sweden. For the roof, airtightness and thermal bridging considerations, and the need to house mechanical ventilation systems, mean that it is likely that an I-beam solution will be adopted despite higher costs. In this case the partnering process has enabled buildability issues and the concerns of the heating & ventilating system supplier (Baxi) to be voiced early enough in the design process to impact on the choice of construction system.

ACKNOWLEDGEMENTS
We wish to thank our partners at York Housing Association, Wates Construction Ltd, RWS Partnership, Baxi and Oregon, without whom this work would not be possible. We also wish to acknowledge the support of our funders, Joseph Rowntree Foundation, the Housing Corporation and the DETR.

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A MULTI-OBJECTIVE OPTIMAL DESIGN OF RESIDENTIAL HOUSE WITH LIFE CYCLE ENVIRONMENTAL LOAD AND COST AS OBJECTIVE FUNCTIONS

Kenzo Maeda[1], Shuichi Hokoi[2]

1) Graduate Student, Graduate School of Engineering, Kyoto University.
2) Prof., Graduate School of Engineering, Kyoto University, Dr.Eng.

Introduction

Environmental problems have become serious worldwide more than ever before, thus an architectural design which reduces environmental load is needed in the building industry. In addition to the environmental load, cost is an important factor to be considered. If a design solution which reduces both the environmental load and the cost can be found at the design stage, it would be quite useful for a decision maker.

In this paper, the problem of selecting building materials for a typical detached residential house is investigated. This problem is dealt with as a multi-objective optimization problem [1] with life cycle CO_2 ($LCCO_2$) and life cycle cost (LCC) as two criteria. This combinatorial optimization problem is solved by making use of genetic algorithms (GA) and a Mini-Max method [2].

The values of the input data used for the life cycle evaluation [3] may be different depending on the design conditions or may fluctuate due to the changes in social and economic situations during a very long period of the building life. The change in the optimal designs is examined when a value of the influential input variable varies. Finally, as a first step to develop a multi-objective optimization method with an uncertain input parameter, a method of expressing design solutions is studied when a probability distribution of the input parameter is specified.

Model of residential house and method of evaluation

A detached residential house used in the present study is shown in Fig.1 and Table 1. The design of the house is defined as a selection process of 16 parameters listed in Table 2 such as building materials, their thickness, etc.

In order to calculate the life cycle values, the whole life consisting of construction, running and demolition stages must be taken into account. It was difficult to obtain suitable data at the demolition stage, however, the CO_2 emission and the cost at the construction and running stages only are calculated in this study. The production and construction of the building elements are taken into account at the construction stage, while the repair, operation of an air-conditioner and lighting systems at the running stage. These values at two stages are summed up and divided by the life span of the house, assumed as equal to life span of the building frames.

A steady-state method of thermal calculation [4] is used to evaluate the life cycle values for running the air-conditioner. Use of daylight is taken into account in the lighting systems. Therefore, these two factors trade-off with each other with respect to the window areas.

Optimal selection of building materials by using GA

There are almost infinite combinations of building elements to be selected in Fig.2. GA can be useful for the combinatorial optimization problem. In order to show the usefulness of this method, the optimization of one objective function by using GA is first illustrated in the following.

Table 1 Size of residential house

total floor area	125.8[m²]
number of stories	2
ceiling height	2.4[m]

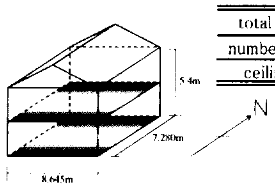

Fig.1 Model of residential house

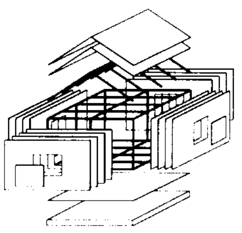

Fig.2
Selection of building elements [3]

Table 2
16 design parameters [3]

	material or type	
frame	structure	
wall	structure	thickness
	exterior	thickness
	substrate	thickness
	insulation	thickness
	window	fraction of window area
roof	structure	
	substrate	thickness
	exterior	
floor	substrate	

Optimal design when $LCCO_2$ value is considered as an objective function

Feasible solutions which appear during an optimization process by GA are plotted in Fig.3 when only $LCCO_2$ values are taken into account as an objective function. The symbols ▲ represent initial solutions, while the subsequent feasible solutions (symbol ●) from these initial values move to the bottom left direction as GA trials are repeated. Finally they converge to the optimal solution with respect to the $LCCO_2$ values. This process shows the usefulness of the GA method to the present problem, because the optimal solution is obtained only by 50000 times of calculation out of almost innumerable combinations.

Table 3 shows the details of the optimal solution with respect to the $LCCO_2$. The percentages of the $LCCO_2$ values consumed for the building elements, air-conditioner and lighting systems are listed in Table 4.

Multi-objective optimization with $LCCO_2$ and LCC as objective functions

When a region S in Fig.4 represents a set of the feasible solutions in designing a residential house, the multi-objective optimal solutions are the points on the segment AB. The multi-objective optimization problem is solved by using GA with the Mini-Max method. Fig.5 shows the result. A set of multi-objective optimal solutions can be divided into two parts, steel and RC framed structures. This is because the feasible solutions can be divided into three subsets featured by the three kinds of building frames (wood, steel and RC in Table 2), since the selection of building frame has a dominant effect on life cycle values (see Table 4). This result can be effectively utilized in designing a residential house.

Influence of input data on multi-objective optimal solutions

There are many kinds of input data used in evaluating life cycle values. They are related to production, construction and performance of building elements, weather data, lifestyle of users and energy costs. These values are changing, for example, with economic situations and the development of building techniques. They also differ depending on the lifestyle of the residents and the local area where a house is to be built. Since their variations have significant influence on the life cycle values, and thus on an optimal solution, the information not only on the life cycle values but also their range of variations, is very important for a decision maker who is committed in designing a house.

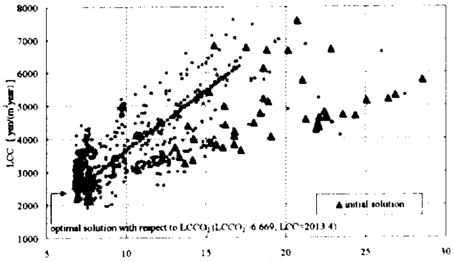

Fig.3 Optimization process by using GA with respect to $LCCO_2$

Table 3 Optimal solution with respect to $LCCO_2$

		result of selection	
frame	structure	steel	
wall	structure	wood	0.1[m]
	exterior	timber	0.005[m]
	substrate	no use	0
	insulation	rockwool	0.12[m]
	window	pair	0.02[-]*
roof	structure	wood	
	substrate	aluminum	0.0002[m]
	exterior	timber	
floor	substrate	timber	

*fraction of window to wall area

Table 4 Percentages of $LCCO_2$ values

		percentage
frame	structure	17.13%
wall	structure	0.13%
	exterior	0.16%
	substrate	0.00%
	insulation	12.01%
	window	0.83%
roof	structure	0.22%
	substrate	0.41%
	exterior	0.07%
floor	substrate	0.12%
foundation		1.89%
air-conditioner		28.72%
lighting systems		38.32%

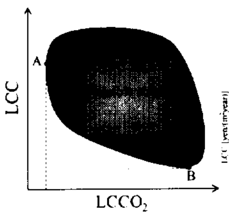

Fig.4 Multi-objective optimal solutions

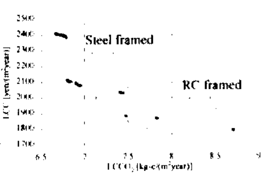

Fig.5 Multi-objective optimal solutions

Influence of material production cost on multi-objective optimal solutions

The selected thickness of the insulation (rockwool) is relatively large in the multi-objective optimal design (see Table 3). Compared with other building materials (concrete, timber, plywood, steel, reinforcement, aluminum, copper, mortar, ALC, clay and glass), the life cycle values of the rockwool are the highest, about 30%. Therefore, the variation of the insulation cost is expected to have a significant influence on design solutions.

The calculated results are shown in Fig.6, where the present production cost of the rockwool is set at 100 and the cost is assumed to vary from 50 to 150. Fig. 6 shows only a part of the optimal solutions, that are featured by steel building frames and steel wall structures, out of the whole set of multi-objective optimal designs. When the production cost of the rockwool becomes cheap, the number of optimal solutions increases in the direction of the larger $LCCO_2$ value.

Multi-objective optimal solutions given probability distribution of input variables

Some of the input values used for life cycle evaluation are hardly predictable or may change with time. In other words, they are uncertain. Therefore, the multi-objective optimal solutions thus obtained using such data are also uncertain. The presentation of the life cycle values of the multi-objective optimal solutions with their uncertainty range is useful for a decision maker in selecting the final solution considering the uncertainty.

The situation where the production cost of the rockwool is affected by the economic changes is studied here. The probability density function is given in the inset of Fig.7.

Fig.8 shows the probability density of the life cycle values of the multi-objective optimal solutions. A decision maker can understand the information on the range of the $LCCO_2$ and LCC with the probability density of the multi-objective optimal designs.

Conclusions

In this paper, the multi-objective optimal designs of a residential house with minimum $LCCO_2$ and LCC were found from nearly infinite combinations of building elements. The multi-objective optimal solutions were presented when an input parameter had an uncertainty. The following conclusions were obtained.

(1) A set of multi-objective optimal solutions is divided into two subsets characterized by steel and RC framed structures.

(2) The direction and range that an optimal solution changes on the $LCCO_2$ and LCC plane is clarified when the production cost of an insulation changes.

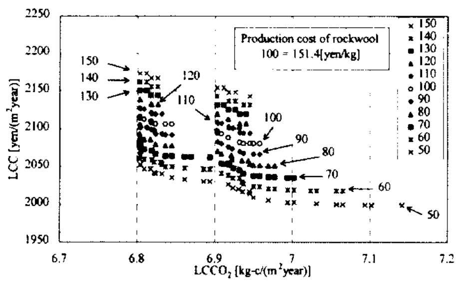

Fig.6 Influence of production cost of rockwool on multi-objective optimal solutions featured by steel building and wall frames

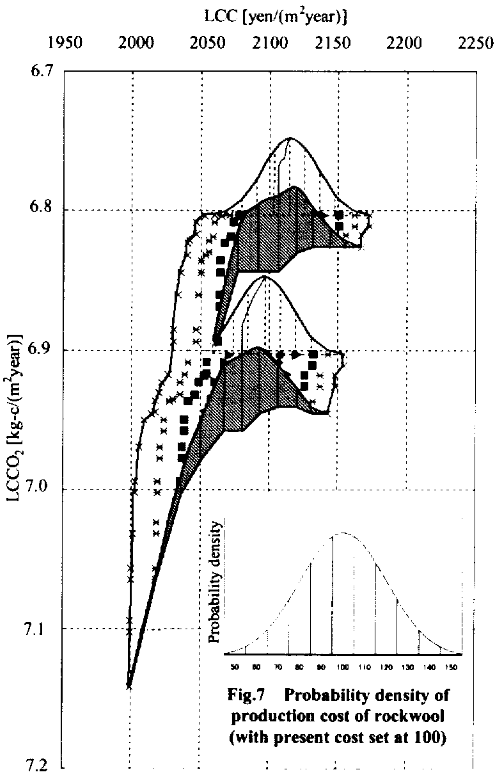

Fig.7 Probability density of production cost of rockwool (with present cost set at 100)

Fig.8 Probability density of multi-objective optimal solutions caused by uncertainty of production cost of rockwool (featured by steel building and wall frames)

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Building in noise impact zones.

Evert de Ruiter
Delft University of Technology,
DIOC-DGO The ecological city
Rotterdamseweg 139a
2628 AL Delft
The Netherlands

Adviesbureau Peutz & Associés BV
Postbus 696
2700 AR Zoetermeer

e.deruiter@citg.tudelft.nl

INTRODUCTION

The Delft Interfacultary Research Centre DIOC-DGO is connected to the Delft University of Technology through the research programme 'The ecological city'. DIOC-DGO searches for the outline of resolutions for a decrease of environmental load, while increasing the liveability and the quality of design processes.
It is DIOC-DGO's mission to develop trail-blazing but realistic proposals for a sustainable and liveable environment. The overall goal is a massive reduction of environmental burden during the entire life time of the built neighbourhood. The gap between the intended sustainable situation and the present asks for the initiation of transition processes, not only with respect to environmental innovations, but including explicit attention for social aspects and spatial quality of buildings and areas as well.
Based on the formula of Ehrlich, Ehrlich and Speth (1990) reduction of the environmental impact by a factor 20 is the ultimate goal. While we are far away from this factor the exact value doesn't matter, nor does the method of calculation, at least we can use it as a metaphor for the necessity of a drastic change in environmental impact.

THE ECOLOGICAL CITY

The ecological city too is a metaphor. Sustainable development can be realised in a newly built city 'in the polder' almost without restraints: new city plan, infrastructure, buildings etc. Noise control will require that industry will be quiet enough to fit in the neighbourhoods, or be situated far away. Transport will take place by underground or surface systems, but hardly with combustion engines. The main sources of external noise will thus be eliminated: the ecological city can be a quiet city!
In our existing cities however, such a degree of sustainability can not be reached, and maybe the amount of time needed for the transition to the ecological status is more than we think now. Therefore solutions for noise control remain important. An important method has always been: keeping distance from the noise source. The Dutch Noise Nuisance Act (1976) is an example of this approach. From the ecological point of view this a luxury we can no longer afford in urban planning: it costs too much valuable land. The land 'sacrificed' to noise control must be taken from nature somewhere else, thus increasing our *ecological footprint*. The ecological city needs a new approach to this (very) old problem of traffic noise control.

CONTROL OF TRAFFIC NOISE

Lesson one in noise control is: *reduce noise emission*! Quiet engines, moderated speed, special road surfaces, smooth flow etc are important and fundamental. Nevertheless high sound levels near busy roads cannot be avoided by controlling emission alone. The other well-known possibilities are:
the application of noise screens, between the source (road) and receiver (house, hospital,

school etc.) and increasing the sound insulation of the façades of the buildings Creating agreeable circumstances for living, indoors but in exterior spaces (garden, balcony) as well, together with the best possible land use asks for a special solution: erect buildings at short distances along the road, forming an uninterrupted screen of sufficient height. At first glance offices and other rather insensitive functions seem indicated destinations for those buildings. Practice has shown however that the allocation of office buildings has its own laws, and the demand for them hardly coincides with the destined screening locations. Also from an ecological point of view (flexibility), those buildings should be designed to include dwellings, and equally or less noise sensitive functions. At ground level logistic functions (passengers and expedition) could be located, near the road. The noise-loaded façade of the dwellings will be a 'deaf' one: with high sound insulation and no openings. The dwelling will be extravert at the opposite side; the connection with 'outdoors' will be located there.
Entrances and staircases/elevators can be located at the 'noisy' side of the building. If sound levels exceed ca 65 dB(A), social contacts (neighbour talks) will be reduced because of the increasing effort it takes to communicate. Therefore it is advisable then to provide (partially) closed staircases and corridors, possibly extending to winter gardens. Noise control in these circulatory rooms is important and requires a special approach. (de Ruiter, 1988)

EXTERIOR SPACE

Although in winter in many countries people live indoors for most of the time, an exterior space for each dwelling is desirable. In The Netherlands it is even obligatory for new houses and apartments. One of the purposes of exterior spaces is recreation in the open air, like drinking tea or coffee, watch children playing, chatting etc. Sometimes however, nuisance arises from people behaving too noisy in the mind of their neighbours. This can lead to serious conflicts and even fights.

In polls concerning neighbourhoods noise nuisance from neighbours always plays an important part. Although specific information on the occurrence indoors or outdoors is not often available, a significant role of exterior noise nuisance is likely. One could wonder if this is just a social phenomenon that can hardly be predicted, or a process in which the acoustical variables can help to understand and maybe even control the risk of nuisance caused by neighbours. This is where the concept of speech privacy comes in. With this concept it is possible to calculate an important quality of the exterior spaces with respect to each other, and thus give a quantitative criterion for the urban design.

SPEECH PRIVACY (SP)

Speech privacy can be defined as the degree in which conversation (in an adjacent room) can not be overheard. It is commonly used to establish requirements for the sound insulation of partition walls, in offices, hospitals etc. The base of this concept is: masking of the speech signal by background noise. This can be expressed in a simple form in the formula (compare Young, 1964):

$$SP = L_m + D - L_s - P \quad (1)$$

where:

- L_s is the vocal output of the speaker (L_p at 1m distance, A-weighted)
- D is the sound transmission from speaker to listener (attenuation from 1m to listener's position)
- L_m is the masking sound level at the listener's position (A-weighted)
- P is weighting term, see under.

In the weighting term P the confidentiality and other non-acoustical influences can be taken into account. In general the value of P ranges from 5 to 10 dB. For positive values of SP the speech privacy is regarded sufficient; for negative values increasingly complaints can be expected.
This formula does not reflect the more subtle influence on masking of the spectra of speech and the background noise. Normal speech, and background noises with spectra like NR-

curves are assumed. With more sophisticated methods like Articulation Index different spectra could be handled; in this case there is no need for that.

APPLICATION OF SP AS AN ENVIRONMENTAL CRITERION

Consider an appartment building with balconies. For pairs of source (speaker) and receiver (listener) position on balconies next to or above each other the speech privacy can be calculated. Assumptions must be made with regard to speech effort (vocal output), and the weighting term P. The other terms are variables, describing the environment: the background noise and attenuation. In other words, assuming certain standard values for speech volume a relation should exist between background noise level and the sound attenuation between neighbours. From this, for each instance the background noise level L_{mn} required to mask the speech signal can be calculated. This level L_{mn} can be used in two ways :

As a target value : take measures to increase or decrease environmental noise (mostly traffic noise)

As an indicator for (an important aspect of) the quality of urban plan.

Of course for houses with terraces in gardens the situation is analogous.

Sound attenuation is a function of distance in the first place. It can be enhanced by screens, and reduced by reflections. For all pairs of source and receiver positions calculations can be made of the sound attenuation, and so for the required masking noise level L_{mn}. For each (receiver) position only the highest value of L_{mn} is important. For all positions a map of L_{mn} values as a function of the position can be made.

Low values of L_{mn} indicate good speech privacy, e.g. 30 dB(A) or below. Even in quiet neighbourhoods this level of background noise is almost always exceeded by natural sounds.

It must be emphasised that the required masking noise levels L_{mn} are properties of the urban plan itself, and not of the surrounding sound sources. From all possible adjoining exterior spaces, the representative highest value can be regarded as an indicator for the quality of the (urban) plan.

CONTINUATION

The work described here has just recently started. Research is intended with respect to noise control in the staircases/wintergardens and integration of logistic functions in the building, in combination with different types of roads, at ground level or elevated roads. Indicators like L_{mn} can be regarded as simple tools to judge the quality of urban planning and building designs. Especially in the compact city there will be a growing need for improvement of these acoustical qualities (noise control, privacy, communication). Developing tools to assess the effects of different designs in a quantitative way is a first, but necessary step towards a compact, ecological city.

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MANAGEMENT OF LIFE-CYCLE COSTS AND ENVIRONMENTAL IMPACTS IN DESIGN PHASE OF RESIDENTIAL CONSTRUCTION PROJECT

Arto Saari Dr. Tech.
Helsinki University of Technology, Laboratory of Construction Economics and Management
P.O. Box 2100, FIN-02015 HUT, Finland
e-mail: arto.saari@hut.fi

INTRODUCTION

Finnish building owners have found it problematic that state-subsidized housing production is controlled by state authorities whose main concern is construction costs. Owners say that they have to eliminate good solutions from the viewpoint of life-cycle economics and ecology since they do not fit within the cost ceilings set by authorities.

At the Construction Economics and Management Laboratory of Helsinki University of Technology was conducted a study that seeks solutions to the above-mentioned problem. The aim was to develop a procedure that allows setting targets for life-cycle economics and environmental impacts as well as a procedure for verifying that the targets are reached. The procedure has been tested in an ongoing project pilot.

CONTROL PROCEDURE

The control procedure of construction project in LCC- and LCA viewpoint is as follows:

- In planning phase:
  - Setting a construction cost ceiling
  - Setting a energy consumption ceiling
- In design phase:
  - Calculating a standard cost estimate for construction costs
  - Calculating a standard estimate of a building's thermal energy need
  - If estimated figures exceed the ceilings, the design solution must be developed

The construction cost methods are presented in the annually published book [Haahtela1999], and the energy management methods has been described in book *Building operating cost data* [HUTCEM1993].

The goal of the control procedure is not to optimize life-cycle costs or environmental impacts. The principle of the procedure is to ensure that the project's construction costs and use-time energy consumption are reasonable.

The economic principle is that project decisions are made on the basis of life-cycle costs. If it can be shown that an additional investment—not in conformance with the prevailing building mode—can save operating costs, otherwise reasonable construction costs may be exceeded by the amount of the additional investment. The condition for the approval of the additional costs is that they are less than the present value of the savings they bring (see Fig.).

The principle is that the reasonableness of energy consumption during use is monitored since it is the key cause of global environmental impacts (climatic warming) in the case of residential buildings that conform to the prevalent Finnish building mode. If it can be shown that an additional investment—not in conformance with the prevailing building mode—can substantially reduce the environmental impacts of a building, otherwise reasonable construction costs may be exceeded by the amount of the additional investment. The condition for approval is that the reduction in environmental impacts is more valuable than the additional costs. The acceptability of an additional investment is determined by value analysis (see Fig.).

Helsinki University of Technology, Laboratory of Construction Economics and Management

LCC-LCA ANALYSIS

PROJECT IDENTIFICATION 14.6.1999

Name and address:	Building owner:	Project management:
ASO/EKO-Viikki, Norkkokuja 6 ja 7 Helsinki	VVO Corporation	VVO Rakennuttaja Oy
Building type: State subsidized apartment buildings	Cross floor area: 6809 gfl-m²	Dwelling area: 5046 fl-m²

ALTERNATIVES

Building element:	Quantity:	Relative quantity:
Window	908 window-m²	0.18m²/fl-m²; 0.13m²/gfl-m²

Alternative A: Window, 3 glasses, U value 1.75 W/m²K
Alternative B: Window, 3 glasses, selective membrane, U value 1.4 W/m²K
Alternative C: Window, 3 glasses, selective membrane, U value 1.1 W/m²K

PERIOD, INTEREST RATE, AND COST LEVEL

Period: 50 years	Real interest rate: 4 %	Cost level: July 1999

LIFE CYCLE COSTS (LCC)

	Construction costs, FIM/fl-m²	Maintenance costs,FIM/fl-m²	Energy costs, FIM/fl-m²	Demolition costs FIM/fl-m²	Total FIM/fl-m²
Alternative A	360	0	140	10	500
Alternative B	380	0	110	10	500
Alternative C	450	0	90	10	540

LCC-LCA ANALYSIS

	LCC FIM/fl-m²	Nor mali zed	Nonrenew material kg/fl-m²	Nor-mal-ized	CO2-eq. kg/fl-m²	Nor-mal-ized	SO2-eq. kg/fl-m²	Nor-mal-ized	Ethene-eq. g/fl-m²	Nor-mal-ized	Weighted normalized value	Rating
Weight		**50**		**5**		**25**		**10**		**10**		
A	500	93	4	100	790	100	1,4	100	20	100	96	3 ☹
B	500	93	3	85	630	80	1,1	80	15	73	85	2 😐
C	540	100	3	85	500	64	0,88	62	12	59	82	**1** ☺

SENSITIVITY ANALYSIS

	LCC FIM/fl-m²	Nor mali zed	Nonrenew materials kg/fl-m²	Nor-mal-ized	CO2-eq. Kg/fl-m²	Nor-mal-ized	SO2-eq. Kg/fl-m²	Nor-mal-ized	Ethene-eq. G/fl-m²	Nor-mal-ized	Weighted normalized value	Rating
Weight	! →	**70**		**3**		**15**		**6**		**8**		
A	500	93	4	100	790	100	1,4	100	20	100	95	3 ☹
B	500	92	**3**	85	630	80	1,1	80	15	73	88	**1** ☺
C	540	100	3	85	500	64	0,88	62	12	59	89	2 😐

Result: If LCC is weighted by 70%, becomes alternative B the most valuable alternative.

CONCLUSION

The most expensive Alternative C is the most valuable alternative. It is closely argued to choose Alternative C.
The standard construction cost budget can be raised FIM 88 /fl-m2
([FIM 2500/window-m2 –FIM 2000/window-m2]*890window-m2/5046fl-m2= FIM 88 /fl-m2).

Figure. A specific LCC-LCA analysis example: Comparison of different window types. The analysis was made for a Finnish residential construction project pilot.

SPECIFIC LCC-LCA CALCULATIONS

Separate specific LCC-LCA calculations are done to rank alternative design solutions on the basis of life-cycle costs, environmental impacts, or both simultaneously. Separate calculations may target a building component or a system: e.g. alternative exterior wall types. Calculations can be made at different phases of a project. Separate calculations include:

- Description of studied alternative design solutions
- Selected weighting factors for costs and environmental impacts that describe ranking
- Length of selected time horizon and rate of interest for calculations
- Estimates of life-cycle events concerning alternatives (e.g. maintenance activities and periods)
- Results of calculations:
  - life-cycle costs of alternatives
  - environmental impacts of alternatives
  - result of value analysis
  - sensitivity analysis of calculations

In the figure is presented a calculation example of specific LCC/LCA calculation.

In project pilot was prepared nine LCC-LCA analysis for comparison of specific design solutions as follows [SAARI2000b]: 1) site surface structures, 2) exterior walls, 3) windows, 4) roof constructions, 5) air ventilation services, 6) lifts, 7) floor finishing of dwellings, 8) finishing of bathrooms, and 9) saunas.

In source [SAARI2000a] is presented result of a LCC-LCA analysis of different exterior-wall types.

CONCLUSIONS

The described procedure does not eliminate well-grounded design solutions based on life-cycle economics as may happen if definite construction cost ceilings are adhered to. That is a good thing from the viewpoint of the life-cycle economics of a building since the described additional investment allows a lower rent level than would be otherwise possible. It also ensures that additional investments valuable for the environment are not eliminated.

Suggested next step is that the State Housing Fund of Finland should take the described procedure in use. It should initially be tested in a selected area in Finland. Before that the ranking of costs and environmental impacts should be determined, as well as the rate of real interest to be used in calculations.

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ENERGY SIMULATION AND BUILDING DESIGN - BRIDGING THE GAP

Gordon F. Shymko, P. Eng.
G. F. Shymko & Associates Inc.
129 Evergreen Crescent SW
Calgary, Alberta
Canada, T2Y 3R2

INTRODUCTION

Despite numerous past and current initiatives by software developers, energy simulation to date has failed to gain widespread acceptance as a legitimate dynamic design tool by the North American building design community. Seldom does simulation materially supplant or even supplement traditional design processes and methods, even though numerous initiatives have demonstrated the value of simulation-supported design. The reasons for this failure are rooted in technical, professional, and political issues.

TECHNICAL ISSUES

In the early years of simulation through the 1980s, most mainstream software packages in North America were directed toward the needs of HVAC designers, with comprehensive and accurate whole-building energy performance rendered to a secondary role. In fact, many of the packages were developed and marketed by HVAC equipment companies. Through this period simulation as a matter of course became firmly entrenched within the professional purview of the HVAC designer. To a very large degree this continues today, with many mechanical consultants using software tools of modest capability, most still heavily biased toward the requirements of the HVAC design industry. These tools are usually based on bin or modified-bin methodology, and have rather limited analytical capability, particularly with respect to whole-building analysis. Additionally, HVAC designers, through no fault of their own, usually lack the necessary knowledge of broader building design issues and energy performance to effectively apply simulation tools in a multi-disciplinary fashion. This is particularly true with the higher-level simulation packages (usually hourly-based methodology) which are generally extremely complex and require broad-based knowledge to properly use. Hence their almost negligible adoption by the "traditional" simulator on the building design team, the HVAC consultant. Moreover, none of the other traditional design disciplines typically possess the multi-disciplinary knowledge base necessary to employ these tools either. In essence, high-level energy engineering and simulation has transcended the understanding and capabilities of the traditional design team. The field is now a specialized discipline unto itself.

Underlying the above issues is a strong sense of skepticism in some quarters of the building industry regarding the accuracy and reliability of simulation. This reputation is not entirely undeserved, and is the consequence of:

1. The low level of sophistication of many of the mid-level simulation packages commonly used.
2. Improper or unqualified use of high-level simulation packages.

The methodologies and algorithms employed by high-level simulation packages are such that rigorous and detailed modeling are absolutely necessary to exact an acceptable degree of accuracy . In fact, with most packages margin of error is inversely proportional to simulation rigor, with error predominantly favoring underestimation of energy use. Unfortunately, the complexity and tediousness of the modeling process tends to encourage shortcuts, particularly in defining thermal zoning. This can lead to disastrous error with some software.

PROFESSIONAL ISSUES

Professional and design process obstacles have arisen in conjunction with the emergence of energy engineering and simulation as a separate design discipline.

First, the building design industry in North America is highly competitive at the best of times, with fee considerations an unfortunate reality. The addition of an energy/simulation specialist to the traditional design team represents an additional cost which must be either recovered through higher fees or absorbed by the team in some manner. Clients often balk at the notion of paying for additional expertise which they, perhaps naively, assume should be part of the normal design service package.

Second, the traditional design process in North America is very much hierarchical and non-integrated. Architectural considerations drive the process with the engineering disciplines following suit. Inter-disciplinary communication is commonly limited to the most cursory issues of coordination. Again, this is in part a reflection of the competitiveness of the industry and the need to be "productive". However, integrated design and simulation go hand-in-hand; in fact simulation is of little value in a non-integrated design process, and integrated design is very difficult without simulation support. The underlying fundamental problem is that integrated design is in the very early stages of acceptance and adoption in North America. It runs contrary to conventional design processes and it is often perceived as troublesome and expensive. The adoption of simulation as a design tool will only occur when the industry moves away from its current hierarchical conventions.

POLITICAL ISSUES

Authorities in North America have tended to subscribe to a regulatory approach to implementing energy efficiency in buildings. Tools for enforcement and compliance verification are accordingly required. The logical solution to ensuring performance-based compliance (as opposed to prescriptive) is a simulation package of some type, usually used by the building designer with the results reviewed and approved by the regulator. Hence, many jurisdictions, including Canada, have made considerable investment in adapting existing simulation packages to suit The problem with this approach is two-fold:

1. In the necessary pursuit of "user-friendliness" of the compliance software, user interfaces or shells are installed over what are usually very sophisticated simulation packages. The most common example in North America is the adaptation of various derivatives of DOE. Unfortunately, by their very nature the shells are usually rigid and relatively inflexible, and deny the simulator access to the very capabilities of the core software which are necessary for effective modeling and design support.
2. Regulators are concerned mainly with pass/fail compliance verification, and this is generally reflected in the design of the interface shells. Little information beyond pass/fail is typically available, and access to the detailed simulation information which is necessary to provide dynamic design support is limited. Consequently design becomes a "hit-and-miss" proposition rather than an informed developmental process.

The situation is compounded when regulatory authorities, for reasons of consistency and lack of review resources, strictly require that the "approved" compliance verification software be utilized. This raises obvious problems of duplication of effort when a design team wishes to use another, more effective software package for design purposes. Additionally, the required compliance software is often still too difficult for designers to use despite the best intentions and efforts of the shell/interface developer. In the end, the design team is discouraged from pursuing performance-based compliance, and instead resorts to prescriptive approaches. In the long term this stifles creative building design and hinders advancement of the industry.

A CANADIAN CASE STUDY – THE C-2000 PROGRAM

The C-2000 Program for Advanced Commercial Buildings supports and advocates design integration, independent energy engineering, and intensive DOE 2.1e simulation as key factors in the design of high performance sustainable buildings. Among other performance criteria, C-2000 buildings must consume no more than 50% of the energy of a Reference building designed to the standards of the Canadian Model National Energy Code for Buildings.

In the interest of evaluating the veracity of the DOE simulations used in the C-2000 design process, two C-2000 buildings were selected for post-construction validation. The first was Crestwood Corporate Centre Building 8 in Vancouver, one of the first C-2000 demonstration projects. The building was thoroughly metered at the system and sub-system level, and accurate operational data was accumulated for a one year period after construction. The original DOE simulations were adjusted to account for weather and operating conditions and reconciled to actual metered energy use. Overall, the simulations were accurate to within 13.0% over the period of analysis, with subsequent corrections in certain aspects of the modeling reducing the margin to less than 5 %. The second validation was conducted on Alice Turner Branch Library in Saskatoon, a later or "second generation" C-2000 project. Although site metering was less rigorous, the original DOE simulations proved to be accurate to within 2.2% for the one year period of study.

CONCLUSIONS AND RECOMMENDATIONS

1. Energy simulation can be an effective and accurate design tool provided that:
   a) Energy engineering and simulation is treated as a separate and specialized design discipline and conducted in an integrated design context.
   b) Simulation is conducted in a competent fashion to a very high level of sophistication, rigor, and detail.
2. The acceptance of energy simulation as a design tool by the North American building industry is inseparably linked to the adoption of integrated design. This will require fundamental changes in current design processes and the models and attitudes associated with retaining and compensating building design professionals.
3. Regulatory authorities must recognize that the current proclivity towards the required use of compliance verification simulation software can be inherently counter-productive. Broader solutions must be developed that actively encourage, rather than discourage innovative building design.

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THE IMPACT OF DWELLING TYPES ON HEATING ENERGY CONSUMPTION IN ISTANBUL

Aslıhan Tavil, M.Cem Altun, Hülya Kus
1. Istanbul Technical University, Faculty of Architecture, Taşkışla, Taksim, 80191, Istanbul, Turkey
2. Istanbul Technical University, Faculty of Architecture, Taşkışla, Taksim, 80191, Istanbul, Turkey
3. Centre for Built Environment, KTH (Royal Institute of Technology) Research School, University of Gävle, SE-80102, Gävle, Sweden

INTRODUCTION

About half of the energy consumption and similar proportion of carbon dioxide emission is associated with the existing dwelling stock in Istanbul. A significant number of existing residential buildings have insufficient heat resistances and therefore fail to meet performance requirements of either national or international standards for energy conservation, reduction in air pollutants and CO_2 emission. One of the most important goals of Turkey is to develop strategies for enhancing the quality of the built environment and to achieve this the country has to fulfil a number of crucial environmental and ecological requirements besides the others. This will also facilitate the membership of Turkey to the European Union. On this process, the challenge is to create a sustainable environment for achieving an acceptable lifestyle and level of comfort while reducing energy consumption. By considering these facts, a research project was set to investigate the thermal performance of the external envelope of existing dwellings in Istanbul and to develop energy efficient systems for retrofitting external envelope of these buildings [1].

In this study, the impact of dwelling types on heating energy consumption is investigated taking account of the variables such as transparency ratio, floor area, house type (terrace/detached), building height and plan type. The effect of these variables on the heating energy consumption of existing and retrofitted buildings are evaluated and thermal efficiency of each retrofitting system is discussed in terms of energy savings.

THE METHODOLOGY

In the analysis, the representative dwellings are typified and different retrofitting systems are proposed for energy conservation of these buildings. Afterwards, the simulations of the existing and retrofitted dwellings are performed.

Description of the Dwelling Types

In the context of the research project, the current situation of the housing stock was investigated in terms of a field survey in selected settlements. In order to evaluate the thermal performance of the proposed energy efficient systems for retrofitting the external envelope of the dwellings, various dwelling types were specialised by considering the results of the field survey and the municipal regulations for characterising the dwellings in Istanbul. In this study, thirteen typical buildings are selected for the simulations. The main variables of the dwellings are considered as transparency ratio, floor area, house type, building height, and plan type. The main facades of the buildings are oriented to north and surrounding residential buildings in the neighbourhood are also specified. Reinforced concrete structure, exterior non-load bearing brick walls of 13 cm thickness without thermal insulation, single clear glazed wooden windows and tile pitched roof are the typical components of the existing buildings. Cantilevered floors of 1,5 m surround the sides of the buildings. There are four balconies with 1,5×4,0 m size at the corner of each floor. The variables, which characterise the typical buildings, are given in Table 1. The lighting and occupancy schemes are also specified for each building for the internal loads [2].

Description of Retrofitting Systems

Three different retrofitting systems are considered for the rehabilitation of the opaque and transparent components. In the first retrofitting system (R1), the walls, roof and cantilevered floors of dwellings are externally insulated with expanded polystyrene of 5 cm and single glazing is replaced with air filled clear double glazing with a U value of 2,81 W/m^{2}K.

Table 1. The variables that characterise the dwelling types.

	Type	W/L	W	L	F	S	Tr
K1A	D	1,0	15,1	15,1	230	5	35
K2A	D	0,7	12,8	18,0	230	5	35
K2B	T	0,7	12,8	18,0	230	5	35
K2C	D	0,7	12,8	18,0	230	5	25
K2D	D	0,7	12,8	18,0	230	3	35
K2E	D	0,7	12,8	18,0	230	7	35
K2F	D	0,7	12,8	18,0	230	9	35
K2G	D	0,7	12,8	18,0	230	5	45
K3A	D	0,5	11,0	21,5	230	5	35
L1A	D	1,0	17,3	17,3	300	5	35
L2A	D	0,7	14,5	20,7	300	5	35
L2B	T	0,7	14,5	20,7	300	5	35
L3A	D	0,5	12,2	24,5	300	5	35

D: detached, T: terrace, W: width (m), L: length (m), F: floor area (m^2), S: number of storeys, Tr: Transparency ratio (%),

In the second retrofitting system (R2), the roof and the walls are internally insulated with expanded polystyrene of 5 cm and the single glazing is replaced with air filled clear double-glazing. In the third retrofitting system (R3), only the single glazing is replaced with air filled clear double-glazing.

Calculation Method

A PC version of DOE 2.1E computer program, which is comprehensive enough for the energy simulation, has been used to calculate the yearly energy losses of the existing and retrofitted buildings [3]. The overall annual heat losses of the existing buildings and their retrofitted alternatives have been calculated by means of computer simulation. In the evaluations the total heating energy consumption required for heating per m^2 floor area is taken into consideration and it is assumed that the heating system of the buildings have a productivity of 70 %.

RESULTS AND DISCUSSION

The heating energy consumption of the dwelling types is given in Table 2. For the existing situation, the highest energy consumption per m^2 occurred in K2D and K2G buildings while the lowest occurred in L2B and K2B buildings among the selected dwelling types. K2F is the one with the lowest energy consumption among the detached building types, while L2B has the lowest energy consumption among the terrace buildings. (Tables 1-2).

Table 2. Heating energy consumption of the existing and retrofitted dwelling types and energy savings due to existing situation.

	Exist.	R1		R2		R3	
	C	C	S	C	S	C	S
K1A	782	318	59,4	350	55,3	640	18,1
K2A	800	325	59,4	358	55,2	653	18,3
K2B	467	237	49,4	255	45,4	409	12,4
K2C	771	315	59,2	338	56,1	667	13,4
K2D	1011	434	57,0	492	51,3	859	15,0
K2E	716	281	60,7	305	57,4	571	20,2
K2F	670	258	61,5	276	58,9	527	21,4
K2G	828	346	58,3	379	54,3	645	22,1
K3A	827	332	59,8	367	55,6	675	18,3
L1A	718	302	58,0	330	54,0	592	17,5
L2A	729	306	58,0	335	54,0	601	17,5
L2B	435	228	47,5	239	45,0	386	11,3
L3A	730	295	59,5	326	55,4	600	17,8

C:Energy consumption (MJ/m^2), S:Energy savings (%)

The efficiency of the retrofitting systems applied on different dwelling types:

According to the results, the existing situation of all types of the dwellings fails to meet the national heating energy standards. If the retrofitting systems are compared with each other with respect to the heating energy savings in a year due to the existing situation, systems R1 and R2 are more energy efficient than R3 in all dwelling types. Maximum energy savings of 61,5 % and 58,9 % are provided in 9-storey high K2F building improved with R1 and R2, respectively. Minimum energy savings of 47,5 % and 45 % are achieved in 300 m^2-terrace L2B building retrofitted with R1 and R2, respectively. The system R3 provides the maximum and minimum energy savings of 22,1 % and 11,3 % in K2G (Tr:45 %) and L2B (Tr:35 %), respectively (Table 2).

The effect of building variables on heating energy consumption:

The dwelling types are compared with each other taking account of the building variables with respect to the variation in the energy consumption for the existing and retrofitted situations. The variation of energy consumption percentage in a year according to the building variables is given in Table 3.

Table 3. The variation of energy consumption

Building Variables		Type	Exist. %	R1 %	R2 %	R3 %
W/L	1	K1A	0,0	0,0	0,0	0,0
	0,7	K2A	2,3	2,3	2,3	2,0
	0,5	K3A	3,5	2,2	2,6	3,5
W/L	1	L1A	0,0	2,2	1,4	0,0
	0,7	L2A	1,4	3,7	2,9	1,5
	0,5	L3A	1,6	0,0	0,0	1,3
D/T	D	K2A	71,2	37,3	40,4	59,5
	T	K2B	0,0	0,0	0,0	0,0
D/T	D	L2A	67,5	34,2	40,0	55,8
	T	L2B	0,0	0,0	0,0	0,0
Tr	25	K2C	0,0	0,0	0,0	3,5
	35	K2A	3,8	3,3	5,8	1,3
	45	K2G	7,5	9,9	11,9	0,0
S	3	K2D	50,8	68,2	78,5	63,0
	5	K2A	19,3	25,9	29,8	23,9
	7	K2E	6,7	9,0	10,4	8,4
	9	K2F	0,0	0,0	0,0	0,0
F	230	K1A	8,9	5,2	5,9	8,1
	300	L1A	0,0	0,0	0,0	0,0
F	230	K2A	9,7	6,1	6,8	8,7
	300	L2A	0,0	0,0	0,0	0,0
F	230	K2B	7,4	3,7	6,5	6,1
	300	L2B	0,0	0,0	0,0	0,0
F	230	K3A	13,3	12,4	12,7	12,5
	300	L3A	0,0	0,0	0,0	0,0

W/L: width/lenght, D: detached, T:terrace, F: floor area, Tr: transparency ratio, S: number of storeys,

W/R ratio of the dwellings does not influence the amount of the consumed energy significantly. The maximum increase in the energy consumption is calculated as 3.45 % in the buildings with 230 m^2 area while the W/L ratio decrease from 1.0 to 0.5.

The consumed energy increases about 70 % in existing detached buildings compared to the existing terrace buildings with the same area due to the increase in the wall area.

The increase of 20 % in the transparency ratio causes 7.5 %, 9.9 % and 11.9 % of increase in the energy consumption of the existing and dwelling types retrofitted with R1 and R2, respectively. The solar gains from the windows reduce the effect of transparency ratio on the energy consumption.

Building height is very much effective on the amount of energy consumed for heating per m^2 floor area. The energy consumption of an internally retrofitted 3-storey high building is calculated 78.5 % higher than the 9-storey high building. The energy conservation difference between the retrofitted dwelling types becomes more effective by the variation of the storey number of the buildings.

The energy consumed in existing and retrofitted dwellings increase between 3.7 % and 13.3 % with the decrease of 23 % in the floor area.

CONCLUDING REMARKS

The highest energy savings can be achieved by increasing the efficiency of the retrofitting systems in all dwelling types. The system consisting external insulation of the opaque components together with improvement of the transparent components is considered as the most energy efficient retrofitting system in the selected dwelling types.

The most effective building variables on heating energy consumption are the building height and house type (terrace/detached). These variables are directly related with the external wall area of the buildings.

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Sustainable Construction in Practice

Dr Sally Uren[1], Andrew Brown[2] and Fiona Gooch[1]

INTRODUCTION

Sustainable development forms a process which meets 'the needs of the present without compromising the ability of future generations to meet their own needs' (Bruntland 1987) and sustainable construction is the contribution which the construction industry can make to sustainable development. Sustainable construction therefore involves conducting business in a socially and environmentally responsible way, while generating a good economic return. This paper presents how a major construction to services company, Carillion, is embedding sustainable construction into its business both at corporate level and in practice in its many projects and sites.

Carillion is the new name for Tarmac Construction Services and is one of the UK's largest construction to service companies. Carillion is involved in every aspect of the built environment, has a turnover of £1.9 billion and over 10,000 employees. Since 1992, Carillion has been implementing a leading edge environmental management programme, which has won several awards. As an extension to this programme, Carillion has begun to address sustainability by implementing initiatives designed to integrate social and environmental issues into mainstream business. Stanger Science and Environment provides strategic consultancy to support this sustainability programme.

CARILLION'S ADOPTION OF SUSTAINABLE CONSTRUCTION PRACTICES

The main goal of Carillion's environmental, and now sustainable development, strategy has been to ensure it creates business benefits, and to implement actions that will embed sustainable development considerations into business practice. To support this goal, Carillion developed corporate objectives for 2000 as follows:

Financial and economic success

A: Develop and implement an environmental cost accounting system

B: Utilise the environmental cost accounting system or any other appropriate tool to explore the relationship between environmental and sustainability performance and financial performance

Employees and management systems

C: All Business Groups to implement an Environmental Management System by 2002

D: Extend EMS ownership to all Carillion Head Office functions

Stewardship & Supply Chain

E: Develop stewardship of Carillion's Supply chain across all Business Groups

F: Increase the purchase of materials and products from sustainable and well managed sources

G: Increase use of Life Cycle Analysis within Carillion projects

Consumption of natural resources

H: Develop measures to reduce consumption of natural resources (use of energy, water & raw materials)

Pollution of the environment

I: Implement a programme to reduce emissions produced as a result of Company activities (waste, CO_2, emissions to air and to water)

J: Introduce "green" fleet management

Suppliers and Stakeholders

K: Raise the profile of sustainable construction within Strategic accounts

L: Increase knowledge of environmental / sustainable issues and best practice across all Business Groups

M: Widen the scope and nature of stakeholder dialogue

These objectives have been put into practice for a number of sites within Carillion. For example, at Dartford and Gravesham Hospital an Environmental Financial Statement has been produced showing total environmental savings to be £181,500, which was 57% of the environmental costs. As

[1] Stanger Science and Environment, Lansdowne Building, Lansdowne Rd, Croydon CR0 2BX, UK

[2] Carillion plc, Carillion Building Special Projects, PMH Relocation, Coate, Swindon, SN3 6AA, UK

this PFI hospital becomes operational, it is considered that the savings are likely to increase. Another example is the work that Carillion is undertaking with its stakeholders, such a Sustainability Briefing for clients and staff and a stakeholder dialogue workshop with representatives from all Carillion business groups to develop programmes for engagement. There are also many examples of local stakeholder initiatives at project sites.

SUSTAINABLE CONSTRUCTION AT PRINCESS MARGARET HOSPITAL, SWINDON

At a project level, Sustainability Action Plans (SAPs) can be used to integrate sustainability considerations into a construction project. To date, SAPs have been developed for two Carillion projects, a social housing project in Bradford and a new hospital for Swindon[3].

Carillion is the lead partner in the PFI consortium developing this £148 million 486-bed hospital project for the client, Swindon and Marlborough NHS Trust, that is due to be completed in 2002. The project was accepted by the Movement for Innovation (M4I) as a demonstration project for innovation in 'Partnering in the Supply Chain'. Carillion's project team made an early decision to design and construct the new hospital in a way that embraces the principles of sustainable development.

Working with The Natural Step, an international movement for sustainable development, all members of the project team have participated in workshops to generate an SAP for the new hospital. The plan identifies short, medium and long-term actions to be taken to increase the sustainability of the design, construction and operation of the hospital. The Action Plan links nine design, process and operation topic areas, and the actions current at the time of this paper are outlined below.

the NATURAL STEP

THE FOUR SYSTEM CONDITIONS	Don't:
Substances extracted from the Earth's crust must not systematically increase in nature.	Overwhelm
Substances produced by society must not systematically increase in nature.	Poison
The physical basis for the productivity and the diversity of nature must not be systematically diminished.	Liquidate
We must be fair and efficient in meeting basic human needs.	Waste

Sustainability Topic	Example Actions
Materials Selection	• Use timber from sustainable sources • Reduce use of PVC and develop alternatives • Encourage suppliers to offer technological developments • Favour suppliers developing 'green' products.
Energy Use	• Incorporate energy efficient features in the design, including solar glazing, effective insulation materials, low energy lighting.
Plant Equipment and Specification	• Select equipment with high efficiency
Wildlife	• Develop habitat management plan • Native tree planting • Protect resident populations - e.g. provision of bird boxes
Local Nuisance	• Good communication, • Partnerships on initiatives • Conform with the Considerate Contractors Scheme, • Minimise road usage near housing, • Minimise dust • Minimise out of working hours operations
Transport	• Route planning to minimise disruption • Minimisation of vehicle movements by maximising vehicle loads • Provide transport for staff to reduce vehicle movements.

[3] Details of the project team are available on http://www.general-hospital.co.uk

Community Relations	• Appoint a Community Liaison manager • Support "New Deal" • Employ local trade contractors • Become member of local Chamber of Commerce
Waste Management	• Recycle all waste material on site. • Procure materials from suppliers able to take back and recycle packaging • Landscape to minimise waste soil on site - soil to be reused on site wherever possible • Purchasing policies to favour recycled materials and those with a long life
Landscape and Visual Impact	• Plant local species • Use organic materials, • Minimise the importation of soil • Minimise the use of herbicides and fertilisers

Application of the SAP to this project predicts significant, and measurable, positive impacts on energy use, carbon dioxide emissions, waste, safety, sustainability of materials and local employment, during both the construction phase and throughout the life of the hospital. The targets for lifetime savings are 30% in carbon dioxide emissions and 50% in waste generation. In addition, the value of the asset at the end of its predicted life as a hospital will be enhanced because the buildings and their services have been designed for flexibility in re-use.

Business costs/benefits of the this approach include the following:

- 7% saved on the cost of the building envelope procurement.
- Net saving of £219,000 resulted from the Energy Action Plan, which doubled the U-value of the roof insulation leading to savings on capital cost of the top floor radiant appliances and in the running costs over building life.
- Net saving of £809,000 resulted from the Materials Action Plan, which uses different timber and wood soap to avoid the use of paint and varnish.
- The only quantifiable cost to the company from the SAP was the investment in initial training, at about 1 day per team member.

CONCLUSIONS AND RECOMMENDATIONS

From Carillion's experience, the success factors for the application of sustainable construction practices on new projects are:

- Engage with the sustainability agenda at the earliest stages of a project
- Generate a clear understanding of the fundamental issues at stake
- Gain commitment from senior management
- Establish a shared vision
- Converse with as many stakeholders as possible
- Listen to what people want and can offer
- Be flexible
- Be open to innovative ways of doing things
- Learn from mistakes
- Use measurement systems to chart progress

The challenge for the building industry's engagement with sustainable construction will be to fully understand its social impacts, as well as the linkages between the social, environmental and economic aspects of its work and to embed the implications of this understanding into business practice. In addition, sustainable development should be used as an opportunity to innovate, and create new business opportunities.

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SUSTAINABLE ARCHITECTURE AT THE CROSS-ROADS

Case Study of an Architectural Competition

by

Bengt Wallin, Architect SAR, PhD Candidate
Chalmers University of Technology, School of Architecture, Dept. of Built Environment and Sustainable Development (BeSus), S-412 96 Göteborg, Sweden
e-mail: bengt.wallin@arch.chalmers.se

INTRODUCTION - THE CASE AND THE RESEARCH PROJECT

The case here reported is a building project called "Universeum", designed to be a Science Center, a major pedagogical establishment, as well as a tourist attraction. It is erected on a site at Korsvägen ("the Crossroad") in Göteborg, Sweden. The commissioner of the building is a foundation, the members being the City of Göteborg, the municipalities of the Göteborg region, the University of Göteborg, Chalmers University of Technology and West Sweden Chamber of Commerce and Industry.

The overall aim of this project is to awaken the interest of young people - and especially girls - in technology and the natural sciences, thus, encouraging them towards studies and professional lives within this field. In these pedagogical efforts, an understanding of the environmental perspective is emphasised.

The building has a programmed area of around 7.000 m2, and the expected number of visitors per year is some 600.00. The project, thus, is a considerable investment (>320 MSEK - some 40 Million Ecu). In a Business Plan, the proprietor expressed as the basis for environmental issues: "The building should be attractive and a symbol of its content; a path-finder to the future. Of course, the ecological perspective will, therefore, be central. The building will become an example of sustainable techniques in an urban environment."[1].

Researchers from the Universities' joint School of Environmental Sciences have participated in three phases of the project: 1) By writing an appendix on environmental issues for the architectural competition programme, February 1998; 2) By participating as experts to the jury in the classification of the competition proposals, August 1998; 3) By constituting a reference group consisting of five researchers, to be advisors to the proprietor in securing the fulfilment of the environmental aims of the project, from September 1998 to May 2000.

The process of environmental ajustment in the project is now being evaluated by the author of this paper, with the aim of summing up and reporting the experiences to the participating parties, and later on, discussing them in a licentiate thesis.

In this paper, a tentative report will be given from the case study. The report is dealing only with the earliest building design phase, the architectural competition.

THE COMPETITION AND THE COMPETITORS

As a conspicuous piece of town architecture, the "Universeum" was decided to be the object of an architectural competition. 51 firms showed their interest in a prequalification application according to EU procurement rules. When selecting architects to be invited, the prioprietor was assisted by the municipal Town Planning Office and Chalmers University of Technology, School of Architecture. In a statement accompanying their recommendation of 6 architects, Chalmers wrote: "The undersigned have chosen not to separate architectonic and ecologic competence, as we understand the future being that these two must go hand in hand and constitute each other's prerequisite."

THE PROGRAMME

In the architectural competition programme, the general ambition from the Business Plan to design an environmentally ajusted establishment was interpreted in this way:

"The building, as well as the surrounding grounds, shall fullfil rigorous demands for sustainable system solutions to energy supply, resource economy, a healthy indoor climate, etc. ..... The project shall, by means of architecture, show the meaning of a sustainable future, and it shall be attractive for a long time. ... the future technology built into it must have a high degree of news value and have lasting qualities." [2]

The commissioner invited researchers from the School of Environmental Sciences to transform this into an appendix to the Competition Programme. Co-ordinating the group was an architect and researcher, who acted as an advisory "environmental co-ordinator" from this phase on. In three pages, entitled "Sustainable Architecture", the programme appendix manifested imperatives of: the sensitive forming of "green spaces", the extensive capturing of energy on site, effective water and material economizing, a healthy indoor climate and conscious land use and managing of nature values of the site.

No figures were set as targets - the extent to which systems and measures should be implemented, or the more exact results to be reached, were left to the architects to propose. Thereby, the environmental programme could be seen as a set of guidelines more than specific demands, leaving for the architects to unfold their professional skills in developing an architectonic combination of the functional programme and the environmental imperatives.

As a complement to the programme documents, the task was presented to the competitors in a whole-day-seminar, where the environmental issues were given a 20 minute presentation. Very few questions on this subject were put forth by the competitors.

THE CLASSIFICATION

The classification was made by a jury, assisted by two expert groups: One being part of the proprietor's staff, having formulated the function programme, with the task of assessing the proposals' functional fulfilment, and the other being the group of researchers with the task of environmental classification.

The researchers' assessment was systematically accounted for in a written public statement, grounded on a memo reserved for the jury. The assessment was carried out on the basis of a systematic comparison of the proposals of the programmatical guidelines, and thereafter, summed up by classifying the proposals according to three categories - "System connections", "Site " and "Symbol" - each being subdivided into characteristics and applied to the proposals by judging these as "more" or "less" fulfilling the characteristics. In a table according to this scheme, the "mores" were assigned with a cross.

In this way, the proposals were classified into three groups: I) High degree of fulfillment of the characteristics and a high potential for development (three proposals), II) low degree of fulfillment and hard to develop (two proposals) and III) low degree of fulfillment and no potential for development (two proposals).

Interesting to note from this group's classification is that not only "ecological" measures were taken in consideration. The researchers made statements not only as to environmental adaptions but to architectural qualities, when assessing some characteristics in the category "Symbol". For example, the characteristic "Also for grown-ups" is defined as "An open house for everybody, yet self-evidently appealing primarily to children ". In so doing, the group obviously "trespasses" the main jury's territory and does not act as solely "environmental experts", but takes a more holistic attitude towards its assignment.

In it's statement, the main jury adds no arguments on ecological issues, but refers briefly to the assessment of "the ecological group", in one sentence per proposal. The winner selected was one of three in group I of the ecological assessment - not the one recommended by the "ecological jury", though.

EXPERIENCES OF THE COMPETITORS

In autumn 1999 - a year after the competition - interviews were made with a majority of the competing architects.

Architects whose proposals were classified as having "low fulfilment and no potential for development" seemed, in the interviews, to be somewhat undecided concerning the "paradigm" of sustainable architecture. One participant has so far not been willing to give an interview, being of the opinion that the ecological aspects were treated " religiously" by the ecological group. Some others had the opinion that the ecological aspects were over-emphasized in the competition.

One architect, having been placed in the group of "high fulfilment and high potential for development", was one who for many years had successfully dealt with ecological issues, and who declared these aspects to be a self-evident part of the work in all his projects, whether the client asks for it or not.

The overall impression of the interviews is that the field of building for a sustainable development, to the architects is a matter of discussion and of differing attitudes, and still not is an evident part of their profession.

EXPERIENCES OF THE ENVIRONMENTAL CO-ORDINATOR

In an article titled "Sustainable Architecture at a Crossroads", the environmental co-ordinator has reflected on his participating in the project. [3] As to the adequacy of the competition form for "achieving innovative environmental architecture and enhance learning", he states: "Yes, but under certain conditions", one being that "the environmental programme should not be attached to, but integrated into the main programme."

As to the dissemination of knowledge, he sees this competition as not being effective, since four out of seven competitors were seen by the "environmental jury" as not having properly treated the environmental aspects. He suggests that these aspects should not be a competitive part, but "rather a common base for all participants", the role of an environmental co-ordinator then being the one of a teacher - to the proprietor, the jury and the competitors - rather than a "deliverer of demands".

DISCUSSION - RESULTS - CONTINUED RESEARCH

In this architectural competition, issues of environmental adaptation and system solutions were treated as being a field for experts. An expert group was called in to write an environmental programme. This programme was appended to the competition programme, which can be seen as underlining the expert or "special issue" character. In the classification of the competition proposals, the environmental research group was asked for a separate assessment of the environmental performance of the proposals.

The architectural competition shortly accounted here is the prefatory but most decisive part of a design process that will be studied in its entirety in the ongoing research project. The studies are expected to contribute to a discussion of how to plan and implement buildings with a "high environmental profile", and what could be the purport of this notion.

The results indicate a couple of important questions to be part of the continued evaluation:

To what extent is sustainable building seen, in the project as a whole, as a field for experts, rather than a common multi-diciplinary task for the proprietor and the consultants? How was the process affected by the approach to this issue?

... AND THE WINNER WAS ...

The competition was won by the well-established office (in Göteborg) of the Swedish architect Gert Wingårdh.

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Construction Related Sustainability Performance Indicators

theory, methodology & initial application

C. J. Walsh B Arch MRIAI MIBCI MIFS AIFireE

Chief Technical Consultant
Sustainable Design International

51 Auburn Hill, Aughrim Street, Dublin 7, Ireland
phone : + 353-1-838 6078 fax : + 353-1-838 6078
e-mail : cjwalsh@sustainable-design.ie

website : www.sustainable-design.com

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1. Introduction

The big picture on this planet, and the long-term goal over the next century in Europe, is the conversion to **sustainable human and social development** , i.e. the creation of a sustainable 'built environment' within a flourishing 'natural environment', each co-existing with the other in harmony and dynamic balance, and each in their own way, capable of providing for responsible and equitable human, social, cultural and economic development.

The 1998 European Charter on Sustainable Design & Construction [a] has placed special emphasis on implementation through informed use of **construction related sustainability performance indicators** , i.e. setting targets and monitoring 'real' performance in the built environment, which includes buildings, civil engineering projects, transport, service support systems, and infrastructure.

In particular, Principle 26 of the European Charter states ....

' Harmonized short, medium and long-term strategies in the policy areas of energy efficiency, environmental protection and sustainable development should be planned for implementation in the European Union over the following time frames :-

(i) up to 2010 ; (ii) between 2011 and 2040 ; (iii) between 2041 and 2100.

Such is the threat to quality of life and human progress caused by current environmental degradation, and such is the great timelag between implementation of corrective actions and resulting beneficial environmental impacts, that sustainability performance should be benchmarked at year 1990 in the Member States of the E.U.

Detailed performance indicators for all stages of design, construction / de-construction, maintenance and disposal should be used to target improvements in sustainability performance, verify target attainment, and continually re-adjust targets at appropriate intervals thereafter. '

This paper examines the theory and methodology of sustainability performance indicators for the European construction sector, and reports on the preparatory phase of an initial 'real' application in a mixed housing/industrial/commercial project in Ireland. The commencement of a related international study co-ordinated by CIB Working Commission 82, and the establishment of the E.U. 'CRISP' Thematic Network in June 2000, are also discussed.

2. Overview of the Long-Term Goal in Europe

- **Arriving at a Consensus on 'Sustainable Human and Social Development'**

  Europe must now decide whether its own future development, and its relationships with other global regions, will take the course of ....
  (i) 'business as usual' **;**
  (ii) 'business as usual - but with a little cosmetic tinkering at the edges' **;**
  (iii) 'sustainable human and social development' .

  The 1998 European Charter on Sustainable Design & Construction raises the issues which must be addressed, and the manner in which decisions should be made.

- **A Futures Scenario for Europe**

  The European Union already has an existing, highly evolved legal base which underpins an extensive array of policies and actions relating to energy, environment, sustainable development and social concerns. Together with regional specific, legally binding commitments arising from the 1997 Kyoto Protocol [b], Europe is well placed, and morally bound, to produce a comprehensive 'sustainability' strategy for the next century, with its core values being social justice and inclusion. The Amsterdam Treaty [c] makes the formulation of this strategy imperative.

- **Action Programme on Sustainable Design and Construction for the 21st Century**

  Critically, emphasis must be placed on creative planning, flexible implementation, reliable monitoring and targeting of performance, and effective management. Each function should be competently exercised.

  Essential components in the Action Programme are ....
  (i) an elaboration of appropriate, detailed construction related sustainability performance indicators - at European, regional and local levels **;**
  (ii) practical design guidance **;**
  (iii) the production of a sharp, focused construction and technical control research agenda.

3. Primary Purpose of Sustainability Performance Indicators

The primary purpose of Construction Related Sustainability Performance Indicators is to allow the construction sector to commence, in earnest, the practical task of implementing a sustainable approach to the future development and modification of the 'built environment' in Europe, while also playing its part in ensuring a flourishing future for the 'natural environment' by carrying out sufficient repair to past, present and potential future damage directly or indirectly caused by construction.

- Principle 26 of the 1998 European Charter on Sustainable Design & Construction intimated that a futures scenario should be developed which would cover the short, medium and long-terms until the end of the next century **;**
- Using this futures scenario, incremental improvements in construction performance required to achieve a sustainable 'built environment' within a flourishing 'natural environment' may then be plotted. The focus of attention, throughout, must be on 'real', rather than theoretical, performance. See **Appendix A** for an example of one method of measuring 'real' performance in buildings [d] - long wave (8 to 12 microns) infra-red thermography **;**
- Construction related sustainability performance indicators, 'harmonized' for application in the European Union, allow us to target, reliably quantify and monitor construction performance in the built environment which, by general international agreement, has been benchmarked at 1990 levels. Rigorous procedures are required to process the data generated in order to ensure that it too is reliable - see **Appendix B** for one example of such a procedure **;**

A secondary, short term purpose in Ireland will be to develop a Sustainability Label Award Scheme for buildings - a major departure from existing methods of energy and/or environmental rating. Based on the understanding of 'sustainable development' which is current, and generally held, at a particular time, this will allow an objective statement to be made about any individual building, facilitate comparison between different buildings, and also indicate more favourable approaches in the building design process itself. See **Appendix H** .

4. Sustainable Development

'Sustainable Development' was defined in 1987 [e], as ....

' development which meets the needs of the present without compromising the ability of future generations to meet their own needs ' .

However, with the benefit of twelve year's hindsight, a more evolved understanding of 'sustainable development' should also embody the following concepts :-

- the place of human beings in the environment, and the relationship between both **;**
- the nature of human, social, cultural and economic development, their current imbalances and inequities, and their future course **;**
- the healing of existing harm and injury to the 'natural environment'.

It is important to distinguish between the natural environment, and the 'built environment', i.e. anywhere there is, or has been, an intrusion or intervention by a human being in the natural environment. The 'built environment' may be urban, sub-urban, rural or marine **;** it includes buildings, civil engineering projects, transport, service support systems, infrastructure, etc.

Principle 1 of the Rio Declaration on Environment and Development [f] states ....

' Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.'

And the World Health Organisation, in the preamble to its Constitution, defines 'health' as ....

' a state of complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity '.

The 1994 Energy Charter Treaty [g] provides us with some useful definitions ....

Energy Cycle :

' The entire energy chain, including activities related to prospecting for, exploration, production, conversion, storage, transport, distribution and consumption of the various forms of energy, and the treatment and disposal of wastes, as well as the decommissioning, cessation or closure of these activities, minimising harmful environmental impacts. '

Environmental Impact :

' Any effect caused by a given activity on the environment, including human health and safety, flora, fauna, soil, air, water, climate, landscape and historical monuments or other physical structures or the interactions among these factors **;** it also includes effects on cultural heritage or socio-economic conditions resulting from alterations to those factors. '

As we near the end of the 20th Century, a small, but growing, popular consensus in Europe is finally acknowledging that in order to accommodate further human and social progress, with an assured minimum quality of life and health for all peoples, harmony between global regions, and world economic stability, it will be necessary to convert from current irresponsible patterns of human and social development, with their attendant wasteful environmental destruction and societal stresses.

However, it may take another 7-10 years before the concept of 'Sustainable Development' is either fully, or commonly, understood.

5. Unrestrained Activity in the 'Developed' World

The 'developed' world has long been characterized by an enormous consumption of resources. It was estimated, in 1998 [h], that 20% of the world's population in the highest income countries consumed 58% of total energy, while the poorest fifth consumed less than 4% - and that the burning of fossil fuels had almost quadrupled since 1950. A vast amount, therefore, of 'capital' has already been invested in this small part of the world. European cities, if we can ever clearly establish their boundaries anymore, represent but a small percentage of its land area.

In stark contrast, a similarly vast amount of natural resources have been 'requisitioned' and plundered from the 'underdeveloped' and 'developing' worlds in past centuries - and it continues to this day. As much of the adverse environmental impact arising from energy production occurs during the early stages of the cycle, countries in these global regions have been burdened with devastation of natural environments, and an accumulation of wastes, emissions and pollution associated with extraction.

6. Limitations of 'Kyoto' as a Driving Force Scenario

The Kyoto Protocol - agreed at the 3rd. meeting of the Conference of the Parties (COP 3) to the United Nations Framework Convention on Climate Change in Kyoto, Japan during December, 1997 - for the first time set legally binding targets, at international level, for different regions of the 'developed' world to limit emissions of an aggregate of six more greenhouse gases **:** CO_2 , CH_4 , N_2O , PFC's , HFC's , and SF_6 . However, limitation of greenhouse gas emissions is only one aspect of performance which must be targeted - a point specifically mentioned in the Presidency Conclusions [j] of the Cologne European Council (June, 1999) .

In the European Union, political commitment of the Council, a clear legal basis in recent legislation, the urgent assignment of the Commission to implement policies on sustainable development, more balanced economic progress, social justice and inclusion, etc., and strong public support for such policies, are generating sufficient pressure to force a radical change of pace on what is still a traditional, inefficient and wasteful major industrial sector - construction. Sustainability performance targets for the 'built environment' must now be set down, monitored, and stringently controlled.

It is important, therefore, to produce a futures scenario in order to clarify the nature of the task in front of us, the actions and timescales required, and the paths to be taken. The following areas should be examined in such a futures study which will cover short, medium and long-terms up to the year 2100, with performance benchmarked back to 1990 levels ....

- Methods of effectively conserving energy which is derived from natural resources **;**
- Cleaner energy from existing sources **;**
- Introduction of the next generation energy sources, e.g. nuclear fusion **;**
- Extension and enhancement of carbon sinks & carbon technologies **;**
- Innovative 'SEED' technologies, covering production and services **;**
- Control of ozone depletion / global warming gases, and the attainment of atmospheric integrity **;**
- Achievement of social justice and inclusion for every 'person' in society **;**
- Enhancement of the 'natural environment' by means of sufficient human repair to past injury in order to encourage a process of self-healing, and self-management.

See **Appendix C - 'New Earth 21' Strategy** for the region of Europe (based on Japanese work [k] from the early 1990's) .

7. Our Responsibility - To Target Sustainability Performance

At global level, the Implementation Plan for the United Nations Commission on Sustainable Development (UNCSD) Work Programme on 'Indicators of Sustainable Development' is now in its 3rd Phase **:** January 1998 until January 2001. An initial <u>Working List of Indicators</u> [l] has already been produced which is intended for global application. It is, therefore, necessarily general in nature (and not at all construction related) . These indicators cover four aspects of Sustainable Development, i.e. **Social** , **Economic** , **Environmental** , and **Institutional** , and are presented in a **Driving Force - State - Response** framework ; trial application is taking place in four global regions : Africa, Asia & Middle East, Europe, Americas & Caribbean .

See **Appendix D - Fundamental Matrix** of construction related sustainability performance indicators.

8. A Reasonable Target for the Construction Industry in Europe

Encouraged and 'incentivized' by institutional and administrative frameworks at E.U., regional and local levels, a reasonable target for construction related performance, in the short term, must be to meet the criterion of 'economic viability and technical feasibility', based on accurate life cycle costing, and using proven state-of-the-art technology which is readily available in the European marketplace. Anything less is unacceptable.

EN ISO 14040 [m] defines **Life Cycle Assessment** as follows ....

> ' Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product (and/or service) system throughout its life cycle. '

9. 'Life Cycle' of a Building

The many actors and disciplines involved in the European construction industry each have their traditional views and opinions concerning the different stages, and the duration, of a building's life cycle. Generically, however, we may identify the following ten segments in a complete cycle ....

- Expressed needs / wants / desires / requirements of the client **;**
- Planning brief and performance specification for the building **;**
- Site analysis and evaluation **;**
- Design **;**
- Preparation for construction **;**
- Construction **;**
- 'Early life' of the building in use - including management, maintenance, servicing **;**
- Adaptable 'middle age' of a building in use - including renovation, refurbishment, modification, alteration, and extension **;**
- De-Construction **;**
- Disposal .

With adequate emphasis placed on 'adaptability' throughout the design stage of a building, and quality of construction on site, it must be a requirement - to realize the target of a sustainable 'built environment' - that the duration of that building's life cycle will be in the order of ....

for structure	100 – 200 yrs **;**
for the building fabric	50 – 100 yrs **;**
for services	20 – 30 yrs **;**
for furniture & fittings	10 – 20 yrs .

10. A Proper Basis for Harmonized E.U. Indicators

Initially, those areas of construction related performance which are particular to regional, climatic and site conditions in the many different parts Europe, or are of concern to people in those areas involved in the design, construction, servicing, maintenance, use and/or de-construction of buildings, should be closely examined. Potential means for encouraging / 'incentivizing' implementation at these levels should also be investigated, e.g. financial instruments, development/management computer tools, planning, design and construction guidance, institutional reform, streamlining of legislation, etc.

The development of a national bank of construction related data and statistics in each Member State, which will feed directly into the framework controlled and managed by Eurostat in Luxembourg, will be a necessity. All statistics gathered should be impartial, reliable, objective, scientifically independent, cost-effective and statistically confidential [n] - E.U. Amsterdam Treaty.

Work at regional / national, and local levels will provide a proper basis for the later production of 'harmonized' E.U. sustainability performance indicators. See **Appendix E** for the beginning of this process in Ireland. The Forum on Sustainable Construction, established in the winter of 1997, comprises representatives from Irish industry, the design professions, the national building research organization, education, and public bodies. Since a meeting in Barcelona, during December 1998, similar studies have commenced in other countries around the world which are being co-ordinated by CIB Working Commission 82 **:** 'Futures Studies in Construction'. The establishment, in June 2000, of the E.U. 'CRISP' Thematic Network has given this entire area of research a very firm foundation.

11. Adaptation of Existing Buildings & Urban Districts - Particularly Those of Cultural, Historical or Architectural Importance

A major challenge for the European construction industry, in the short term, will be the refurbishment / modification / alteration / extension of existing building stock, and derelict or contaminated lands in urban centres. By the year 2010 in Ireland, for example, houses built before 1980 (representing just 50 % of total housing stock) will account for 80 % of that market segment's energy consumption.

With regard to buildings of cultural, historical or architectural importance, the difficulty is increased because of the absolute necessity of respecting the original integrity of the building - consult the Venice Charter [o]. Our aim here must be to protect and conserve, but also to sustainably exploit the wealth and value of cultural heritage as an important ingredient in 'social wellbeing'.

12. Construction Related Sustainability Performance Indicators

Some examples of the wide range of required urban sustainability performance indicators, which must be mutually compatible across all fields of design, construction and logistics, might be as follows ....

- Unit area of derelict land / buildings in an urban area, per person **;**
- Impact of an urban area on global climate **;**
- Periods during which external air quality in the city adversely affects human health **;**
- Quantity of wastes, per person, generated, re-used, recycled, and finally disposed **;**
- Use / consumption of energy, per person **;**
- Use / consumption of water, per person **;**
- Maximum distance travelled (un-aided) to nearest transportation node **;**
- 'Social wellbeing' of neighbourhoods in a city (long term unemployment, homelessness, numbers of people below the poverty line, or living in inadequate housing, 'fuel poverty', etc.) **;**
- Rates of crime / anti-social behaviour **;**
- Life expectancy of inhabitants & rates of illnesses, accidents and fatalities **;**
- Percentage of construction costs required to be expended on incorporating works of art **;**
- Reliability, accessibility, efficiency and affordability of public services **;**
- Accessibility and health / safety of an urban environment for people with disabilities **;**
- Quality of public open spaces **;**
- Free access to activities / institutions of cultural, artistic or historical interest **;**
- Transparency of city governance & 'meaningful' participation of the citizen.

See **Appendix F** - initial application of a sample of indicators (building related) in a mixed use development project in Ireland. Construction commenced in mid-2000.

See **Appendix G** - finished examples of some detailed building related sustainability performance indicators, in functional, performance and prescriptive formats, which are ready to be transposed into legislative instruments, standards, guidance documents, etc., at any level of the European Union.

Once a substantive body of 'harmonized' E.U. construction related sustainability performance indicators has been produced, the final objective will be to surgically insert these indicators into the framework of the existing UNCSD <u>Working List of Indicators</u> , already mentioned in **#7** above.

13. Sustainable Human and Social Development

Realistic implementation of a strategy for 'sustainable human and social development' in Europe will be a complex, phased, cyclical and iterative process **;** it will not be easy, and it will certainly involve considerable financial cost. To be gained, however, will be 'social wellbeing' - an overall state of health and happiness in society.

This option, for the construction industry, will be characterized by ....

(i) Consensus, on a common understanding of sustainable human and social development, by all elements of this industrial sector - working in 'partnership' **;**

(ii) Establishment of a reliable, construction related databank in each E.U. Member State - which will interlink directly with Eurostat in Luxembourg **;**

(iii) Completion of the Fundamental Matrix shown in **Appendix D** - at all appropriate levels **;**

(iv) Meeting initial construction related targets - and then reviewing, re-adjusting and improving the next round of indicators based on 'real' performance feedback **;**

(v) Continual repetition of the above 'indicator' cycle **;**

(vi) Introduction of a wide range of positive incentives to encourage acceptance, by all elements of the construction industry, of the necessary burdens and change in practices required to convert to sustainable design and construction **;**

(vii) Substantial E.U. <u>and</u> national expenditure on construction and technical control related research, and on practical implementation guidance, training and education **;**

(viii) Dramatic improvement in construction related education programmes, at all levels, throughout Europe - to develop creative and flexible thought, and to instil a 'person-centred' and 'socially inclusive' approach in the planning / design / construction of a sustainable 'built environment' **;**

(ix) Protection of cultural heritage - <u>and</u> 'indigenous' architecture and methods of building.

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15. Appendices

A Long Wave (8 to 12 microns) Infra-Red Thermography - Sample Exterior and Interior Views
B Technical Guidance Note No. 95/101 - Energy Survey Reports
C A Futures Scenario for Europe - 'New Earth 21' Strategy
D Fundamental Matrix of Construction Related Sustainability Performance Indicators
E Commencing the Process at National Level
F Initial Application of Indicators in Ireland - Building Related Sample
G Selection of Finished Sustainability Performance Indicators
H Sustainability Label for Buildings

CONSTRUCTION ECOLOGY AND METABOLISM

Charles J. Kibert, University of Florida, PO Box 115703, Gainesville, Florida, 32611-5703 USA

INTRODUCTION

The built environment interacts with the natural environment at a variety of scales, from individual structures affecting their local environment to cities impacting the regional environment. This "constructed" ecology has in turn created an ecological illiteracy and has had profound psychological and human health impacts (Orr, 1994). The extended chain of responsibility and the separation of responsibilities for manufacturing materials, design and construction, operations and maintenance, and eventual adaptation or disposal, have resulted in a breakdown of feedback loops among the parties involved in creating and operating the built environment. Although the design life of modern buildings is typically 50 to 100 years, their service lives are unpredictable because their major component parts wear out at different rates, complicating replacement and repair schedules. Stewart Brand describes these variable decay rates as "shearing layers of change" that create a constant temporal tension in buildings (See Figure 1) (Brand 1994). Faster cycling components such as Space Plan elements are in conflict with slower materials such as Structure and Site. Management of a building's temporal tension might be achieved with more efficient use of materials through spatial decoupling of slow and fast components. Components with faster replacement cycles would be more readily accessible. This hierarchy is also a hierarchy of control, with the slower components controlling the faster components. However, when the physical or technical degradation of faster components surpasses critical thresholds, they begin to drive changes in the slower components such that dynamic structural change can occur. For example, in a typical office building, electrical and electronic components wear out or become obsolete at a fairly high rate compared to the long-lived building structure. At some critical threshold the motivation to maintain the overall building ebbs and the building rapidly falls into disuse and disrepair due simply to the degradation of the faster, more technology dependent components.

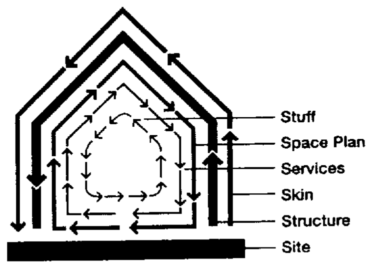

Figure 1 Shearing layers of change indicate turnover rate of building components

Efforts to close the materials cycle in construction are hampered by many of the same problems facing other industries. The individuality and long life of buildings pose some additional obstacles when considering the potential for closed loop materials cycles for the built environment:

1. Buildings are not currently designed to be eventually disassembled.
2. Products comprising the built environment [transformers, air handlers, doors, windows] are not designed for disassembly.
3. The materials comprising building products are often composites that make recycling extremely difficult [plastic-laminated wood, plastic coated wiring, co-extruded plastics].

These difficulties also increase resource consumption because some building components require frequently replacement. Buildings may experience different uses during their lifetimes and they periodically undergo renovations or modernization. In each case the inability to readily remove and replace components results in significant energy inputs to alter building systems and large quantities of waste.

LESSONS FROM NATURAL SYSTEMS

The primary lesson construction industry can learn from nature is to cycle its materials in a closed-loop manner, the goal being a 'zero waste' system. This could be achieved by designing all components from recyclable materials and for quick disassembly. For example, when its useful life has ended, an air handler in a large commercial building would be returned to its producer who would then be able to quickly separate all steel, copper, and aluminum components for recycling, compost the organic insulation, and throw away essentially nothing. Building structural elements would be designed to be unpinned or unscrewed rather than demolished in place. Integrated with a similarly functioning industrial system, builders and manufacturers of building materials and products would exchange resources with automobile industry, computer chip manufacturers, and consumer products on an as-needed basis. The outcomes of applying these natural system analogues to construction would be a built environment [1] that is readily deconstructable at the end of its useful life; [2] consists of components that are decoupled from the building for easy replacement; [3] is comprised of products that are themselves designed for recycling; [4] whose bulk structural materials are recyclable; [5] whose metabolism would be very slow due to its durability and adapatability; and [6] that promotes health for its human occupants.

DEMATERIALIZATION

Some have suggested that buildings, like other human systems, need to be 'dematerialized', that is the quantity of materials used in their production and operation has to be significantly reduced. The Wuppertal Institute, a German environmental think-tank, is leading international efforts to dematerialize human activities. They suggest that the 'materials intensity per service' [MIPS] must be reduced by a factor of 10 to move into a regime that could be considered sustainable (von Weiszäcker 1997). Dematerializing construction by a factor of 10 may not, in all cases, be the optimum strategy. Building mass for energy storage is often a prerequisite for being able to take advantage of passive heating and cooling opportunities presented by the local climactic regime. Heavy materials such as rammed earth, adobe, concrete, granite, and other similar materials have a long tradition of use in construction and are often connected to vernacular architecture, thus also representing to some degree the culture of a region. Focusing on building longevity, durability, adaptability, deconstructability [making buildings readily able to be disassembled], recyclability, and the social/cultural impact of the building can greatly decrease the throughput of materials even if the actual mass of buildings is unchanged.

INDUSTRIAL ECOLOGY AND DESIGN FOR THE ENVIRONMENT

industry is beginning the first steps in formalizing some of the strategies that would create benign processes, close materials loops, and make industrial systems mimic and integrate with natural processes. Industrial Ecology and Design for the Environment are two of the leading efforts in this movement. Industrial Ecology can be defined as the application of ecological theory to industrial systems or the ecological restructuring of industry (Rejeski, 1997). In its implementation it addresses materials, institutional barriers, and regional strategies and experiments. One major direction of Industrial Ecology is the optimization of materials flows by increasing resource productivity or dematerialization. The notion of a service economy, alternatively referred to as 'systemic dematerialization,' which sells services instead of the actual material products, is considered the sine qua non of this strategy.

An emerging discipline, Design for the Environment [DFE] has as its goal the creation of artifacts that are environmentally responsible. DFE can be defined as a practice by which environmental considerations are integrated into product and process engineering procedures and that considers the entire product life (Keoleian, 1994). This proactive approach to creating artifacts that can be readily adapted, removed, reprocessed, recycled and reused, embodies the concept of "front-loaded" design (Wilson, 1998). Front-loaded design is simply insuring the end-of-life fate of artifacts is not waste but other artifacts. Applying Industrial Ecology and DFE to buildings is the cornerstone of Construction Ecology. Relative to buildings, Industrial Ecology underpins Construction Ecology by providing a framework for the construction materials and products industry to follow to place its activities on a sustainable path. As products of service, all building components could be leased to the owners and be returned to their manufacturers when obsolete, worn-out, or needing replacement. Architects and engineers would design buildings with decoupled systems that allow ready removal at periodic intervals and for large scale deconstruction when necessary for economic or planning purposes.

CONCLUSIONS AND RECOMMENDATIONS

A new concept for materials and energy use in construction industry is needed if sustainability is to be achieved. Construction Ecology can be considered as the development and maintenance of a built environment [1] with a materials system that functions in a closed loop and is integrated with eco-industrial and natural systems; [2] that depends solely on renewable and recyclable materials, and [3] that fosters preservation of natural system functions. The result of a shift toward Construction Ecology creates a host of issues and problems to be resolved. Can construction be readily dematerialized by a factor of 10? What lessons from natural systems are feasible for application to the built environment? What are the roles of synthetic materials in Construction Ecology? How can construction materials production and recycling be integrated with the other components of the industrial production system? These are all difficult questions that must be answered to move forward into an era approximating sustainability in the built environment.

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ENERGY-RELATED PROPERTIES OF BUILDING ENVELOPES IN ENVIRONMENTAL OPTIMISATIONS

Jan Tywoniak, Assoc. Prof., CEng., PhD, Czech Technical University Prague
Thákurova 7, 166 29 Praha 6, Czech Republic, TYWONIAK@FSV.CVUT.CZ

It is essential to use realistic values on every level of environmental assessments of buildings. This paper presents the effects of irregularities in building envelopes. Results of detailed analysis using 2D combined heat transfer model are compared with laboratory measurements and with investigations of buildings. Additional heat flows can be interpreted as thermal bridges.

INTRODUCTION

The evaluation of energy-related properties of building envelopes has become an integral part of every environmental assessment. The use of realistic material data (thermal transmittance, useful thermal capacity, etc.), realistic utilisation factor of heat distribution system together with a realistic estimated service-life of each building element is very essential.

IRREGULARITIES IN BUILDING ENVELOPES - NUMERICAL SIMULATIONS

The heat transfer through buildings envelope is calculated using thermal transmittances (U-value) of separate building elements. The effects of thermal bridges are usually expressed by the linear thermal transmittance (Ψ-value) and by the point thermal transmittance (χ-value). However, the additional effects of "small" irregularities (not correct installed thermal insulating boards, different cavities, open joints, fastening, etc.) should be taken into account, too. To identify these phenomena, detailed studies were performed using a model of the combined heat transfer by both, conduction and convection [2] - see *Fig.1, 2.*

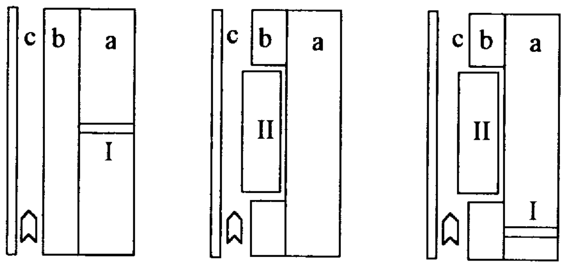


Fig.1 Scheme of studied construction - internal part of double skin facade with irregularities (a - load-bearing layer (200 mm concrete), b - insulating layer (100 mm mineral wool), c - ventilated air cavity, I - open joint with thickness of 1 mm, II - insulating board at a distance of 5 mm)

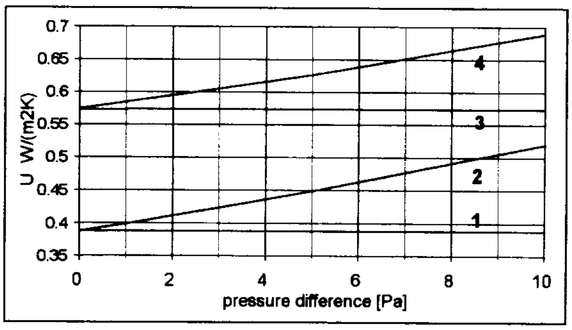


Fig.2 Thermal transmittance of constructions with irregularities corresponding Fig.1. Result of numerical simulation (1-ideal, 2-open joint in load-bearing layer, 3-insulating board at distance 5 mm, 4-combination: open joint + insulation without contact)

MEASUREMENTS AND OBSERVATIONS

The model of the internal part of a double skin facade (scale 1:1) with the artificially created irregularities was placed to the front side of the cold box. The surface temperature was investigated using both, thermocouples and infrared thermography. The temperature profiles in the area of irregularity looks similar for both situations presented here - (a) adjacent insulating boards at a distance of 16 mm and (b) open joint 1 mm in gypsum board - see *Fig.3*.

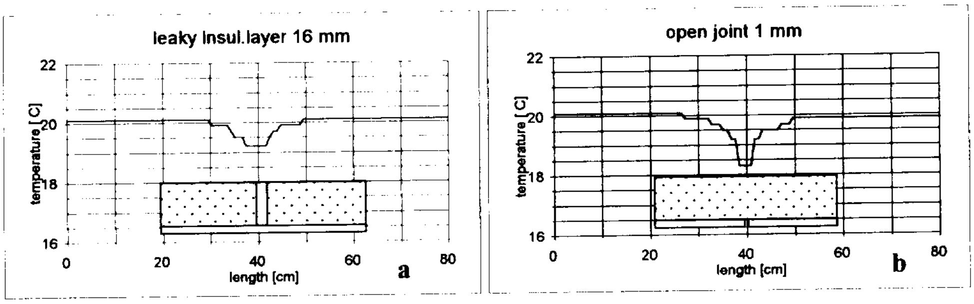


Fig.3 Internal surface temperature on 1:1 scale model of the internal part of a double skin construction with irregularities - laboratory measurement

a) gypsum board, 100 mm polystyrene with 16 mm distance between adjacent boards

b) gypsum board with 1 mm open joint, 100 mm mineral wool

INVESTIGATIONS OF BUILDINGS

Fig.4 illustrate the typical situations in buildings: The quality of the design (principle + detailing) and the workmanship is not corresponding to the architectural form. The measurements of the internal surface temperatures followed by the blower-door technique (artificial created air pressure difference by 50 Pa) were used to make all irregularities visible.

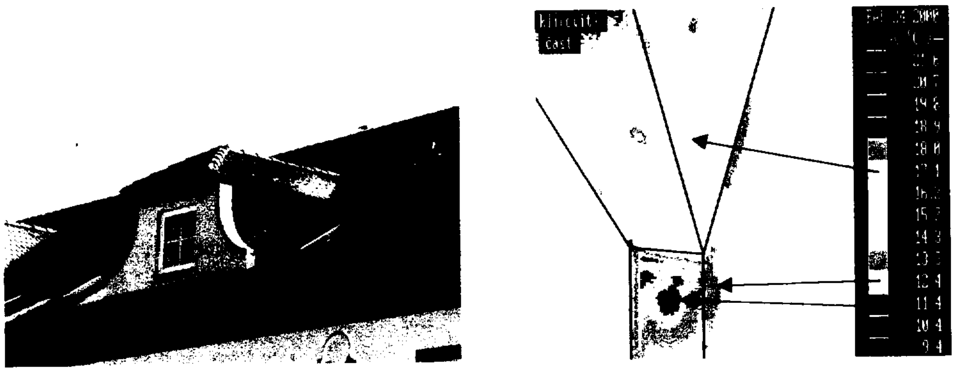


Fig.4 Example of investigations

a) Older building with new flats in attic – exterior view

b) Infrared picture of interior by 50 Pa air pressure difference - complicated shape in detail. Expected surface temperature according to the thermal transmittance declared in the design documentation (and used for sizing of heating system) is approx. 19 °C. Long-term problems of hygrothermal comfort, non-adequate energy use and resulting too high environmental load are the consequences.

DISCUSSION: IRREGULARITIES EXPRESSED AS THERMAL BRIDGES

The irregularities can be treated like thermal bridges (*linear thermal bridges* for open joints etc., *point thermal bridges* for not well placed boards). The commonly accepted approach (superposition) could be easily extended as follows:

$$L = \underbrace{\sum U_i A_i + \left(\sum \Psi_k l_k + \sum \chi_j\right)}_{\text{usual scheme [3]}} + \underbrace{\left(\sum \overline{\Psi}_k l_k + \sum \overline{\chi}_j\right)}_{\text{effects of irregularities}}$$

Corresponding data from the numerical studies presented here and in previous works [2] are collected in *Tab.1*. This method is to be used for: a) draft analysing of real situation on site, and b) creating safety factors related to the type of construction in the future.

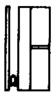
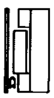
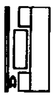
Irregularity	**Description** (assumed insul.boards 50 x 100 cm, 10 Pa air pressure difference)	**Additional linear thermal transmittance Ψ [W/mK]**	**Additional point thermal transmittance χ [W/K]**
	distance 5 mm between adjacent insulating boards	**0,18**	
	open joint (gap) in supporting layer 1 mm	for mineral wool **0,13** for EPS **0,01**	
	insulating board at distance 5 mm from supporting layer, cold air penetration		**0,14**
	insulating board at distance 5 mm from supporting layer, cold air convection		**0,27**

Table 1: Additional linear and point thermal transmittances of irregularities (first draft)

CONCLUSIONS

The environmental load due to embodied pollutants (for GWP: CO_2) in building envelope must be in co-relation to the reduction of emissions by operating of the building. Building physics could be therefore understand as an important tool on the way to sustainability – supposing all calculations are based on the realistic values.

To introduce the approach presented above into the daily practice, a further development is needed: an extension of *Tab.1*, study of the workmanship effects etc. The environmental consequences of other related phenomena, such as hygrothermal performance [1] and the real effects of the thermal accumulating mass should be analysed parallel.

ACKNOWLEDGEMENTS

Presented studies were supported by research projects VZ CEZ J04/98:2100005.

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ENERGY/CARBON INTENSITIES OF BUILDING MATERIALS AND LIFE CYCLE ASSESSMENT OF SI (SKELETON/INFILL) HOUSING

Kenji Yokoyama [1], Tatsuo Oka [2]
1) Deputy General Manager, Tokyo Gas Co., Ltd., 3-13-1, Minamisenjyu, Arakawa-ku, Tokyo, 116-0003, Japan
2) Professor, Utsunomiya University, 2753 Ishii-cho, Utsunomiya city, Tochigi-Prefecture, 321-0912, Japan

INTRODUCTION

According to research conducted by the Prime Minister's Office, the average life span of Japanese houses is 30 years compared to 80 to 150 years in European countries and the United States.

From this point of view, the concept of Open Building—called SI (Skeleton/Infill) Housing in Japan—has been attracting a great deal of attention among Japanese condominium builders and building researchers. The main definition of SI housing is to separate the skeleton (the structural part of the building) and the infill (interior and equipment) clearly, so that the interior part will be more flexible, thus able to correspond to the changes in the resident's lifestyle. Consequently, the building itself can be used longer and the environmental loads from the building will be reduced.

The Ministry of Construction, the Ministry of International Trade and Industry, the Urban Development Corporation and several contractors have researched and developed building components and equipment as well as the social systems that are suitable for SI housing.

In this study, energy and carbon emission intensities are derived from the 1995 input-output table in Japan. Using these intensities, a life-cycle comparison between conventional housing and SI housing has been done on energy and carbon emission.

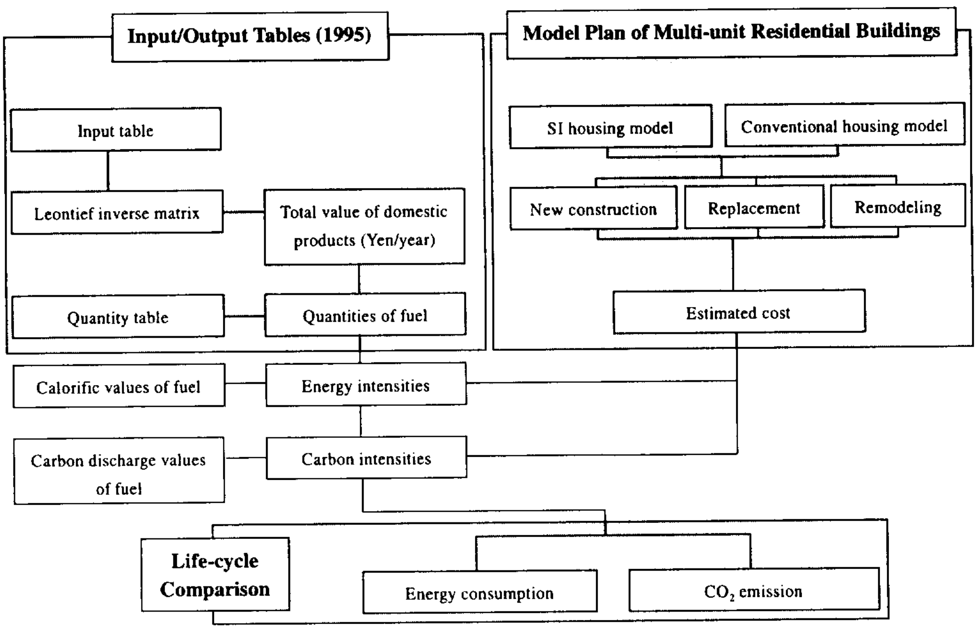


Fig. 1 Research flow chart

ENERGY/CARBON INTENSITIES OF BUILDING MATERIALS

An input-output table has been published in Japan every five years by the Management and Coordination Agency since 1955. The most recent one (1995 table) was published in May 1999. When demand of one million yen occurs in one industry, energy consumption and CO_2 emission caused by this demand will be calculated using the input table, quantity table, and calorific values and carbon discharge values per unit of each energy source (Table 1).

Table 1 Calorific values and carbon discharge values of energy source

Energy Source	Calorific Value (kJ/)	Carbon Discharge (kg /)
Coking coal	29,260 / kg	0.6920 / kg
Steam coal,	29,260 / kg	0.7228 / kg
Crude petroleum	38,720 / ℓ	0.7225 / ℓ
Natural gas	41,023 / m^3	0.5526 / m^3
Gasoline	35,162 / ℓ	0.6433 / ℓ
Jet fuel oils	36,418 / ℓ	0.6669 / ℓ
Kerosene	37,255 / ℓ	0.6896 / ℓ
Light oils	38,511 / ℓ	0.7212 / ℓ
Heavy oil A	38,930 / ℓ	0.7357 / ℓ
Heavy oils B and C	41,023 / ℓ	0.8016 / ℓ
Liquefied petroleum gas	50,232 / kg	0.8200 / kg
Coke	30,139 / kg	0.8856 / kg

Energy/Carbon intensities of major building materials per one-million-yen demand are shown in Table 2.

Table 2 Energy/Carbon intensities per one-million-yen demand

	Energy Intensity (MJ / one-million-yen demand)		Carbon Intensity (kg-C / one-million-yen demand)	
	Intensity of production process	Intensity including fixed property	Intensity of production process	Intensity including fixed property
Gravel and quarrying	51251	56520	962	1075
Plywood	26655	30363	504	584
Wooden furniture and fixtures	19881	23050	377	443
Metallic furniture and fixtures	31828	35553	637	715
Corrugated cardboard	85839	91425	1697	1815
Paints and varnishes	85296	89939	1629	1727
Gelatin and adhesives	92187	96624	1752	1845
Plastic products	74698	79746	1410	1516
Sheet glass and safety glass	61330	66308	1177	1281
Cement	347080	352556	15989	16106
Ready mixed concrete	89370	93693	3259	3351
Ceramic, stone , clay products	48518	52036	1015	1090
Hot rolled steel	172870	178428	3914	4032
Steel pipes and tubes	119941	125879	2674	2799
Copper	21613	24940	446	518
Lead, zinc (inc. regenerated)	95022	99868	2042	2146
Aluminum (inc. regenerated)	22425	24698	443	492
Electric wires and cables	35957	41109	686	798
Metal products for construction	52129	56143	1104	1188
Gas and oil appliances	37167	41096	764	846

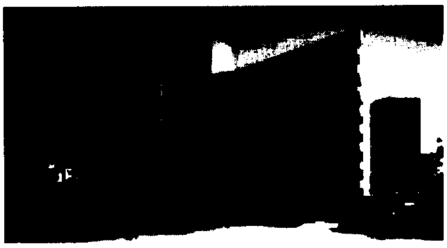
ESTIMATION OF LIFE-CYCLE ENERGY CONSUMPTION AND CO_2 EMISSION OF MULTI-UNIT RESIDENTIAL BUILDINGS (MURB)

A comparison of life-cycle energy consumption and CO_2 emission between a SI MURB and a conventional MURB was done. The model project is a Tokyo Gas corporate housing condominium built in 1998, and the actual cost data was used in the conventional MURB analysis. The building outline is shown in Fig. 2. Cost data based on the design and experiments of the Tokyo Gas Infill System were used for the SI MURB analysis.

The life cycle of the residents and the replacement / remodeling cycles are set according to the research of the Urban Life Research Institute of Tokyo Gas. A newlywed couple will start to live in the new apartment, 15 years later remodeling consisting of the addition of a room for a child will be done, 30 years later, remodeling that takes into consideration the advancing age of the residents will be done. Ordinary replacement will be carried out between the remodelings. Fifty years later, the conventional MURB will be demolished and rebuilt, but other newlyweds will continuously use the SI MURB and the same life cycle will be repeated over the next 50 years.

In this study, the energy and CO_2 caused by the residents' living (such as heating and cooling) are considered the same in both MURBs and those caused by the construction, remodeling, replacement, and demolition are calculated. As more concrete and reinforcing bars are used in the SI MURB, the initial amount of the energy and CO_2 is greater than that of the conventional MURB. However, in its 100-year life span, the energy and CO_2 of the SI MURB will be 23 percent and 25 percent less than those of the conventional one, respectively.

Although this case study has been done on only one building, the possibility of a reduction in the environmental load with SI housing can be suggested.



Number of units: 90 units
Number of floors: 9 stories
Floor area / unit : 65 ㎡
Structure: RC

Fig. 2 Outline of Tokyo Gas corporate housing condominium

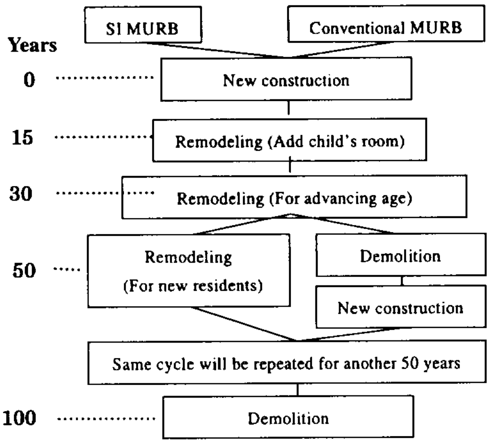


Fig. 3 Life cycle of the MURBs

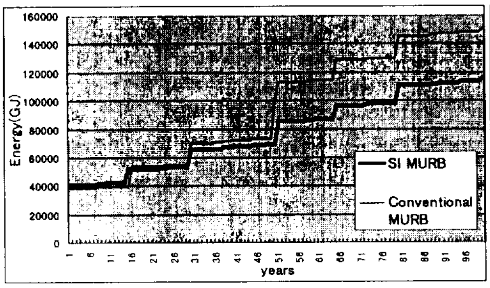


Fig. 4 Energy consumption comparison

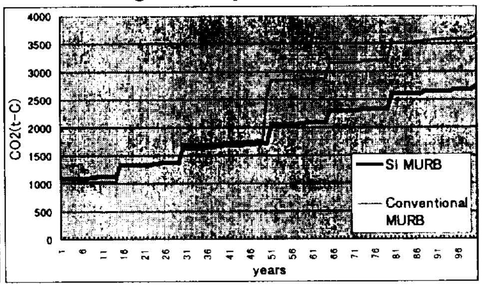


Fig. 5 CO_2 emission comparison

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CONSTRUCTION MATERIALS AND SUSTAINABILITY, THE LIMITATIONS ON PRESENT METHODS OF SELECTION.

John Sturges and Robert Lowe,
School of the Built Environment, Leeds Metropolitan University, UK.

INTRODUCTION

The construction industry is a huge, and increasing consumer of materials both in the UK and world-wide. Total materials 'take' by all industries currently runs at over 10 billion tonnes per annum, with construction responsible for around 80% of that amount. Construction uses a wider range of materials than almost any other industry, including metals, ceramics, plastics, natural materials such as timber and natural stone, etc.

Construction materials are not particularly high-technology type, neither are they expensive. Compared with other industries, the materials of construction are, in general, among the cheapest. They are not high embodied-energy materials. This is shown in Table 1 below.

Table 1. Embodied Energies of Construction Materials.

Material	Embodied Energy (MJ/kg)
Hard and Softwoods	1.8 - 4.0
Concrete	3.0 - 6.0
Bricks	3.4 - 6.0
Stone	1.8 - 4.0
Cement	4.5 - 8.0

SUSTAINABILITY

The terms green, sustainable and sustainability have become very widely and indiscriminately used in the past decade. It is important to be exact with use of language and so these terms will be defined.

The term 'green' implies something which is environmentally friendly, and should be used in this sense. The term 'sustainable' implies something which can be sustained, and be sustained indefinitely, not for a limited period of months or years. It seems logical to use the term sustainable in this sense, and by this logic it follows that many processes currently in use are NOT sustainable.

Cole (1999) has proposed that the term sustainable be used to describe the ideal situation where something is truly sustainable, i.e. it is the ideal to be aimed at. The word green can then be used to indicate how closely any arrangement approaches to the ideal. A "pale green" solution would approach less closely than a "dark green" solution. This seems to be a sensible and overdue clarification in the use of these terms.

MATERIALS CONSUMPTION AND SUSTAINABILITY

One major concern is whether or not our present level of materials consumption is sustainable. This concern can be viewed from the three standpoints of materials availability, energy availability and pollution generated by the extraction and production of materials. The balance of these concerns will be different for the different material types. The problems of environmental impact and sustainability will be considered in this paper.

Environmental Impact

Consideration of the various ways of assessing environmental impact will be examined at this point, leading to ways of evaluating it. The use of construction materials impacts by scale of use, consumption of energy and by pollution given off as the materials are extracted and produced. (Greenhouse gases CO_2, CH_4 and CO, acidification agents, SO_x, NO_x, energy, embodied CO_2, ecological rucksack, etc., to obtain an assessment of the aggregated burden on the Earth's resources. However, this aggregated value will still be a number or statistic, conveying to the designer no sense of the ecological impact, severe or mild, of his material specifications.

Embodied CO_2 (say) is only one aspect of the environmental impact of material usage. It may not be the most important one, in some cases the difficulty of recycling, emission of toxic by-products, or high embodied energy could be the major environmental threat. The designer would benefit from having some index of overall environmental impact, which was derived from all the individual impact values, properly balanced to represent their degree of severity. Such an index might be derived in three steps. Firstly, the individual property (kg CO_2/kg, say) would be normalised. This could be done by dividing the contribution by the average contribution per person per year. The second step is to weight the contribution to reflect the severity of the problems it causes (how far it deviates from the sustainable ideal). Finally, the weighted contributions are summed to arrive at an overall index number (see Fig. 1 below).

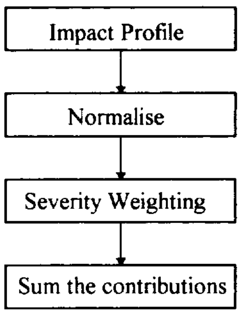

Fig. 1. Deriving an ecological impact index.

An individual designer cannot attempt a detailed analysis of the environmental impact of all the materials and design solutions used. Probably the best approach is for him to set, or have set for him, an overall envelope within which to work. He will then be able to carry out the usual 'trade-offs' which are part of the design process. However, in making a material selection, he will be made conscious of the ecological impact index of each material used.

Conclusions
Materials selection methods are capable of allowing rational selections to be made which minimise energy consumption, CO_2 emissions, etc., per tonne of material. However, even the aggregate use conveys no sense to a designer of how sustainable an individual case might be. What is required is a material index in each case, which indicates how far short from the sustainability ideal the material falls (or how severe is the environmental impact of using it).

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particulates, etc.). The greenhouse gas CO_2 is seen as the greatest threat, and the construction industry has a major impact upon global CO_2 emissions.

Impact Assessment

Various methods have been proposed for the assessment of environmental impact, including the concept of the ecological footprint (Wackernagel & Rees, 1996) and the ecological rucksack (Schmidt-Bleek, 1994). The rucksack is a measure of material efficiency, and it enables the impact of producing unit weight (say 1 tonne), of material to be calculated. On the other hand, the ecological footprint gives a measure of the aggregate impact of consuming a material. Some environmentalists are making a plea for absolute limits to be imposed on mankind's activities, and the footprint approach has the merit of linking the consumption of resources and energy to the total land area required to sustain them. Since the land area of Earth is finite, impact is compared with a physical limit; and this makes the footprint an invaluable tool for evaluating impact.

Other useful concepts include those of embodied energy and embodied carbon dioxide. Using these, impacts in energy terms and in terms of CO_2 emissions can be evaluated. These are not fundamental properties of a material, they depend on the level of technology used to extract/produce the particular material. As the technology improves, embodied energy values tend to fall over time. However, this trend is countered by increasingly poor ore grades with some materials (increasing the ecological rucksack with time).

Materials Selection Methods

Rational selection methods for materials have been devised; the impetus for their development was two-fold; firstly, the sheer number of materials now in use and secondly, the need for efficiency in their use. The method due to Ashby (1992) is an expert system capable of being implemented on a personal computer. It allows intelligent material selections to be made, with the designer retaining control. Sturges (1999) has indicated that whereas certain environmental criteria, such as the ecological rucksack concept can, in principle, be built into such a system, the ecological footprint cannot. However, the footprint does give an assessment of overall or global impact, and the real concern should be to make the other methods give a similar measure of aggregated impact. Indeed, all selection methods should be capable of assessing impact as part of the selection process, and they should be mutually compatible, if possible.

The development of rational selection methods, and the ecological rucksack concept will clearly assist more efficient production and use of materials. The theory is that by minimising the impact of each unit of material, the overall impact will be reduced. However, history tells us otherwise. Coal was the fuel which made the Industrial Revolution possible. In his classic, comprehensive study of the coal industry, Jevons (1906) showed that increased efficiency in the production and use of coal resulted in a huge increase in demand.

The realisation that improved efficiency leads inevitably to increased demand has led to proposals for placing absolute, upper limits on consumption and development. Such demands are probably not practicable, and in any case, what should these upper limits be? It would be better to assign some index of environmental impact to each material, to help designers in hteir choice of materials.

DISCUSSION

Ehrlich *et al.* (1972) first pointed out the fact that impact is given by the product of three factors, population, conventionally measured prosperity per person, and environmental impact per person per unit of prosperity. This concept can be extended to the embodied

Key Inputs and Leverage to Green Construction Projects – Surprising Results from Applications of Baseline Green

Gregory A. Norris, Pliny Fisk, III, Jason McLennan

Sylvatica, 147 North Berwick, Maine, 03906 USA
CMPBS, 8604 FM-969, Austin, TX 78724 USA
BNIM Architects, 1200 Main Street, Suite 1515, Kansas City, MO 64105 USA

Introduction

Green building design is about trying to minimize the "total" environmental impacts of construction over the "total" life cycle of the building, from materials manufacturing and transport through construction, use, maintenance & repair, through end-of-life management. A life cycle environmental perspective means broadening our scope along 2 dimensions: the life cycle and the environment. The "total" impacts of a building include those from its *useful* life, *and* those from manufacturing and transporting all the materials (and energy) used to build and maintain the structure.

It's easy to get lost in this effort. The solution is to prioritize, to sort the trivial from the important advice, and to focus our green design energies on the aspects of the construction project which matter most – that is, those which offer the greatest potential for environmental improvement of the project's total life cycle impact. Prior studies have continually shown that "upstream" environmental impacts of a building are an important part of the total life cycle burden, equaling or exceeding the burdens associated with 10-20 years of operational energy even in cold climates.

There are hundreds of inputs to even a simple building. It is not practical to consider the upstream environmental impacts of all 500 during project design and material selection. Fortunately, there's no need to, either. Upstream analyses are showing that for a given environmental impact category, roughly 2 dozen inputs account for roughly three quarters of the total upstream environmental impact. The key is to identify those components and focus efforts on greening *them*. This is the objective of the Baseline Green system developed by Sylvatica, the Center for Maximum Potential Building Systems (CMPBS), and BNIM Architects.

The Baseline Green Method

Baseline Green allows project commissioners or designers to conduct an upstream environmental analysis of project inputs at several stages during project design, starting at the conceptual design stage where design freedom is greatest. It first groups the several hundred inputs by system category using the popular Uniformat II categorization system in order to aid in summarizing results. Next it estimates the share of upstream environmental burden due to each input using life cycle assessment (LCA), based on detailed models of their supply chains and the pollution emitted from each sector of the economy. The results are used to identify which building system categories make the highest contributions to total upstream burden of the project, and which specific inputs within each category are rank highest in terms of the environmental improvement leverage they provide.

The upstream LCA is accomplished using a model constructed entirely from US government data. Databases from the US Department of Commerce describe the hundreds of inputs to each of over 50 distinct types of new and maintenance & repair construction project, from new hospitals to repair of electric utility power plants. Other databases from the Department of Commerce provide quantitative models of the supply chains of each project input: specifically, how much of each sectors' outputs are used by all other sectors in producing their products. A third set of databases comes from the US EPA, and quantifies the releases of pollution from each sector as it produces its products. The three sets of databases have been combined to create an input/output life cycle assessment system for evaluating detailed inputs to construction projects of all types.

Example output at the category summary level from Baseline Green is shown in Figures 1 and 2 for the Montana State University EpiCenter project designed by BNIM. In this application the tool has helped designers focus their green energies on the inputs that matter most for that building type. A surprising aspect of the results is the relative importance of some of the less massive input categories, such as electrical, HVAC, and interior finishes.

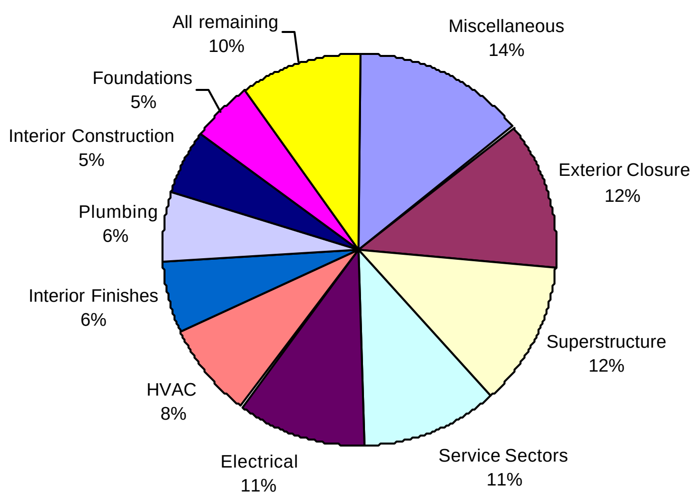

Figure 1: Upstream air pollution shares of input categories: MSU Project

Another surprise is the importance of some "service sector" inputs. This category includes electricity sold directly to the construction industry from electric utilities, but it also includes inputs to the project from professional service sectors such as Architects and Engineers. Recall that for each input to the construction sector, the method performs an entire supply chain Life Cycle Assessment. Thus, the environmental burdens of Architectural Services includes an estimate of the pollution from manufacturing all the paper, office equipment, electricity, and so-on used by the firms; it also includes business travel by A&E personnel, and an apportioned share of the construction and renovation of office space for the industry itself.

Figure 3 shows the major components of the "Services" category. The results indicate that together, inputs of A&E services (and their supply chains) account for 4-5% of the total upstream air pollution burden of constructing a project like the MSU EpiCenter. To put this into perspective, this is roughly equivalent to the air pollution burdens from all electrical input to the construction sector for the same project. It is also on a rough par with the air pollution burden of manufacturing the structural steel for the project.

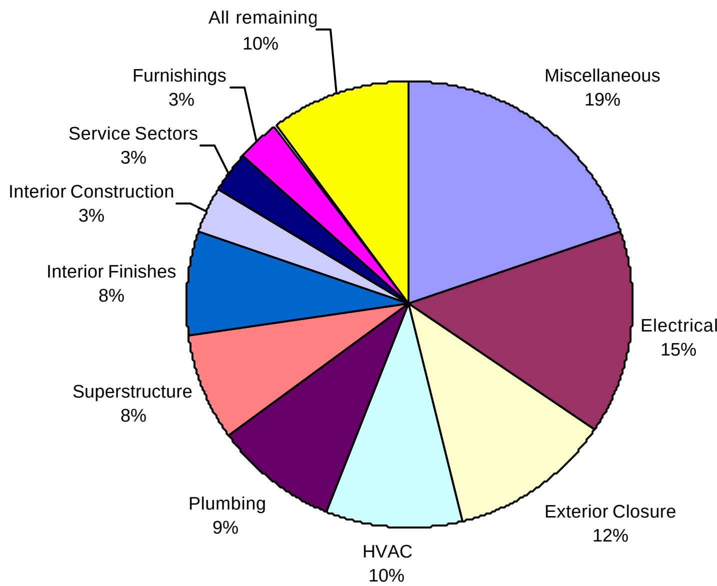

Figure 2: Upstream toxic release shares of input categories: MSU Project

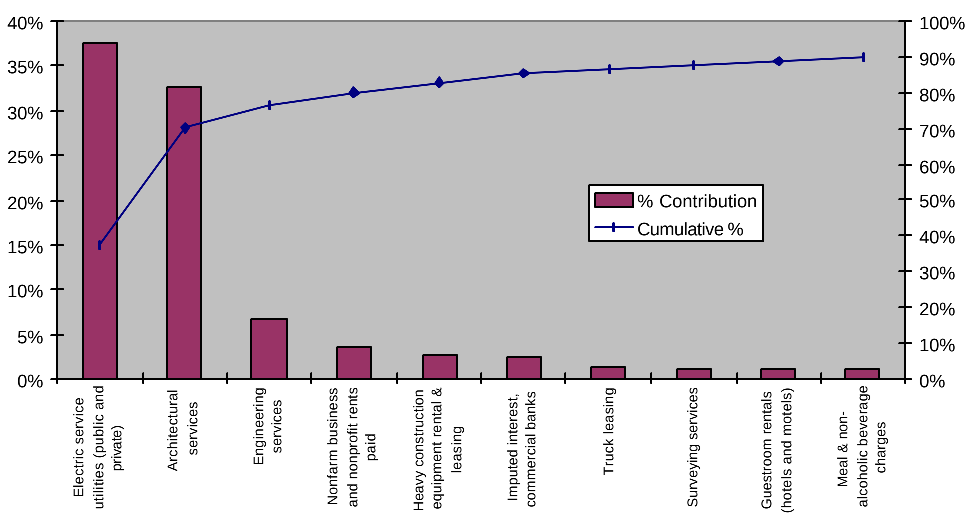

Figure 3: Upstream air pollution shares of "Service" inputs: MSU Project

<u>Reference:</u>

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BUILDING MATERIAL TRANSPORT: UK PRACTICE

Benedict Critchley MSc, University of East London

INTRODUCTION

Published transport data specifically for building materials are scant given the strong interest in the issue of local sourcing, and a possible new will by the UK government to reduce road transport.

The topic's neglect by building scientists may be due to it's having being seen hitherto solely as a component of embodied energy (ee). Transport only contributes around 10% of energy embodied in all building materials. Since ee itself is still small compared to energy in use, transport would seem to be a low priority for advancing building sustainability. Seen thus, transport is insignificant for materials with high processing energy such as aluminium and the petrochemical derivatives. Representing transport energy (T_e) by typical figures in ee estimates negates its essential variability.

In terms of transport, building materials are one of the most significant categories of goods. Bulk building materials are responsible for almost a third of 'tonnes lifted'[1] and building materials as a whole account for about one fifth of all freight T_e (my estimate). However, from the transport specialist's perspective, economic factors have worked to minimise travel distances and the modal shift to road for most bulk materials. 'Food Miles', not 'Building Material Miles', has been made the *cause celebre* of avoidable transport. Viewed this way, transport is actually a problem in those materials where its *insignificance* in terms of cost (and ee) has encouraged ever greater travel distances, poor lading factors and the consolidation of distribution patterns. So this study set out to bridge this gap between specialisms, with a new emphasis on minor building components. It reveals that even taken individually some are responsible for the same order of T_e as bulk items, or more.

METHODOLOGY

Despite this, energy is still the best single measure of transport since it incorporates the three variables distance, quantities and efficiency and, for transport, it is directly proportional to atmospheric emissions. It does not incorporate a 'nuisance factor' for each journey - a subjective but important measure of other very considerable costs to the human and non-human environment . Also, the energy used to produce and maintain vehicles and transport infrastructure - in themselves massive energy and resource consumers (e.g. a third of all UK aggregate use[2]) - was ignored.

During the first phase of research, manufacturers, hauliers and trade organisations of generic materials were contacted to build up an overview of current UK practice, supplemented by the DETR statistics. Typical patterns readily emerged for such characteristics as vehicle type, lading factors, the prevalence of empty return journeys, proximity of raw material sources. Specific energy consumptions (SECs, in MJ/tkm) were calculated for each vehicle class using published maximum payloads, lading factors for each material and fuel consumptions. The single SEC for each commodity in table 1 is the average of these weighted by the proportion of the commodity's total tonne-kilometres using each vehicle type.

The second phase traced the transport of each item in the bill of quantities of a 'typical' house[3] back to the source of its raw materials. The house was part of a large estate under construction by a national developer in SE London. It is a 73m^2 three-bedroom mid-terrace version with two floors and no garage, constructed of loadbearing blockwork with a brick and imitation flint exterior, concrete tiles and raft/strip foundations. Conditions dictated that the survey could not be a record of specific logged deliveries for a specific house, but all sources and transport characteristics were as used for the development. All finishes, fittings (but not appliances) and furniture installed before sale were included. T_e values were obtained for each item in the house as initially built and during its 100 year lifespan. This operation skewed the quantities towards type 2 materials and gave an indication of the relative use of materials for similar housing at any one time. The hypothesis could then be tested that highly processed and high-value components ('type 2' in table 2) are responsible for a proportion of transport energy far in excess of their contribution to tonnage.

The fuel consumption figures used[4] allowed sensitivity to lading as well as vehicle type. Where they occurred, empty return journeys by road and shipping were included. Vessel operators provided information on shipping fuel use[5].

RESULTS AND DISCUSSION

material	MJ/tkm	incl returns
aggregates, quarry to site: well laden largest artics predominate	0.79	1.30
blocks, final journey to site: generally largest lorries well laden	0.81	1.33
cement, all finished dry product	0.87	1.43
sawn timber and panel products, unfabricated	0.95	1.34
bricks, brickworks to site	0.98	1.59
glass, manufacturer to sites via stockist	1.05	1.86
steel, for structure and components, finished products	1.68	2.53
insulation,finished product to site, including via stockists	5.90	10.61

table 1 SECs for generic materials, road transport only

Transporting weight-constrained goods in 3.5-7 tonne lorries with 90% lading means efficiency of about 3.5MJ/tkm while the largest and most efficient artics means 0.65MJ/tkm. Shipping efficiencies range from 0.3MJ/tkm (0.47 including typical 70% empty returns) for Baltic softwood via 6,000DWT coaster, through 0.038 (0.047) for longhaul timber via 33,000DWT bulk carrier, 0.02-0.03 (0.025-0.036) for ores via 100-160,000DWT carrier, to 0.029 (0.032) for the largest 340,000DWT supertanker.

The detailed results of the casestudy confirmed that T_e accounted for a considerable proportion of the ee of non-polymeric insulation (22%), small steel components (15-20%), sand and aggregates (55-70%), timber (11-38%), and plasterboard. It was indeed negligeable compared to the total ee of aluminium and polymeric finishes and insulants.

The results supported the hypothesis: **A very sizeable proportion of T_e was spent on materials of very minor bulk.** Bulk is not a good indicator either of ee or of T_e. Type 2 materials with 5.5% of mass contribute 66% of ee and 43% of T_e. Type 2 categories, except plastics, have T_e of the same order as blocks or OBM. Ranked individually, 11 out of the top 20 items are type 2, including sanitaryware, kitchen units, radiators, metal studs and patio door; and 12 of the bottom 20 are type 1. It is remarkable that roof insulation and the cistern/hot water cylinder are in third and fourth place.

Road transport contributed 79%, shipping 20%, and rail and pipeline together only 0.07% of the house's initial T_e. 58% of shipping was due to Baltic softwood. Timber overall used 60% of shipping energy, metalwork 35%. The transport of all crude oil for use in polymeric products used just 2.4%.

Long road distances were often more significant than shipping (even longhaul) so an imported item may not use more $T_{e/tonne}$ than its UK-produced equivalent. This was the case with the UK mineral wool and fibreglass insulation compared to eps imported from the US as pellets. The transatlantic voyage accounted for just 7-12% of its road T_e. What made insulation by far the most intensive

$T_{e/tonne}$ of all materials were its extremely inefficient final journeys to site. Similarly, the plastics category owed only 10% of its T_e to crude oil shipping. Though Latvian softwood used the least efficient shipping and owed most of its T_e to the sea journey, its $T_{e/tonne}$ was only marginally greater than Scottish chipboard with equivalent road efficiency, due to the much shorter road component of the Latvian import. Metalwork seems the exception to this rule: 64% of steel's (Australian ore) was due to shipping, *and* primary steel with any ore source will *always* use more $T_{e/tonne}$ than UK recycled steel at any road distance. This ignores extra smelting fuel but treats the 66% slag content as waste. There were no transeuropean road journeys for any material to this site.

type	materials	initial tonnes	tonnes lifespan	ee/house MJ	$T_{e/house}$ MJ	T_e / ee %	% all T_e	$T_{e/tonne}$ MJ
1	blocks	34.31	34.31	76955	4570	5.9%	9.7%	133
1	bricks	6.14	6.14	27603	2125	7.7%	4.5%	346
1	other bulk mas'ry	89.76	71.80	36965	4576	16.4%	9.7%	64
1	plasterboard	5.45	7.26	8971	3685	41.1%	7.8%	508
1	timber	3.62	6.05	45929	10923	9.4%	23.2%	1805
2	finishes	0.35	2.15	35092	3017	1.4%	6.4%	1403
2	insulation	0.32	0.76	27520	3520	8.1%	7.5%	4621
2	steel	0.74	1.07	25113	4036	10.3%	8.6%	3788
2	non-ferrous	0.40	1.36	33335	4328	3.6%	9.2%	3185
2	glazing/sundries	0.63	1.53	10178	2716	9.3%	5.8%	1774
2	plastics	0.13	0.43	14139	1328	2.9%	2.8%	3123
	total	**141.8**	**132.8**	**342560**	**47025**	**6.2%**	**100%**	**354**

table 2 transport energy use by category over casestudy house's lifespan

Casestudy transport minimisation

Had the developer switched a few unnecessarily distant items - coursing blocks (195km), bricks (280km), fabricated timber items (N England)[6], and hardcore (40km) - to currently available local sources, a 26% reduction in T_e would result. This involves no change to design, materials or mode. The block decision alone caused extra T_e nearly equivalent to all the steel items. In addition, if presently available nearer sources for iron ore and oil, and more efficient shipping for softwood (0.12MJ/tkm), are presumed, the reduction rises to 36%.

This points to priorities for concerned specifiers. First, make sure *all* bulk masonry materials and big one-off items are locally sourced, especially if they are inefficiently transported like the factory-made trusses. Insulation is key to reducing energy in use but be conscious of its source every time it is replaced: cumulatively this could make as big a difference as bricks or blocks. This applies to a lesser extent to other joinery - and exert pressure for larger more efficient timber ships. Lastly, cut down on minor and necessarily distant items.

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[1] 'The Transport of Goods by Road in Great Britain', yearly DETR statistical compendium
[2] 'Transport and the Environment', 18th. Report of the Royal Commission on Environmental Pollution, HMSO 1994
[3] also the subject of a detailed embodied energy study: Anderson,J, UEL MSc thesis 1997
[4] Freight Transport Association's Report No.59 'Fuel Consumption in Freight Haulage Fleets' (1996)
[5] prevalence of empty running and lading anecdotal but corroborated by Danish SBI and Nigel Howard (pers. comm.)
[6] factory-assembled kitchen units consumed more transport energy over the house's lifetime than the 20 tonnes of the principal type of block, for example.

MATRIX APPROACH FOR ENVIRONMENTAL PERFORMANCES IN THE WEST-EUROPEAN STEEL CONSTRUCTION INDUSTRY

drs. J.P.R. Meijer (jme@intronbv.nl), ing. R.R.J.H. Rouwette (rro@intronbv.nl)
INTRON B.V., the quality assessment institute for the building industry
P.O. Box 80, 4190 CB GELDERMALSEN, The Netherlands

INTRODUCTION

Steel construction products are of environmental interest for their recyclability and flexibility. Everybody is aware of the ongoing discussions on how to deal with recycling in quantitative assessments, such as LifeCycle Assessments (LCA). This discussion is now extended to flexibility.
In the light of the growing importance of sustainable building, which focuses on the environmental performances at the building level, it is of the utmost importance to provide objective and well-founded conclusions on recyclability and flexibility.
In this paper we outline the steps to be undertaken by the steel producing and steel construction industry to be well prepared for sustainable building with steel construction products.

THE LIFE CYCLE OF STEEL PRODUCTS SEEN AS A RIVER

You start with iron ore and scrap to produce steel intermediate products, such as beams, plates, columns etc. Recent work by IISI (the international iron and steel industry) shows a comprehensive LCI database on products leaving the blast furnace in bulk. The steel industry is characterised by a global economy with a relatively small number of large producers.
Imagine a river delta, which springs from one or two sources, then devides into numerous small flows and ends up in an ocean. This delta is profound for its diversity and dynamics. It changes every minute, but always ends up in the ocean. The sources are the IISI producers, the ocean stands for the recycling of scrap. What happens in between, in the delta? We are very eager to find the answers to this question when assessing sustainable building with steel construction products.

EXPLORING THE STEEL CONSTRUCTION DELTA

Entering the steel construction delta we are impressed by its diversity. We find road barriers, bridge decks, columns, but also clips and nails. When we go further into details, we find hundreds and hundreds of manufacturers rolling, bending, clinching, welding and bolting IISI steel intermediates into products. The steel construction industry can be characterised by its small scale and large number of actors.

After the construction of a building several years pass, sometimes involving maintenance, replacements, conservation, and finally dismounting and sometimes reuse of elements, products and materials. Several actors are responsible for different processes. But they all share the same responsibility in aiming at sustainable building.
A lot of difficulties are to be expected in trying to organise this variety.

HANDLING VARIETY: THE MATRIX APPROACH

To be able to assess the sustainable performances of steel construction products we have reduced our scope to the environmental part of sustainability. We want to be able to explore our river delta with some sort of magnifier that will tell us the environmental performances of every single step of a specific product within the scope of its life cycle. For that purpose we need an interface. We believe we have found a flexible approach: a matrix. With this matrix it will be possible for each steel construction product to produce its own environmental profile. The idea behind the matrix is presented in table 1.

In my presentation I will outline the contents and working of the matrix. Therefor I will not describe it in this paper.

FILLING THE MATRIX

To be able to fill the matrix with valid data, the West-European steel construction industry is closely involved. Not only through Corus UK and Corus NL but also through the Dutch, Swedish and English Steel Construction Institutes. The different associations manufacturing the actual steel construction products are invited to share their insights and knowledge. From there on we will involve constructors, building owners and demolishers.

The key issue is to find the right unit for each 'cell' (read 'process') in the matrix and attach the environmental performance to it. Within the matrix all possible combinations and assertions are allowed.

STEEL AND SUSTAINABILITY AS SYNONYMS?

We envisage filling out the matrix the next coming year. After that we have a powerful tool. This tool will substantiate assertions into sustainability. We can show where steel delivers opportunities and benefits. Hopefully we can quantify our confidence in the power of steel construction products regarding their flexibility and contribution to sustainability. What do you think?

Process		IISI intermediate product	Transport	Stockholder	Transport	Cold forming			Transport	Fabrication			Transport to site	Assembly on site		Maintenance	Deconstruction	Transport	Disposal		
Sub-process						....	Painting	Bending		....	Drilling	Punching		Lifting	Painting	Replacement			Recycling	Reuse	Landfill
Unit																					
Product	Universal beam	Sections	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X
	Universal column	Sections	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X
	...	Plate	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X
	...	Hot dipped galvanised coil	X				X	X				X	X			X	X	X	X	X	X

Table 1. The matrix approach, example of separate processes interlinked

ENVIRONMENTAL PRACTICES IN CONSTRUCTION

Associate Professor John J Smallwood
Department of Construction Management, University of Port Elizabeth, P O Box 1600, Port Elizabeth, 6000, South Africa

INTRODUCTION

The environmental cost resulting from the construction process is substantial (Ofori, 1992). Much energy is used in the: production of materials such as cement, steel, aluminium, wood products, plastics and paints; movement of materials and components to sites, and running and operating of plant and equipment on site. Construction waste resulting from the construction process results in, inter alia, the waste of land resources and the contamination of natural resources and ecologies. Ofori (1992) contends that the environment should be the fourth goal on construction projects, along with cost, quality and schedule.

This paper addresses the impact of the construction process, and related issues, on the environment. The condensed findings of a literature survey and an exploratory descriptive survey are presented.

LITERATURE SURVEY

There are three reasons the industry needs to act: to pre-empt unfavourable consequences as a result of the increasing array of environment-related statutes, regulations and policies; to prepare for the changed nature of items it will be required to design, construct and manage, the new materials it might have to use and the processes it will have to adopt, and to contribute to overall environmental related efforts and issues (Ofori, 1992).

Environmental concerns are often interrelated with construction health and safety issues (Coble & Kibert, 1994). Unhealthy and unsafe practices, inter alia, concrete run-off or spillage, fires, oil spillage, waste and uncontrolled sanitation impact negatively on the environment (Coble & Kibert, 1994). Generation of dust, hazardous materials and the release of non-biodegradable material into the environment contribute to the impact (March, 1992).

According to Griffith (1995) organisations in the engineering sector, representing clients of the construction industry have taken environmental initiatives, whereas designers and contractors have been reticent to do so.

Kein et al. (1999) advocate that contractors should consider registration to the ISO 14001 Environmental Management System (EMS) if it: is a client or industry requirement; complements their marketing strategy, or can be a motivational factor. They cite the Swedish contractor, Skanska's experience, namely, that an EMS improves environmental performance, increases employee commitment and understanding of the organisation's environmental impact. Reducing environmental impact ensures optimal use of resources, which results in cost savings.

Kein et al. (1999) surveyed Singaporean contractors who had attained ISO 9000 Quality Management System certification. Keeping roads and drains adjacent to site clean was ranked first among environmental practices, followed by: conserving water; reducing noise; reducing, reusing and recycling; using environment friendly materials/products, and using lead-free fuel.

According to Nates (1999) savings and returns-on-investment from implementing an EMS by generic industry include: reduced material and energy wastage; reduced and/or elimination of process and operational inefficiencies, and improved environmental and general management. Other benefits include: compliance with environmental legislation; maintaining sound relations with all stakeholders; enhancement of the organisation's environmental image; reduced insurance rates, and client assurance with respect to environmental requirements.

RESEARCH

13 General contractor (GC) members of a regional contractor association responded to a postal survey, representing a response rate of 14.8%. The survey constitutes an exploratory phase of a long term study.

84.6% of GCs undertook industrial construction, 84.6% commercial, 46.2% domestic and 23.1% infrastructure. On average, the GCs subcontracted 14.2% of the value of construction to labour only subcontractors, and 45.8% to 'full' subcontractors. The GCs mostly worked at the 'double storey' (38.5%) and the '3-10 floors' (46.1%) height categories.

It is notable that only between 20 and 40% of GCs had the tabled environmental related documentation in written format (Table 1). Only 33.3% of those GCs who stated that they had an environmental policy, attached a copy thereof.

Table 1 Existence of environmental related documentation.

Documentation	Response (%)			
	Written	Verbal	Don't have	No response
Environmental policy	38.5	7.7	38.5	15.3
Environmental mission statement	23.1	0.0	53.8	23.1
Environmental management programme	23.1	0.0	53.8	23.1
Environmental rules	30.8	15.3	46.2	7.7
Emergency procedures to protect the environment	23.1	15.4	53.8	7.7

Only one GC responded that they have a documented EMS, which GC is not ISO 14001 certified. 46.2% of GCs stated that they were aiming to achieve ISO 14001 certification within differing time periods. 53.8% responded in the negative.

38.5% of GCs stated that they had undertaken contracts where they were required to implement environmental management / protection. No GCs had ever undertaken a contract for an ISO 14001 certified client.

Table 2 indicates the extent to which GCs implemented measures to reduce and control the impact of construction and control the usage of substances. Given the possible range of responses in terms of frequency: always; often; rarely; never; don't know, and no response, an importance index (II) with a maximum of three and minimum of zero was computed to enable interpretation of the responses and rankings. Given that the IIs relative to dust, litter, material waste, noise and water usage are above the midpoint value of 1.50, it can be concluded that measures to reduce and control the impact or usage thereof can be regarded as prevalent. This conclusion is reinforced by the average IIs.

Table 2 Ranking of the extent to which GCs implement measures to reduce and control the impact of construction and control the usage of substances.

Impact/ Substance	Implement measures to reduce		Control impact / Control usage of substances		Average	
	II	Rank-ing	II	Rank-ing	II	Rank-ing
Dust	1.92	4	2.00	3	1.96	4
Effluent eg. RMC wash-off water	1.15	6	1.15	6	1.15	6
Energy waste	0.85	8=	0.92	8	0.89	7=
Hazardous chemical substances	0.85	8=	1.00	7	0.93	9
Hazardous waste	1.00	7	0.77	9	0.89	7=
Litter	2.31	2	2.31	2	2.31	2
Material waste	2.46	1	2.39	1	2.43	1
Noise	2.08	3	1.85	4	1.97	3
Water usage	1.54	5	1.54	5	1.54	5

30.8% of GCs responded that they separated waste and 61.5% responded in the negative. Paper, bricks, steel, non-ferrous metal, glass and plastic featured among the materials separated from the waste. 30.8% of GCs also responded that they recycled waste and 61.5% responded in the negative. Paper, metal which is sold as scrap, and suitable timber is recycled.

61.2% of GCs did not conduct medical surveillance of construction workers, 15.4% did not know and 15.4% undertook chest X-rays.

Table 3 indicates that 'improved health and safety' predominated in terms of benefits of prioritising the environment.

Approximately half of the GCs identified: employee awareness; enhanced public relations; reduced material waste, and improved worker quality of life.

Table 3 Benefits of prioritising the environment

Benefit	Response (%)
Improved health & safety	84.6
Employee awareness	53.9
Enhanced public relations	53.9
Improved worker quality of life	46.2
Reduced material waste	46.2
Competitive advantage	23.1
Improved quality	23.1
Increased client satisfaction	23.1
Increased worker satisfaction	23.1
Improved productivity	15.4
Enhanced overall performance	15.4
Increased profits	15.4
Earlier completion	0.0

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CONCLUSIONS

The construction process impacts on the environment in many ways. An EMS formalises and engenders environmental related actions. Many environmental and health and safety issues are related.

Environment related actions complement health and safety and performance relative to other project parameters. EMS certification enhances organisation image and market competitiveness.

The exploratory survey conducted among South African GCs indicates a low level of attention to the environment, particularly with respect to: documentation; measures to reduce and control the impact of or usage of effluent, energy waste, hazardous chemical sustances, and hazardous waste; the separation and recycling of waste, and medical surveillance. Benefits do accrue from addressing the environment.

RECOMMENDATIONS

A more in-depth study should be conducted to validate the representivity of the exploratory study.

Contractor associations should evolve guidelines relative to construction and the environment.

TO CLOSED MATERIAL CYCLES FOR CONCRETE AND MASONRY IN CONSTRUCTION

Evert Mulder, TNO, dept. of Chemical Engineering, PO-Box 342, 7300 AH Apeldoorn, The Netherlands, tel. +31-55-5493919, fax +31-55-5493740, E-mail Evert.Mulder@mep.tno.nl

This new concept is an outline for the development of integrated technology for the sustainable production of raw materials for construction from demolition waste.

INTRODUCTION

In The Netherlands one of the goals of the government is to increase the recycling of waste materials. For construction and demolition waste (C&D waste) a recycling target has been set of 90%. One of the tools to fulfil this criterion is a disposal ban for recyclable fractions of C&D waste. This legislation has already led to a remarkable degree of recycling in the construction industry, primarily because of the re-use of the stony fraction of C&D waste in road bases. However, this is not the most sustainable way of recycling, because the production of new concrete and masonry bricks still requires virgin materials, in huge amounts. Besides, still large amounts of (mixed) C&D waste have to be disposed of in landfills.

Though there is an opportunity to re-use concrete granules as a coarse aggregate in new concrete, this is not practised, because of the fact that all concrete rubble is needed for the production of a mixture of concrete and masonry granules. Masonry granules alone do not fulfil the requirements for re-use in road bases, as to mechanical strength.

For that reason a new concept has been outlined to develop technology for the separate processing of concrete and masonry rubble, thus obtaining raw materials for the production of new concrete and new masonry. This enables the use of C&D waste on the original level. At the same time material cycles of concrete and masonry will be closed.

BRIEF DESCRIPTION OF THE NEW CONCEPT

The new concept is visualised in the figure on the next page. On the basis of this figure a brief description will be given of the technologies that are being developed and that will be integrated in a total process for the sustainable production of construction materials from C&D waste. Subsequently the following four material streams that enter the process will be followed through the process:

- undiluted concrete rubble;
- undiluted masonry rubble;
- mixed (stony) rubble;
- mixed C&D waste.

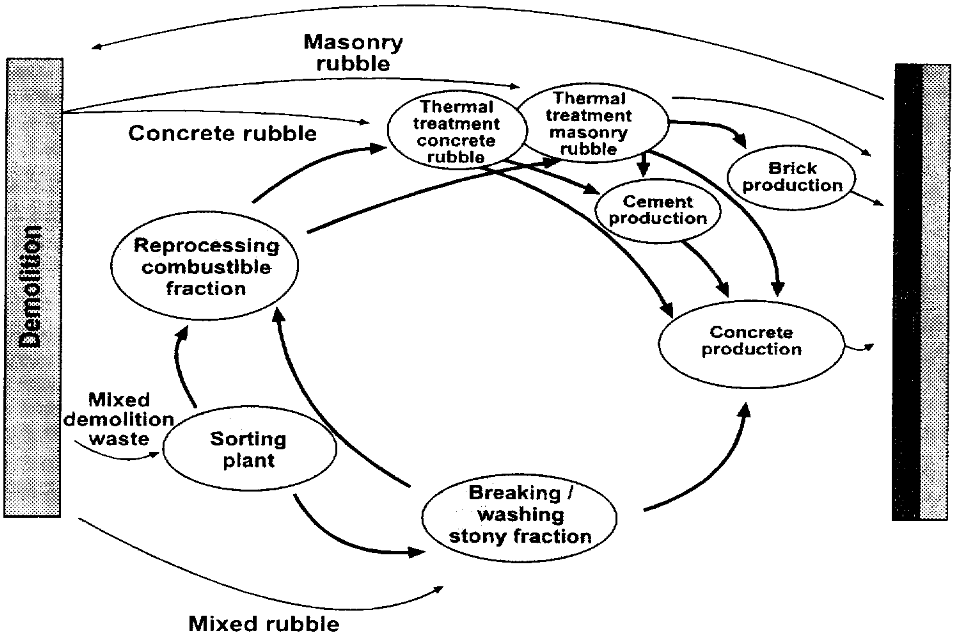
Undiluted concrete rubble

As is shown in the figure, the undiluted concrete rubble is thermally treated, aiming at the disintegration of the concrete matrix. After an additional mechanical treatment the original materials (gravel, sand and cement stone) are obtained. These mineral fractions can be used again for the production of new high quality cement and concrete. Besides, a certain amount of reinforcing steel will be recovered, that can be sold to a steel producer.

Undiluted masonry rubble

Also for the large pieces of undiluted masonry debris the choice has been made for the thermal treatment. In this way the mortar can be removed from the bricks without heavy mechanical forces. This process step yields, beside mortar, whole bricks, that can be re-used, and brick pieces, that can

be broken and used as a raw material for the production of new bricks. The mortar can be fed to the above mentioned process step, disintegrating it into sand and cement stone.
The whole bricks can be used for restoration purposes or for the construction of buildings in an old fashion.



Mixed rubble
To be able to process the entire supply of C&D waste, and not only the undiluted fractions, the above mentioned processes have to be implemented in an overall process. This overall process also requires a process for the treatment of a mixed stony fraction, consisting of concrete rubble and masonry rubble of ceramic bricks and sand-limestone bricks. This stony fraction of C&D waste (mixed rubble) is broken and washed in such a way that decontaminated granules are obtained. These granules can be used as a coarse aggregate in several types of concrete. The fine fraction can be used as a sand substitute, in concrete or in civil works. Only a small sludge fraction will have to be disposed of.

Mixed C&D waste
The demolition waste not being separated at the source, is sorted in an additional process step. Gypsum and hazardous materials are separated by means of advanced detection and separation techniques. The hazardous wastes will have to be disposed off, the gypsum can be recycled. The remaining material is divided into an heavy (stony) fraction and a light (combustible) fraction. The stony fraction is treated with the mixed rubble. The combustible fraction is reprocessed to obtain a fuel for the thermal processing plants.

ADVANTAGES OF THE NEW CONCEPT

The new concept has several advantages. The most illustrative advantages are:

- Closing the material cycles for concrete and masonry within the own chain. This fulfils one of the desires of the Dutch government, in the framework of sustainable development. It also fits into the policy of the industry, from the viewpoint of producers responsibility and long term raw materials availability.
- The production of high-grade raw materials for the production of new concrete and ceramic bricks. This means most probably higher profits for the C&D waste treatment industry and / or reduced rates for the demolition firms, in case undiluted concrete or masonry debris is delivered (thus promoting separation at the source). It also reduces the extraction of virgin materials, as sand, gravel, clay and marl.
- Utilising the combustible fraction of demolition waste as a fuel. This doubles the environmental profit, namely the reduction of the amount of waste to be disposed of and the reduction of the amount of fuel that is required for the thermal treatment of the concrete and masonry rubble.
- Benefit for the environment (less extraction of virgin materials and less waste disposal).
- The integrated character of the process furthermore implies a reduction is transport kilometres. This means less fuel consumption and because of this less exhaust gases.

CONCLUSIONS

The development of integrated technology for the sustainable production of raw materials for construction from demolition waste leads to closed material cycles for concrete and masonry. This has several environmental benefits, and most probably also economical benefits.

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The use of energy saving technologies in a social housing project

Van Bael, Johan
1. Vito, Boeretang 200, 2400 Mol, Belgium

Introduction

The general objective of social housing companies is to build houses for low-income people at reasonable costs. Usually, limited attention is paid to energy saving technologies. Energy saving is however important because of the limited family budget and because of the important share of energy costs in the budget. This project will pay special attention to energy savings and sustainable building at acceptable incremental construction and installation costs while maintaining a high level of comfort. The aim of the project is to demonstrate an integrated global energy design for 23 new energy efficient social houses in the municipality of Hulshout, Belgium. The investor is the social housing company Zonnige Kempen (Westerlo, Belgium). The project is funded by the European Commission in a Thermie project "European Global Energy and Environmentally concerned Neighbourhoods and Cities" and by the Flemish Government within the framework of the energy demonstration program.

GENERAL DESCRIPTION

The social housing project consists of 23 new energy efficient social houses in the municipality of Hulshout, Belgium. The building project consists of three blocks of respectively 3, 12 and 8 building units. The size of the buildings and the floor area per building unit are illustrated in table 1.

Building block	Number of units	Total floor area (m^2)	Average floor area (m^2/unit)
1	3	351	117
2	12	1231	103
3	8	620	78
Total	23	2202	96

Table 1: Size of the project

At the start of the project, all decisions with an impact on energy demand and with environmental effects still had to be made. The only limitations were building conditions stipulated by the administration of town and country planning (AROL) and the absence of external heat suppliers (e.g. CHP-plant, power station, ...) in the neighbourhood of the project. The architect was commissioned to present a preliminary design taking into account energy and environmental effects. A general energy performance standard for the project of Hulshout has been proposed and accepted. Based on an energy performance standard the preliminary draft and the final design of the houses can more easily be worked out and evaluated. Instead of using the global insulation level K55 applied by the Flemish Government, a performance standard based on the energy requirements for heating is applied. This performance standard takes into account both transmission / ventilation heat losses, internal / external heat gains and the efficiency of the heating and ventilation installation. The objective of the project is to satisfy a performance standard of 50 kWh/m^2/year (energy consumption for heating), based on an average inside temperature of 18°C, a ventilation level of 0.5 air changes per hour (ac/h) and an overall heating installation efficiency of 75%.

In order to decrease transmission losses, special attention is paid to increased insulation (sloping and flat roofs, walls, floors, windows, ...). Ventilation losses are limited by applying mechanical

ventilation with heat recovery in combination with airtight building. Remaining heating requirements are met by high performance heating installations.
Solar collectors are installed to decrease energy consumption for domestic hot water. An energy management system collects and processes energy consumption data per individual building unit.

Detailed description

heating

The global insulation level K55 required by the Flemish government depends on both the insulation level and the compactness of the building: the higher the level of insulation and compactness, the lower the global insulation level K. The global insulation level K is calculated as follows:

$K = 100 * ks \quad V/A \leq 1$
$K = 300 * ks / (V/A + 2) \quad 1 < V/A \leq 4$
$K = 50 * ks \quad V/A > 4$

where ks = average heat loss coefficient ($W/m^2/K$)
V = heated volume (m^3)
A = heat loss surface (m^2)

In addition to the global insulation level K55, the Flemish Government imposes maximum U-values for each part of the building construction. Table 2 compares the legally required insulation levels with the insulation level of the project Hulshout. The global insulation level of the project Hulshout amounts to K24, which is far below the legally required level K55.

Construction part	Legally required K55	Project Hulshout K24	
	U-value ($W/m^2/K$)	U-value ($W/m^2/K$)	insulation
Sloping roof	0.6	0.17	15 cm mineral wool + 6 cm polystyrene
Flat roof	0.6	0.17	20 cm mineral wool
Walls	0.6	0.25	10 cm mineral wool (brick wall) 12 cm mineral wool (wooden coating)
Floor	1.2	0.30	8 cm polystyrene
Glazing	3.5	1.50	special double glazing + wooden frames

Table 2: Insulation level (legally required versus project Hulshout)

A detailed energy analysis has been carried out for each unit of all the building blocks in the project. For each building unit a severe energy performance standard of 50 kWh/m²/year has been set. In order to attain this standard, the following measures are taken: compact building, airtight building, passive solar energy design, high performance heating system, super-insulation of roofs, walls, floors and glazing and mechanical ventilation with heat recovery. The energy analysis for one building unit is shown in table 3.
The total energy consumption for heating amounts to 220 kWh/m²/year for a standard house in Belgium. Paying special attention to compact building, airtight building, passive solar energy design, ... and meeting the legally required insulation level K55, the total energy consumption decreases to 190 kWh/m²/year equivalent to an annual energy requirement of 22,185 kWh/year (18°C, 0.5 ac/h). In the project Hulshout the total energy consumption for heating further decreases:

(1) from 190 kWh/m²/year to 162 kWh/m²/year as a result of high performance heating systems based on condensation of flue gasses, (2) from 162 kWh/m²/year to 79 kWh/m²/year as a result of increased insulation of roofs, walls, floors and glazing, and (3) from 79 kWh/m²/year to 50 kWh/m²/year as a result of mechanical ventilation with heat recovery and with low electricity consumption. As a result the energy requirements for heating in the project of Hulshout are more than 70% lower in standard building projects in Belgium.

Global insulation level	K55	K55	K24	K24
Average heat loss coefficient (W/m²/K)	0.62	0.62	0.27	0.27
Compactness	1.4	1.4	1.4	1.4
Average inside temperature (°C)	18	18	18	18
Ventilation rate (ac/h)	0.5	0.5	0.5	0.5
Heating system efficiency (%)	64	75	75	75
Type of ventilation	natural	natural	natural	mech.
Heat recovery	no	no	no	yes
Annual energy requirements (kWh)	22,185	18,930	9,200	5,900
Performance number (kWh/m²)	190	162	79	50

Table 3: Annual energy requirements for heating

domestic hot water

In order to decrease the energy requirements for domestic hot water, an individual solar collector system is installed in each unit of building block 1 and a collective solar collector system is installed in building block 2 (12 units). Solar collectors supply about 50% of hot water needs, thus decreasing total annual energy requirements for domestic hot water

- from 3,768 kWh per year to 1,884 kWh per year (per unit of building block 1)
- from 28,248 kWh per year to 14,124 kWh per year (for the total of 12 units of building block 2).

MEASUREMENTS

The project will be locally monitored and evaluated during a one year measuring period by the research institute Vito. The measurements will be concentrated on the efficiency of the technical installations (heating system, ventilation system with heat recovery, solar collectors). In building block 1 the following measurements will be performed: (1) the natural gas consumption of the heating system, (2) the heat demand for room heating, (3) the heat demand for domestic hot water, (4) the efficiency of the mechanical ventilation system and (5) the efficiency of the individual solar collector system. In building block 2 the following measurements will be performed: (1) the natural gas consumption of the collective heating system, (2) the collective heat demand for room heating, (3) the collective heat demand for domestic hot water, (4) the efficiency of the individual mechanical ventilation system and (5) the efficiency of the collective solar collector system. In each of the dwellings of building block 2 flow meters and calorimeters are installed for the actual heat consumption and the domestic hot water consumption. The measurement results are used for the evaluation of the project and for individual billing according the real consumption.

SUSTAINABLE CONSTRUCTION PRACTICES
LYNNE BARKER
SELLEN CONSTRUCTION COMPANY, INC.

It Began with A Heightened Awareness

Sellen Construction Company, located in Seattle, Washington, began development of sound sustainable construction practices more than five years ago when field superintendents took the initiative to explore jobsite recycling and erosion control methods because it made good sense for their projects. Now, we view it as a company-wide responsibility to our clients to emphasize the positive environmental and economic benefits that can be achieved through good environmental practices at all stages of a building's life — from planning and design through construction and lifetime occupancy. We're actively pursuing emerging green building technologies, exploring both the costs and benefits associated with emerging green design and construction so that we can share this rapidly evolving technology — materials, applications and innovations — with our clients. We are proud to be an industry leader in sustainable building practices where the contractor directly impacts the level of results achieved. Today, we lead the industry in construction waste management and watershed protection. Because of the success of our pioneering efforts in these areas, local municipalities have been able to rewrite ordinances with stricter regulations governing the work of contractors.

CONSTRUCTION WASTE MANAGEMENT PROGRAM

Since its inception, Sellen's Construction Waste Management Program has diverted a substantial amount of materials from local landfills. Sending these materials to recyclers for processing into new materials conserves natural resources and reduces overall energy consumption. Reducing energy consumption prevents pollution in the form of greenhouse gas emissions. With our Construction Waste Management Program we have four main goals:

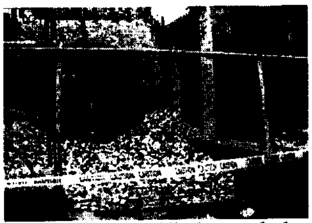
Prevent waste with resource-efficient materials & methods

Preventing waste reduces both supply costs and disposal fees. For example, we estimate material supplies accurately using the latest technologies including CAD drawing takeoffs; lease building materials such as formwork that are reused over and over; and employ centralized manufacturing areas to promote efficient use of materials.

Recycle materials to their highest and best use whenever economically feasible

In western Washington we have some of the best markets in the nation for recycling construction waste. On our jobsites we recycle: concrete, asphalt, bricks, wood waste, metals, gypsum drywall, acoustical ceiling tile, cardboard and office materials such as paper, glass and cans. In the past, these materials were landfilled, as shown in the waste container to the right.

Sellen also salvages materials for resale or reuse. Salvaging building materials is gaining in acceptance and is providing Sellen with opportunities to extend the life cycle of building materials. Sellen successfully salvages materials such as brick, doors and frames, hardware, fixtures, structural wood, and wood flooring. The bricks pictured to the left were salvaged and sold to a local salvage firm.



Promote the use of recycled-content building materials

Sellen has identified recycled-content building materials for easy substitution on our projects. For example, crushed concrete or glass can be used as fill material and recycled asphalt can be used for temporary roads during construction. Sellen also purchases recycled-content office products and continues to broaden the list as more reliable products enter the marketplace.

Provide industry leadership

We believe that sharing our success will help to strengthen market conditions and further enhance our opportunities to reduce waste, recycle and buy recycled-content building materials. We have presented our Program at both local and national conferences and seminars. Sellen served on the Board of Directors of the Washington State Recycling Association and was one of the founding members of the Washington State CDL (construction, demolition & landclearing debris) Council.

Results

We have had great success with our program. For the projects listed below the average recycling rate was 76%. That means that only 24% of construction waste went to local landfills. The projects recycled a total of 4,654 tons of material including 1,222 tons of wood waste, 632 tons of gypsum drywall, 88 tons of cardboard, 2,154 tons of concrete, asphalt and brick, 432 tons of metals, 94 tons of acoustical ceiling tile, and 17 tons of office recyclables. The results on several large projects are listed below:

Project	**Tons Recycled**	**% by Weight**	**Saving**
AT&T Wireless (new construction)	748 tons	83%	$79,94
Microsoft Pebble Beach Campus (new construction)	2,312 tons	74%	$191,48
Target Stores (new construction)	255 tons	82%	$24,83
KCPQ (renovation and expansion)	809 tons	78%	$80,48
Microsoft Buildings 4,5 & 6 (renovation)	373 tons	60%	$37,74
Providence / St. Peter Hospital (renovation)	158 tons	64%	$14,90

WATERSHED PROTECTION

As soon as you break ground on <u>any</u> construction project in the Greater Puget Sound Basin, the potential for water pollution is created. Erosion from construction sites poses <u>the</u> biggest single threat to our watersheds.

A comprehensive, proven program that works

Today, our watershed protection program consists of two closely related but distinct processes — erosion control and storm water treatment. Treatment depends on the site and amount of water to be controlled, contained or treated. The program allows us the flexibility to respond to the severity of each jobsite situation.

Erosion control

Erosion control — one of the simplest, yet most effective watershed protection measures — is a method that uses various combinations of silt fences, straw bale filters and catch basin filters. This is followed by seeding or replanting of non-invasive vegetation and reintroduction of native plant species.

Sellen teams are well versed in the state guidelines for maintaining water purity, outlined in the Department of Ecology's Best Management Practices. Erosion control practices provide for immediate dust control and temporary soil stabilization until permanent, stabilizing vegetation can be established. The specific techniques employed depend on the site, its slope, natural vegetation, soil types and other contributing conditions — such as wetlands and water table levels.

But, even the most effective, properly installed BMP erosion control methods can fail in 50- to 100-year storm conditions. In the past, in order to ensure that these kinds of accidents did not occur, City agencies did not allow excavation between October and April.

Storm water treatment

Chemical stormwater treatment has evolved as the state-of-the-art method for contractors to control stormwater runoff, when Best Management Practices are not enough. Sellen is one of the few companies in the State of Washington that is authorized by the Department of Ecology to carry out chemical water treatment on a construction site. In the past two years alone, we have cleaned more than 35 million gallons of water on our jobsites using the onsite stormwater treatment process.

The process was the brainchild of Sellen's project team during the construction of two major projects for Microsoft — Redmond West Campus and Pebble Beach Campus — that were constructed through the winter months on sloped land during some of the wettest months ever recorded. Due to the sensitive nature of the drainage basin, nearby wetlands and the timing of the projects, the City of Redmond permits were granted provided supplemental watershed protection measures would be used. Under the close scrutiny of the DOE, and onsite participation by City of Redmond officials, these projects became the proving ground for onsite stormwater treatment in this region, and Sellen's Watershed Protection program was born.

A model program for others

The results of this process have been exceptional, and Sellen has been allowed to continue to refine the process on subsequent projects. Although, its potential to impact the way BMPs are written for the construction industry is revolutionary, the DOE cautions that it isn't ready for use by every contractor. The process is still in the development stage, and successful implementation requires experience, chemical knowledge and a willingness by owners to invest in the increased costs for storage and treatment ponds, engineering, pumps, pipe and testing equipment. Sellen has shared its success with this exciting breakthrough in Watershed Protection with other area contractors working on projects with similar soil conditions. Due to the success of our program, and the success of other contractors who have followed our lead, local and state regulations governing site development are once again being tightened, because we've proven that optimal watershed protection can be achieved even in the most inclement weather.

The benefits of Sellen's watershed protection program

Prevents water containing high phosphate, sediment or pH levels, created by contact with construction sites, from ever reaching the watersheds where it can kill fish and other aquatic life

Cleans storm water to levels which meet or exceed Department of Ecology and City standards, enabling water to be pumped directly into municipal storm systems

Allows sitework activities to proceed even in inclement weather

Gives our clients more flexibility with project start dates and minimizes jobsite shutdowns in adverse weather conditions

Continuing improvements

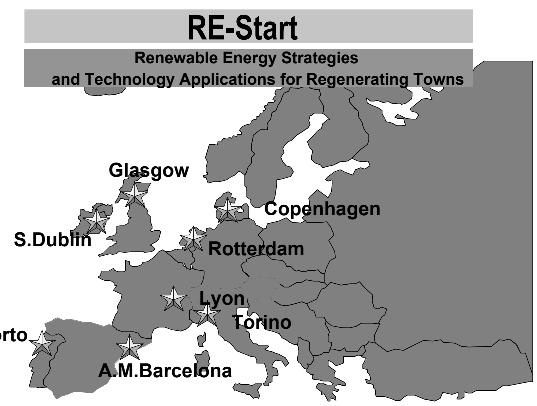
Sellen is continuing to improve on its Sustainable Construction Program, adding new practices and programs as we go along. For instance, we have developed a Commuter Trip Reduction Program for our jobsite crews, and a Green House-Keeping Program for final clean-up of our construction projects. Currently, we are researching opportunities for improving energy-efficiency during construction.

RE-START: NIEUW TERBREGGE - ROTTERDAM
INTEGRATED ENERGY EFFICIENT AND SUSTAINABLE URBAN SCHEME

Chiel Boonstra [1], Henk Smelt [2]

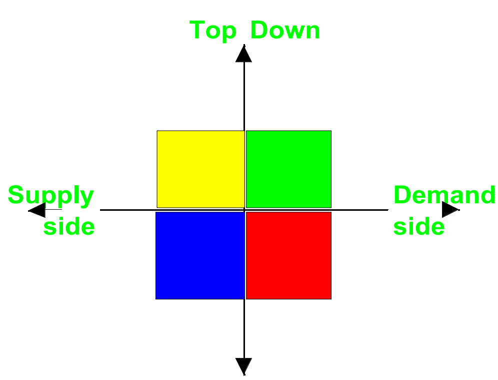
1. DHV Accommodation and Real Estate, P.O. Box 1427, 3800 BK Amersfoort, The Netherlands, Tel : +31 33 476 06 41, E-mail chiel.boonstra@dhv.nl ; ex W/E consultants sustainable building
2. City of Rotterdam, dS+V, bureau projectmanagement, P.O.Box 6699, 3002 AR Rotterdam, The Netherlands, Tel : +31 10 489 73 12, E-mail: hes@dsv.rotterdam.nl

RE-Start is a project involving 8 European Cities, addressing Renewable Energy Strategies and Technology Applications for Regenarating Towns.



Exemplary Urban Projects were demonstrated between 1996 and 2001 under the EU Programme Thermie:

- Each RE-Start City demonstrates a district where a regeneration project is executed, with new comprehensive rules
- The area of influence of each City-Project allows a strong impact on the decisional mechanisms of the city
- A mix of functions are comprised in REStart, representing the complexity of urban situations



Implementation of Renewable Energies in City Policies requires an integrated approach addressing at the same time:

- **Top-down approach** - Related mainly to the activity of governments and/or institutions when introducing new regulations
- **Bottom-up approach** - Organising the needs of a community and preparing the policies which comply with these needs
- **Demand-side approach** - Concerning the end-uses of citizens and their needs
- **Supply-side approach** - Refers to the capability of the market to organise the production of goods and technologies which respond to consumers' needs.

Integrated Urban Design

The City of Rotterdam is part of RE-Start through the demonstration project Nieuw Terbregge. The main environmental aspects are reduction of energy use, the use of environmentally sound materials, reduction of water consumption and nature development. The relatively polluted water of the nearby river Rotte, for example, will be filtered by halophytes before it enters the area.

Public Private Partnership
Nieuw Terbregge is innovative for its energy technology application at large scale. Also the process is innovative.
The development of the whole project of 860 houses is in hand of a commercial project developer, who works on the basis of performance requirements provided by and and agreed with the City of Rotterdam.

The public private partnership created the possibility to integrate urban and architectural design of various parts of Nieuw Terbregge. Four architects were developing parts of Nieuw Terbregge while one was in charge of the urban development.
The energy strategies became integral part of urban and architectural design.

landscaping – highway-ringroad Rotterdam

Nieuw Terbregge is separated from a major highway by a hill containing well kept and controlled polluted sand. This hill is developed into a linear park, from which one can overlook the highway and the buildings.

landscaping – existing waterfront

On its north border Nieuw Terbregge faces dykes of the Rotterdam river Rotte.

INNOVATIVE ENERGY TECHNOLOGIES

Active and passive solar systems

A part of Nieuw Terbregge demonstrates the application of solar energy in buildings. As the aim was to focus on replicable technologies passive solar and active solar thermal systems are applied. Two storey sunspaces on the entrance façade of the houses and 6 m2 solar collectors contribute to the energy demand of space heating and domestic hot water.

Design integration heat delivery station

Other parts of Nieuw Terbregge demonstrate the integration of heat delivery through small scale combined heat and power stations.
Each heat delivery station provides heat to about 40 houses, thereby minimizing the length of transportation pipes.
Several solutions of planning and design integration are demonstrated in Nieuw Terbregge, Rotterdam.

Small scale combined heat and power

Small scale combined heat and power (chp) units are placed 'in cascade', so that the heat load is optimised. Heat is temporarily stored in a central storage tank. Electricity enters the electricity grid, and is partly used on site. One heat delivery station also contains a ground water heat pump system. Combinations of heat/power installations and heat pumps are especially efficient while the heat/power installation produces electricity that can be used for the heat pump. The heat delivery stations are developed, managed and maintained by the utility company.

High-insulating glass (U-value of 1.0 W/m^2K) and appropriate insulation levels (U values below 0.3 W/m^2K) have been applied to minimize the heat demand. The City of Rotterdam also required this project to meet the requirements of their Sustainable Building program. The choice of sustainable building materials has been a design input.

National benchmarks
Since 1996 the Dutch Building Code contains an Energy Performance Standard for new houses. In 1998 and 2000 the maximum coefficient admitted was lowered. The RE-Start project developed in 1996 demonstrates energy performances below the 2000 level. The measures taken reduce the emission of CO_2 by 25% to 55% compared to new houses in 1996. Further reduced levels are anticipated for the second part of Nieuw Terbregge which is currently under development.

CONCLUSIONS
The RE-Start Rotterdam project Nieuw Terbregge demonstrates the how innovation can be achieved on the scale of the development of an area of 860 houses. The project serves as an example for the 10,000 's of houses Rotterdam shall build in the near future.

Site visit of Rotterdam alderman

Commercially valid
The project developer experienced how commercially valid the project was. Their policy to use urban, architectural and technical quality as a benchmark allows the integration of energy issues. New project initiatives already build on the RE-Start Rotterdam project experiences.

Monitoring and evaluation results shall become available by the end of 2001 when the full project is in use for over a year.

References:

1. More information on RE-Start can be found at www.resetters.org

Maintenance design and scheduling to support sustainable construction

V. Caffi, M.G. Rejna
1. DISET Politecnico di Milano V. Bonardi 15 - 20133 Milano, Italy, vittorio.caffi@polimi.it
2. DISET Politecnico di Milano V. Bonardi 15 - 20133 Milano, Italy, mariagrazia.rejna@polimi.it

Introduction

This paper presents methodology and instruments useful to evaluate, even by mean of the maintenance design and scheduling, the correspondence of a building to the principles of sustainability.
The building quality is a measure of how a building meets the functional and performance requirements defining, at the design level, the very quality level desired. The parameter of durability is the main indicator in order to describe the attitude to maintain the quality level of buildings and their materials and components at the required level over time.
A maintenance design and scheduling is needed, in order to achieve the goal of maintaining the building performances able to satisfy the design requirements.
This means to decide the times for intervention and to allocate resources for the building maintenance. As higher the durability of building works is, as lower time and resources needed for the maintenance works are.
This is why the maintenance design and scheduling have a main role, together with other considerations, even to evaluate a building in terms of sustainability.
The method here presented allows to specify and evaluate the parameters describing the durability of materials and components: service life span and compliance.
Evaluations, experimental programmes and field tests on materials and components are main tools in order to define their compliance in every aspect: functional compliance, fabrication compliance, inherent compliance and compatibility compliance.

A maintenance oriented design method

In order to plan a correct and sustainable maintenance programme, prevision for maintainability must be undertaken since the design phase of a building.
In fact, the project has a strong impact on the durability of a building, consequently it has great impact on maintenance as well.
A proper design of the building, thought to be long time lasting, is the premise for reducing maintenance needs as most as possible.
The main tool here suggested for detailing building components design is known as functional analysis method.
Such an instrument, resumed in fig. 1, takes into account performance parameters such characteristic quality, durability, maintenance quality and executive quality.
The functional analysis is performed on the base of the full set of fundamental functions required for the technical solution to be designed. The complete list of fundamental and analytical functions for external non bearing walls is given in Table 1. The list of functional characteristics and significance conditions, for external non bearing walls, is given in Table 2.
The functional analyse outcome is a set of repertoires, collecting many design solutions satisfying the functional requirements.
The following step has to compare the established alternative solutions with sustainability criteria: the best technical solutions would be those matching the settled functional requirements as well as sustainability principles: using a low amount of energy and materials and a minimum, if not zero, of not renewable resources. Then, the selected design alternative solutions

hypothesis have to be compared once more to sustainability requirements, now related to durability and maintenance needs and to building site operations.

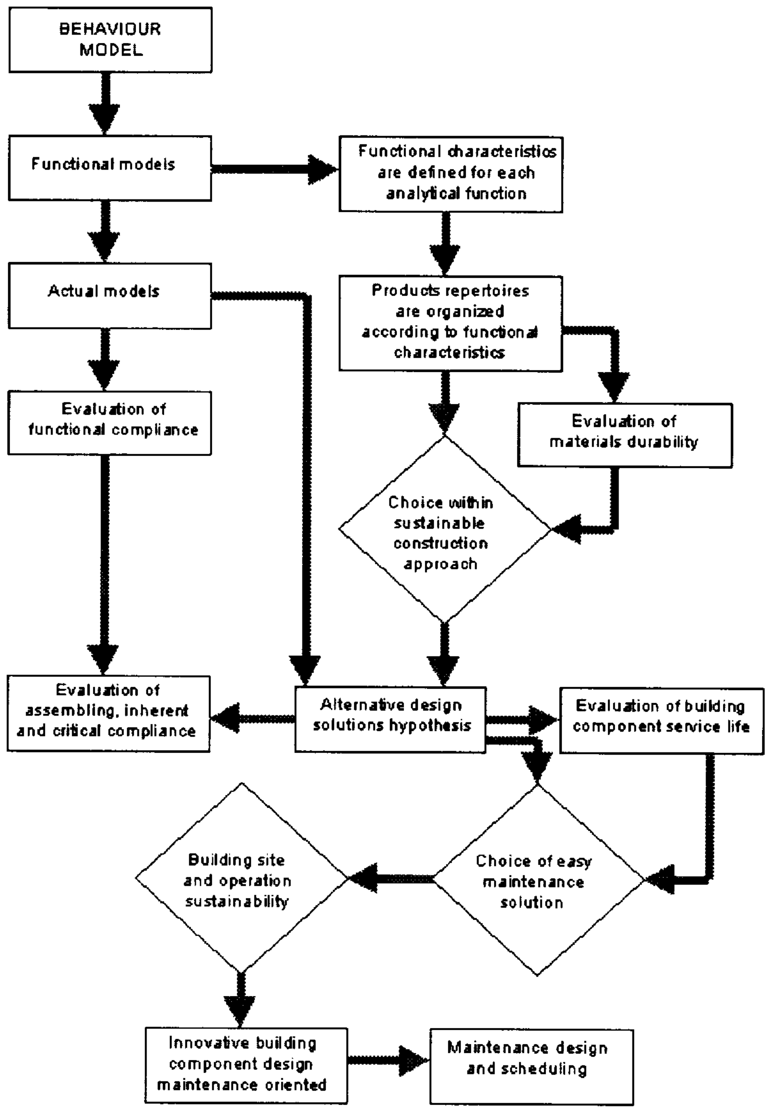


Fig. 1 Flow chart of a design process oriented to maintainability according to sustainability criteria. The process outcome is the maintenance design and scheduling.

fundamental functions	analytical functions		parameter
F1 to control interstitial condensation	fc	to resist to conductive heat flows	R or r
	ff_1	to foster water re-evaporation of interstitial condensation	presence of air in layers
	fg	to resist to water vapor permeation	μsN
	fh	to provide vapor water permeation	μsN
	fi	to provide constant resistence to vapor water permeation	Δμ
	fl	to provide constant resistence to heat trasmission	Δλ
F2 to control superficial condensation	fa	to resist to radiative heat flows	α
	fb	to resist to convective heat flows	presence of still air in layers
	fc	to resist to conductive heat flows	R or r
	ff_2	to foster water re-evaporation of superficial condensation water	open superficial prorsity
F3 to control thermal inertia in hot season	fa	to resist to radiative heat flows	α
	fb	to resist to convective heat flows	presence of still air in layers
	fc	to resist to conductive heat flows	R or r
	fd_3	to provide heat storage	ttc or TTC
	fe	to foster convective heat flows	presence of air in layers
F4 to control thermal inertia in cold season	fa	to resist to radiative heat flows	α
	fb	to resist to convective heat flows	presence of still air in layers
	fc	to resist to conductive heat flows	R or r
	fd_4	to provide a buil-up adiacent to the internal environmental	rc
F5 to control acoustic insulation	fm	to hinder by mass the trasmission of sound waves	ρ.s
	fn	to interrupt the trasmission of sound waves solids	presence of still air in layers
	fo	to provide visco-elastic dampening in solid mean	resistance to compression
	fp	to provide air tightness	absence of discontinuity
	fq	to provide acoustic absorption	α
F6 to control thermal insulation	fa	to resist to radiative heat flows	α
	fb	to resist to convective heat flows	presence of still air in layers
	fc	to resist to conductive heat flows	R or r
F7 to resist to hanging loads	fr	to provide compressive strengh	σ
	fs	to provide bending strengh	η
F8 to coltrol water infiltration	ft	to provide resistance to the flow of water	μ
	ff	to fpster re-evaporation of water flow	discontinuity
	fu	to provide opposition to capillary water permeation	presence of air in layers

Table 1 Fundamental functions, analytical functions and relative parameters for external non bearing walls.

The preferred solutions will be those simple to assemble and maintain, requiring the less amount of energy and not renewable resources for the building site phase as well as for the maintenance phase.

In order to properly plan the maintenance program, it is very important having information about the technical solutions behaviour overtime. This is why an experimental programme on building components, co-ordinated by Prof. P.N. Maggi, is currently carried on by Politecnico di Milano in co-operation with SUPSI of Lugano (CH) (P.N. Maggi et al., 1999).

Functional characteristics	*parameter*	*significance*
resistance to water vapor flow in the air	N(m.s.Pa/kg)	continuous
relative resistance to the flow of water vapour	μ (adim)	$\mu \geq 1.10^3$ or $3 \leq \mu < 1.10^3$
$\mu_{max} - \mu_{min}$	Δμ	$\Delta\mu < 0,1\mu_{med}$
thermal conductivity	λ(w/m°C)	
$\lambda_{max} - \lambda_{min}$	Δλ	$\Delta\lambda < 0,1\lambda_{med}$
absorption coefficient of thermal radiation	α (adim)	$\alpha \leq 0,5$
thickness (presence of still air in layers)	s(m)	$s \leq 0,08$
thermal resistance of the building component	R(m²°C/W)	$0,1 R < r < 0,5 R$
thermal resistance of the layer	r (m²°C/W)	$r \geq 0,5 R$
open superficial porosity	p (adim)	continuous
thermal time constant of the building component	TTC (h) or ttc (h)	$ttc \geq 0,5$ TTC or $0,1 TTC \leq ttc < 0,5$
air speed in layers	V (m/s)	$V > 0$
thermal capacity of the layer	c (wh/m²)	$10(h) \leq r c < 100 (h)$
absolute gravity	ρ	
unit/area mass	ρ.s (kgm/ m²)	$\rho.s \geq 100$ or $50 \leq \rho.s < 100$
resistance to compression	σ (kg/cm²)	$\sigma \leq 10$ (kg/cm²)
500 Hz acoustic absorption coefficient	α_{500}(adim)	$\alpha_{500} \geq 0,15$
resistance to compression	σ (N/mm²)	$\sigma \geq 2,5$
maximum displacement for the stressing moment of 300N.m	η (m)	$\eta < 1/1000$ h
height of the wall	h (m)	
relative resistance to the flow of water vapour	μ (adim)	$\mu \geq 1.10^3$ or $3 \leq \mu < 1.10^3$

Table 2 Functionals characteristics and significance conditions for external non bearing walls.

Conclusions and recommendations

The design phase is very important to allow a correct choice of building technical solutions, in order to match sustainability goals and requirements. An holistic bottom-up approach such the functional analysis is, is suitable, because it gives the best control of the defined performance requirements according to environmental and sustainability issues.

In order to manage at best the maintenance phase, authors think that experimental data are required about technical solutions behaviour overtime.

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A FEW REFLECTIONS CONCERNING ENVIRONMENTAL SUSTAINABILITY: TRADITIONAL CONSTRUCTION METHODS AND THE NEW PROPOSALS OF BIOECOLOGICAL ARCHITECTURE.

Authors: Carlo Caldera (C.C.), Marika Mangosio (M.M.), Caterina Mele (C.M.)

POLITECNICO DI TORINO – Department of Construction and Territorial Systems Engineering
Corso Duca degli Abruzzi, 24 - 10129 Torino ITALY

INTRODUCTION

Starting with the definition of "sustainable development", a number of reflections are made regarding the change in collective conscience that has taken place in recent decades in those countries having advanced industrial economies; this change reflects the way in which the man-environment relationship is understood, in relation to the ever-deepening awareness of the ecosystem concept and its implications.

PRESENTATION

Sustainability of the relationship between economic development and environmental protection (M.M.)

The concept of sustainable development, introduced at the beginning of the Seventies, reflects a major change of direction in the man-environment relationship.
This is the result of the recently acquired awareness that today's society is living beyond its means, that human civilisation is an integral part of the natural world and that it is vital for the survival of the community that nature be conserved and maintained in the long-term.
A range of symptoms that afflict our society and particularly the environment in which we live leads us to conclude that existing development models are not sustainable.
A growing gulf can be observed between human consumption of resources and the Earth's capacity to refurbish them and re-absorb the waste from our transformation processes.
It is now possible to re-establish the lost harmony between man and the environment, provided that a balance can be achieved between human needs and protection of environmental resources.
There are different interpretations of the concept of sustainable development, but in general these can be summarised into three aspects:

- improvement in man's quality of life whilst fully respecting the production and receptive capacity of the ecosystems;
- acceptance that a limit exists in terms of natural resources and their reproducibility;
- recognition of the importance of using only the renewable portion of resources at a rate that allows them to reproduce.

Moreover, according to the definition prepared by the Environment and Development Commission of the United Nations, sustainable development must be able to met the needs of today's generations without compromising the capacity of future generations to meet their own needs. Our lifestyle must hence be made compatible with the cycles and processes of nature; it is hence a question of radically changing current development schemes.
The frenetic technological development that characterises our societies has, in fact, drastically accelerated man's life rhythm in respect of nature's own timescales, giving rise to a deep schism. Man's policy of controlling nature through technology has generated situations that are unsustainable in bioecological terms for the environment.
Over the past decade European policy on the environment has taken a significant step as regards the production system. Capital investment linked to technological and economic development and environmental protection is finally being seen no longer as an antithetic process, but as complementary. It is now being recognised that, when identifying and meeting the needs of the community, the development has to be planned and constructed with an awareness of the interrelationships between the cultural, natural, social and economic resources for the situation as a whole. The real challenge lies with managing resources responsibly on the basis of global and interdisciplinary criteria.
A development process interpreted in this way must clearly be subdivided into various stages so that the environmental response and subsequent weighing-up of the intervention strategies can be monitored. An attempt is being made to direct current society toward a global change of the socio-economic development model with measures designed to avoid negative effects for mankind and the environment and to preserve natural resources. This innovative development

scheme hence presumes a design and planning approach that is preventive and regenerative.

Conscious technical decisions in the man-environment relationship (C.M.)

Although the historical role of technology (defined as *techne*, practical activity, as opposed to *episteme*, speculative-philosophical activity) in Western scientific thought, from Greek civilisation onward, has consisted in giving form, through invention and the use of increasingly sophisticated machines, to man's capacity to dominate nature, during the last few years of the century, hand in hand with the new awareness of the fragility and unique nature of environmental systems (of which man is an integral part and not an external and dominating element), a new strategic role is being defined for technological decisions, one that is no longer based on the indiscriminate exploitation of natural resources but on their respect and conservation.

Architecture is an ecological activity in a lateral sense, as directly confirmed by the origin of the word "ecology" that derives from the Greek *oikòs*, or home, in that it interprets man's material and psychological needs through diversified and interconnected actions. Right up to the pre-industrial age, man's activity did not substantially alter the balance of nature; it is only since the XIX century that the drive for indiscriminate exploitation of natural resources for use in manufacturing production resulted in an economic development model that is in furious competition with the physical environment and is threatening its very survival for the very first time.

Technology, particularly during the past thirty years, has encouraged the tendency to design without taking into account environmental conditions. The attempt to dominate the forces of nature is represented in Greek mythology by the tale of Prometheus, who gives man fire and hence symbolises the power of the *techne*. The same myth does, however, teach us that, without control, without respect for the natural and eternal order of things (the Aristotelian *Dike*), *techne* can bring mankind to ruin, just like Prometheus. If not supported by a broader understanding of the complexity [1] of reality, and the bond that links all elements of the natural world, man included, scientific and technical knowledge itself runs the risk of becoming the *hybris* of modern mankind.

In the architectural field the culture of industrialisation has produced a "dissipative" model, in other words one that is indifferent to the energy question. Within a complex sustainable project, there is no doubt that one of the variables to be included and controlled from the very beginning of the design process is the energy aspect; secondly, design must take account of parameters such as durability, reparability, the minimum use of virgin raw materials, of harmful substances, future ability to recycle different components. In essence, design must optimise performance with the least environmental impact.

A good example of design that is not merely architectural, in which basic ecological philosophy is associated with management strategy, is represented by the Hotel Ariston in Milan (designed by the architect Serena Omodeo Salè) [2]. The refurbishment project for this small hotel in the centre of Milan took its inspiration from the view that tourism is a sector that should invest in conservation and not dissipation of the environment, as is normally the case. Apart from the technical decisions to use materials and products biologically compatible with the environment, to optimise the energy aspect in consumption-performance terms, within the hotel a complex policy was implemented to reduce environmental impact by means of a shrewd management strategy. This entailed, for example, the implementation of a differentiated waste collection system in the rooms, the adoption of ecological paper for all purposes, the use of 98% biodegradable detergents, the separation of bedrooms into smoking and non-smoking, providing each guest with a bicycle for travel in the city, and so on. The financial impact of the initiative is positive because the extra 10% refurbishment project costs compared to a "traditional" design can be offset against the lower maintenance costs and the longer expected life of the materials used when compared to more conventional materials. Moreover, the implicit requirement for guests to take an active and conscious role in the ecological decisions of the hotel has been rewarded by an increase in usage; this demonstrates that a far-sighted and ecological management of decisions about design, in the lateral sense, even in a delicate area such as tourism, does not necessarily bring economic values into conflict with environmental values.

CONCLUSIONS

Restoring traditions and a new technological awareness (C.C.)

Any human intervention, in respect of the environmental ecosystem, introduces factors that

are, by their very nature, extraneous and potentially destabilising for the ecosystem itself; and so it is our belief that a fundamental factor for enabling and assuring the sustainability of each action is respect for the environmental and cultural differences of different places and territorial contexts.
At this moment in time of encounter between different cultures, there is a growing awareness of the formation of multi-ethnic societies, with movements of people and exchanges of technologies. We are also witnessing the global dissemination of information and taking part in its interweaving into networks of increasingly more complex and extended relations. (in "real time" and also without the physical displacement of people).
This situation may evolve in two diverging or opposing directions: the direction of standardisation, identity, validation (when superficial interpretations of events, interpreted as individual entities and not as elements of a "complex system", prevail), or one where there is an appreciation of differences, a deep understanding of their significance and reclamation of their values. This second direction requires the broadening of the sphere of knowledge to different cultural contexts (scientific, technical, human sciences, etc....), based on an interdisciplinary approach, in the "polytechnic culture" tradition. It could provide the key to enable us to participate consciously in the transformations taking place in the direction of sustainability. From the design and architectural standpoint, respect for the environmental and cultural differences of different places and cultural contexts may result in the restoration of traditions and special design techniques that are peculiar to each context. Reclamation of the value of traditions is often unconscious, but unconsciously appreciated; traditions are not seen merely as the use of materials or construction techniques of the past, but also as preservation of lifestyles determined by environmental, cultural and social "factors" and the inter-relationships between these very "factors". The concepts that today characterise modern and correct technological design, such as the ability to separate, dismantle, dispel with solidarity, aimed also at maintainability, deconstruction, recovery, re-employment, re-use of component materials, are inherent in the application of traditional construction techniques and in the use of local materials. The use of locally available materials is a conscious design decision that assures sustainability. This is due not only to the fact that it promotes optimisation of resources, minimisation of transport costs and energy for processing, but also because it restricts degradation of the same materials to "physiological" degradation, whilst maintaining environmental and micro-climatic conditions.
The use of traditional raw material transformation and processing techniques is hence compatible with the environment, even more so if achieved using local human resources and with consequent respect for the cultural value of traditions.
The rediscovery of the *genius loci*, when combined with the re-use of elements deriving from ancient building skills together with the new technological awareness and supported by modern knowledge and current legislation on the matter of Quality Control of the design and the built product, may constitute a valuable tool for creating integrated buildings and cities that are no longer alienated from the natural world.
These considerations increase awareness of how place, site and environment have a major impact on the design decisions for a single and non-repeatable building "event" (prototype), in space and time. And it is with respect for these "balances" that materials, construction techniques, lifestyles, cultures and so on have evolved over time, with slow transformations that are physiologically compatible with man's genetic transformations and implemented at a rate and/or acceleration compatible with human existence, in tune and in synchronism with one another. Using these basic premises we may be in a position to guide the evolutionary tendencies of the technological process along "paths" of compatibility between the different ecosystems, on the different "scales", consciously convinced of their absolute equivalence and equality of status.

[1] Complexity is the new scientific paradigm that has replaced in recent decades the mechanistic and linear vision of the world in Cartesian thought. In general terms, both in terms of so-called "common sense" and within the scientific community of the Western world, there has been a growing awareness that the phenomena that describe the physical and social reality that surrounds us are incomprehensible when considered separately, but are, instead, interconnected and interdependent. Cfr. for example M.M.WALDROP, *Complexity*,1989, It. trad.. Turin 1996, or J.GLEIK, *Chaos the birth of a new science*,1994, It. trad.. Rome, 1996
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A fuzzy ecoprofile of plaster products: an application by F.a.l.c.a.d.e. software

Eng. Maurizio Cellura, Eng. Davide Ardente, Prof. Giorgio Beccali, Eng. Valerio Lo Brano
Organisation: DEAF – Università degli Studi di Palermo – Viale delle Scienze 90128 Palermo (Italy): Phone: ++39–091–236127, ++39–091–236123; Fax: ++39–091–484425;
e-mail: beccali@unipa.it fta@unipa.it lo_brano@deaf.unipa.it

Introduction

Linear methods used to solve "Life Cycle Inventory system (LCI)" provide results which seems to have more accuracy than we could expect from available data. In other words, linear models used to describe LCI of materials hide the uncertainty affecting data. Traditional mathematical techniques used to model higher complexity systems (such as statistical analysis or non-linear models) require a large amount of additional data, whereas in real world we make use of incomplete or obsolete databases. It seems necessary evaluate "data quality" during the ecoprofile estimation phase.

In this paper the F.A.L.C.A.D.E. (Fuzzy Approach to Life Cycle Analysis Decision Environment) software is showed. It sketches a different way of LCI redaction, based on fuzzy logic. A Life Cycle Inventory (LCI) for a building plaster product is derived. Plaster building material comes out in three stages: extraction of resources, processing of materials and product manufacturing. The study performed ranks the environmental burdens due to the production of the specified material. The LCI has been derived using the matrix method and the linear inventory functional unit (FU) is compared to fuzzy FU.

A F.A.L.C.A.D.E. software

A first innovation introduced is the use of fuzzy numbers to represent the items of environmental matrix considered more uncertain. The second innovation is the quantitative modification of the "raw data" using expert knowledge, expressed by qualitative judgement. This enables the analytical interaction between "data quality" and "raw data". The proposed model enables the interaction between numeric data and the human expert knowledge (see figure 1), seldom estimated in similar models. Authors have built the fuzzy rules (the proposed model contains 240 rules) that summarise their knowledge about the relationship between four qualitative judgements (statistical relevance, data age, technological parameters, and geographical characterisation) and data values, expressed by scenarios (see figure 1).

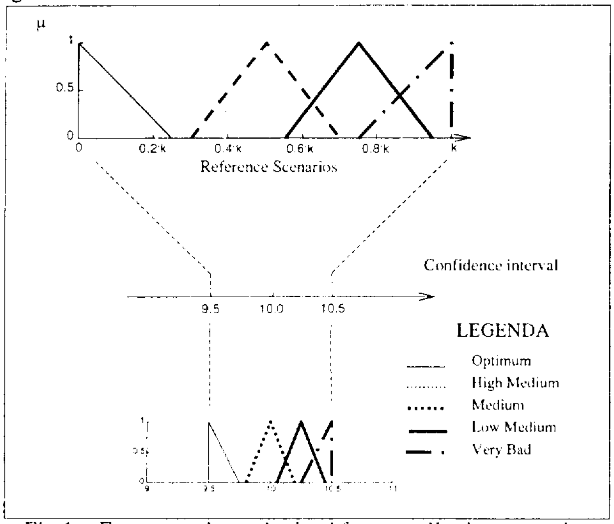

Fig.1 – Fuzzy numbers obtained from qualitative scenarios

In this context, the LCI became a decision support tool, where qualitative information can be merged with numerical data. Consequently, the estimated EcoBalance should be considered a decisional process, instead of a "precise" ecoprofile of functional unit. We define fuzzy rules as follow: *if* $G_1 is \tilde{X}_{j1} \wedge G_2 is \tilde{X}_{j2} \ldots \wedge G_n is \tilde{X}_{jn}$ *then* $S \; is \; \tilde{Y}_k$

where is judgements, $_j$ linguistic terms and S represent scenario linguistic variable. In a synthetic form: $\tilde{X}_{j1} \wedge \tilde{X}_{j2} \ldots \tilde{X}_{jn} \Rightarrow \tilde{Y}_k$

where k_i is a generic linguistic term. The overall number of rules R is: $R = \prod_{i=1}^{n} k_i$

Figure 2 shows a sketch of linear inventory table of ready whitewash. Software calculate Xarray, Environmental matrix, environmental Functional Unit (FUenv) and condition number. The condition number of a matrix describes how sensitive it's to errors in the right end side vector when solving systems of equations. When this number is near 1, the matrix is said to be well conditioned. When the reciprocal condition number is near 0, the matrix is ill conditioned. The solutions obtained for ill conditioned matrices may not be very accurate

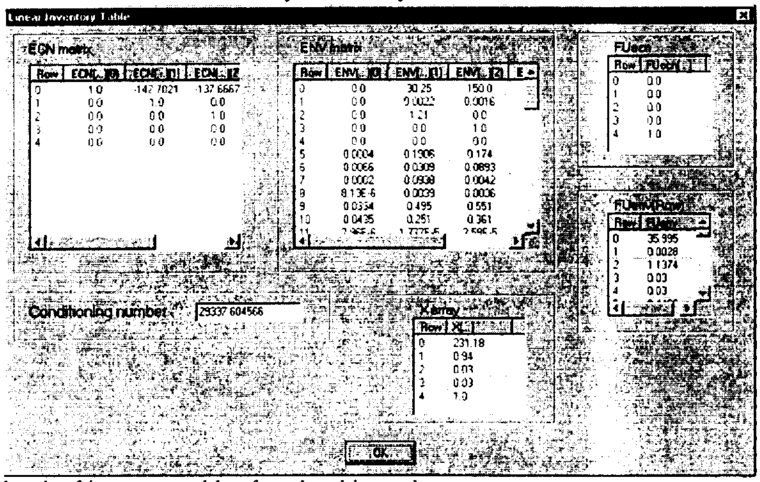

Figure 2: sketch of inventory table of ready whitewash

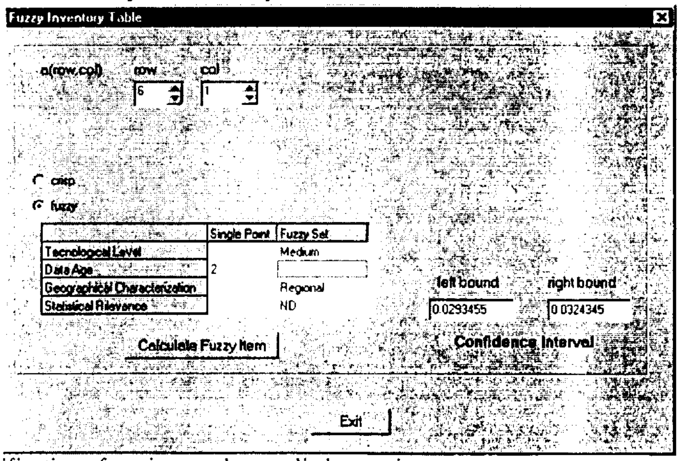

Figure 3: Fuzzification of a crisp number applied to a_{61} item

In a comparison between linear ecoprofile and fuzzy ecoprofile, items of Economic matrix (ECN) considered more uncertains are linked to the consumption of power energy (Factory consumption is 142.7 MJep/(ton UF) and media national consumption is 738 MJep/(ton plaster products). Figure 3 illustrates a fuzzification of a crisp number in the case of a_{6l} item of ENV matrix. In figure 4 is showed the fuzzy item obtained with the fuzzy inference. Finally, figure 5 describes final stage of F.A.L.C.A.D.E.

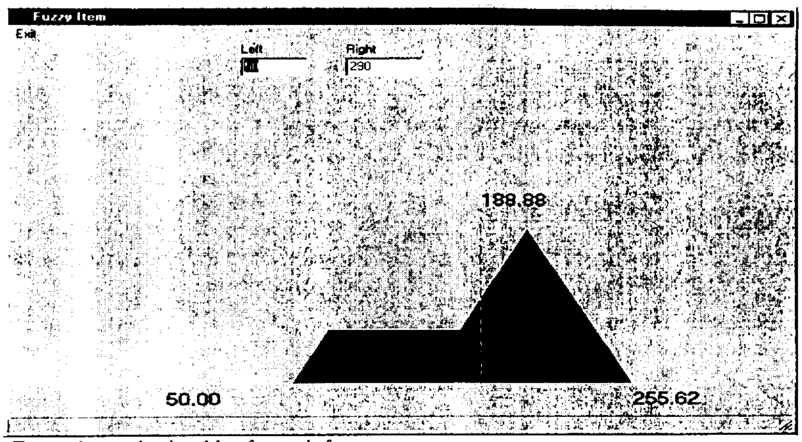

Figure 4: Fuzzy item obtained by fuzzy inference

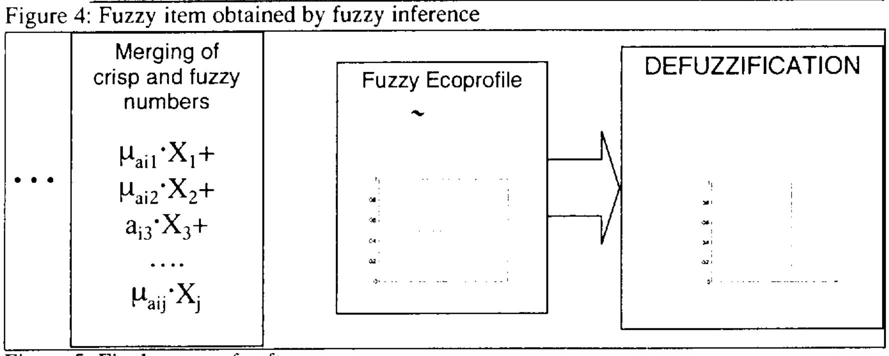

Figure 5: Final stages of software

Conclusions

Traditional linear methods utilised in order to solve the material/processes relationships systems seem to be "much exact" if compared to the quality of available data. F.A.L.C.A.D.E. define an original model founded on interaction between *expert knowledge – datum quality – numerical datum*. The software permits to users a definition of more flexible procedures which, from data collection to the final evaluation of ecoprofile, could represent a complete tool for the LC analyst. A comparison between linear and fuzzy ecoprofile of plaster product show a meaningful differences caused from a wide interval of confidence in a case of energy power consumption's.

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THE EFFECT OF STABILIZED WASH WATER ON EARLY STRENGTH GAIN AND THERMAL PROPERTIES OF CONCRETE

Abdol R. Chini*, Larry M. Muszynski*, Anthony Pavlides*, and Michael Bergin**
*M.E. Rinker, Sr. School of Building Construction, University of Florida, Gainesville, FL, USA
**Florida Department of Transportation, State Materials Office, Gainesville, FL, USA

INTRODUCTION

The disposal of wash water is becoming increasingly difficult for the ready mix concrete industry. The United States Environmental Protection Agency has imposed regulation changing the disposal practices of wash water due to its high pH. Concrete producers have to contain the truck's wash water either on-site or ship it to facilities that can handle this toxic wash water.

In order to overcome the potential problems of recycled wash water and plastic concrete in new concrete, stabilizing admixture systems were introduced in 1988. The use of these admixtures that temporarily stops the hydration process circumvents the necessity to remove any wash water from concrete truck drums, and allows wash water to be reused for mixing new concrete.

Much of the concrete placed in the southern parts of the US is placed at temperatures in excess of those maintained in the laboratory. This study determined the effects of increasing the concrete temperature and its surrounding environment on the properties of concrete made from stabilized wash water. Most of the State Highway Standard Specifications require a minimum percentage of 28-day compressive strength for form removal. This study measured the early strength gain of concrete made from stabilized wash water and determined if it affected form removal. The effect of stabilized wash water on thermal properties of concrete is an important consideration, especially in mass concrete applications. The magnitude and shape of the adiabatic temperature rise verses time curve, which are important measures of the heat-generating potential of a concrete mixture made with stabilized wash water were determined and compared to those of a control mixture made with tap water. This determined if stabilized wash water affected the thermal properties of concrete.

This paper presents the results of a study conducted to determine the effect of using overnight-stabilized wash water in production of fresh concrete. Early strength gain and thermal properties of concrete made from stabilized wash water were compared to those of untreated control mixtures.

CONCRETE MIXTURES

Four control mixtures were proportioned and evaluated using a number of fresh and hardened concrete tests (temperature, slump, unit weight, air content, set time, compressive strength, flexural strength, drying shrinkage, resistance to chloride-ion penetration, and adiabatic temperature rise). Each of the four mixtures was then evaluated in the laboratory under conditions that simulated overnight stabilization of their wash water to determine how the fresh and hardened properties changed. Two replicates were made for each mixture, which resulted in a total production of 8 trial batches of concrete. Each mixture was designed to have a 28-day compressive strength of 31.1 Mpa.

The Stabilizer dosage was determined for the control mixture such that time of initial setting was not achieved until approximately 30 to 36 hours after mixing. This would comfortably permit stabilization of the concrete wash water for 12 to 20 hours, which is the typical duration of interest for ready-mixed concrete producers. The laboratory mixer was found to retain approximately 13.5

Kg of concrete in the drum after discharging a batch. The calculated ratio for the laboratory mixer was 50 ml DELVO: 13.5 Kg concrete: 14.5 Kg of water. In the laboratory a 0.17 m^3 batch was mixed, so the 13.5 Kg of cementitious material represented 3.5% of the new mix.

After a particular control mixture was batched and mixed, it was discharged leaving only a butter, the 13.5 Kg of cementitious material, remaining in the mixer drum. Tap water was added to the mixer drum for cleaning and the amount was recorded. Fresh concrete tests were performed and hardened concrete specimens were molded from the discharged material. After two hours elapsed, the DELVO Stabilizer was then added to the drum, and the wash water mixture was mixed for 3 minutes to ensure uniform distribution of the Stabilizer. The laboratory mixer was then covered to prevent evaporation of the wash water. No additional agitation of the stabilized wash water occurred after covering. Twenty-two hours after addition of the DELVO Stabilizer, a batch of concrete similar to the control was batched into the stabilized wash water mixture. This concrete had proportions similar to those of the control, except water was withheld to compensate for that added to create the wash water. The total trial batch was then mixed and discharged. Fresh concrete tests were performed and hardened concrete specimens were molded.

TEST RESULTS

Table 1 provides a summary of the fresh concrete test results. Mixtures number 1, 3, 5, and 7 are the control mixes and do not contain Stabilizer, whereas mixtures numbers 2, 4, 6, and 8 contain stabilizer.

Table 1 Fresh Concrete Test Results

Mix	Temp C Conc.	Temp C Room	Slump mm	U.Weight Kg/m^3	Air %	Initial Set Time Hrs:Min	Final Set Time Hrs:Min	W/C Ratio
1	37	28	51	2313	2.5	4:05	5:10	0.42
2	35	28	43	2287	3.0	4:50	6:05	0.42
3	37	30	25	2294	2.7	4:20	5:35	0.44
4	38	30	25	2313	2.9	6:10	7:30	0.44
5	24	23	51	2268	4.0	X	X	0.38
6	23	22	51	2270	3.7	X	X	0.40
7	21	20	89	2243	4.5	X	X	0.44
8	22	20	89	2244	4.5	X	X	0.40

- "X" Indicates item was not measured.

There were minimal differences in unit weight between the control mixes and the experimental mixes. The stabilized wash water mixes took longer to set both in their initial times and their final times of set.

For mixtures 1 - 4, the compressive strength cylinders were tested at five different times to find the effect of stabilized wash water in early strength gain of concrete. As Table 2 shows, the early strength gain of concrete has not been affected by the use of wash water. The compressive strengths at 28 -day for stabilized wash water, were generally higher than the control mixtures.

Adiabatic temperature rise is important in determining the thermal properties of concrete. Extreme differentials in thermal properties of concrete may cause excessive cracking in a structure using

Table 2 Average Compressive Strength, Mpa

Mixture	1-Day	2-Day	3-Day	7-Day	14-Day	28-Day
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	19.8	25.6	27.8	34.0	X	42.1
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	21.2	27.9	31.0	36.1	X	44.2
5	X	X	X	[illegible]	[illegible]	[illegible]
6	X	X	X	36.9	40.0	43.4
7	X	X	X	[illegible]	[illegible]	[illegible]
8	X	X	X	31.6	35.6	39.8

large quantities of concrete. Excessive cracking will cause the concrete to fail in its intended design use. Figure 1 shows the adiabatic temperature rise of concrete samples 5 though 8. The graph shows that stabilized wash water does not have any adverse effects on the thermal properties of concrete. Both sample groups were very close in comparison with their respective control samples. The sample groups were tested for fourteen days.

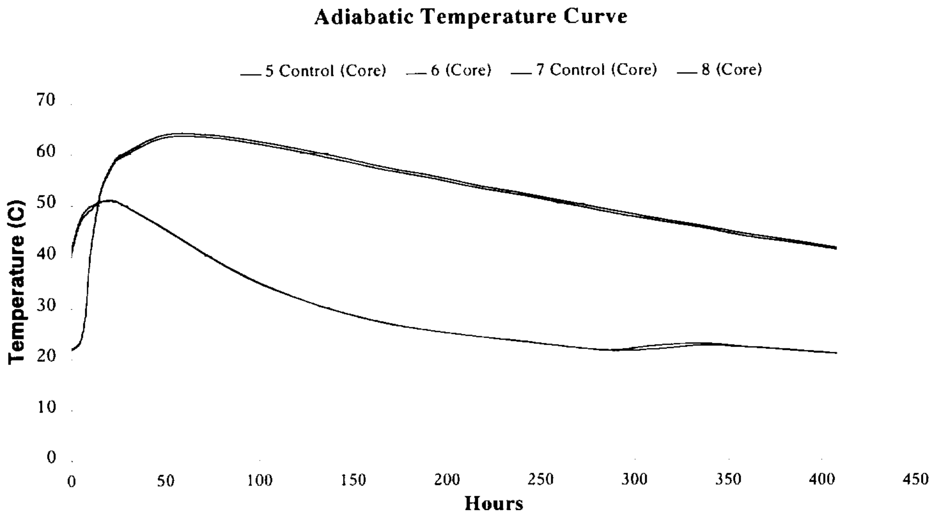


Figure 1 Adiabatic Temperature Rise for Mixtures 5 - 8

CONCLUSION

Compared to control concrete samples, the compressive and flexural strengths and drying shrinkage properties of the stabilized concrete are acceptable. The difference between stabilized mixtures and their control mixtures was in set times. Set times for the stabilized mixtures were greater than those of their control mixtures.

Building real buildings with cardboard

Dr Andrew Cripps, Buro Happold Consulting Engineers, 17 Newman St, London,
In partnership with: www.cardboardschool.co.uk

Cottrell and Vermeulen Architects	Architect
Westborough School	Client
Essex Tube Winding Ltd	Manufacturers of card tubes
Paper Marc	Manufacturers of paper and board
Quinton and Kaines	Manufacturers of panel products
C G Franklin	Building Contractor
Dept of the Environment, Transport and the Regions	Government Sponsor

Introduction - why build with cardboard

Cardboard is a material with an image problem. People think of it as a disposable, short life packaging material with poor properties. In reality it can perform very well over an extended period if it is designed correctly and treated properly. Perhaps most importantly from an environmental and sustainability point of view it is also made from a waste product for which there are few alternative uses - paper. This makes efforts to find appropriate construction uses of cardboard appealing in environmental terms, as well as offering an interesting challenge.

There are already several common uses of cardboard in construction, and more still in the furniture sector. A large proportion of internal doors are filled with a cardboard honey-comb, covered with a thin laminate. Tubes are used for column forming because they are cheap and available in large numbers. This not only reduces cost compared to other sorts of form work, but can save time as well. Tubes are also being used to help the process of pile driving. Panel products are widely used in temporary and Exhibition structures.

Cardboard dominates the packaging industry, because of its low cost, but also its ability to give enough protection to the object being packaged. There is no need for greater strength for breakfast cereal boxes; these products normally reach us in good condition so it is clearly doing its job. But by coating cardboard it is possible to use it for transporting frozen fish. Perhaps most striking where a vast quantity of liquid is transported in cardboard boxes lined with aluminium and plastic.

What these examples show is that like any other material, cardboard, when engineered correctly, can do the job it is asked to do.

Figure 1:Card beam under two man test load!

Environmental issues

The process of paper and cardboard production is interesting from an environmental point of view, and has often generated debate. All of the materials involved are relatively cheap and bulky, so that transportation is a key issue for consideration. However fundamentally, using cardboard products must help to find a secure market for the waste paper that is otherwise finding its way into landfill sites.

Worldwide the annual use of paper and board is about 300 million tonnes, and this requires a lot of trees. The card industry is one of the largest users of post consumer waste paper.

The issues to consider in terms of paper recycling are the collection and movement of the material, and any waste products removed in the process. These wastes are both solids, like plastics or any stray metal, and liquids, including any inks or water repellents. The energy balance of recycling also deserves checking, as if it is carried out sufficiently inefficiently it might be less energy intensive to use new trees instead.

Overall I am confident that wider appropriate use of cardboard in construction will have a positive impact on the environment.

What has been done before

The largest number of cardboard buildings have been designed by the Japanese architect Shigeru Ban, most recently the very large gridshell for the Japanese pavilion at the Hannover Expo. However, in my opinion, the most important work he has done has been in emergency shelters. These have been used in Africa and more recently in Turkey following the earthquake there, and have been based on cardboard tubes.

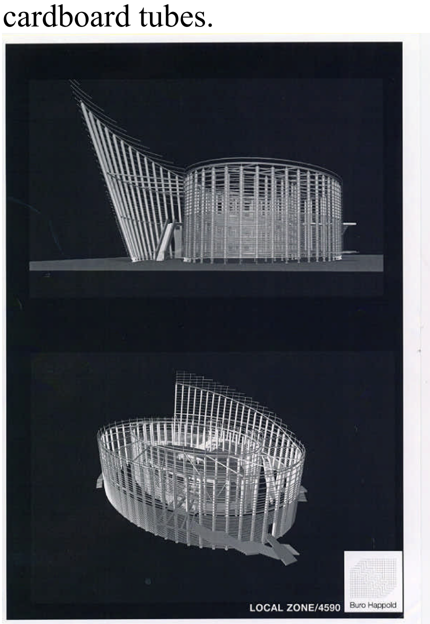


Figure 2: Local Zone in the Millennium Dome

Buro Happold has experience of large scale construction with cardboard, with three important projects being the Local Zone (also called Shared Ground) in the Millennium Dome, the Japanese Pavilion for the in the garden of MOMA (Museum of Modern Art) in New York. All three of these examples involved the architect Shigeru Ban again, although others were also involved.

Our project

One of the features of most of the previous examples is that they are short lifetime buildings. At Westborough school we wanted to develop something more modest in terms of size, but with a longer useful life.

The Westborough school, near Southend to the East of London, is a large school for the under 11s, with over 700 pupils. The project is for an 'after school club', which also provides toilets for the playground, and a general purpose space for the school.

Our current design thinking is shown in the two images below. The intention is to make an interesting building, so that people have further reason to take note of it. Its form reflects the nature of cardboard, in particular the corrugated nature of the South facing wall. The main approach is to use 50 mm thick honeycomb card built up in three layers to make a complete wall or roof panel. These are timber edged to aid jointing. Across the centre there is a wooden truss, necessary to span the width of the building. This is supported by cardboard tubes; other tubes support the roof on the side with the large windows.

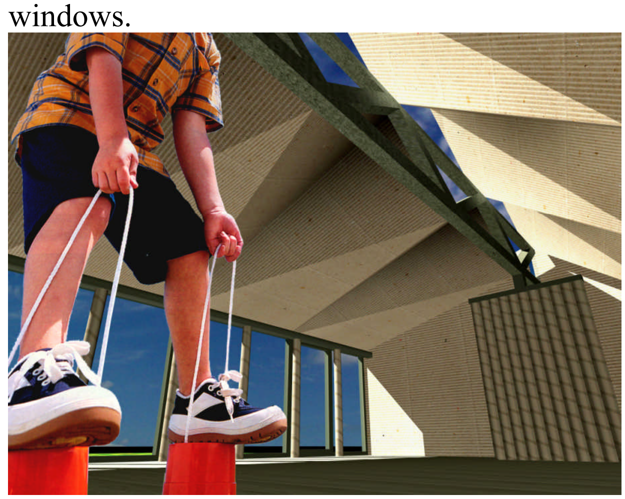


Figure 3: Internal view from design concept

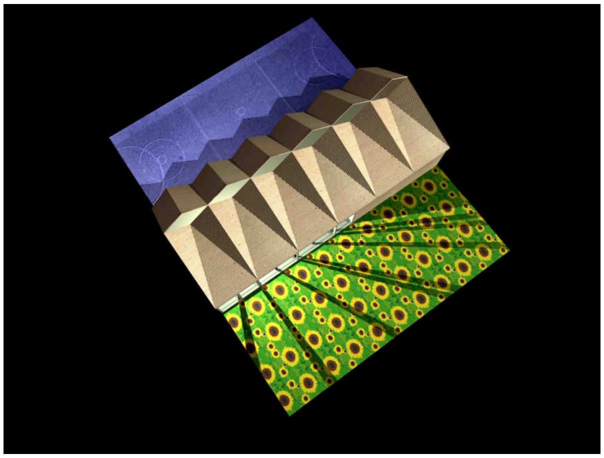


Figure 4: Aerial view of design concept

Dealing with fire and water and other hazards

Water

When you talk with people about building with card, they nearly always ask something like, 'Won't it get soggy when it rains?' The answer is of course yes - unless you do something to stop it. In this case we have opted for a 'belt and two sets of braces approach', we do not have time to test options.

First we are treating the card with a water repellent chemical, to prevent the card absorbing moisture from the air, and to allow it to survive any accidental wetting. This chemical is removed in the re-pulping process, so allows recycling, although in an ideal world it would be avoided.

Secondly, each panel is coated with a plastic layer, to keep moist air or liquid water out. This coating is also removed by the pulping process.

Finally, on both the inner and outer faces of the panel, there will be a protective top layer. On the outside this will serve as a rain-screen or tile, and on the inside as a pin-board for the classroom. This outer layer may well need to be replaced every few years, as it will bear the brunt of footballs on the outside, and whatever the children are doing on the inside!

Fire

Although cardboard obviously does burn, it is actually very similar to wood in its fire performance. This means that it tends to char on the surface, and therefore although it is damaged, it does not contribute significantly either to the heat of the fire nor to the spread of flame. Hence, in this case at least, the issue of fire is not as critical as might be expected.

Other hazards

The description of the panel system covered the approach to natural wear and tear with the outer and inner layers. The outer layer is not fully specified yet, but will also need to be tough enough to discourage deliberate damage. However the school does not have a problem with vandalism so this aspect does not need to be excessive.

In other locations there could be more of a problem with vermin of various types. Care is needed in the detailing to make it difficult for any to gain access. We can learn from the straw building community in this respect.

Conclusion: Environmental impacts

One particular benefit of using honeycomb cardboard as the main structural component, is that it provides good insulation at the same time. Calculations show that the panel structure we plan to use has a U value of around 0.3 W/m^2 and this is sufficient to exceed the UK building regulations.

In setting out on the project, we set ourselves the target of achieving 90% recyclability, and 90% recycled material input. It is important to emphasise that the need to deliver a viable building supersedes those targets, but we are still confident we will be close to achieving this through the use of so much card.

Everything in sustainable construction involves some compromise, and we are comfortable with where this project is taking us - but believe others could go further.

THE USE OF THE BLOCKS IN CELLULAR CONCRETE: A BIOECOLOGICAL RESIDENTIAL GROUP OF BUILDING IN ITALY

Curtetti S., Boido N., Osenga F.

1. Polytechnic of Turin, Department of Building Engineering and Territorial Systems
   C.so Duca degli Abruzzi, n.24 10129 TORINO, ITALY, tel.+39 011 5645320 fax +39 0115645399
2. Constructors Association 's of Alexandria
   Via L. Tolstoj n.5 15100 ALESSANDRIA, ITALY, tel +39 0131 348095 fax +39 0131 341235

INTRODUCTION

" Today the architecture, understanding like phenomenon that governs all the morphologic modifications of natural atmospheres and antropised, has been invested from the knowledge that the interactions between plan and the fallen back ones that it determines, with its outcomes, on the natural atmosphere and the human society, must be faced with conceptual contributions renewed and adapted operating instruments ".

In an optical of environmental awareness, in the definition of new horizons for the architecture plan, a fundamental role can be carried out from environmental technologies that are demonstrated; not polluting, adapted to the material culture of the place, correlated to the morphologic and climatic conditions of the participation place, opened to possible variations in the time and the space.

The peculiarities of the environmental, therefore delineated technologies, demand one put to new point of iter design one that comprises the environmental analysis like forecast instrument and control of the participation techniques.

A process design, that is, oriented to diminish the environmental impact, that it can articulate the participations with continuous transformations of the " matter ", in a position to reducing accumulates injurious and wastes of resources.

This attitude design consequently involves the overcoming of the traditional contrast between existing ambient innovative proposal and, and demands the study above all and the use of a new materials which as an example of blocks of cellular concrete.

The present paper would therefore to introduce a case of use of blocks of cellular concrete in a bioecological residential group of building in Italy to Cella Monte (Alexandria).

This participation has been introduced to the European Community in the within of the financial demands for support for the plans of Life-Ambiente demonstration.

PRESENTATION

The bioecological residential complex of Cellamonte is composed from 4 country house monoplan, organized second the traditional functional outlines, with a wide stay localized centrally regarding the other buildings, than it is inspired to the ancient conception of the " villae Roman ".

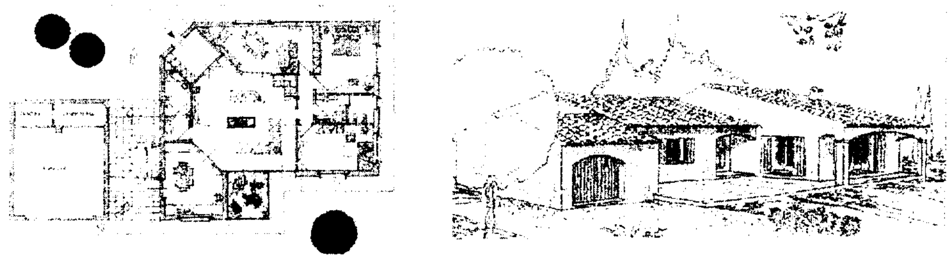
The space is organized second two levels: one zone of conversation and dining room to the flat earth; and a zone with soppalco in wood where has been placed the study.

All the building is equipped of wide glasses that they perspectively widen the volume towards surrounding hills and allow is the natural lighting system that the ventilation.

Every building has been oriented with the main facade turned the south-west, while the kitchen, the baths, the laundry and the rooms from night of occasional use have been turned to north.

Along the side south it has always been placed a greenhouse, bioclimatico element essential in order to capture the energy of the sun, through the superficial widths windows, heating therefore the inhabited spaces adjacent and inducing a fort energetic saving.

The carrying masonries external and the solai have been executed with constructive materials to the high thermal inertia, constituted from blocks and panels in cellular concrete (Ytong) and certifyd from the Federal Association Biological Products for the Building of Monaco.
These blocks from the thickness of 30 cm, equipped of joint male and female on the vertical faces and of handles of raising propose optimal levels of thermal and acoustic isolation and of elevated traspirability that is in monitoring.
In particular through the use of this material in this work site pilot resolves to do to improve the environmental conditions of the work site of construction and demolition, diminishing the powder formation, of working refuse, of refusals, allotting in the best possible way the resources available in the respect of the principles of building Biology, verifying the sustainability of use of the blocks in cellular concrete, like raw material.



n.1 View and plan of one country house of the residential complex of Cellamonte.

The project would have therefore to stretch to diminish wastes it of water, avoiding concentrations of dangerous substances on the ground.
In particular the subject promoter (Constructors Association 's of Alexandria)will realize a prototype in laboratory where will come simulated a demolition worksites and where which it will come put into effect a monitoring system in order to estimate the indicators of environmental eco-sustainability of the product.
In practical the project is organized in work package:
WP1 Planning of the 4 buildings taken to champion second the shared principles of the bio-achitecture.
WP2 Planning and definition of the 4 worksites pilot (areas, phases of working, choice of the indicators of eco-sustainability to estimate)
WP3 Planning of the system of monitoring of the data
WP4 and WP5 Preparation of the worksites pilot and beginning of the collection of the data of the monitoring

n.2 View of work siteof the residential complex of Cellamonte.

WP6 Collection of the data during the phases working

WP7 Collection of the data during the phases conclusing of the work sites
WP8 Collection of the data on the constructed buildings champion
WP9 Realization of the prototype
WP10 Simulation of a yard of demolition of the prototype and collection of the data
WP11 Activity feedback of procedural models
WP12 Major deliverables and Validation of the models
WP13 Final professional formation and spreading of results.

Objective of such experimentation is to compare the pointers of ecoefficiency of a work site in which they are used of the blocks in cellular concrete, like raw material with a work site in which they are used material and arranges traditional, holding account of their environmental impact, of their cycle of life (under shape of raw materials, in the phases of rests, use and treatment post-use and recycling) to the aim to write up a procedural protocol of performance of the constructive technique and recycling post use of the blocks of cellular concrete, aimed to maximize the ecoefficiency pointers.

CONCLUSIONS

The job, that is still in progress, proposes to improve above all uses it of the products and the innovative techniques for all the duration of their cycle of life (from the construction to the dismissione) and in the " daily consumption " of the ecological building (environmental impact, maintenance, small saves daily paper, etc), integrating process and product.

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THE ENVIRONMENTAL GEOTECHNICS AND ENVIRONMENTAL QUALITY OF SOIL

Y.G. Diab and D. Morand
LGCU, Marne la Vallée University, 2 Rue Einstein, 77420 Champs sur Marne, France. Email :ydiab@univ-mlv.fr; morand@univ-mlv.fr

INTRODUCTION

The Geotechnology is the field of understanding of soil and rock materials and is defined as a field of professional practice and research. No area within geotechnology has developed more rapidly, or seen wider application over the past 15 to 20 years than has the one that is concerned with the specific application of geotechnical engineering to solve environmental problems. The term geoenvironmental engineering has been widely used to describe these activities; however this term is better reserved for the overall engineering of environmental projects that encompass the earth, groundwater, safe waste containment, site remediation and which require the expertise of scientists and engineers from several disciplines. Thus, all engineering should incorporate environmental engineering, and all engineering that involves the earth and earth materials should incorporate geoenvironmental engineering.

PURPOSE

The purposes of this paper are to review some technical and professional practice issues that are special to environmental soil behaviour. Classical concepts and theories that are properly understood, adapted, extended and applied provide solutions of most problems related to the environmental quality of soil.

Although, a number of studies of the properties of waste materials had been reported, and the potential for utilisation of wastes in construction or for other purposes had been recognises earlier, it wasn't until the late 1970's that the geotechnical engineering profession became seriously involved in environmental issues. Nonetheless, there remains much to be done. The estimated costs for site cleanups and corrective actions is prohibitive. In addition, attention is now being directed at urban 'Browfield' sites where environmental cleanup and restoration is being used as a catalyst for sustainable urban development. Thus the need innovative environmental expertise will continue strong and the contributions to make are many, including :

- The development of standards founded in scientific reality.
- Working towards increasing the importance of economical sound solutions in the prescription of remedial solutions.
- Doing the investigations and analyses required for successful sustainable projects.

TECHNICAL CONSIDERATIONS IN ENVIRONMENTAL GEOTECHNICS

Almost all geoenvironmental fields that contain large geotechnical components fall within one of these general categories ; namely a) design, construction, operation and maintenance of new waste disposal and containment facilities, b) isolation of contaminated ground and c) remediation of contaminated sites. A brief description of these projects types are given

Safe containment of wastes :

The primary concern in the design of such facilities include :

1- the liner system must restrict the escape of leachate to acceptable limits through a combination of an effective leachate collection and removal system.
2-The cover must restrict the infiltration of surface water and support vegetation and prevent intrusion by animals.
3- The landfill must be safe against stability failure during the construction and the filling period and after closure.

Dealing with the geotechnical aspects of landfills requires the correct application of principles and procedures that have been developed over many years. This requires knowledge of the stress deformation relation, hydraulic conductivity and durability properties and the soil mechanics principles.

Isolation of contaminated ground

The purpose is to prevent contact between hazardous and toxic materials and uncontaminated ground water, soil and air. A typical containment barrier system usually involves some type of cutoff wall, a bottom seal and a cover (Diab, 1996). Some instructive case history examples to illustrate the role of soil mechanics in containment barrier are described by Mitchell (1996)

Remediation of contaminated ground

Technologies for the cleanup of contaminated sites include pump and treat, bio remediation, soil washing... These technologies were evaluated by many searchers like Grubb and Sitar (1994). Geotechnical issues are very important in all remediation projects. The specialist in environmental geotechnics is likely to be a member of an interdisciplinary team, with responsabilities for soil characterisation, soil property assessment, installation of treatment systems into the ground, and monitoring activities during and after treatment.

Site Characterisation

It is the most important part of any geoenvironmental project. It permits to develop a complete picture and accurate understanding of what is beneath the ground surface as is possible. Geophysical methods are under continuing development and being more extensively used as an indirect means for seeing into the earth for environmental assessment..

The importance of materials

If the characterisation of soils and their properties is improperly done, the analyses might generate misleading conclusions. This problem is even more important in the field of environmental geotechnics because it is important to know every thing about the groundwater chemistry, the, soil-waste interaction, the effects of gases, biological transformations, etc..

It is important to observe that a large difference may exist among properties of the different components of a geoenvironmental system and that the interaction waste and soils can provoke cracking, clogging and less of strength.

THE PRACTICE OF ENVIRONMENTAL GEOTECHNICS

The scientific and technical problems identified in earlier sections of this paper, require specialised knowledge and experience in the fields of compositional, physico-chemical and conductivity properties of soils, seepage and groundwater flow. Some of the characteistics of the geoenvironmenal engineering that differ from classical geotechnical engineering, we can quote :

- the interdisciplinarity of the projects.
- there are contradictory regulations and the geotechnical input in these rules were very limited.
- legal and liability issues dominate in many cases and the progress of many projects are controlled by regulators.
- many projects are done at very high cost with benefit/cost ratios that are not readily definable or which would be very low if compared with more traditional projects.

-Health and safety issues are essential of all projects.

These parameters that give a uniqueness to geoenvironmental engineering are neither scientific nor technical, expect as to the interdisciplinary nature of most problems and projects. Instead, they are social, political, legal, regulatory and economic. Thus the success in the practice is not easy.

THE CLASSIFICATION

Actually many researchs are realized to identify the quality of soil by identifying the the potential contamination behavior and to estimate the sensitivity to pollution. Between all of these studies we can quote Fang (1994) and Diab (2000). The first results are intersting and might be included in the in rules like the AASHTO, USGA, AFNOR...The parameters to be considered in the classification of a contaminated soil, we can quote.

Chemical ones like :

- Silica / Sesquioxide ratio,
- sorption and adsorption
-specific area

Physical parameters like the color, the cracking patterns and volume change.

The combination of these parameters permits to define the PSI (Pollution Sensitivity Index). A classification was proposed by Fang (1994) for USA and modified by DIAB (2000) for the soil in France. (table 1)

PSI	Soil Type	Surface area cm^2/cm^3	Sensitivity
0-2	Gravel	15-0,125	Very low
2-4	Sand	600-15	Low
4-6	Silt	6000-600	Medium
6-8	Clay	30000-6000	High
8-10	Colloids	>30000	Very High

Table (1) : Preliminary classification of contaminate soil

This classification permits to build on soil well-environmentally identified. It is important to observe that this identification of soil contamination is not well considered in the analysis of sustainable building or urban development.

CONCLUSION

For design, construction and maintenance facilities, the condition of the site must be known. Consequently, the controlling parameters used for characterisation of contaminated soils must be evaluated. A simple numerical number was introduced to predict the the polution potential of soils for preliminary investigations. We hope that many other researhs assist in the identification of soil-water-pollutant interaction in the environment.

However, there are also aspects of environmental geotechnical problems that require new understanding. This includes dealing with new materials and their time dependant mechanical and chemical transformations.

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GREENBALANCE™:
A Step Beyond Sustainability in Building Performance
And
A Complementary Method to BaselineGreen™

Pliny Fisk III
Richard MacMath
Center for Maximum Potential Building Systems, Inc.
8604 FM 969
Austin, Texas 78724

INTRODUCTION

BaselineGreen™ examines the upstream external environmental costs and regional employment impacts of construction-related inputs of a generic baseline building based on a proposed building design. The upstream external environmental costs are summarized in an "external environmental cost ratio" (EECR) while the upstream employment impacts are summarized in an "employment impact ratio" (EIR). Both an EECR and an EIR are assigned to high priority construction inputs within major architectural Uniformat Building Group Element categories identified for the baseline building. This green baseline becomes the new benchmark for measuring the proposed building design using national peer reviewed data. However, the process does not fully eliminate externalities. GreenBalance™ assessment provides a framework to go beyond the present approach of simply minimizing environmental burdens and attempts to neutralize or "balance" these conditions with the objective of mitigating and, in some cases, counteracting external environmental costs.

BASELINEGREEN™

Step One of BaselineGreen™ identifies the high priority building group elements associated with upstream environmental burdens. (In this report, negative environmental impacts are called environmental burdens since they impose health risks and economic costs to society.) The method of analysis is environmental life cycle assessment (LCA) using Bureau of Economic Analysis (BEA) national data. The upstream (or "embodied") environmental consequences of the hundreds of inputs required to provide the bill of materials and products for the baseline building design are assessed using an economic input-output model of the entire construction sector of the U.S. economy. The input-output model is fully comprehensive and includes inputs of raw materials, energy, equipment, fabricated products, intermediate products, and services that can be correlated to various geographic locations and scales.
Three summary environmental burden indicators associated with each upstream input to construction of the baseline building--total air pollution, global warming (greenhouse gases), and toxic releases—are identified and quantified. After all upstream inputs to construction are categorized according to Uniformat Level 2 Building Group Elements, the Building Group Elements are subsequently ranked according to each of the three environmental burdens and then an overall "final ranking" is given that combines rankings for all three burdens.

In the case of an example municipal building, Interior Finishes Uniformat Level 2 Building Group Element is the most significant in terms of all three types of environmental burdens combined. Superstructure is the second most significant, Exterior Closure is third, and so on. (Note that this simplified ranking method does not prioritize the three summary environmental burden indicators. Some toxic releases for example, although regulated, may be a greater environmental burden per unit than the other two indicators.)

External Environmental Cost Ratio
Based on a literature review of societal costs of air pollution, monetary values were calculated for upstream environmental burdens associated to each input to construction in the Uniformat Building Group Element categories. This monetary value can be expressed as a ratio. The units of the ratio are external cost of upstream environmental burden in dollars per dollar (or thousand, hundred, etc. dollars) of the market cost of the input to construction. We call this ratio the "external environmental cost ratio" (EECR) for each input to construction within the Uniformat categories.

Employment Impact Ratio
Finally, the BaselineGreen™ analysis can estimate the employment impact for major Uniformat categories as well as each input to construction for local, regional, or national geographic regions. Summaries of associated economic impacts by county and state within the Uniformat categories can be provided, as can the total number of jobs associated with the input to construction for the baseline building alongside the market cost of that input to construction in the baseline building. The "employment impact ratio" (EIR) is the ratio between these two numbers.

GreenBalance™
The analysis thus far has described the inputs to a generic baseline building in terms of a) upstream environmental burdens equated to external environmental cost for each input to construction and b) regionalized economic impact in terms of employment per $M of input to construction. In addition, a new benchmark, BaselineGreen™, has been established as the "green" reference for the proposed building design.

GreenBalance™ attempts to neutralize or "balance" upstream environmental burdens with the objective of mitigating and, in some cases, actually counteracting upstream external environmental costs. To date, GreenBalance™ has been applied in the design phases of several proposed building and infrastructure projects in response to the following high-priority environmental issues:

1) Greenhouse gases (GHG): balance atmospheric carbon dioxide and methane emissions with carbon accumulation in long-life biomass building materials and forest mantle wastewater treatment systems.
2) Atmospheric pollution: balance sulfur dioxide emissions with the use of sulfur in long-life, sulfur-based building materials.
3) Indoor air quality: balance volatile organic compound (VOC) emissions by indoor vegetation.
4) Water supply and quality: balance annual on-site surface water supplies and on-site wastewater treatment with building and site needs.
5) Renewable energy: balance annual consumption with site-available (e.g., daylighting) and site-generated (e.g., photovoltaics) energy supplies.
6) Toxic releases: obtain the goal of zero upstream toxic releases and/or incorporate interior and exterior landscapes that bio-remediate toxic chemicals and render them harmless.

Projects undertaken that include these principles include: paving specifications for the U.S./Mexican border with the North American Development Bank (NADBank); University of Texas/Houston Health Science Center Nursing and Biomedical Sciences Building (NBSB); and the Advanced Green Building Demonstration Project (AGBDP) in Austin, Texas.
The NADBank project investigates the potential for all present SO_2 pollution emanating from petroleum

refining industries in both countries to be balanced through the use of proven sulfur paving technology. A briefing described low-cost, durable, sulfur-modified paving materials that can be made along the border and that annual demand for alternative paving materials greatly exceeds annual sulfur emissions.

The NBSB project demonstrates how upstream carbon dioxide (CO_2) emissions can be balanced with the carbon content of long-life biomass building materials. For example, Interior Construction and Interior Finish product types such as medium density fiberboard, cellulose board, and strawboard, if manufactured from renewable or by-product sources, can store more carbon dioxide (in the form of carbon) in biomass then emitted upstream during their manufacture. These "CO_2 sink" product types can offset (or balance) the CO_2 emissions of other product types used in the interior of the proposed NBSB project. The design objective is that the Superstructure, Exterior Closure, Interior Construction, and Interior Finishes Uniformat categories be CO_2 balanced, i.e., have zero net CO_2 emissions for the life of the building.

The AGBDP exemplifies the CO_2 balancing concept in the selection of Superstructure and Interior Construction material and product types. Upstream CO_2 emissions are significantly reduced by using high recycled content (95% or more) structural steel and fly ash substitutes for portland cement. Long life CO_2 accumulation in the carbon content of biomass materials is accomplished through the use of fiberboard and strawboard panel products in movable partitions. Balancing of water and wastewater is also demonstrated at the ABGDP.

These cases of applying the GreenBalance™ methodology suggest that a deeper re-evaluation of many sustainable architecture performance assumptions, including design objectives, material and product specifications, and operational performance, is needed, both within the boundaries of the building as well as the supporting landscape and infrastructure. GreenBalance™ attempts to balance the upstream environmental burdens with use/downstream building environmental mitigation to promote and develop a new set of standards that could bring building environmental performance to a new and more relevant level. GreenBalance™ attempts to shift the focus of building design from general (and often vague) sustainability guidelines to quantitative and more definitive materials balance assessment tools.

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Greening Pittsburgh's Convention Center

Rebecca L. Flora, AICP, Executive Director
Green Building Alliance
Pittsburgh, PA, United States

INTRODUCTION

The Green Building Alliance (GBA), is a Pittsburgh based non-profit that educates a regional market on green building practices and facilitates project implementation. In response to its strategic plan[i], GBA targeted the region's largest public development project, the new one million square foot Pittsburgh convention center, as a centerpiece for driving market demand for green building. This highly visible project provided an opportunity to educate a broader constituency by providing a hands-on example of green building techniques. The process that GBA undertook to green this project, the impact the project has had on the local market, and the challenges will be examined in this paper.

THE GREENING PROCESS

The Southwestern Pennsylvania Design Commission, created by Pennsylvania State legislature to oversee the design of Pittsburgh's new convention center (Center), set as its goal to "make Pittsburgh the #1 medium-sized convention center in the world"[ii]. Achieving this goal, and incorporating green thinking into what it means to be #1, presented a strategic opportunity for GBA. GBA's Executive Director, Rebecca Flora, secured a position on the Design Commission to begin the green education process. Creating an exceptional building would require more than the standard public request for proposal process. Ms. Flora proposed a design competition as a means to attract a world class designer. As chair of the competition process, she helped to integrate green concerns with functional and aesthetic concerns throughout the competition. Thanks to Pittsburgh's foundation community, funds were secured for the competition that led to the selection of world renowned Rafael Vinoly Architects as the lead designer. This $300+ million project requiring one million square feet of new construction in an urban infill, riverfront setting presented both design challenges and opportunities.

The Design Commission members are appointed by various sectors of the local hospitality industry along with political appointments. The project owner is a public authority controlled by both City and County government. None of these audiences were previously familiar with green building practices.

Team Selection

Competitions are not an ideal approach to green design because they typically begin design in a vacuum without the benefit of an integrated team process. However, the Center's design competition process[iii] required the Commission to establish clear design, program and selection criteria. The drawbacks of a competition were also overcome by a unique process that included briefings, workshops, and the availability of technical consultants. Ms. Flora's role on the Commission, as chair of the competition process, and as a juror created an ideal position from which to educate stakeholders and advocate the inclusion of green criteria into all competition documents. In addition, the Commonwealth provided $149 million of funding for the project that came with conditions for greening the Center. The result of this upfront planning was the selection of a team that fully integrated green into its conceptual design submission. In addition, the Heinz Endowments awarded GBA a 4 year grant to assist the project team in the greening process and to extend GBA's education mission.

Green Goals

Following the selection of the design team, GBA hosted a day long green goal setting workshop with the project team. The U.S. Green Building Council's LEED™ rating system was used as the framework for goal setting and remains the team's barometer for determining the degree of green that is being achieved. At the end of design development, the project was well within reach of its gold rating goal. Establishing this goal early on, educating the team, and identifying realistic areas of opportunity were key to moving green beyond conceptual design.

Green Team Building

With the exception of the engineering subcontractor, Burt Hill Kosar Rittelmann Associates, the overall project team lacked significant knowledge and experience in green projects. GBA staff and key consultants[iv] became an integral part of the project team utilizing the Heinz grant. GBA serves as the green champion for the project and holds green team meetings that include the construction and project management teams, and design team members are held on a monthly basis to identify issues and create solutions, and reassess the status of the LEED™ rating. In addition, the U.S. Department of Energy provided computer modeling assistance through its Lawrence Berkley Laboratory. GBA also participates in weekly project meetings to remain abreast of ongoing project progress. To address the education issues, GBA coordinates its education programs with the project schedule to provide professional training on pertinent topics. These training workshops have included an introduction to green building strategies and process (structured around the U.S. Green Building Council's LEED™), green specification writing, commissioning, construction waste management to-date. Each workshop is held at the existing convention center with a diverse attendance of over 100 persons from the entire region per workshop. This educational component and team building component was instrumental in taking the project team from skeptic observers to committed participants.

In an effort to achieve maximum optimization of the building systems, GBA utilized its grant funds to host a 2-day peer review process with a focus on systems integration[v]. Experts in mechanical systems, sustainable site planning, green design and systems integration were retained to review and optimize the design. Several opportunities for savings were identified along with issues and solutions. The key to success of this process was planning, knowledgeable and strong facilitators, full participation by the team and owner, and a collaborative working atmosphere between outside experts and team members.

Green Strategies

It was evident early on that some green strategies would require life cycle cost considerations. The competition brief provided a $5 million allowance for strategies that could be justified through a five-year payback. Several strategies have survived value engineering as a result of this early established attitude and a first ever $3 million green loan fund that was underwritten by the Heinz Endowments. Use of the loan fund requires that a gold rating be achieved, that modeling be used as a design tool, and full building commissioning be included. Green strategies that are dependent on the loan fund include: daylighting, natural ventilation, aquifer cooling, gray water system, and light sensors. Another $1-2 million will be required to cover the added upfront cost of green strategies that have up to ten year paybacks. This approximately 1.5% added project cost will reap significant saving to the operations following the initial ten years of operation. Energy is projected to decrease from 30-50% and water use is expected to be 50% less. Other strategies follow those outlined in LEED™: site, materials, waste, and environmental quality considerations[vi] that in total reflect a potential gold rating as of the end of design development, May 31, 2000.

Market Impact

This project will be completed in Spring 2003, a five year period from Design Commission formation to project end. The project will continue to be a major component in GBA's strategy to drive market demand. If successful, this will be the first green convention center in the United States Our hope is that Pittsburgh's Center will set a new standard of design quality and performance for convention centers in the U.S. Several other cities have already contacted GBA about how to green their convention centers. The following are considered drivers for the green market:

- **Promotion:** Already two videos have been produced with highlights on the green strategies. One of these videos aired on national public television and both with local media. The opportunities for the promotion of the green components of this project will continue throughout the life of the project and beyond due to the size and high profile of the project.
- **Market Education:** In addition to the entire project team and government related owners, the hospitality and tourism industry is also learning about the merits of green building. Education

efforts are expected to continue with more workshops and the creation of a specialized web site, a CD, fact sheets, power point presentation, lessons learned publication, and visitor information kiosk or signage.

- **Heightened Credibility:** The greening of a complex and specialized building type such as this, diminishes market skepticism of green being applicable to only high tech office buildings. This project proves that green is adaptable to any building type. The Commonwealth's willingness to tie funds to green also attracted significant market attention and credibility.

Challenges

The Center is far from complete. While much has been accomplished, there remain many challenges that could derail all efforts to-date. Because it is a public project, the Center is vulnerable to the public bid process, which does not always result in the best selection. The hospitality industry is economically dependent on the Center opening on time with shows already booked for 2003. This real deadline has required a fast track design process that works against the need for modeling, commissioning, and adequate team interaction. The project will have a phased opening, which has complicated the location and sizing of mechanical systems. The convention market in the U.S. is not accustomed to daylit exhibit halls. There was much debate and opposition to anything other than a black box. The users of the building will change constantly, which will hinder green operation strategies. The building occupancy loads present a variable that is extremely difficult to fix for modeling purposes. In a building with such variability of occupancy and use, the common engineering practice of providing for the worst case scenario exacerbates the potential for oversized systems and reduced efficiencies. These are just a few of the complexities faced by this project. The process that has been established, the team commitment to excellence, the green loan fund, the ongoing involvement of GBA and its many partners, and the review powers of Design Commission will all be instrumental to ultimate success.

LESSONS LEARNED

The project continues to provide a learning laboratory for all involved. GBA is committed to honest and objective documentation of the project and the lessons learned. The lessons to-date may seem obvious to many, however, a continued focus on these process related elements are key.

- **Upfront planning:** get in early, educate and infiltrate the team with an emphasis on the owner.
- **Set and Use Performance Goals:** use of a quantitative rating system such as LEED™ is critical to setting goals and measuring performance.
- **Establish a green champion:** it is critical that a key person with authority take responsibility for advocating and assisting in the implementation of the green goals.
- **Evaluate and document:** Project teams and owners must become familiar with and make use of available tools such as modeling, commissioning, post-occupancy evaluation, and peer review. Projects must be honestly assessed and documented if we are to continue learning from experience.

The technical aspects are no longer the primary challenge for green building. Instead, adopting a team-oriented process that supports smart application of technical knowledge is a greater challenge, because it requires experienced practitioners to change their behavior. Time will tell as to whether the greening process for Pittsburgh Convention can endure the challenges of time, money and politics.

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DEVELOPING A DESERT VERNACULAR: GREEN BUILDING AND DESIGN IN THE CONTEXT OF AN URBAN DESERT COMMUNITY

Anthony Floyd, AIA, CBO
Sustainable Building Manager
City of Scottsdale, Arizona, USA

"The most important building convenants are those dictated by the earth. If a dwelling fails to heed its surroundings, if it is not energy and resource efficient, if it does not make frugal and elegant use of local building materials, then it cannot, will not, ever be beautiful".

- *Stewart L. Udall, former US Secretary of the Interior*

Introduction

Scottsdale is located in southwestern United States within the metropolitan region of Phoenix, Arizona. The Phoenix region is the fastest growing metropolitan area in the United States. Scottsdale has a population of 210,000 and is the 4th largest city in Arizona. At current growth rates, the city will be built out by the year 2020. This presents many tough challenges related to green building and sustainability.

Despite Scottsdale's resort status, it has been considered a well-designed and livable community. Many visitors to Scottsdale comment that the streetscapes are uncluttered, the neighborhoods are well maintained, and the services are convenient. However, this is rapidly changing as a result of intensive growth and development. Maintaining the integrity and beauty of Scottsdale's unique environment is an ongoing priority for the community. History shows a commitment by the city's residents to achieve the strongly held community values of protecting, preserving and sustaining Scottsdale's unique environment. This commitment is demonstrated by the policies highlighted in this paper.

Towards a Sonoran Desert Vernacular

Scottsdale is located in the northern region of the Sonoran desert, which stretches south to cover most of the Mexican State of Sonora. The Sonoran desert is one of the most unique deserts in the world embodying a diverse ecosystem of flora and fauna. The region has long hot dry summers and pleasant winters. The climate averages 86% sunshine and 7.05 inches (17.9 cm) of rain through the year.

Scottsdale's economic and environmental well being depend a great deal upon the community's distinctive character and its natural amenities. These attributes have been nurtured by initiatives intended to protect the community's esthetic and environmental qualities. Scottsdale environmentally efforts include the following programs and initiatives:

> Sensitive Design Principles, Green Building Program, Environmentally Sensitive Lands Ordinance, Native Plant Protection, and Character Area Guidelines.

The most recent of these efforts is the Sensitive Design Program. Sensitive Design Principles were developed with the guidance from the City Council, Planning Commission and Development Review Board. These principles outline the city's design expectations and are based on the overall belief that development should respect and enhance the unique climate, topography, vegetation and historical context of Scottsdale's Sonoran desert environment, all of which are considered amenities that help sustain the community and its quality of life. One of the major goals of the program is to address design and sustainability in the context of regional architectural character. With the involvement of staff from departments throughout the city, this program will provide a comprehensive focus on integrating the design of the built environment with Scottsdale's development and natural settings.

Following are Scottsdale's Sensitive Design Principles:

1. The design character of any area should be enhanced and strengthened by new development.
   - building design should consider the distinctive qualities and character of the surrounding context and, as appropriate, incorporate those qualities in its design.
   - building design should be sensitive to the evolving context of an area over time.
2. Development, through appropriate siting and orientation of buildings, should recognize and preserve established major vistas, as well as protect natural features such as:
   - scenic views of the Sonoran desert and mountains.
   - archaeological and historical resources.
3. Development should be sensitive to existing topography and landscaping.
   - a design should respond to the unique terrain of the site by blending with the natural shape and texture of the land while minimizing disturbances to the natural environment.
4. Development should protect the character of the Sonoran desert by preserving and restoring natural habitats and ecological processes.
5. The design of the public realm, including streetscapes, parks, plazas and civic amenities, is an opportunity to provide identity to the community and to convey its design expectations.
   - streetscapes should provide continuity among adjacent uses through use of cohesive landscaping, decorative paving, street furniture, public art and integrated infrastructure elements.
6. Development should integrate alternative modes of transportation, including bicycles and bus access, within the pedestrian network that encourage social contact and interaction within the community.
7. Development should show consideration for the pedestrian by providing landscaping and shading elements as well as inviting access connections to adjacent development.
   - design elements should be included to reflect a human scale, such as the use of shelter and shade for the pedestrian and a variety of building masses.
8. Buildings should be designed with a logical hierarchy of masses.
   - to control the visual impact of a building's height and size.
   - to highlight important building volumes and features, such as the building entry.
9. The design of the built environment should respond to the desert environment.
   - interior spaces should be extended into the outdoors both physically and visually.
   - native materials, with colors and coarse textures associated with the Sonoran desert region.
   - a variety of textures and natural materials should be used to provide visual interest and richness, particularly at the pedestrian level; materials should be used honestly and reflect their inherent qualities.
   - features such as shade structures, deep roof overhangs and recessed windows.
10. Developments should strive to incorporate sustainable and healthy building practices and products.
    - design strategies and building techniques, which minimize environmental impact, reduce energy consumption, and endure over time.

11. Landscape design should respond to the desert environment by utilizing a variety of mature landscape materials indigenous to the arid region.
    - the character of the area should be emphasized through the careful selection of planting materials in terms of scale, density, and arrangement.
    - the landscaping should compliment the built environment while relating to the various uses, such as shading and buffering.
12. Site design should incorporate techniques for efficient water use by providing desert-adapted landscaping and preserving native plants.
    - water, as a landscape element, should be used judiciously.
    - water features should be placed in locations with high pedestrian activity.
13. The extent and quality of lighting should be integrally designed as part of the built environment.
    - a balance should occur between the ambient light level and the designated focal lighting needs.
    - lighting should be designed to minimize glare and invasive overflow, to conserve energy, and to reflect the character of the area.
    - use of natural light as a part of function and regional architectural expression.

Summary

Scottsdale has the legacy of Frank Lloyd Wright and organic architecture. We are continually inspired by the example Mr. Wright left in his design of Taliesin West at the base of the McDowell Mountains in north Scottsdale. Over fifty years ago, Mr. Wright said, "I don't see how we can consider ourselves as civilized people if we live ignorant of the *nature* of our environment; if we do not understand what we do to make it".

For the past fifty years, many of the sustainable concepts essential for living in the desert have been ignored. Any building that ignores its setting in a harsh desert environment must be over-compensated with air conditioning. The sole reliance on mechanical solutions does not recognize environmental constraints that can be turned into aesthetic opportunities. There must be a continued effort to integrate natural energy sources with building design utilizing the innate characteristics of the desert climate.

Scottsdale is beginning to define it's sense of place by addressing the indigenous character of the Sonoran desert as a distinct geographic area that has a continuity of climate, land-forms, native plants and animals, and other natural characteristics. Through sustainable building principles, we're learning to work with our desert environment in order to minimize our impact while at the same time learning to embody it's bountiful riches. This outlook will create a fundamental shift in the way buildings look and perform in the desert. The greater awareness being generated through Scottsdale's Sensitive Design Program will help buildings become unique expressions of the Sonoran desert region.

SUSTAINABLE KINDERGARTEN PRODUCTION BY THE CITY OF HELSINKI

Jukka Forsman, Office Manager
The City of Helsinki Public Works Department, Finland

Johanna Saarivuo, Project Manager
RAKLI The Finnish Association of Building Owners and Construction Clients, Finland

INTRODUCTION

The objective is to develope a construction management model for ecologically sustainable kindergarten production in Helsinki. The model consists of critical decisions and stages in design and construction processes. Measures and tools, which project manager needs to take into account the environmental viewpoints have been developed in two pilot kindergartens. The tools are e.g. call for tenders, contracts and selection procedures for designers and contractors. To provide a bencmark level of ecological impacts of kindergartens, the ecoprofiles of two existing kindergartens were assessed. The new kindergartens will also be assessed and compared with the older ones.

A TYPICAL ECOPROFILE OF A KINDERGARTEN IN HELSINKI

At the beginning of the project the environmental profiles of two existing kindergartens in Helsinki area were studied. One of the buildings was completed in 1969 and renovated in 1996, the other was a new building completed in 1996. Period of time for the study was 50 years. The goal was to examine the criteria for construction according to sustainable development in existing buildings and to determine the reference level in future kindergarten projects.

Result of the study was a quantitative ecoprofile based on life span examination, discharges and consumption of resources being the indicators. The examination covered material production, consumption of natural resources during the construction period and during the use of the building as well as discharges from energy consumption during the whole life span of 50 years.

As the most important result of the study it can be stated, that in the circumstances in Finland the emphasis of the environmental burden of a building lies on the consumption of heat and electricity in the use of the building. This consumption during the use equals to ca. 90-95 % of the total primary energy. The share of construction work and building material production in the total energy consumption and correspondingly in discharges is only ca. 5 %.

Environmental reviews based on the results of the study were drawn up for kindergartens; please find enclosed " ENVIRONMENTAL REVIEW"

KINDERGARTENS MERITUULI AND KAMOMILLA

The result of the ecoprofile made on kindergartens cleared the fact that diminishing the environmental burden of a building during its life span is most efficiently affected by diminishing the use of energy and water during the use of the building. Target values for energy consumption were placed on pilot kindergartens; in Merituuli 10 % reduction and in Kamomilla 30 % reduction in energy consumption compared to the "normal level".

Kindergarten Merituuli will be constructed as so-called "normal production" and kindergarten Kamomilla has been granted 5 % "eco extra", which means 5 % additional funding compared to normal production. It will be used in additional work to find ecologically better planning solutions and in additional costs caused by realising ecological solutions as well as in evaluating and following the success of the project. The idea was that additional funding would be received back in costs saved during the life span of the building.

With the help of knowledge and experience gathered from the pilot projects, a set of instructions will be created for designers and construction managers on how to construct a building, which is ecological during its whole life span. At the same time, co-operation between the construction manager, the owner and the future occupants will be developed.

Developing ecological ways of procedure consists of, among other things, the following actions:

In the project planning phase, the following environmental goals were set for kindergarten Kamomilla:

- 30 % decrease in energy consumption = decrease in discharges
- creating healthy microclimate of room (good microclimate class of room, M1 class materials)
- required ventilation according to needs
- architecture taking environmental viewpoints into account
- taking needs for transformation and flexibility into account
- planning taking maintenance viewpoints into account
- long-term and easy-to-manage constructional solutions
- energy saving HVAC technology solutions

In kindergarten Merituuli the criteria for selecting the designer was his knowledge of environmental matters. Tender requests for architectural planning were sent to four firms of architects, whose knowledge of environmental matters was ensured beforehand from their references. The final choice was made by using construction manager's normal criteria. The capability of the planner of heating, plumbing and ventilation was proved when he drew up the kindergarten ecoprofiles mentioned earlier. The choice for the planner of electricity was a firm, which has not yet become familiar with environmental matters, but is otherwise active in its development. The idea was to increase the knowledge of environmental matters in a greater number of consulting firms in the field.

The criteria for planning were the principles of sustainable development followed by Helsinki City Public Works Department, which the planners were also supposed to follow. Environmental viewpoints were added to the planners' lists of tasks. In order to clarify the assignment of tasks between the planners, instruction "Outlining tasks of planners in environmental-conscious planning" was drawn up.

1) Environmental review of building site (architect)
2) Target values of energy consumption, calculating the energy consumption (architect)
3) Calculation of life span costs (HVAC-planner)
4) Calculation of life span loading (special consultant)
5) Matters of room microclimate (HVAC-planner)
6) Transformation and flexibility (architect)
7) Service life plan; periods between renovations, life span of construction parts (architect)
8) Service and maintenance of the building (service manual)

In the early stages of planning work, in kindergarten Kamomilla, calculations of life span costs were performed for the part of heating, plumbing and ventilation, by comparing the costs of a basic alternative to those of an "eco-alternative". The period of observation was 30 years. Saving measures included water saving water supply system, electric appliances control, ventilation CO_2 control, improving the u-value of windows, improved heat insulation as well as changing drying cupboards to operate by heat pumps.

Contract phase is based on following the plans and instructions. The obligations of the contractor are defined in the contract documents.

Environmental demands set on the contractors include, among other things, materials and products, diminishing environmental damages caused by the building site, and realisation of the project according to plans and taking environmental matters into account. Materials and products cannot be changed to others without an approval from the construction manager and the general contractor. The contractor has to check the properties of products to be changed in environmental reviews received from the producer.

CONCLUSION

The project has shown that it is entirely possible to develop a construction method which is efficient in ecological terms, and which can be applied to the normal kindergarten construction performed by Helsinki City Public Works Department. Also in the long run, the method is cost efficient when evaluating life span costs instead of investment costs.

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ENVIRONMENTAL REVIEW	based on LCSEA method

Kallahti day care centre
Period of time for observation: 50 years
Calculation unit: 1 building = 660 gross m^2

Products:

- base floor of reinforced concrete panel on natural foundation, u-value: 0,28 W/m^2K
- structural body of mainly wooden external walls. u-value: 0,28 W/m^2K. Facade of wooden panel. A minor part of the external wall is covered with Lecatherm lightweight aggregate block.
- load-bearing structure in roof slab mainly of prefabricated glued laminated beams. In ridge roof parts of the building the covering material is sheet steel with plastic layer. The flat roof surfaces have bitumen roll covering, u-value for roof slab: 0,18 W/m^2K.
- wooden windows mainly with double sashes, triple glasses – the outer sash with single glass and inner sash with double-glass sealed panel, u-value 1,50 W/m^2K
- dividing walls mainly of wooden frames, covered with plaster board and painted. Washing rooms and personnel dressing rooms have steel structure walls. A minor part of the diving walls are 200 mm or 290 mm thick lightweight aggregate block walls straightened with plastering. Inner surfaces of external walls in dry areas are mainly of painted plaster boards. The floors are mostly covered with plastic carpets.
- the building is connected with the water supply and sewerage system of Helsingin Vesi (Helsinki Water) as well as with the district heat supply system of Helsingin Energia (Helsinki Energy), the heating system being closed hot-water heating rotated by pump, radiators and convectors.
- the building is equipped with mechanical supply and exhaust air ventilation system. Heat recovery by means of plate heat exchanger.
- ordinary electrical systems used in a day care centre

Consumption of natural resources (period of 50 years)

Raw materials:		
Non-renewable raw materials:	309 t	0,47 t/gross m^2
Renewable raw materials:	110 t	0,17 t/gross m^2
Energy:		
Non-renewable sources of energy	$60*10^6$MJ	$0,091*10^6$MJ/gross m^2
Renewable sources of energy:	$1*10^6$MJ	$0,002*10^6$MJ/gross m^2

Environmental effects (period of 50 years)

Greenhouse gases:	4770 t CO_2 -equivalent	7,2 t/gross m^2 CO_2 -equivalent
Emissions causing acidification:	1 t SO_2 -equivalent	0,002 t/gross m^2 SO_2 -equivalent
Increase in ozone near the surface of earth:	3 t O_3 -equivalent	0,005 t/gross m^2 O_3 -equivalent

THERMAL AND ACOUSTIC PERFORMANCE OF LIGHT STEEL FRAMING

Dr Mark Gorgolewski

The Steel Construction Institute, Silwood Park Ascot, Berks, SL5 7QN, UK.

INTRODUCTION

The market for light steel framing in domestic buildings is potentially large as the construction benefits of durability, high strength, reliability, versatility and speed of construction, and environmental benefits such as recyclability, long life, and adaptability, are realised. Residential construction using steel frames has increased significantly in the USA, Japan, Canada, Sweden, France, Australia and in the UK in recent years. The reasons for the increased interest in light steel framing include:

- Increased interest in prefabrication in construction.
- The durability, and quality offered by light steel framing.
- Speed of construction.
- The volatility in the timber market and the declining quality of structural timber.
- Concerns about environmental issues such as sustainable forestry practices and the destruction of natural habitats.

The American Institute of Architects in their Environmental Resource Guide recommends that steel may be considered less environmentally harmful than many other alternatives because many steel products are made totally or partially from recycled scrap.

INSULATION LEVELS

Light steel-framed construction allows high levels of insulation to be achieved economically and without leading to excessively thick walls. Steel-framed walls with U-values of below 0.2 W/m^2K have been built in the UK within tight budgets for social housing.

However, in framed construction it is important to consider the effect of the framing elements as a thermal bridge through the construction. Traditional framing has tended to put insulation between the framing elements which then penetrate from the inside to the outside of the thermal insulation. This leads to areas of reduced thermal resistance and increased heat loss through the structure, and can increase overall heat losses by 10% to 50% depending on the materials and details used. Furthermore, there may be a risk of interstitial or surface condensation. Such detailing is particularly problematic in steel-framed construction since steel has a high thermal conductivity.

A variety of methods have been developed worldwide for dealing with this issue in light steel framing. These include slotted steel studs with reduced conductivity, insulated sheathing boards and thermal breaks. In the UK the "warm frame" principle is generally used. Most or all the insulation is placed on the outside of the steel frame so that the steel is within the insulated envelope and remains at or close to the internal room temperature. This reduces heat loss through the steel and avoids interstitial or surface condensation. There is a slight penalty of increased wall thickness, and to reduce this polyisocyanurate or polyurethane insulation boards with low conductivity are used.

SITE TESTS PERFORMANCE TESTS

The SCI have recently completed a series of tests of light steel framed dwellings to establish their "as built" thermal performance[1]. These include air infiltration tests to establish the air leakage through the envelope (with improved insulation levels air infiltration is becoming the dominant heat loss from dwellings); thermographic surveys to measure the surface temperature of the building envelope and identify areas of increased heat loss or thermal bridging; and measurements of the "as built" wall U-value (for comparison with theoretical values). Acoustic tests were also carried out included the airborne sound insulation through a separating wall and floor, and the impact sound transmission through the floor.

The measured U-values for light steel frame envelope elements are compared in Table 1 with calculated values and with current industry standards. These demonstrate that the light steel framing dwellings are achieving low U-values, and that is possible to achieve very low U-values using this form of construction, well below the current UK requirements. In the UK at present this is often being achieved with no insulation between the studs. In other countries, some or most insulation is placed between the studs for reasons of economy and reducing wall thickness.

Table 1 *Comparison of the measured and calculated U-values and air infiltration tests achieved in light steel frame construction in the UK.*

Buildings	**Wall U-values**	**Floor U-values**	**Roof U-values**	**Specific air leakage rate**
	W/m^{2}K	**W/m^{2}K**	**W/m^{2}K**	**Q_{50} (m^3.s^{-1}.m^2)**
1995 Building Regulations				
For SAP energy rating of <60	0.45	0.35	0.2	n/a
For SAP energy rating of >60	0.45	0.45	0.25	
Good practice	0.35	0.32	0.2	5
Ultra-low energy homes	0.2	0.2	0.2	3
Values in light steel frame dwellings *(measured figures in italics)*				
Oxford Brookes University	0.2 ***(0.216)***	0.38	0.2	7.5
Northampton Lane	0.21	0.18	0.14	8.1
Bryncethin Road, Garnant	0.16 ***(0.20)***	0.37	0.17	9.8
Dos Road, Newport	0.4	0.34	0.18	6.4
Rosedale house	0.37	0.19	0.51	n/a

The thermographic surveys confirm that thermal bridging is avoided by using the "warm frame" principle with insulation placed on the outside of the steel frame, although a few areas were identified where insulation was incorrectly or poorly installed. The air infiltration tests confirmed that light steel frame dwellings are similar to the average for all new UK housing. There is currently a lack of knowledge in the UK construction industry about how to achieve low air infiltration rates, and this is an area where light steel framing can achieve considerable improvements.

ACOUSTIC TESTS

Table 2 compares the measured acoustic performance of light steel framed walls and floors with the acoustic requirements of the current English Building Regulations, and a proposed new enhanced acoustic standard for the UK (Quiet Homes). The tests show that typical, currently used, light steel framing separating floor and separating wall constructions can achieve acoustic insulation standards well above current requirements, and generally meet the new enhanced acoustic standard. The main area of concern highlighted was that of flanking transmission, where sound is transmitted by walls around a separating floor. This requires suitable detailing to reduce the effect.

Table 2 *Comparison of the acoustic tests of light steel frame dwellings*

Building	**Separating wall**		**Separating Floor**		
	D_{nTw} (dB)	**D_{nTw} +C_{tr} (dB)**	**D_{nTw} (dB)**	**D_{nTw} +C_{tr} (dB)**	**L_{nTw} (dB)**
1995 Building Regulations	>53	none	>52	none	<61
Quiet Homes standard	56	>50	>55	>50	<58
Values in light steel frame dwellings *(measured in italics)*					
Oxford Brookes University demonstration building	65	56	57	49	54
Orr Square Church, Paisley	60.5	52.5	63	55.5	50.5
Northampton Lane, Swansea	63	n/a	58.5	50	55
Chequers Way, Enfield	60	49	53.5	46	57
Bryncethin Road, Garnant	52	n/a	n/a	n/a	n/a
Dos Road, Newport	62	52	n/a	n/a	n/a
Britannia Close, Hedge End	65.5	58	n/a	n/a	n/a
Holiday Inn, Peterborough	59.5	51	52.5	46	47.5
Terrapin test units	72	n/a	72	n/a	49

CONCLUSIONS

The thermal performance tests at six light steel frame constructions indicate:

- The light steel frame with warm frame detailing causes negligible cold bridging of the external fabric.
- Air movement within the thickness of the external wall may increase localised heat loss.
- The measured U-values compare well with the theoretical values. Light steel framing is shown to be able to achieve very low U-values, much better than current English Building Regulations requirements, or even current UK recommended good practice.
- Air pressure tests indicate typical air infiltration rates of about 7 air changes per hour at 50 Pascals, which is about the current UK average for new dwellings.
- Some air leakage seems to be through the steel frame wall which needs better detailing. However much of the leakage is through poorly sealed openings and penetrations.

The acoustic performance at nine light steel frame constructions indicate:

- The typical airborne sound insulation of light steel frame separating walls and floors is well above the current requirements of the English Building Regulations.
- The proposed new enhanced acoustic standards can be met using double stud light steel framing walls of the type which are usually specified between light steel framing dwellings.
- The proposed new enhanced acoustic standards floor airborne sound insulation (D_{nTw} + $C_{tr(100\text{-}5000)} \geq 50$ dB) is more difficult to meet. However, a made up floor construction with a resilient layer beneath the floor finish and a plasterboard ceiling fixed using resilient bars can achieve the new standard.

[1] SCI, 1999, Thermal and Acoustic Performance of Floors and walls in light steel framing, Report RT757 to DETR, Steel Construction Institute

Diffusion of environmental innovations in housing

ir. Anke van Hal, prof. dr. ir. Han Brezet and prof. ir. Kees Duijvestein
Delft University of Technology, the Netherlands
Faculty of Architecture and Faculty of Design, Construction and Production
avhenhbr@wxs.nl

INTRODUCTION

This paper is based on a promotional research that will be completed and published in October 2000. This research is on the diffusion of environmental innovations in housing. The purpose is to embarrass knowledge and insights, which can promote the diffusion of environmental innovations in housing. It is directed at the environmental innovations brought on the market and then mainly at the innovations of which the environmental impact is big and the implementation in regular housing is difficult to execute. Experience shows that many environmental innovations are only applied in demonstration projects. Application in regular housing projects without a demonstration-status is often left out.

Among others the findings of the Dutch National Government imply that it is desirable to promote large-scale application of environmental innovations in housing, of which the environmental impact is big. This Government has determined that its goal is to 20 times reduce the environmental impact per unit prosperity by the year 2030 but it also concludes that only a small part of the route in the realization of this Factor 20 has been covered. The government concludes that the innovative power of the construction industry will need to be fully utilized. Hopefully this research will help in using this innovative power.

METHODOLOGY

Experience tells us that the diffusion of environmental innovations in housing depends on many factors. Moreover, there is an assumption that some factors have more influence than do others. A more effective and efficient diffusion of environmental innovations in housing is expected by concentrating the attention and activities on the most influential factors.

This expectation lead to the central question in the research, which is:

> Which factors have determining influence on the diffusion of environmental innovations in housing and in which manner can these factors be used to further the diffusion of environmental innovations in housing?

As a basis for this research theories on innovation-diffusion in general have been used, in particular the approach of Rogers. Based on literature studies and empiric research a number of factors have been selected which have certain influence on the diffusion of environmental innovations in building. The first and largest part of the research is based upon the Dutch situation. These research results lead to a model in which for the Netherlands the most influential factors have been linked together. The second part of the research has an international character. The Dutch model is analysed with the results of seven European case studies (in Denmark, Sweden, Germany, Flanders, Italy, England and Estonia). The purpose of these international studies is to research the possibility of prioritising within the acquired summary of influential factors. The actual research results, portrayed in a renewed research model, give an indication on which factors the emphasis lies in the activities to further the diffusion of environmental innovations in housing.

For the processing of the research the choice had been made for intensive interaction with scientific representatives and trade professionals. These people were part of an advisory board meeting semi-annually. In the conclusive stages these meetings were held every two months to discuss a semi-report. These semi-reports kept giving a complete picture of the research results to that point. These meetings formed a great source of inspiration and stimulation because of the diverse points of view of the members of the advisory board and the precise information discussed.

CONCLUSIONS AND RECOMMENDATIONS

Factors of which this research determines as having a determining influence on the diffusion of environmental innovations in housing are:

1. quality of the innovation
2. organization of the demonstration project
3. organization of the information transfer
4. influences of government

Research results suggest that external factors also have a determining influence. These are factors which cannot be influenced but influence the diffusion of an innovation such as crises, international agreements, influences from the European Union (EU) and other affairs such as political composition of government, culture and the power position of large corporations. However, the number of case studies to support the incontrovertibility of these factors is insufficient, further research is desirable.

The research shows that the inclination in practice is to concentrate attention on the innovation itself and the realization of the demonstration project. Given the limitations and the framework of this research a valid statement on the role of these factors can be made. Governmental influence can also be validated. Of the cases studied, only a few had carefully organized the information transfer. For that reason a valid statement is difficult to make regarding this factor.

However, in sub-researches conducted in the Netherlands and Sweden, regarding knowledge transfer, it determines that poor organization is an impediment for the diffusion of environmental innovations in housing. The research also shows that the diffusion of complex innovations has good progress in cases where innovation information transfer has been carefully planned (Germany). In these German cases some factors are insignificant, despite the fact these have been determined to have influence. Based on these findings, the impression arises that organization of knowledge transfer is underestimated in the development of activities and policies on behalf of diffusion of environmental innovations in housing. Despite the lack of broad empiric material, one of the conclusions in this research is that organization of knowledge transfer deserves more attention than is now the case.

The following hypothesis has been formulated for further research:

The diffusion chances of environmental innovations in housing increase particularly when information transfer regarding the innovation is well organized.

Regarding quality of the innovation:

A requirement for the diffusion of an environmental innovation in housing is that the innovation not only has environmental qualities but also has financial quality (=equal to or less expensive than alternatives). Other qualities of the innovation such as comfort, liveability, status and flexibility have a considerably lesser measure in the diffusion.

Regarding organization of the demonstration project:

The chance of success in a demonstration project, thus the chance of diffusion of the innovation, increases when at least one of the members of the project team acts as innovation champion (=a charismatic individual who throws his/her weight behind the innovation, symbolised by a locomotive in the model). Research points out the importance of multi-disciplinary cooperation within a project organization (symbolised by integrated circles in the model). Specific circumstances were found in a number of countries where case studies were conducted, making it difficult to support this with sufficient empiric material. The involvement of an opinion leader (=an individual able to influence others, such as a prestigious architect or a well-known project-developer, symbolised by a star in the model) also contributes to the diffusion but has a considerably lesser measure.

Regarding organization of the information transfer:
Diffusion of environmental innovations in housing is furthered when innovation experiences gained are evaluated (in the model evaluations are symbolised by a questionnaire).
Research results also point out the importance of a change agency, in the form of a public authority, responsible for informing the building sector of innovations. Because in a number of case study countries very specific circumstances were found, it became apparent that this was not possible to sufficiently prove with empiric material.
Moreover, research results also point out that information transfer must be based on unambiguous evaluations having similar composition and that information transfer must target different professional groups within the building industry individually (symbolised in the model by pawns).
The diffusion of environmental innovations in housing is also furthered by the prospect of publicity for projects where, imitating the demonstration project, the innovation is also being applied (PR-stimuli for imitation projects, symbolised by a loud speaker). For many reasons, unambiguous testing of these hypotheses turned out to be difficult in the European case studies.
The involvement of opinion leaders in the target group information transfer has a positive influence on diffusion, though in a considerably lesser measure.

Regarding governmental influence:
Government as a regulator, initiator, stimulator and change agency has great influence on the diffusion of environmental innovation in housing. When regulation has a flexible composition (=regulation where the goal is determined and not the measurements taken leading to that goal, symbolised by law books in the model) it furthers diffusion. A long-term perspective (symbolised by field glasses in the model) determined by government (national, regional and local) also furthers diffusion of environmental innovations in housing. Research results also point out the importance of the adjustment of long-term perspectives nationally, regionally and locally. It became apparent that unambiguous testing of these hypotheses is difficult in the European case studies. Large-scale subsidiaries and research budgets (symbolised by money) also have a positive influence. Although this hypothesis has not been submitted to unambiguous testing, research points out that tax measures also have a positive influence.

The conclusions are visualized in the model in figure 1.

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FIELDS OF TENSION IN ECOLOGICAL ARCHITECTURE by Jean-Elie Hamesse

Introduction: „Fields of tension" means in this context that we are influenced in our thinking and doing by opposing poles which can roughly be defined as economic on the one hand and ecological on the other. These tensions will be described in „new housing", in „reconstruction" and in „environmental planning".

Passive sustainable new housing

„Passive" means to use environmental energy, physical as well as intellectual, to integrate different systems that lead to an all-over symbiotic benefit. Housing is a dynamic process including growth, reduction and recovery of buildings. This is the active side. But sustainability has a passive component: „Passive" means to use the local or regional distinctive energetic components to build and to live in our architecture, without disturbing or destroying our ecological values. This can be realized on the following levels:

The physical level:

Just the location of a project means already gain or loss. The romanic churches, for example, were built upon spots where natural forces influenced people who visited the church. Today the location of housing areas is not reliable on long-term as it is based upon political, economic and technical decision making. The natural environment plays a less important role.

The climatic level:

Local climatic conditions can influence the acceptance of housing. Sustainability is not reduced to building materials only, but extends itself on long-term ecological acceptance.

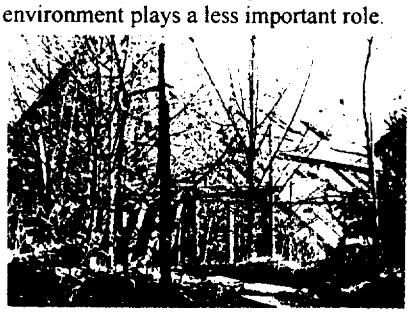

Fig 1. House, glasshouse, nature.

The form:

Form can save energy without any extra costs. Some forms can even supply energy, e.g. pyramids in ancient civilizations. Previously architectural forms were based upon harmonical intervals. Such buildings still give us a feeling of mental security. In our time forms are dictated by economic parameters and building bye-laws. The construction of simple glasshouses, e.g. in mid- European architecture, can supply us with energy and, at the same time, provide us with interesting indoor living areas. This renders our architecture more sustainable.

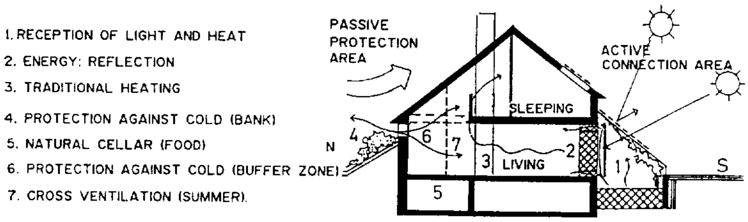

Fig 2. The bio-thermal envelope

Materials:

In the future the ecological balance of materials will provide us with a new quality in the choice for a sustainable architecture. Nature-based building materials can influence our physical and mental health in such a way that the acceptance of such housing lasts longer than that of housing made out of artificially produced materials.

Energy:
In order to accept energy it has to be consciously perceived. Regional and renewable energy sources are introduced in our market. Their ecological value has been recognised, their economic values, due to present-day market habits, have still to be developed. Sustainable housing needs sustainable technology.

Ecology and economy in reconstruction
In our fast developing economy, buildings with about 25 years of age, are, to some extend, considered as old. In industrial countries these old buildings may represent up to 90% of the total building stock! Another point of view is that older buildings can supply us with valuable material that may be reused on the spot or in other constructions.
Our present time is characterised by the opposing poles „economy - ecology". Economy means to distribute our surplus to the right man or place at the right moment. Ecology means to plan with our deficiencies, to be careful with resources in order to reach a sustainable product. A compromise between these poles is difficult to realize, because most of the time we follow the short-sighted view on economic feasibility and we forget the long-term value of ecological sensitivity. This deficiency can lead us to the loss of cultural values, which will be followed by the loss of identity and will lead to social problems. With the renewal of old buildings, which is more or less an adaptation of contemporary ways of life to old walls, we are involved in ecologically balanced systems. The respect of traditional architectural forms is a cultural target of architecture that should be included in our modernization process.


Fig 3. New living in old walls

Two examples can be shown here:
1. The reuse of timber, saved from old constructions, in new constructions or in the renewal itself. Timber has a very low energy consumption from ist growing as raw material to the „finished" product. Compared with brick, concrete or plastic it only needs about one fifth of energy.
2. The reintroduction of clay in all its forms offers possibilities for small and medium building constructions where men live or work. Ecologically clay is best balanced, economically it is not yet (or not yet again) feasible.

Like timber clay is not pollutive, both have low requirements of primary energy for their production, their construction and their recycling process.
They are two natural materials that can play the role of climatic regulators inside buildings. Consequently they are better accepted for construction by inhabitants and users, and lead to a life with less inner disturbances.


Fig 4. Clay filling in half-timbered building

Local recycling of material in environmental planning
The use of recycled or re-use material is important for a sustainable physical environment. Landscape and buildings develop into an entity, a symbiosis. Old material and time-honoured ideas are resources for the future.
Most of the time the surroundings of a building are left to hasards or to pure physical planning, without regards to the characteristics of the environment and to the availability of existing forces and materials. Most of the time the building has a parasitical influence on its surroundings. This is due to our present-day life conditions: on the one hand we are overrun by different forms of technology, on the other hand we are longing for natural things. The rediscovery of nature and its development system might help us to discover new technologies leading us to more sustainability. Our natural environment will therefore lead our thoughts in the first place, our concerns about constructing will then follow, and be adapted to environmental conditions.
One of the ways to reach sustainability in landscape and gardenscape is the use of recycled material. Here the factor time plays an important role. Once the time for initial use of building materials has passed, a second period of time begins. The idea issues from nature herself. She reuses her own waste products as raw material for her further development. Recycling of building material makes the latter more valuable.
Also the energy used for this development is a renewable one, mainly solar energy.
A further energy used is human ingenuity to achieve more output with less input.
Although most of the so-called natural landscape, in which we build, has become a cultural landscape, we are still involved in a constant dialogue with the remains of our natural environment. That means our work will have no end, because gradually nature will take back our recycled products for her own development. Consequently we have to interfere constantly to cope with this development to sustain our cultural landscape and gardenscape.

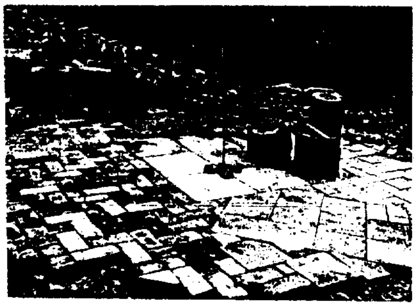

Fig 5. Ba-Gun terrace made out of recycled material

Fig 6. „The Snail" made out of reused concrete

Conclusion:
Sustainability is involved in a wide range of problems that take us sometimes far beyond architecture. Therefore sustainable architecture rests on three pillars: Humankind, environment and technology, it is a development without end.

THE AUTONOMOUS ENVIRONMENTAL INFORMATION CENTRE AT THE CENTRE FOR ALTERNATIVE TECHNOLOGY

Author: Ms Cindy Harris

Address: Centre for Alternative Technology
Machynlleth
Powys
SY20 9AZ

INTRODUCTION

This presentation will focus on the design, specification and construction process of the new Shop and Information Centre at the Centre for Alternative Technology. This is a 450 square meter development with a budget of just under £0.5m and incorporates a number of environmental features in the area of materials specification and resource use.

Innovative Aspects

- the use of unstabilised, non-reinforced, rammed earth elements as load bearing supports internally.

It is important to temper enthusiasm for the advantages of using a particular material, with an awareness of its limitations. We recognise that exposing an unprotected earth wall to the weather, especially in our wet Welsh climate, is unlikely to be successful in the long term. We also realise that an external earth wall in itself is not going to achieve the high levels of insulation which we regard as desirable.

This building therefore is designed with loadbearing rammed earth wall panels and columns, located within the footprint of the building and surrounded by a superinsulated timber stud external wall. With the earth components protected from the elements, we have concentrated on demonstrating the earth's structural, loadbearing capacity, of which we are confident.

We believe these earthen elements to be unique in their size, composition and function, in the context of modern U.K. buildings. We are also using 1700 compressed earth blocks, manufactured on site, in a conventional cavity wall construction

- the use of sheep's wool insulation within the 325mm thick timber framed external walls.

For many years, we at C.A.T. have been searching for a user friendly and eco friendly insulation material that we can recommend. On the one hand we are constantly advising people to instal as much insulation as possible. On the other hand, providing a satisfactory answer to the question 'What kind of insulation should we use?' is very difficult. In practice, the easily installed products are the most environmentally damaging, and vice versa . The 'greenest' product - loose fill cellulose fibre, marketed as 'Warmcel' - is also the most diffcult to instal.

The arrival of a genuinely eco-friendly insulation product on to the market, in the form of a quilt or batts, would be a real boon to the green builder. We think there is great potential to use locally produced sheeps wool as a basis for such a product. It was therefore decided at an early design stage to use raw unprocessed fleeces in the walls of the Ateic building . In the event we were fortunate to be given three tonnes of scoured and carded wool by the British Wool Marketing Board.

Each layer was sprayed with a boron solution to protect against fire and insect attack. Prior tests had showed that in terms of thermal conductivity, it was comparable with other fibre based quilt materials, and that there was no trace of any sheep dip related chemicals in the wool.

- the design decision to exclude the use of cement from the whole development.

Cement manufacture is very polluting and is responsible for between 7% and 10% of all global CO_2 emissions. However, one of the problems with using lime on building sites today, is that it takes a relatively long time to 'go off' or harden. As a compromise, we have used a hydraulic lime made from limestone with certain impurities, which gives a quick chemical set similar to cement, followed by slow carbonation. This process will reabsorb about 60% of the CO_2 produced chemically during manufacture. Lime manufacture also requires lower firing temperatures than cement, (800°C) which helps to make it a lower energy product.

- the large array of roof integrated solar water heating panels(120 square metres), linked to a heat main which is also supplied by a biomass fuelled boiler. Solar heated water will pass initially to a five cubic metre heat store in the Plant Room under the building. From there it can be used directly to heat the building via a low temperature underfloor heating system or exported to other buildings on site. In this way we are using two renewable sources of energy, available at different times of the year, to match different patterns of demand across the site, thus increasing our overall autonomy and decreasing our dependence on fossil fuels.

- public toilets, incorporating a dry composting toilet, waterless urinals and low flush W.C.s. There is on site sewage treatment and rainwater collection and storage for toilet flushing.

The Project Team

This is essentially a self build project based on a co-operative approach. All the members of the project team are C.A.T. employees, with the exception of the architect who is an ex-member of staff and long term supporter. The construction work is being managed in-house using mostly self-employed builders. A project coodinator relays information between the technical team and the management group, and keeps overall control of the budget. C.A.T.'s own experts in building services, renewable energy technologies, water conservation and sewage treatment, form the technical team along with the project manager and architect. External consultants have been employed in specialist areas.

Where problems arise, a concerted effort is made to resolve them. Passing the buck or blaming someone else simply does not work in this context. There is an inbuilt understanding of the particular difficulties and constraints that can arise when environmental considerations are part of the design and construction process.

Conclusion

As a leading 'Eco-Centre', C.A.T. has to practise, as well as preach, the principles of sustainable development. Our buildings are as much a display in themselves, as are the solar panels and wind turbines more commonly associated with our image. In designing new buildings, we try to look at the overall environmental impact of our activities, particularly with regard to resource use in the form of energy, water and materials.

The 'eco-friendliness' of different materials is often a complex calculation, but is usually based on the following considerations:
- embodied energy content, based on Life Cycle Analysis
- pollution created during all stages of production
- use of scarce or non-renewable resources
- waste creation / recyclability
- human health impacts.

The choice of locally sourced subsoil as a major component of the structural elements of this building, satisfies most of the above criteria. Relatively little energy has been used, or pollution created, to obtain the soil and most of the energy and pollution 'cost' has been incurred during transportation. This cost can be minimised further if suitable soil is available very close by - ideally on the site itself. Although earth is strictly speaking not a renewable resource, it is relatively plentiful and is often created as a waste product in quarrying operations or in the process of clearing a site.

Virtually no waste is created in the production or installation process, and on demolition the earth can either be recycled into other buildings or will simply revert to its natural state. Earth is a harmless material to handle and has certain properties, such as hygroscopicity, which help to create healthy internal spaces. It is often self finished, as in rammed earth, and therefore does not need to be coated with paints or varnishes, which can offgas inside a building.

Moreover earthen elements provide an alternative to the use of cement and aggregates which by and large carry far greater environmental impacts. As an element of thermal mass within a building, the use of earth can form an essential part of passive solar design, reducing the demand for fossil fuel based energy and improving comfort levels.

ECO-EFFICIENCY OF BUILDING

Tarja Häkkinen, Pekka Huovila, Kai Tattari
1. VTT Building Technology, P.O.Box 1805, SF-02044 VTT, Finland
2. VTT Building Technology, P.O.Box 1801, SF-02044 VTT, Finland
3. VTT Building Technology, P.O.Box 1805, SF-02044 VTT, Finland

INTRODUCTION

The concept of eco-efficiency was first introduced by World Business Council for Sustainable Development (WBCSD) 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 /1, 2/ 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 ouput 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.

$$\textit{Eco-efficiency} = \frac{\textit{Value of products or services}}{\textit{Environmental pressures}}$$

This paper deals with the application of the eco-efficiency definition for buildings. In addition to the eco-efficiency concept of building and the need of eco-efficiency indicators are discussed.

ECO-EFFICIENCY CONCEPT FOR BUILDING

One of the focuses of Sustainable Building at VTT Building Technology during the last year has been the development of the concept "Eco-efficiency of building". Within the concept, the object is to bring together

- the perfomance approach of building and
- the environmental aspects of building.

The eco-efficiency of a building is defined with help of the performance and environmental loadings of a building during the entire service life.

PERFORMANCE APPROACH

Performance approach within building sector means that the client states the requirements by describing the required performance of the building on the basis of the planned use of the building without describing the technical solutions. In order to do this, one has to be able to outline the performance of buildings. At VTT this has resulted in the development of VTT ProP systematics. The concept includes a tool which helps the client to formulate and state the performance requirements. The tool is a Visual Basic coded Excel tool, the tailored versions of which has been developed for real estate property owners in Finland.

LIFE CYCLE ASSESSMENT

The other parameter in the equation of eco-efficiency describes the environmental impact of a building or building product estimated on the basis of LCA methodology.

This concept, where the LCA methodology is tried to combine with the performance approach, actually means that the Functional Unit within LCA methodology is defined with help of the performance of a building. According to this kind of systematics, the quality of buildings as well as the development of performance of buildings can be dealt with as parts of the environmental development of building technology.

With regard to the eco-efficiency approach, the further studies aim at the development of

- valuation system for performance and
- weighting system for environmental loadings.

ENVIRONMENTAL DECLARATIONS OF BUILDINGS

The eco-efficiency concept is first applied in case studies. For example, the eco-efficiency of the urban building block Leppäviita in Espoo, Finland, is being assessed and the environmental declarations of these residential houses will be formulated so that those include both the description of the performance of the houses as well as the environmental pressure from technical solutions that have been selected in order to fulfil the required performance (Fig. 1).

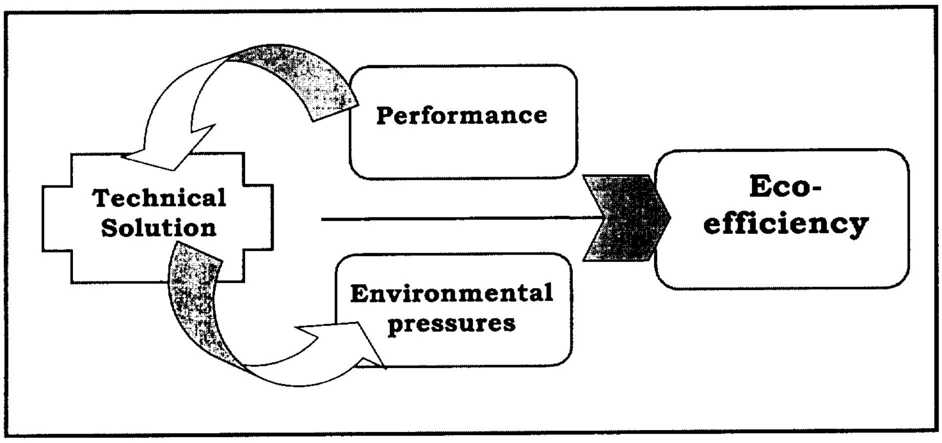

Figure 1. Eco-efficiency of a building.

INDICATORS FOR ECO-EFFICIENT BUILDING

Indicators are simple figures or other signs, with help of which the information on complicated phenomena like environmental pressure, is simplified in a more easily understandable format. Indicators help to follow the change of phenomena in time scale and the development of phenomena in relation to the stated objects. Indicators should be objective and the results should be repeatable. The main risk with regard to indicators concerns excessive simplifying and loosing of important information.

Need of indicators

The environmental impact of a building assessed on the basis of LCI/LCA and related to the performance of the building can be taken as an indicator for the eco-efficiency of the building. However, the approach is rather complicated and sometimes also more simplified indicators are needed. The needs of ecological or sustainability indicators can be defined as follows:

1. Indicators are primary needed because there are no absolute measures, which could be applied. For example, there is lack of measures that could be used explicitely with regard to biodiversity effects. We also lack absolute measures that express the ecological condition or describe the ecological effects. Instead, the ecological impact is typically indicated on the basis of induced emissions and consumption of resources.
2. Indicators are needed because of the stage of a process. For example within planning and decision making during a project there is not yet adequate data in order to take the ecological and/or other sustainability effects into account based on thorough impact assessment, but simplified indicators are needed.
3. Indicators are needed because of the scale or complexicity of the project. In the case

of extensive projects or processes, it would be too difficult to collect comprehensive data in order to thoroughly assess the impact, and thus simple indicators are prefered.

4. Indicators are also needed, if the activity that is looked at, has mainly indirect effects on sustainable development. For example, management, R&D and planning and design may have only minor ecological impact in terms of inducing hazardous emissions and consumption of resources. However, the indirect impact may be significant, if for example R&D results in the development of efficient energy-saving processes etc.. In order to show the environmental performance, indicators that express the indirect effects of activities are needed. In these cases the simple indicators could deal for example the sort of facilities, know-how, methods tools etc. that probably are necessary in order to produce outcome that supports sustainable development.

Indicators in the sense of 14031

According to ISO 14031, evironmental indicator is defined as a special expression that provides information about environmental condition or performance. The definition is rather general and does not put other requirements on the type of specific expressions, but providing information on environmental issues.

Indicators of sustainable development

The Commission on Sustainable Development (CSD/UN) has worked out a working list of Indicators of Sustainable Development /3/. It is a flexible list which countries can choose indicators according to national priorities. The 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.

If these indicators were applied for the assessment of activities or end products - like building and buildings - , part of the Driving Force indicators can be used within one socio-economic sector in a society as primary indicators. The on-going research project in Finland Eco-efficiency of Building discusses the Driving Force indicators that are possible to apply on the assessment of building and buildings from the point of view of sustainable development. The main stress is on ecological issues.

Finland has also developed a national set of sustainable development indicators to meet its country specific needs. The indicators are divided in three classes - environmental, economic and socio-cultural issues - and sub-divided into kind of effect categories like climate change, acidification, employment etc.. The Finnish sustainability indicators are not outlined according to the CSD indicators as Driving Force, State and Response indicators. The Finnish indicators mainly deal with driving forces, like release of emissions, but also State indicators are included, like threatened pieces. The aim on measurable indicators is distinctive. Many of the ecological indicators - like the release of emissions - can be applied not only to the whole society, but also to its separate sectors like building and facility management.

In addition to the primary indicators, secondary, simplified indicators are also being developed for projects, processes and activities within building.

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ECO-EFFICIENT HOTEL PROJECT

Markku Inkeroinen, Project Manager
JP-Terasto Oy, Jaakko Pöyry Group, P.O. Box 5, FIN-01621 VANTAA, FINLAND

Johanna Saarivuo, Project Manager,
RAKLI The Finnish Building Owners Association, Annankatu 24, FIN-00100 Helsinki, FINLAND

INTRODUCTION

The objective was to develop a co-operation model between the user (Scandic Hotels), the owner (The Tapiola Group) and the contractor (Skanska) in a building project, which takes into consideration environmental issues. Scandic Hotel Simonkenttä in the heart of Helsinki was selected as the target project. The leading idea was to construct the building and the premises so that they support the user's environmental goals connected with the hotel chain business. The owner and the contractor develop together a joint building procedure, which includes practical methods and models for adopting environmental issues as a part of the building process, starting from design and procurement, going through site logistics and waste management, and ending up to handing over procedures and service manuals.

The Tapiola Group was in the charge of the development project. So the project was based on Tapiola Group's environmental policy's target to take into account environmental aspects in property management and to promote environmentally favourable alternatives in investments and in purchases of goods and services.

MEASURES FOR ACHIEVING THE TARGETS

The builder, contractor and also the user had a strong effort on ecological building with good indoor climate, visual comfort and optimal energy use. The decision-making was based on life cycle costs and ecological impacts. To meet all the client's requirements the building services designer used advanced design tools in a highly integrated environment. This way all the design data can be used through the whole life cycle of the building. It will be updated with the as-built data in the construction phase and then the same data can be used in the building operation and maintenance.

DESIGN ENVIRONMENT

The building services designer used an advanced integrated design environment, where all cost calculations and technical simulations produced material for the decision-making. When targeting life cycle economic and ecological systems, it is even more important to use advanced and highly integrated design tools in various phases of design. Some examples of different simulations and calculations are presented in Figure 1.

Good indoor climate

In the early phases of HVAC design typical spaces were simulated to meet the target values for indoor air quality and thermal comfort. The simulations were used to design the required airflows and cooling capacity. The effect of different window constructions was also studied.

Ecological system selection

Air handling units were selected by using both life cycle cost and ecological impact calculation. Energy consumption was calculated based on requirements defined by building contractor and technical data defined by ventilation contractor. This way the calculation basis was the same for all offers and life cycle costs were compared equally. Not only energy but also pollutant loads related to energy production were calculated and used for decision-making.

Performance of HVAC components were monitored and accepted by measurements in the commissioning phase. Energy monitoring will continue in the operation phase, and the advanced energy metering system is used for energy cost sharing.

PROCUREMENT

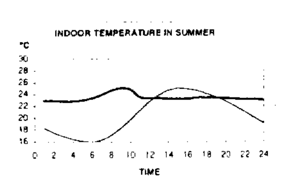
Scandic has clear instructions concerning environmental matters in hotel business, e.g. interior decoration guidelines for using 97% recyclable material in hotel rooms. Environmental aspects were also taken into account when selecting ventilation equipment systems. Equipment suppliers were requested to provide the efficiency and pressure data on their ventilation equipment. This information was used to calculate the energy consumption and energy costs of the equipment. The data received from the equipment suppliers was checked and the suppliers could also check the calculations made with their equipment. The environmental calculations included the indirect emissions caused by the production of energy required by the ventilation equipment. In addition, the values given by the selected equipment supplier were measured in the taking over phase of the building.

REDUCING THE ENVIRONMENTAL IMPACTS OF THE SITE

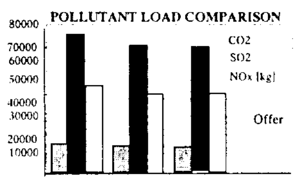
When the construction started, the contractor prepared an environmental plan, which included:

- measures to reduce, sort and utilize the waste of the site and guidelines for handling of hazardous waste
- management of energy use during construction
- working methods and operating tests to ensure the lifetime and health of the constructions, construction components and systems
- safety matters, e.g. handling of hazardous material and cases of emergency
- training in environmental matters
- internal and external communication in environmental issues

Space IAQ simulation



Ecological system selection



The quantities of the site waste are measured and reported by waste fraction. The amount of the waste to be disposed of at the landfill has fallen to 17% (of the weight of the waste) All site waste is sorted both on the site and then mechanically by the waste contractor at the intermediate waste collection station. Figure 2 shows a waste-handling chart.

LOGISTIC SOLUTIONS TO SAVINGS OF NATURAL RESOURCES

The owner together with the principal user decided in the early phase of the project that the amount of mixed waste will be minimized. To this end, the quantity and quality of waste were evaluated, a preliminary plan for the number and volume of waste containers was made and the need for waste management facilities was checked. Traditionally, a building has a waste press for mixed waste. A tenancy agreement usually includes the tenant's commitment to sort waste at the place of origin. To reduce mixed waste it was decided to purchase a waste press for energy fraction. Waste is also measured per user. Estimates of streams of goods were collected from the tenants of the business premises.

Since the space for loading is limited, the purpose is to use the timing and rotation of deliveries to make transport smooth and to avoid unnecessary idling. In addition, the tenants are desired to plan their deliveries of goods so that as much goods as possible would be ordered at the same time. The purpose of the preplanning of logistics was to avoid unnecessary traffic in the crowded streets of the centre of Helsinki and to save natural resources.

TAKING OVER AND START-UP PHASE

Energy consumption management is ensured by calculating the nominal energy consumption values for the building and by monitoring regularly its energy consumption. The maintenance personnel are trained to monitor the energy consumption and to use environmentally responsible ways in the service and maintenance of the building. To ensure the energy economy of the maintenance and operation of the building the taking over and test runs of the technical systems were scheduled six months before the completion of the building.

The preparation of operation and maintenance guidelines started in January 2000. The guidelines state the life cycle targets set for the building and parts of the building (e.g. lifetimes, maintenance intervals) and give service and maintenance instructions. The guidelines also include: arrangement of training (maintenance personnel and the user's personnel), the environmental aspects in the service manual, ensuring the continuity after the guarantee period of two years. The purpose of these measures is to ensure that the methods and ways used are according to plan.

The users of the building and the customers will be informed, for example with signs, of the possibility to use environmentally benign ways of moving around (metro, bus, train, foot).

CONCLUSIONS

The cooperation model (user – owner – contractor) offers significant benefits to all parties when new methods are introduced. Motivation to develop new matters emerges from the genuine demand and interest of final users and through the builder affects the main contractor and the whole subcontracting network.

ACKNOWLEDGEMENTS

The principal parties involved in the pilot project:
The Tapiola Group, Investor, owner
Scandic Hotels Oy, Hotel operator
Skanska Etelä-Suomi Oy, Contractor

JP-Terasto Oy and Soil and Water Ltd, Environmental matters; co-ordination
Engineering office Olof Granlund Oy, HVAC engineering and LCA-calculations, service manual

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.

ENVIRONMENTAL PERFORMANCE OF THE DUTCH FUTURE HOUSING STOCK

Ir Gerda Klunder
OTB Research Institute for Housing, Urban and Mobility Studies/Delft Interdepartmental Research Centre The Ecological City - Delft University of Technology
P.O. Box 5030, 2600 GA Delft, the Netherlands, e-mail: klunder@otb.tudelft.nl

INTRODUCTION

'Factor 20' is a well-known slogan in policy and science related to the built environment in the Netherlands. It is a metaphor, which refers to a huge increase of environmental efficiency with respect to societal needs, corresponding with a reduction of the environmental impact by 95%, compared to the actual situation (Commoner, 1972; Ehrlich and Ehrlich, 1990). In other words, it encourages long term views with a very high ambition level. It also increases the need for quantitative information about the environmental effects of building activities. Until now, Dutch sustainable building depends for a great deal on more intuitively taken measures without knowing the results with respect to the reduction of the environmental impact. Yet, today's built dwellings are tomorrow's housing stock. Founding of currently sustainable initiatives gives good chances to substantially improve the environmental performance of the Dutch future housing stock just now.

This paper aims at identifying spearheads to reduce the environmental impact of dwellings. For that, the environmental effects of current housing construction, which is represented by three dwelling types, were analyzed with the Eco-Quantum tool. It concerns the terraced dwelling, the semidetached dwelling and the gallery flat (Novem, 1999). Eco-Quantum carries out a Life Cycle Assessment of a dwelling and expresses the results in twelve environmental effects: exhaustion of raw materials, exhaustion of fuels, greenhouse effect, ozone layer depletion, photochemical oxidant formation, human toxicity, ecotoxicity, acidity, nutrification, energy, harmless waste and harmful waste (Mak et al, 1996). It successively addresses the following questions: What is the amount of the flows of materials, energy and water of current housing construction?, What are the environmental effects of the material use, energy consumption and water consumption?, What are the major contributors to the environmental impact?

ENVIRONMENTAL ANALYSES

The terraced dwelling, the semidetached dwelling and the gallery flat all meet the contemporarily demands with respect to technological and functional quality and are set up by regular building materials and construction techniques. This makes it possible to compare the environmental effects of the dwelling types. Similar assumptions are that all dwellings comply with an Energy Performance Coefficient (EPC) of 1.2 and have a life span of 75 years. Main differences in construction techniques follow from the typology. The gallery flat comprises boundary walls and a flat roof of concrete, whereas the terraced dwelling and the semidetached dwelling are built of lime-sand stones and a sloping roof of wood. The foundation and the floors of all dwellings are made of concrete. Furthermore, the gallery flat is a multi-family dwelling with common spaces, such as staircases, and shared construction elements, including foundation and roofs, against the terraced dwelling and the semidetached dwelling as single-family dwellings.

It goes without saying that the semidetached dwelling brings about the largest amounts of the flows of materials, energy and water, the gallery flat the smallest and the terraced dwelling in between, considering the entire life span of the dwellings. This is also valid for the environmental effects of the material use, energy consumption and water consumption. Therefore, the analyses are based on the usable floor areas of the dwelling types: 111 m^2 for the terraced dwelling, 134 m^2 for the semidetached dwelling and 75 m^2 for the gallery flat.

The absolute amounts of the flows of materials, energy and water of the dwelling types are listed in Table 1, both for the total usable floor area during the entire life span, and per square meter of the usable floor area per year. It points out that the gallery flat uses most materials per square meter. The terraced and the semidetached dwelling contain 7% respectively 9% less materials. The energy and water consumption is largest for the semidetached dwelling. It differs from the gallery flat by 9% and 32% and from the terraced dwelling by 4% and 25%. The range for material use and energy consumption does not exceed 9%.

Table 1. Absolute amounts of flows of the dwelling types

Flow	Terraced dwelling		Semidetached dwelling		Gallery flat	
	Total	Per m^2	Total	Per m^2	Total	Per m^2
Materials	205 ton	25 ton	254 ton	25 ton	153 ton	27 ton
Energy	4,157 GJ	0.50 GJ	5,251 GJ	0.52 GJ	2,680 GJ	0.48 GJ
Water	6,772 m^3	813 m^3	10.847 m^3	1.079 m^3	4,110 m^3	731 m^3

The dwelling typology is of importance when comparing the environmental effects of the flows of materials, energy and water. It appears that the semidetached dwelling is most detrimental with respect to the exhaustion of fuels, the greenhouse effect, ozone layer depletion, ecotoxicity and energy. The gallery flat is worse for the exhaustion of raw materials, photochemical oxidant formation, human toxicity, acidity, nutrification, harmless waste and harmful waste. This has much to do with the differences in the amounts of the flow of materials on the one hand and the amounts of the flows of energy and water at the other had. The terraced dwelling scores in between on all environmental effects. However, contributions vary at most 11%.

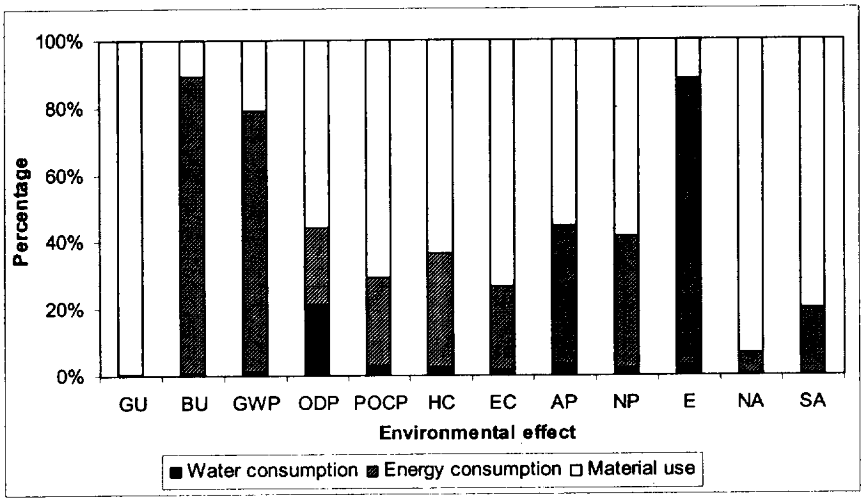
It is striking that the distribution among material use, energy consumption and water consumption of the dwelling types show substantial similarities, although the dwelling typology influences the environmental effects. This is also valid for the distribution among the building elements as for material use, energy functions as for energy consumption and water functions as for water consumption. The distribution among material use, energy consumption and water consumption is shown in Figure 1 with regard to the terraced dwelling. From Figure 1 it can be seen that the energy consumption contributes more than 50% to four environmental effects and the material use to three environmental effects. The water consumption only has a notible share on one environmental effect.

It turns out that there are nine building components which determine the environmental effects of the material use to a large extent: fronts: outer walls, frames and glazing; structural work: foundation, floors, boundary walls and roof; finish: inner walls and covering floor layers. Besides, there are several building components from very environmentally unfriendly materials with regard to one or some environmental effects. Lead, copper, zinc and bitumen belong to those materials.

More than three-quarters of the energy consumption is related to the gasfired functions of hot tap water and space heating. About a quarter is used by electricity for lighting, auxiliary energy and ventilation. Nevertheless, electricity use account for the greatest share on seven environmental effects of energy consumption. Hence, it is not only the energy consumption, but also the energy carrier that is of great interest in assessing the environmental impact.

Finally, the environmental effects of water consumption depend completely on the amount of water consumption. Compared to the environmental effects of material use and energy consumption, the environmental effects of water consumption are as good as negligible.

Figure 1. Distribution among material use, energy consumption and water consumption of the environmental effects of the terraced dwelling



CONCLUSIONS AND RECOMMENDATIONS

The terraced dwelling, the semidetached dwelling and the gallery flat show significant differences in the amounts of the flows of materials, energy and water. However, the dwelling typology is not so relevant, when identifying spearheads for improving the environmental performance of the Dutch future housing stock. We have to focus on reducing the environmental effects of the material use and energy consumption. For the decrease of the environmental effects of the material use, attention has to be paid not only to building elements which require large amounts of materials, but also to certain materials which are very environmentally unfriendly, regardless of quantities.

It has to be beared in mind that the 'Factor 20' metaphor asks for major changes in housing construction. Present sustainable building projects in the Netherlands reduce the environmental impact by only 30%, so a factor of 1.4 would be achieved (Klunder and Blaauw, 1999). That means that the question will arise how the identified spearheads will shift as a result of, for example, big progression in technological development or progressive legislation. More research is needed to answer that question. Besides, the primary focus on the spearheads does not put aside that improvements that are easy to accomplish definitely have to be implemented.

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APPENDIX

Figure 1. Drawing of the terraced dwelling

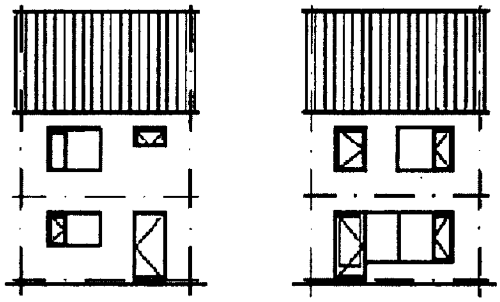


Figure 2. Drawing of the semidetached dwelling

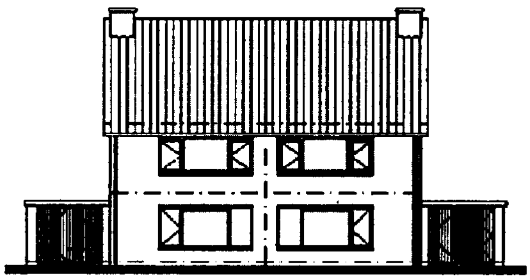
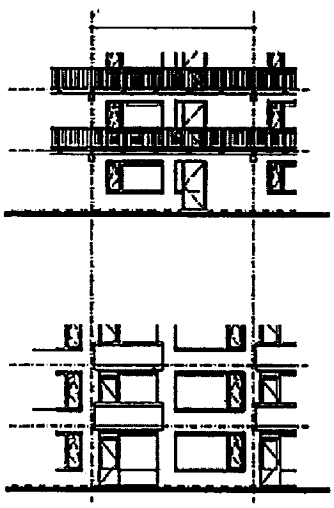


Figure 3. Drawing of the gallery flat



CASE STUDIES DEMONSTRATING THE INTEGRATION OF ENVIRONMENTAL RESPONSIBILITY (QUALITY) INTO THE ARCHITECTURAL PROCESS (PROGRAMMING, DESIGN, CONSTRUCTION, MANAGEMENT) – A COLLABORATIVE EFFORT BETWEEN CLIENT, ARCHITECT, AND SITE.

Nate Krug, AIA, Professor of Architecture;
University of Nebraska, Lincoln, Nebraska, 68588-0107, USA.

"SUSTAINABLE 2000 BUILDING" International Conference – Maastricht, the Netherlands.

When a building truly responds to the issues, the directive forces, the who, what, and where that encompass design and process, it becomes direction within its own setting; quality; responsibility; Architecture. Both the Mitteness and Upp-Martin residences demonstrate the successful integration of programming, design, construction, and management necessary to adequately address a full range of environmental issues.

INTRODUCTION

The notion of environmental quality in architectural design is not new. However, the recent popularity of environmental responsiveness in architecture most often stops with climatic or energy concerns helping only to establish or substantiate a surface aesthetic. Albeit these attempts are important, still they fall short in terms of a true environmental response, for environmental quality is much more than "skin deep."

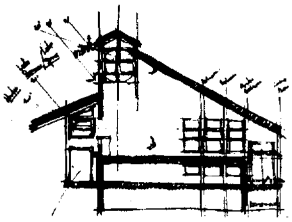
PRESENTATION

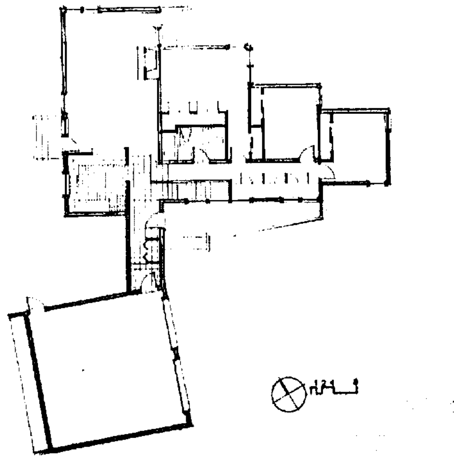
This is a presentation of two case studies successful in addressing and subsequently integrating a full range of environmental issues into a completed architectural response. Both projects were initially shaped by social issues engrained in the programmatic statement specific to the Clients, "environmental" issues covering climate, context, and technology played dominate roles in the building designs. In addition, the economic, social, and cultural environments associated with the users, the buildings, the sites, and the surroundings became the factors that gave the projects their "environmental," as well as architectural, depth.

The thoughts presented here center around a more grass roots approach to sustainability. Much in the same vane as Harold Hay's "water bed roof" house in Atascadero, California and other do-it-yourselfers of the Sixties and early Seventies, the venue I have turned to for the implementation of my ideas and concerns centers in the single-family housing sector in Middle America. For it is within this population that I feel some of the most wonderful opportunities exist and the mindset and attitudes of those willing to pursue the issues of conservation and ultimately sustainability is not only genuine, but results are expected. These projects help to fulfill their owners' "American Dream" on a much higher level; for not only do they provide the "house in the suburbs" (although both were designed and built on acreages), the houses truly become expressive of who their owners are.

CONCLUSION

The point that I originally set out to make, that of an expanded view of environmental response and the positive role it has in shaping architecture, should be well substantiated by now. The road to completion was long and frustrations at times were high. But if architecture is to be a broad-based activity resulting in a synthesis of the social, political, artistic, economic, and technological concepts necessary to ensuring environmental quality, we must not only theorize about and research environmental quality needs, we must also learn from successful implementations. The Mitteness and Upp-Martin Residences are two such examples.

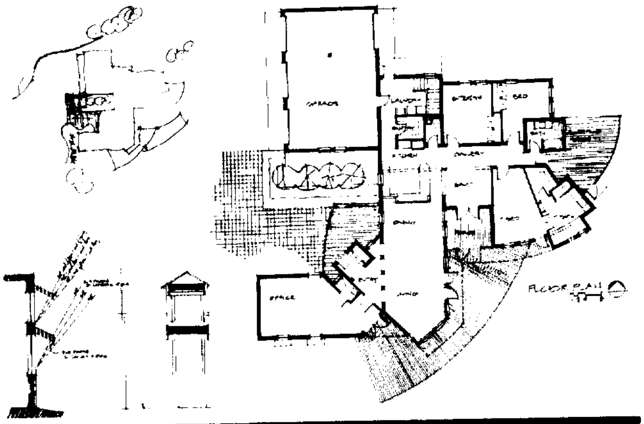




■ Ground water heat pump operating off of domestic water well ■ Passive solar design ■ solar hallway with circulating fans for heat pump preheat ■ Minimized waste materials during construction ■ limited on wood sizes, large spans structured with box beams made from smaller members ■ Strategic location and orientation ■ Natural ventilation.

MITTENESS RESIDENCE

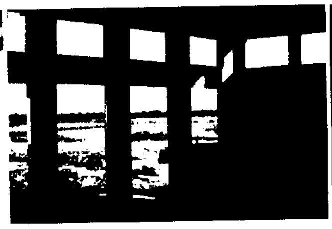
TRAVERSE COUNTY, MINNESOTA 1986

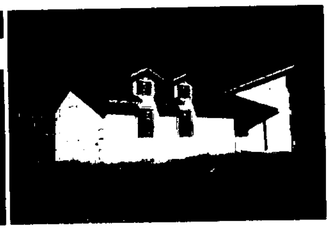


Passive [illegible] – strategic location and [illegible] Windmill with battery capacity for [illegible] domestic needs [illegible] and thermal comfort • Do-it-yourself [illegible] – [illegible] polystyrene [illegible] providing super insulated and structural walls [illegible] construction.

Upp - Martin Residence

LANCASTER COUNTY, NEBRASKA 2000

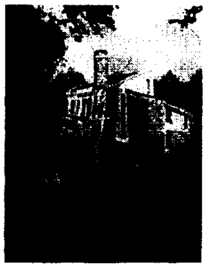




Endemic / Systemic Resistance to Sustainable Practice in the Construction / Development Sector

Paul Leech:GAIA ecotecture;
11 Upper Mount Street,
Dublin 2, Ireland
Tel; 00 353 1 6610957
Fax: 00 353 1 6785124
paulleech@eircom.net

Leech is an architect / engineer in private practice for 21 years in Ireland.



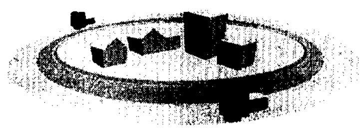
INTRODUCTION & SUMMARY

The interface between policy and practice with regard to sustainable building progress presents many resistances, due to market reality. In order to effect change, quickly enough to make a timely difference, it is crucial to research and understand the dynamics in an increasingly uni-polar, market-driven, society. Many grave concerns about our future lie just below the surface of apparent 'Western' affluence. Our glib departure, in the name of 'growth' from global protocols freely entered into is disquieting. The capacity of the 'free' market to think must therefore be questioned and market correctives from the demand side (and governance) much more urgently effected.

Vested interests are enormous: Short-term forces determine actual behavior in both the market and electoral politics: a term of political or administrative office and the 'boom' or 'bust' of the moment are relatively short-lived: the sustainable 'payback' period is too long for most conventional 'players': **this calls for intervention by more permanent governance to realise public policy.** Such an approach requires empiricism and targeted fiscal instruments by governance coupled with consciousness-raising on the demand side of the market.

DISCUSSION

Top-down' and 'bottom-up' impulses for change are already evident, indicating an instinct for sustainability, but unbridled supply-side avarice and profit protection tend to frustrate the new models. The legal and commercial inertia of the construction sector must be recognized including the **vested interests and heavy investment in established working methods,** on which very many livelihoods depend: insufficiently considered or aggressive attempts to change these could have the opposite effect. There have been several heavily funded legal challenges to explicit negative ecological rating of specific products. The difference between legal proof and common sense / common knowledge, will be obvious: resources must be marshaled strategically to confront specific producers.



Moreover market awareness on the demand side has not been sufficiently nurtured to encourage the supply side to compete for market-share in a newly configured sector. In many respects this quality- of- life approach is the most promising: but *tangible benefits for the ordinary person* must be demonstrated, the ultimate consumer, if real demand is to change.

With increasing growth in GDP terms, the *inequalities* in society seem to increase so that there is a progressive disempowerment of the real consumer in the face of a highly controlled market by a small wealthy minority, (whose interests are generally at variance with the common good, in sustainable development terms): democratic values insist on correctives: It is part of the European cultural inheritance to have such.

CONCLUSION

The sustainable evolution of the supply side will only follow **regulation** and **demand from specifiers**. for sustainable building techniques, over a realistic **period**, allowing reasonable time for the sector to adjust, without undue economic distress, or threat of heavy job losses or business collapse, but within a sense of real urgency about environmental degradation, at disturbingly increasing rates. A key factor is to give the sector adequate signposts to 'carrots' (**incentives**) and fair warning of 'sticks' (punitive **sanctions**) to bring sustainable building practice into being. New **market opportunities** exist in an exciting growth area, based on sustainable development policy. Opportunities generally arise for change in industry when 'new tooling up' is called for, when existing plant and equipment becomes inefficient , obsolete or out of date: these can be planned in advance if the new demand from the marketplace is 'flagged' well in advance. Indeed industrial commitment to the sustainable sector can lead to **diversification,** to advantage, including **competitive edge and greater market share**. To this extent free market mechanisms can be helpful toward change, conditioned by enlightened consumer demand. However it would be a grave error to imagine that the supply side of the market alone will act in this manner without correctives from governance and insistence from the demand-side.

Paul Leech: GAIA ecotecture

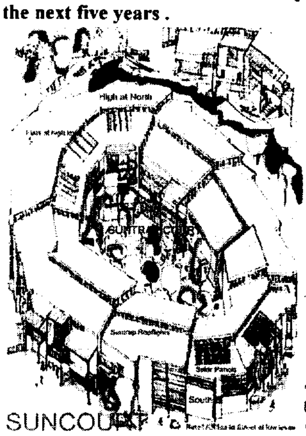
High quality ecotecture remains our priority goal so that the beauty of enhanced quality of life remains a strong incentive toward sustainable changes in demand

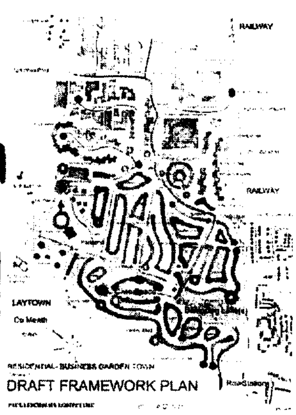
GAIA ecotecture has experience of realised sustainable design, from built works to a current project for macro town planning in Ireland: this has involved overcoming obstacles encountered and lead to some successes. These include

. a doctor's surgery/dwelling in woodland; This live /work building is sited in a restored managed \woodland
in a worked out quarry: renewable energy; rainwater management; reed-bed waste-water treatment; low embodied-energy, non-toxic materials are all employed

. Seven-storey timber credit union building incorporating sustainable features.

. 75 hectare mixed eco-urbanism development : live /work settlement :this is a fully integrated proposal incorporating public transport (rail link to Dublin city/national network) ;integrated land use planning; renewable energy, chp /district heating. The Planning Authority have now incorporated the framework plan into the development plan for the next five years .





All-aluminum-extrusion house
---Module system design

Associate Researcher Lin, Shu-Tseng
Industrial Technology Research Institute, Materials Research Laboratories
Bldg. 52, 195-5 Chung Hsing Rd., Section 4 Chutung, Hsinchu, Taiwan 310, R.O.C

Introduction

Traditional perception about housing should be strong, durable and long-lived. But it is changing now. Many people like to make some changes for their house, such as buying another one, making an addition, refit, redecoration etc. They are rich but also wasted. For the sake of environmental protection, the perception about inhabitation needs some adjustment after world-wild energy shortage and pollution.

The paper discusses an experimental house. Under consideration of whole building and housing renewal, we are trying to introduce a new idea about inhabitation with a high quality, recyclable, reusable material and saving energy design within modular system design.

Geography and climate

Housing design will not the same in different climatic conditions. Taiwan is an island in semi-tropics, hot and humid climate. Thermal insulation and shading are very important for housing external wall. Because of the humidity, it is more concerned about the constructive materials. Wood or wood by products are dozy with termites and other vermin. Steel, even galvanized steel studs, deteriorates rapidly with rust. Because of siting in earthquake areas, the preference is reinforced concrete in Taiwan. Between 1993-1997, 88.19 % of new buildings are constructed with RC. Though earthquake resistant and durable, RC is very poor in thermal insulation with high thermal capacity. And that also makes serious pollution during the process of construction or after being wasted.

Therefore, looking a new material for housing is one of the important developments in Taiwan.

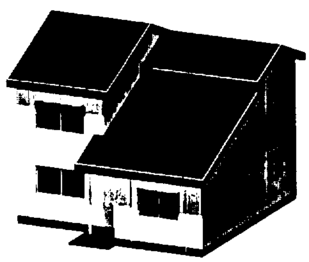


Fig 1: all-aluminum-extrusion house

Design thinking

There are four main points in this project: (1) Aluminum application; (2) integration of interfaces between building system and components; (3) modularized system design; (4) energy conservation design for external-wall. The major material is aluminum. This house is being designed to perform as systems rather than components including structure, cladding and anchoring devices.

(1) Aluminum alloy application

Aluminum is a lightweight material that will lighten building weight and be helpful for earthquake-proof. Moreover, it will be much easier to transport and to erect structure components.

Using aluminum extrusion will simply not only the interfaces between structure and cladding but also the anchoring devices. These systems will make the construction easier and faster.

Though high thermal transmittance, aluminum also cools easily. It will be a great thermal insulating material with proper energy conservation design.

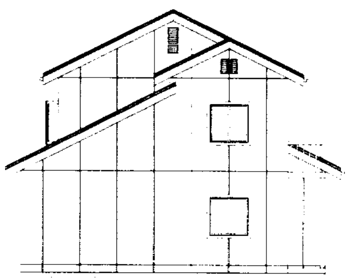


Fig 2: Elevation after modular design

(2) Structure

Aluminum studs is used for structure. There will be some standard wall-types by modular design. The scarf joint is designed between wall-types, wall and aluminum-plate, wall and component. These connections will diminish anchoring devices used. A few part of component use welding in manufactory, but never for erection on-site.

(3) Modular design

At the beginning of designing the house, we consider the possibility of renewal in the future. Therefore, units or components, both of which compose the house, can be recycled and assembled into different spatial layouts. That shows inequality about this house when inhabitant has a different demand. It is most important for the development of future housing to consider the inhabitant's demand in different time and to enhance its convertibility and compatibility.

There are some points need to be taken into consideration about modular design and scale.

a. Consideration about the compatibility of components between different parts
b. Dimension 、 intensity and life cycle
c. Convenience for manufacture and transportation.

The modules are 60cm and 120cm. The standard wall-type is 120cm width, corner type is 60cm width, height is 300cm.

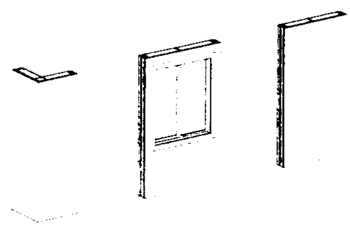


Fig 3: modular wall-type
From left to right, corner type, type with open, type with no open

(4) Ventilating layer design

External-wall having direct solar exposure should be insulated under hot conditions. It will be an effective protection against radiation impact to have a ventilating layer behind the external-wall surface, especially for certain materials with high absorptivity and emissivity.

The ventilating layer with 2~3 cm width can control the heat gain and emission because of insulating space or buoyancy ventilation. Aluminum releases the absorbed heat as thermal radiation more readily, which bring about lower temperatures within the house. It could diminish energy cost and be more comfortable for inhabitation.

In addition, condensation, which often happens when time lag is large, will also be improved.

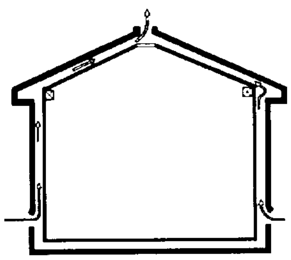


Fig 4: A ventilating layer behind the external-wall surface

External-wall surface is connected with structure by "Open Joint". In this way, wind could be led into the ventilating layer. Likewise, wind pressure could be reduced for 30-40%, which will diminish structural section.

Conclusions and follow-up

This project utilized 6000 series extrusion and 3000 series aluminum-plate. There are fewer than 15 custom extrusions designed with special assembly features and tolerances.

Aluminum is a great green material, because the energy for recycling is 5% of one for producing original material. Using aluminum lighten weight of the house effectively. It is 1/10 of reinforced concrete and 1/3 of steel-studs.

In additions, the width of external-wall is 15cm including a ventilating layer. Thermal insulation will prospectively be 3 times of RC with ventilating layer designed.

We don't attempt to build a standardize house and try not just focus on building a better house, but on create a better environment for living. Based on geography and climate, the aluminum house leads the way to materialize the possibility of energy conservation.

We are thinking about the problem of thermal-bridge, which is important as thermal insulation. But we focused on ventilating layer and do something initiative design for thermal bridge in this project. The follow-up research will give a further consideration about the problem.

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BUILDING 2040, FACTOR 20 LESS ENVIRONMENTAL LOAD ?

EVALUATING THE LIMITS OF REDUCING THE ENVIRONMENTAL COSTS OF BUILDING MATERIAL, USE OF ENERGY, USE OF WATER AND MOBILITY

Kees (ir. A.C.) van der Linden, Andy (ir. A.A.J.F.) van den Dobbelsteen

Delft University of Technology, Faculty of Civil Engineering and Geosciences
Building Engineering Division, P.O. box 5048, 2600 GA Delft, The Netherlands
e-mail: kees@aacee.nl

INTRODUCTION

Within the framework of the National Programme on Sustainable Technological Development (DTO) four examples of office buildings are designed for the year 2040. This programme aims to reduce the environmental load in the year 2040 to 5% of the actual load (1990): "Factor 20".
What the factor 20 approach deals with is the environmental load of a product per functional unit. In the case of office accommodation this is the environmental load per worker in the building.
The design assignment is executed for a concrete location with an already existing building in The Hague (Netherlands).
Calculations with the program GreenCalc (version 1.1/1998) have been executed as an assignment of the Government Buildings Agency (GBA), which is interested in making a maximum use of the insights given by the DTO-designs. Meanwhile there is a new version of GreenCalc available (version 2.0/May 2000). The database that goes together with the computer programme includes the latest notions regarding the environmental effects of construction materials and of the use of different kinds of energy. All the calculations have been executed once again, which means that all the information in this article is updated, compared with the figures given in the GBA-report. The conclusions described in this report however remain valid, even if some considerable differences arise in certain sections due to these new calculations.

HIDDEN ENVIRONMENTAL COSTS

The hidden environmental costs of the aspects "materials", "energy", "water" and "mobility" are calculated in GreenCalc. These are the costs that should be made to repair or prevent environmental damage that is or may be caused by accommodating activities. For the annual recurring environmental costs of energy, water and mobility, a period of 75 years is considered. The translation of the environmental load into monetary terms brings all the different environmental effects under one denominator, giving the possibility to compare construction projects as a whole.
The advantage of working with the environmental load expressed in monetary terms is that different environmental aspects can be compared, based on an objective approach, instead of "political choices".

ENVIRONMENTAL INDEX

The hidden environmental costs (e.c.) of the actual design are compared with the costs of a reference building. The reference situation is a building of the same size and with the same function, constructed in the way it was done in 1990.
To get a clear figure, the "environmental index" E.I. (as formulated by GBA) is used. A "factor 20" leads to an index of 2000.

E.I. = (e.c. ref / e.c. actual design) x 100

DESCRIPTION OF THE PROJECTS

In the four DTO-projects all types of measures are applied to diminish the environmental effects: light, detachable load bearing structures, products of recycled/re-used and renewable materials, extra well insulated facades and roofs, replacement of fossil fuel by renewable energy, optimal use of sunlight, passive solar energy, natural ventilation, use of rainwater, biological purification, etc.

In the area of mobility, a high quality public transport and the maximum use of renewable energy sources are expected.

RESULTS

Table 1: Calculated environmental costs (environmental guilders), division of costs and achieved environmental indexes at an object level (building as a whole).

design	ref.	DTO 1	DTO 2	DTO 3	DTO 4
% existing	0%	20%	65%	65%	95%
Environmental costs in 10^3 guilders					
Materials	7486	1593	819	1151	493
Energy	19610	206	219	150	185
Water	978	102	102	102	102
Mobility	967	73	73	73	73
total	29041	1974	1213	1476	854
Percentage division					
Materials	26	81	68	78	58
Energy	68	10	18	10	22
Water	3	5	8	7	12
Mobility	3	4	6	5	8
total	100	100	100	100	100
index					
Materials	100	470	925	650	1500
Energy	100	9500	9000	13000	10500
Water	100	950	950	950	950
Mobility	100	1350	1350	1350	1350
total	100	1450	2400	1950	3400

The assumption that in 2040 nearly all of the energy will come from renewable sources leads to high indexes in that section: 9000 – 13000. The desired index 2000 is amply achieved. This offers possibilities for the projects as a whole, compensating lower indexes for other aspects.

The index 2000 is not achieved in the areas of water and mobility, but because of their small share in the total environmental costs in all the projects, this has only a relatively insignificant influence on the total result. Besides, the use of water and the mobility are directly proportional to the number of users of the building. Since the DTO-designs expect an occupation of the building twice as high as the present one, the index for water and mobility is actually twice as high as the ones given here. The index per worker is therefore achieved. The bottleneck is found in the environmental costs as a result of the building materials.

The index 2000 for the building as a whole can only be achieved if at least 65% of the existing building is used. It is nevertheless clear that most probably there are not enough existing buildings to fulfil all the demands concerning new accommodation. Besides, a re-used existing building can not always offer a sufficient utilisation quality. Within the context of the DTO expectations for 2040, the materials are responsible for 60 to 80% of the total environmental costs, depending on the extent of the re-use of the existing building. At a re-use rate of 65% the environmental index for the materials in these projects lies between 650 and 925. At a re-use rate of 20% the index decreases to 470. The materials are critical to achieve the index 2000 for the building as a whole.

Figure 1 shows the environmental costs for the use of building materials.

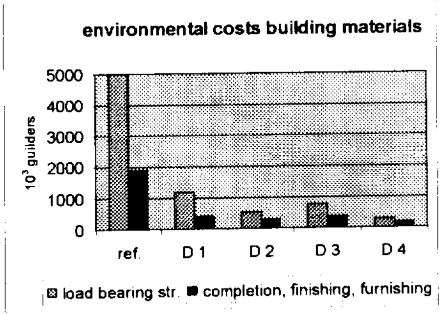

Figure 1: Environmental costs for the reference and for the DTO-designs for load bearing structure (including ground floor, façade and roof) and for completion, finishing, furnishing.

The biggest environmental load for materials comes with the load bearing structure. Also the item finishing plays an important role in the environmental load. In the DTO projects ro-anhydriet finishing floors are applied on wooden floors and suchlike, to improve the sound insulation. Even if ro-anhydriet environmental costs are a factor 2,5 lower than the ordinary anhydriet, these floors are responsible for approximately 65% of the environmental costs of the item finishing.

THREE SCENARIOS

Calculations have been made in order to examine the influence of the assumptions concerning the application of renewable energy on the results for the DTO-designs. For this reason also a situation is defined in which the efficiency of electricity production increases only by 50% (scenario 2015). Also calculations are made for the situation of 1999 (see table 2). Next to these numbers for the building as a whole, standardizations per square meter of gross floor area and per worker are shown.

Table 2: summary of results achievable environmental indexes

scenario	building level	per m²	per worker
2040	1450 - 3400	1400 - 2700	2900 - 6800
2015	975 - 1650	950 - 1350	1950 - 3300
1999	240 - 300	230 - 280	480 - 600

(floor area 3743-4212 m² depending on design; reference 150, DTO-designs 300 workers)

Less application of renewable energy in the scenario 2015 also influences the results for mobility. In the case of a nearly completely re-use of the existing building, energy becomes the decisive factor, but the materials become again influential with just a limited share of new construction. In the scenario 1999, the biggest share of the environmental costs belongs to energy use. The index that can be achieved for the building as a whole lies between the 240 and 300. The effect of the re-use of the existing building becomes smaller.

CONCLUSIONS

Based on the study, the following conclusions can be drawn:

1. A large-scale application of renewable energy sources is crucial and enables the achievement of factor 20.
2. The index of 2000 for water use is practically achieved, considering an absolute daily minimum of 2,5 litres drinking water per person. The rest of the needed water has to come from own recycling and use of rain water.
3. A choice of location close to public transport junctions is the starting-point to achieve the first environmental gain in the topic mobility. A substantial progress is possible, but it can only be reached through completely new transportation concepts and far-reaching application of renewable energy in transportation means.
4. A high environmental index for the design as a whole can only be achieved through a maximum use of the existing building and through minimal additions.
5. The limitations are to be found mainly in the environmental costs as a result of the use of building materials.
6. The development of new concepts for the load bearing structure and material use should be considered of high priority.

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ENVIRONMENTAL COSTS OF THE CONSTRUCTION AND THE USE OF RESIDENTIAL BUILDINGS IN GERMANY

Dr. Gerd Lintz, Dipl.-Ing. Architekt Clemens Deilmann
Institut for Ecological and Regional Development (IÖR), Dresden, Germany
Weberplatz 1, D-01217 Dresden, http://www.tu-dresden.de/ioer

The Concluding Report of the German " Protecting Humanity and the Environment" Study Commission in 1998 re-affirmed just how considerable the impact of the construction and the use of residential buildings (building and habitation) on the environment is. The Dresden-based Institute for Ecological and Regional Development (IÖR) has now assessed the macro-economic environmental costs of energy consumption in building and habitation.

ENVIRONMENTAL INVASIVENESS HAS A PRICE

Environmental damage brought about by economic activity is generally described in terms of physical changes to the environment or physical impacts on people and assets. Thus, global climate gets warmer at a given rate, a given number of people suffer from environmentally-induced illnesses, and the outsides of buildings are afflicted to this or that extent by environmental pollution.

As a means of more precisely quantifying levels of environmental invasiveness, it makes sense to attempt to formulate the damage as a financial variable - money, after all, is a pre-eminent yardstick for industry and society. Such environmental costs are also referred to as external costs, since they are not usually charged to the account of the perpetrator. The methodology of 'monetarising' environmental damage is far from straightforward, if not sometimes actually impossible. Putting a price on someone who has died of environmentally-induced cancer, for example, cannot be done. There are, however, reliable and proven means of at least establishing the financial 'bottom line' by, for instance, specifying the cost of building dams to prevent climate-related flooding catastrophes, the cost of treating environmentally-related illnesses, the cost of cleaning up blighted buildings, or by conducting surveys of how willing people are to pay for a clean environment.

Staff at the Institute for Ecological and Regional Development (IÖR) in Dresden have now carried out a variety of computations correlating monetary damage values per unit of emission of four energy-related mass atmospheric pollutants with specific emission levels in building (residential construction) and habitation (utilisation thereof). Damage values per unit of emission were provided by ÖKO-INSTITUT of Freiburg and by INFRAS et al of Zurich/Basle. The specific emission values for building and habitation were assessed by IÖR, with the estimate of building-related emission levels in particular being demonstrably on the conservative side.

AMBIVALENT DEVELOPMENT OF THE ENVIRONMENT COSTS OF BUILDING

The energy-related environmental costs of building inclusive of fabricated materials were ascertained for 1991 and 1996. Adopting the monetary valuation of emissions produced by ÖKO-INSTITUT, the external costs of building amount to DM 2.7 billion, or roughly DM 106 per square metre of dwelling built (see Figure). Assuming straight building costs per square metre of DM 2,500, external costs constitute approx. 4.2 % of these 'internal' costs. Basing assessments on the monetary valuation produced by INFRAS et al yields external costs of DM 8.3 billion, i.e. DM 325 per square metre of housing built or 13 % of internal costs.

The development between 1991 and 1996 is ambivalent. There was a heartening fall in building-related emissions per unit of energy, notably as a result of restructuring in what was East Germany, but this was largely offset by the effects of increased house-building, the absolute damage value being DM 2.8 billion using ÖKO-INSTITUT figures and DM 7.9 billion with INFRAS et al figures. This is very much in keeping with trends in damage done to the environment by private motoring. Here, emissions per kilometre have fallen but this positive effect has been cancelled out by the increasing mileage being put in.

Viewing absolute damage values for 1996 against the sizeable expansion in newly built figures for 1996 only. Taking the money damage values of ÖKO-INSTITUT, energy-related costs amount to DM 15 billion or so, or roughly DM 5 per square metre of total housing stocks per year. This constitutes 3.5 % of energy-specific internal habitation costs per square metre and year. Departing from INFRAS et al assumptions, absolute damage values amount to approx. DM 41 billion or DM 14 per square metre of total housing stocks per year. This makes up 9.7 % of internal habitation costs.

A comparison of the energy-based external costs of habitation and building respectively reveals that, at approx. DM 3 billion, the external costs of building only represent a

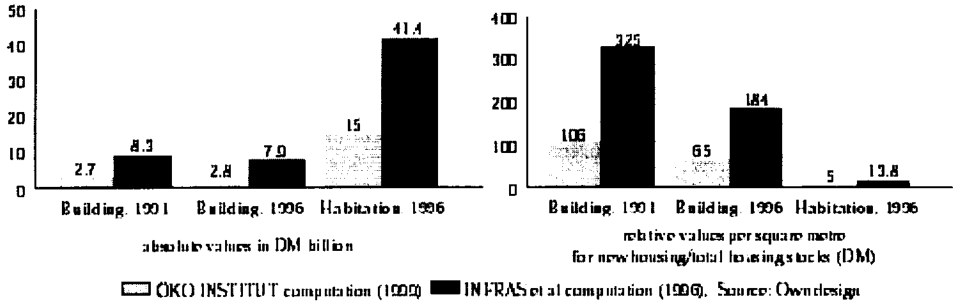

Figure: Energy related environmental costs of building and habitation

housing underlines the degree to which emissions have been cut per unit of energy. External costs per square metre are significantly down, from DM 106 to DM 65 and from DM 325 to DM 184 respectively. As a proportion of internal costs, they fall from 4.2 % to 2.6 % and from 13 % to 7.4 % respectively. Given the rise in building levels, however, it would be inappropriate to sound the environmental 'all clear'.

ENVIRONMENTAL COSTS OF HABITATION WEIGHS MORE HEAVILY

Energy-induced damage relating to habitation (heat, hot water, electricity) was computed on the basis of Federal Environment Agency

fifth of the external costs of habitation, which stand at DM 15 billion (valuation by ÖKO-INSTITUT). It needs to be borne in mind here that this share was even smaller in previous years, since there was far less building going on in the early 1990s and hence the environment suffered comparatively little damage through building. In the light of this, particular attention needs to be devoted to energy consumption in inhabited dwellings, a point underlined by studies of the life-cycles of buildings. Building and habitation together generated energy-related environmental costs of between roughly DM 18 billion (ÖKO-INSTITUT valuation) and roughly DM 49 billion (INFRAS et al figures) in 1996, or between 0.5 and 1.4 % of GDP for that year.

POSSIBLE CONSEQUENCES

Applying the "polluter pays" principle in environment policy would require the (minimum) energy-related environmental costs identified here to be passed on in full to owners and occupiers of housing by way of taxes or levies. In March 1999, the German federal government made the first move towards internalisation at a general level with the Act initiating ecological fiscal reform.

A decisive factor for owners and occupiers of housing is the ability in the medium to long term to significantly reduce the level of additional costs and of previous energy-related costs - in a manner that is creative and adapted to specific needs - through energy-conscious building and habitation. Primary energy requirements per cubic metre of built space in a multiple dwelling incorporating ecological principles, for instance, are half those for a conventionally built multiple dwelling. Primary energy requirements per cubic metre of built space may differ as much as four-fold depending on the method of construction and type of building (Deilmann/Böhm 1996). In addition to energy-efficient new-build practices, there is also considerable potential for savings in the way housing is used. Higher bills can be circumvented, for example, by resorting to thermal insulation, advanced heating systems, energy-saving household appliances and solar power.

It is to be assumed that internalisation-driven levies and taxes in respect of building and habitation will serve as an effective long-term incentive to reduce the environmental costs described. Internalisation will lead to sparing approaches to the environment and natural resources being inseparably married to the general goal of saving on outlay, the most effective engine of innovation.

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DESIGNING AND BUILDING GREEN: CREATING AN ENVIRONMENTAL CULTURE FOR EDUCATION

Caroline Lobo
The Orcutt/Winslow Partnership/Arizona State University, Arizona

INTRODUCTION:

The project involves the master plan design of two of Mohave Community College Campuses, located at Lake Havasu and Mohave Valley in North West Arizona, USA. The building additions provide an opportunity for designing in a desert climate Library, Bookstore and Classroom facilities in the existing campuses. Construction is expected to be completed by June 2001.

THE DESIGN PROCESS:

The process involved programming with the College board, faculty, staff and students in order to arrive at a master plan for each of the campuses. In addition to the individual campus requirements, the programming session also focussed on environmental conscious design. LakeHavasu and Bullhead city belong to the climatic zone that experiences summer temperatures as high as 40°C for nearly four months of the year. Mohave Valley in addition experiences strong winds throughout the year. Winters in both the regions are generally mild. The harsh climatic conditions render most of the outdoor spaces non-usable. In a desert landscape setting, the existing campuses include standard classroom and administrative buildings, some of which are modular. Lack of a sense of place in each of the campuses drove the users to come up with a vision statement that shed light on what the users expected their campus to be like.

VISION STATEMENT:

Change the image of each campus: to have its own identity, be cool and inviting through variation in building materials, use of water, creating common green spaces, and utilizing other environmental features to provide protection from the sun and the wind.

DESIGN REQUIREMENTS:

Lake Havasu Campus:
The challenge at the site is the existence of a wash , running diagonally north to south that divides the existing campus. The design calls for a 28,000 sft Library, Bookstore, Northern Arizona University facilities and a classroom building that is well connected to the existing buildings. The topography of the site is hilly in nature, which is a design challenge.

Mohave Valley Campus:
The site design is challenging due to its characteristic severe slopes. The design includes a Library, Bookstore and Classroom facilities of approximately 20,000 sft area. An important characteristic of the site is the view of the surrounding mountains towards the north-west.

ENVIRONMENTAL DESIGN FEATURES:

Site Design: In case of the Lake Havasu campus, the location of the existing buildings on one side and the wash on the other side dictate the location of the Library, Bookstore, NAU facility. The location of the buildings is designed in a way that it creates an interesting, integrated connection with the buildings on the other side of the wash. The buildings at Mohave Valley are designed to take advantage of the views towards the northwest.

Landscaping: The quantity and quality of water being a problem in the region, Xeriscape is the key concept of the Landscape design. Desert landscaping is carefully chosen to enhance the natural beauty of the site. At Mohave Valley campus, trees are located to act as wind barriers. Small-scale water bodies in the landscaped courtyards improve the microclimate of outdoor spaces and enhance the quality of the spaces with the sound of water streams.

Form: The design of the buildings at Lake Havasu is sculptural in nature relating to the wash as an integral part of the campus. The classroom building and part of the Library building is 2 stories. The buildings at Mohave Valley are single storey structures.

Orientation: The buildings at Lake Havasu are oriented 30° West of south, as constrained by the location of the wash. Although it is not the best of orientations, the form of the building is designed to integrate north light for daylighting of the library. The form of the building further shades the adjoining central courtyard making it a highly desirable space. The buildings at Mohave valley are designed with a North-South orientation.

Windows: Thermally broken, double glazed low-e windows are used at both campuses. Windows on East, West and South orientations are shaded with calculated shading devices. It was important from daylighting point of view to provide windows in every room, however the size have been adequately controlled, in some cases eliminated on east and west facades.

Daylighting: The buildings are designed with clerestorey windows ensuring natural daylight into every room.

Cooling Tower: Lake Havasu campus is designed with a cooling tower primarily to cool the central outdoor courtyard space which is designed as a central interaction space.

Shaded Walkways: These are provided for comfortable pedestrian flow within the campus and encourage the use of outdoor spaces.

Shaded Courtyards: With the help of trees and other landscape elements, courtyards are designed to serve as the heart of the campus; a space which is inviting, comfortable and encourages interaction as opposed to the existing courtyard spaces which are often empty. Shaded outdoor reading courtyards are an integral part of the design.

Natural Ventilation: Every habitable space is provided with an operable window that can be controlled by users for natural ventilation. The indoor corridor of the classroom building at Mohave Valley is designed with a skylight that acts as a solar chimney and enhances cross-ventilation with cooler air being drawn from the courtyards.

Building Materials-Resource Efficiency: The buildings at Lake Havasu are designed to minimize site disturbance with equal amount of cutting and filling of soil. All exterior walls are built out of R-19 concrete masonry units. The R-value of the built-up roof and metal roofs is R-30. Recycled steel is one of the main construction materials for interior walls.

Rainwater Harvesting: Due to the sloping nature of the sites, surface water is collected and used for irrigation purposes.

Indoor air quality: All interior finishes like paints, carpet have zero VOC content.

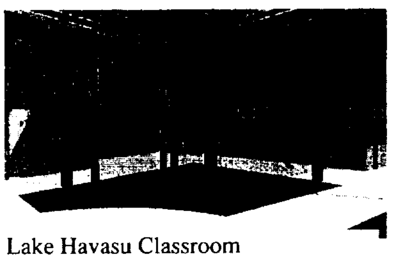
Air-conditioning system: Energy efficient systems have been designed at both campuses.

DESIGN EVALUATION - ENERGY SIMULATION AND DESIGN RATING

The simulation software Energy-10 was used at the schematic design stage to arrive at optimum energy conserving design strategies. It is estimated that the building will use about 20% less energy as compared to a standard institutional building type. An in-house green building evaluation of the buildings was carried out using the LEED rating system. It is interesting to note that during the schematic design stage the buildings were evaluated to have a Silver ranking. After the construction document stage evaluation, the ranking fell to a Bronze level.

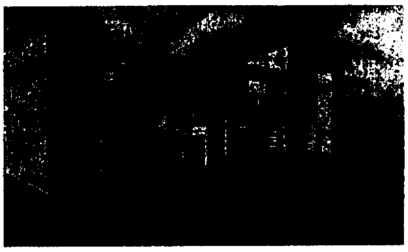
PROJECT EVALUATION AND LESSONS LEARNT:

It is envisaged that after the buildings are constructed the campus environment will change to be an even more friendlier and welcoming campus. In desert areas, outdoor spaces are rarely used, as they are never designed to be comfortable spaces. The focus during the design process, was to educate the users about environmentally and people friendly outdoor as well as indoor spaces. The buildings relationship is not only to the sun but is also to the rest of the site. The design focus has been to explore this indoor-outdoor connection. The orientation of the buildings was a challenge at the Lake Havasu campus. The success of any design lies in the hands of the users. It is easy to lose the effect of all energy efficient principles if the user is not aware of the basic concepts. The design of the buildings call for notes to users that will be provided in every room to ensure the proper functioning of the individual buildings. An important aspect of green design is the choice of building materials. During the schematic design, Integra blocks made out of flyash and cement were chosen as the exterior building material, but during the design development stage the use of these blocks had to be ruled out as the site locations is remote and qualified masons cannot be ensured to do a quality job without a major expense. Similarly, a green roof system was also ruled out of the design as the concept would be the first of its kind in the region making it a liability issue for the firm and the owner. As a result of these changes, the rating of the building changed considerably. Achieving green design in locations other than cities is a problem, as it ends up being a more expensive affair. The mere resources that are required for construction waste management are not available in far away locations. The other challenge in green design has been this unique relationship between green design, green designer, architecture (aesthetics), client and project cost. It's a unique mix that has been challenging throughout the design process and continues to intrigue the author. Is it just sufficient to think and design green? Or is there more to it than meets the eye.

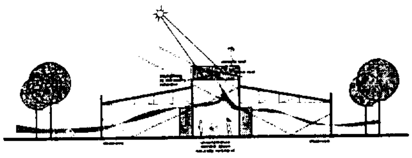


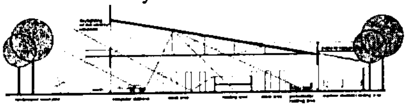
Lake Havasu Classroom

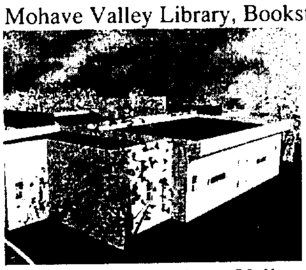
Lake Havasu Library, Bookstore, NAU


Mohave Valley Library, Bookstore


Lake Havasu Classroom


Mohave Valley Classroom Section


Mohave Valley Library, Bookstore Section


Mohave Valley Classroom

ENERGY EFFICIENCY IN BUILDINGS - THE ANALYSIS OF TWO CASES

Prof. Dr. Fernanda Magalhães
Arch. MSc. Silvia Duarte
1. Instituto Presbiteriano Mackenzie, São Paulo
Rua da Consolação 896 - 5º Andar - 01302-907 São Paulo, Brasil
Tel. (11) 236-8669 Fax: (11) 236-8660 e-mail: posgrad@mackenzie.br
and Cesur, Instituto Superior Técnico, Lisboa
2. Rua Espírito Santo, 126/91 – 11075-390 Santos – SP – Brasil
Tel. (13) 2212464 e-mail: arquiteta@bol.com.br

Introduction

Energy today is an important resource. The investment on energy production and in maintenance of power transmission lines is very high. The production of energy itself often causes severe environmental impacts. The use of eletricity in Brazil dates a century ago, introduced in 1879 by the imperor Pedro II. Nowdays, Brazil is the 10th world eletrical energy producer and consumer (world thrid hidraulic energy producer), but the consumption growth is increasingly higher than the hability to it. For this reason in 1985 it was created the National Programme for Energy Consumption (PROCEL) aiming to improve energy efficiency to reduce consumption.

During their construction, for their maintenance and use, buildings consume a high amount of energy and resources. Building design can largely reduce the consumption of energy, since in a badly designed building people have to use more appliences to compensate for the poor energy building performance with a large number of energy consuming devices, such as heaters, coolers, showers and fans (the eletric shower and the freezer together are responsible for almost 60% of the residential energy consumption). These have been incresingly incorporated into buildings with little contribution from design to reduce or restrict their use.

Local environmental conditions have to be considered as a main determinant to building projects. This should consider specially three aspects: first, the micro-climate (solar radiation, wind, temperature and humidity); second, human comfort; and third, design solutions of building projects regarding specially with solar orientation, naturalventilation, geometry, openings, building materials, cooling and heating devices.This paper deals with the subject through the analysis of how building project can contribute towards improving energy efficiency,and users comfort. It aims to offer a contribution to architects to incorporate energy conservation as a key variable to the design of buildings, considering that consumption can be reduced up to 50% (1) through project. It discusses the use of high tech, arguing that there is a difference between high tech and intelligent building in the sense that is not the use of high technology and authomatization that guarntees a building an intelligent use of resources, particularly energy.

Hight tech buildings are known by the use of the latest integrated services, manegement and comunications technology. To be intelligent, nevertheless, a building had to be designed to combine spatial and constructive solutions with control systems in a way that allows for flexibibility, adaptability to users, human comfort and climate adequacy. Only buildings that are able to match local conditions and resouces with building facilities regarding to glazing, cooling and heating, lighting and services networks might be considered to be intelligent. To be sustainable (2), architecture and building have to be very carefull with the use of resouces, particularly non renewable, considering the conservation of energy in the long term (3).

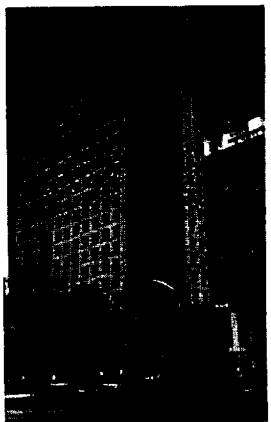
Energy is specially relevant in cases of corporate/comercial buildings, since lighting and air conditioning are reaponsible respectively for 45% and 20% of energy consumption (4).The study looks at two buildings, examples of commercial coorporate architecture designed and developed recently, the first is the Citicorp/Citibank in our hometown of São Paulo, Brazil and the second is the Commerzbank Frankfurt in Frankfurt, Germany.

Presentation

Citicorp/Citibank, the first hight tech building in Brazil designed by Croce, Aflalo & Gasperini, was opened in 1982. Commerzbank Frankfurt by Foster & Partners who won an international competition after responding a brief with high ecological and energy concerns, was completed in 1997. This building is considered to be a good example of meeting environmental concerns with the use of hight tech.

The building in Brazil has 47.000 sqm total built area and 21 floors height (93 m), consuming an average of 229kwh/sqm/year. The Frankfurt building has a total of 85.000 sqm built area and 55 floors (259m height), with a consumption of 169 kwh/sqm/year.

Figure 1. External view of Buildings



Citibank–SãoPaulo

Commerzbank-Frankfurt

The case analysis concentrates mainly in three aspects of the projects: (a) spatial solution, (b) construction options and (c) resources used. Regarding the spatial solution the following aspects were considered: (1) surrounding, (2) orientation, (3) geometry, (4) width and length, (5) openings and walls and (6) internal layout partition. The construction was studied in terms of the built material and thermal performance walls selected in special to: (7) glazzing and (8) walls. The resources used are represented by the services required to allow user comfort, namely: (9) heating water; (10) lighting; (11) water supply and (12) eletric supply. The results of this analysis for the two buildings are summarized in the table bellow (Fig. 2).

Figure 2. Data result from building analysis

	Citicorp/Citibank	Commerzbank
(1) Spatial solution	No spatial interference	Modify space
(2) Orientation	No option of total site development	Best possible
(3) Geometry	Rectangular block with edges cut	Triangular +central atrium
(4) Width/lenght	Disproportional	Disproportional
(5) Openings/walls	Envelope over 50% glazed	Envelope around 1/3 glazed
(6) Internal layout	Favour internal air circulation	Favour internal air circulation

(7) Glazzing	Set back facade 10 mm laminated glass	Double glazzing+ innerlayer
(8) Walls	Concrete structure+granite finish	Glass+alum.thermal insulated
(9) Heating water	Eletricity	Eletricity
(10) Lighting	Artificial	Natural when possible
(11) Water supply	No control of flow+consumption No recyling	Recycled for WC facilities Forseen future treatement
(12) Eletric supply	Only emergency generation	Higherflexibility, BMS monitoring. No generation

Conclusions and recommendations

The relationship between project and eletric energy consumption should be based on environmental and economic concerns. The study of this two cases shows that there was overtime an evolution of the concept of energy conservation in buildings. In Citicorp/Citibank there is an emphasis in management control of resources with little concern for profiting from the local favorable conditions, whereas the Commerzbank project appears to be tatking all pssible advantages from local natural conditions, allowing users to be on control of ventilation and lighting conditions, and using management resources and equipment as a complement to that to reduce evenmore energy consumption.

Overall, this paper argues that buildings should be aim to be autonomous in terms of energy, using available technology to produce enough for their own consumption. In this way environmental resources can be used in a more rational and sustainable form.

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OVERVIEW OF MORE SUSTAINABLE MULTI-RESIDENTIAL PROJECTS IN CANADA

Sandra Marshall
Canada Mortgage and Housing Corporation
700 Montreal Road, Ottawa, ON, K1A 0P7

BACKGROUND

There is great climatic variation across Canada, from frigid arctic winters to temperate rain forest conditions on the Pacific coast. Relatively cheap gas prices are increasing again as a result of international demand. Some areas have developed hydroelectric power, while others rely of fossil fuel to provide electricity. Due to the influence of relatively low fuel costs, cheap available land and abundant resources (such as water), there has been little market incentive to develop resource-efficient buildings.

Furthermore, with North American reliance on cars to commute, public transit systems are less developed than in European cities. In many municipalities, multifamily housing is required to provide on site parking space for all suites.

TYPICAL MULTIFAMILY BUILDINGS

Mechanical systems in typical Canadian multis are relatively simple. Ventilation is not distributed to suites: air movement relies on open windows and corridor air filtering under door cuts. Exhaust is provided by oven and bathroom fans. In many buildings this has led to high humidity levels in units. Air movement in high-rise buildings is strongly influenced by "stack effect" in winter. Through air leakage, cold air is drawn in at lower floors as hot air rises and exits at the top. The overheated occupants of the upper stories open their windows and increase the air flow, encouraging the lower occupants to raise their thermostats. Also due to "stack effect", poor air from underground parking migrates to upper levels.

Too often, building envelopes do not perform well. In typical apartments, insulation levels are low compared to single family housing construction. The "stack effect" again increases energy requirements. Poor envelope air tightness allows cold air to infiltrate through the walls. This results in moisture condensation, the cause of rusting of ties and metal studs and premature failure of the cladding systems, as well as reduced thermal insulation performance.

It is not surprising that in these multis, suite energy use is as high as for detached single family housing of same area.

HEALTHY MULTIS GOAL

Newer Canadian multi-residential designs have begun to address reduced energy and resource consumption, improved ventilation and investigate the synergies possible with integrated systems. Designers consider improved envelope performance: better insulation and windows, the elimination of thermal breaks, and how to air tighten walls and interconnections. This paper discusses three buildings whose design goals were to be healthier, high performance and resource conserving. These buildings have been monitored and evaluated over the last five years by Canada Mortgage and Housing Corporation. What did the designers hope to achieve and how well did they succeed?

CONSERVATION COOPERATIVE, OTTAWA, ONTARIO

Canada's residential choice for GBC98, this four storey cooperative addressed a broad range of environmental issues. The rain screen system and higher insulation levels in the envelope, helped reduce energy demand. Materials were selected to reduce embodied energy where possible. Both construction and operational waste reduction were planned: Construction waste was reduced by one third. Water use is reduced to 2/3 of a typical household by a rainwater cistern used for gardening, and by low-flow fixtures. A water reuse research study is underway. Original trees were conserved and much of the space of the courtyard was retained for garden and play area. Only 8 car spaces were provided on site, for 84 units. Bicycles are given priority, with drive-in underground access for 240 bikes. Individually metered, hi-efficiency gas heating units are located in each suite. Likewise, ventilation is supplied to each suite room, drawn from rooftop heat recovery ventilators (HRV).

Results-

- Below average heating costs were achieved .
- Ventilation systems (120 fans) resulted in higher electrical costs. Supply air is drawn off the roof, circulating hot air in summer. Although large balconies are intended to provide shade, the south facing units still overheat in summer.

Issues to be addressed-

- Need to reduce ventilation energy costs while maintaining all-room ventilation
- Need to resolve passive cooling strategies
- Need to provide systems that are simple to run and maintain - "black box" technology. Managers are not trained to run unconventional systems.
- Consider compartmenting suite systems to prevent cross contamination between suites.
- Plan maintenance at design stage. **Success-**
- No underground car parking reduced capital and maintenance costs, IAQ less effected by fumes from garage.
- Continued involvement of occupants in environmental issues from conceptual design

LE CLOS ST-ANDRÉ, MONTRÉAL, QUÉBEC

Québec winner of IDEAS Challenge competition, this concrete framed condominium proposed to reduce energy use by half of ASHRAE 90.1 To do this improved thermal insulation was used: RSI 4.9 for walls and 5.3 for the roof. High performance double glazed low-E windows and hi-efficiency central gas fired water heater were also intended to reduce fuel demands. A central air system moves fresh air into each room. This air is preheated by exhaust air at the central HRV. Hi-efficiency fans, variable speed drives and direct digit controls also helped to reduce energy use.

Results-

- Uses one third less energy than standard construction, although more than predicted.
- Building financial problems resulted in partial occupancy before central heating system was fully commissioned: Poor workmanship in radiator installation. Noise and heat distribution problems. Superintendent must deal with frequent complaints.
- Central hot water heating plant owned and operated by gas supplier.
- Electricity use high: central HRV requires long duct runs. Dehumidifier reduces summer discomfort.

- Individual air conditioners used: south facing units overheat

Issues to be addressed-

- Plan commissioning central systems prior to occupancy, especially with split ownership
- Training and operations manuals with log book updated with each service visit
- Education program for residents to explain systems
- Air tightness of whole building needs to be tested prior to occupancy: care to verify penetration of envelope by mechanical system, around windows, etc.

TATRY-PATHWAY COOPERATIVE, TORONTO, ONTARIO

The two building cooperative was winner of 1995 World Habitat Design Award for its advanced concepts and environmental concerns. This building also has in-suite combo units for heat and hot water. Fresh air is distributed through en suite HRVs. Expected to reduce energy consumption to 50% of ASHRAE standard 90.1 Large glazed areas maximize daylighting. Balconies were replaced by enclosed terraces to eliminate thermal bridging

Results-

Failure to realize energy use expectations: Co-generation system too expensive to maintain; couldn't sell electricity back to utility. Incomplete commissioning of cogen meant that absorption chiller and passive convection fin-tube system in suites did function properly. Auxiliary backup electrically fired chillers high consumers of electricity.

- Overheating due to solar and internal heat gains (large glazed units, well insulated walls).
- Occupants have little control with small operable windows.
- HRVs in closets are difficult to access for maintenance.
- Hot air drawn from south side of buildings heated in hot summer sun.

Issues to be addressed-

- Define commissioning needs, frequency and time required at design stage.
- Commission central systems prior to occupancy. Consider "domino effect", when one system does not perform to expectations, how does it effect the other systems?
- Co-gen systems which address the sizing and maintenance requirements of multis
- Operational and repair strategies need to be defined at design stage
- Occupants need to provide feedback at design stage

For more information about these and other innovative multi-unit residential buildings and other research, visit CMHC's Highrise and Multiples Innovation website at:

http://www.cmhc-schl.gc.ca/research/highrise

ENERGY SAVING TECHNOLOGIES FOR THE CENTRE FOR SUSTAINABLE BUILDING IN WESTERLO

Erwin Mlecnik, Geert de Bruyn, Tim Van Dyck, Kris Baert
CENERGIE cvba, Gitschotellei 138, B-2600 Berchem, Belgium.

INTRODUCTION

The Province of Antwerp is constructing a demonstration centre for sustainable building in Westerlo, Belgium. As part of a building team, together with Studiegroep Omgeving and IRS, Cenergie cvba gave advice on energy saving technologies and aspects of sustainable building. Several innovative aspects were elaborated during discussions and implemented in the final design. In the conclusion, the necessity of total building commissioning procedures is discussed.

PRESENTATION

Building definition

The provincial government of Antwerp wished to establish a Centre for Sustainable Building at a former military domain 'Kamp C' in Westerlo as a first step towards further regional development. It included in the first place a preliminary development study for situating an information centre and an experimental habitat [PA 1999]. In a second step, the sustainable building information centre, including a demonstration habitat, was defined as a centre of information, education and demonstration for professionals, particulars, administrations, schools and recreation purposes. A further step will include the demonstration of sustainable employment schemes in a separate part of the military domain.

The Centre for Sustainable Building was defined with 250 m^2 exhibition area, cafeteria and auditorium for 120 persons, 120 m^2 education rooms, offices and reception area for 10 people and technical and sanitary facilities. The designers (Studiegroep Omgeving) decided to restore and use a former military chapel as an integrated part and attraction point of the new building. Also, the demonstration habitat was integrated in the main building as demonstration of a sustainable option and to be directly accessible from the exhibition facilities.

Demonstration of a solar oriented approach

The contribution of Cenergie in the building team resulted in a constant concern for, amongst others, solar gains for heating and natural lighting. Since lighting would be the most important energy use, offices and education rooms were provided with adequate north oriented glazing by means of shed roofs. The south oriented part of the shed roofs could thus be used for demonstrations of different types of solar heating equipment. Since the budget was strictly limited, passive housing techniques like super-insulated glazing and window frames could not be applied. For other facades a constant compromise was sought between natural lighting, better thermal insulation and improved heat capacity, balancing gas filled double-glazing and massive insulated. For the whole building, low energy artificial lighting was chosen, specifying daylight control techniques and thorough calculation of the placement of necessary equipment.

The placement of the building above the chapel resulted in a north-south orientation of the smaller facades of the building. The resulting space between this building and the chapel was elaborated with an inclined green roof to form the exhibition and reception space. For winter conditions, it was investigated if solar gains could be used through the south oriented façade. Design considerations lead to the choice of using a ventilated solar wall for demonstration purposes. A shading simulation showed that using overhangs for the inclining roof and solar shading on the west oriented façade eliminates the direct solar gains in summer conditions.

Demonstration of energy saving technologies for heating and ventilation

The building was divided into different ventilation and heating comfort zones. Since the exhibition space included a large temporarily used volume, the design team decided to use less strict comfort criteria in this zone. High comfort standards were used for the cafeteria, offices, library (in the chapel) and education rooms. The demonstration habitat was equipped with separate domestic demonstration technologies.

The consideration of airflow and preheating strategies has lead to an integrated energy saving concept for heating and ventilation, using specified border conditions like U-values of building walls, thermal comfort criteria and the use of the south oriented ventilated solar wall and roof integrated solar heating equipment.

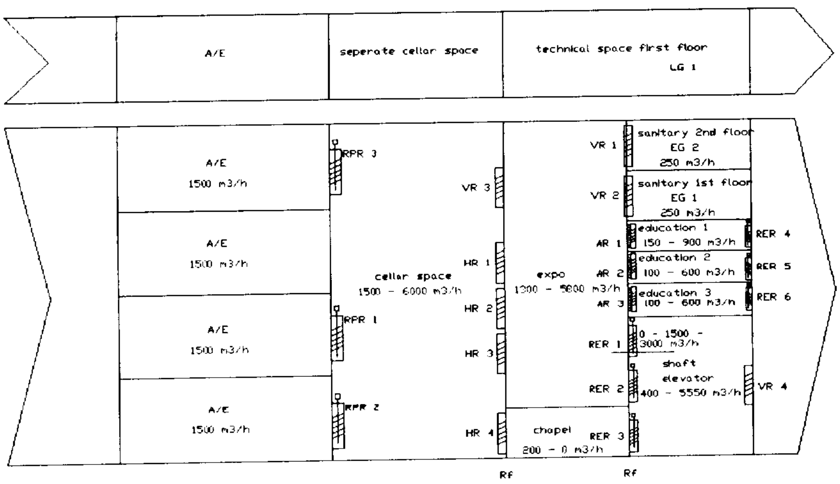
Heating for the whole building, except the demonstration habitat, is provided by a modulating 60 kW high efficiency condensation heater, using the roof solar gains to heat a 500 l water buffer. The heat is distributed through low temperature central heating equipment for the high quality zones and floor heating for the demonstration zone.

Due to high comfort and ventilation demands the cafeteria and auditorium were regarded separately. For ventilation, these were equipped with a regenerative air-to-air heat exchanger with efficient DC-motors. The air is preheated/ pre-cooled by means of an air-to-earth heat exchanger (see Fig. 1). The local central heating equipment preheats the room air and further heat is provided by internal gains.

Also, the habitat and the offices were regarded separately, using central heating equipment and a compact high-efficiency air/air heat exchanger on the ventilation side.

An innovative demonstration was provided for the ventilation concept of the demonstration space, the offices and the education rooms. The flow stream concept for controlled natural ventilation is demonstrated in Figure 1.

Figure 1: flows stream of cafeteria ventilation (above) and controlled natural ventilation (below).



Legend:

RPR:	controllable pulsion grid;	RER:	controllable extraction grid
HR:	horizontal grid	VR:	vertical grid
AC:	acoustical grid	A/E:	air-to-earth heat exchanger
Rf:	fire control		

Air is inserted into a collector beneath the demonstration space by means of four tubular air-to-earth heat exchangers. Some of the tubes can be closed to reduce airflow rate, considering night/day and seasonal control. Airflow rate can thus be varied from 1500 to 6000 m^3/h. The airflow is in general controlled on the extraction side. Controllable grids allow using the preheated air from the demonstration zone to provide a specified airflow rate for the education rooms. A similar approach is used for the ventilation of the former chapel. The preheated air from the demonstration zone is further also extracted in the sanitary facilities, which are provided with highly efficient mechanical extraction. The remaining air from the exhibition space is extracted via an elevator shaft by using the stack effect and controllable grids.

CONCLUSIONS AND RECOMMENDATIONS

As the science of life cycle assessment and management is still in its infancy, it is important that energy, environmental and technical advisers work together. Preferably they should represent the future owner or user to protect and define rights towards building teams.

In an early stage of the design, advisers can review building documents, document the owner's needs and goals and help with definition of design goals. The design intent can objectively be described by means of a Programme of Requirements [Cenergie, 2000]. Objective performance criteria can also be a basis for performance contracts.

Good communication is required with the design and engineering team and preferably also with future constructors. The definition of building teams and the responsibilities of the different partners is a necessary condition to reach goals of timing, cost and quality assurance. Without quality and constant follow-up, it is highly unlikely that performance criteria like energy savings and environmental considerations can be maintained.

It remains important that advisers stay involved in the total building commissioning process. This should be, not only for heating, ventilation and air-conditioning, but also for the control of automated building systems, lighting, security and fire-safety, and functional aspects of building components (structure, shell, finishes).

At the conclusion of the construction field-testing of systems and components and final reports for the owner are important. For example, computer modelling can be an adequate tool to describe the conditions that equipment and systems 'should' be creating. However, on-site verification remains necessary. Monitoring for a year or two should provide information if performance goals are honored.

Details should be provided about operational guidelines and maintenance requirements. During the follow-up period operation and maintenance guidelines and problem solution should be provided. Also, transfer of operation and maintenance requirements and supporting should be established documents for the future building management.

In general, it is felt that further research and development is needed in the field of 'building' commissioning, performance contracting and for establishing quality related sustainability indicators. Quality assurance is an important and necessary drive in sustainable building and construction. Tools and processes for quality assurance should be implemented for an objective definition of the environmental goals.

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Reduction of Environmental Loads by Increasing Investment of House Construction

T.O., Dr.Eng. : Prof., Tatsuo Oka, N.Y., Dr.Eng., Noriyoshi Yokoo
Utsunomiya University., 7-1-2, Yoto, Utsunomiya 321-8585, Japan

Introduction

Intensity is defined by the energy consumption (MJ) or CO2 emission (kg-C) due to the expenditure of 1000 yen (1 US$=105 Yen). The energy intensity of building construction is 1000E/X, assuming that the construction cost is X yen and the embodied energy of the building E(MJ). The intensity may also be considered as the value of environmental load divided by the social benefit.

It is said that the sum of CO2 emission is due to building construction, public works and building operation which reaches to 45% of the total CO2 emission in Japan, therefore CO2 emission related to construction must be decreased. However, assuming that the gross domestic expense is fixed, in case of that the investment applied to construction is decreased, the equivalent amount of the investment should be applied to other industrial sectors. CO2 intensity (kg-C/1000yen) is defined as the value of CO2 emission due to the investment divided by the sum of the investment. Defining that the CO2 intensity of household expenses is A (kg-C/1000yen) and that of the house construction is B (kg-C/1000yen), in the case of A>B, the total CO2 emission in Japan may be decreased by increasing the investment of house construction.

The premises are that the domestic production is fixed and invariable from the industrial sectors to be invested and the amount of energy is invariant, because energy saving houses may be constructed instead of decrepit houses, so that new houses do not always increase the energy consumption.

When the intensity of a commodity is less than the average, it is possible to decrease the domestic energy consumption while keeping the economical level by acceleration of selling the commodity in the market.

CO2 emission related to buildings in Japan

Figure 1 shows the CO2 emission of Japan, in which the CO2 emission due to building construction is 4.6% for residential houses and 3.2% for non residential buildings such as office, commercial buildings and factories. The CO2 emission due to construction including public works is 19.2% of the total CO2 emission in Japan. The operation energy of residential houses is 12.5% and non-residential buildings is 10.7%. Energy consumption and CO2 emission are calculated with IO tables and table of material quantities published in Japan.

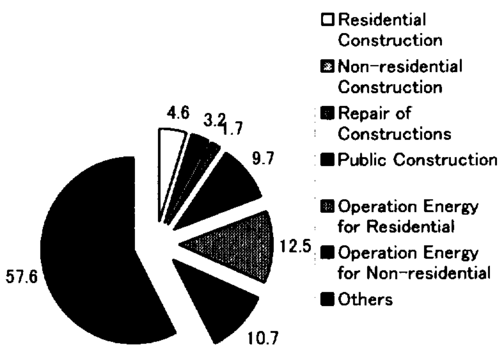

Figure1. CO2 Emission in Japan(Total 1,309 Million t-C/year in 1995)

Intensity of Household Economy

Table 1 shows energy and CO2 intensities due to household economy. Energy consumption of electricity, gas and oil is 23.2 %, and the energy consumption due to house construction, durable goods and commodities etc. is much more than the direct energy uses in the houses. Table 2 shows the relationship between earned income and intensities, in which intensities seem to be independent of the income.

Table 1. Energy Consumption and CO2 Emission due to House Construction and Household Economy

	Energy Consumption (×Million GJ)	(%)	CO2 Emission (×Million ton)	(%)
Wooden House	267.3	3.1	22.3	3.4
Non-wooden House	424.5	4.9	38.0	5.8
Electricity	1009.0	11.6	72.9	11.2
City Gas	385.1	4.4	20.1	3.1
Oil	628.1	7.2	45.4	7.0
City Water	119.6	1.4	9.9	1.5
Others	5842.5	67.3	441.3	67.9
Sum	8676.1	100.0	649.9	100.0

Intensity of House construction

Table 3 shows the intensities of household and building constructions. CO2 intensity due to wooden house construction is 1.64, reinforced concrete multi-family house is 2.8 and household expenses are 2.44

Table 2. Household Energy Consumption and CO2 Emission Classified by Annual Income (1US$=105yen)

Annual Income (×1000Yen/Year)	Energy Intensity (MJ/1000 Yen)	CO2 Intensity (kg-C/1000 Yen)
1. 3,000-4,000	43.48	3.08
2. 4,000-5,000	42.14	3.00
3. 5,000-6,000	41.78	2.98
4. 6,000-7,000	41.22	2.95
5. 7,000-8,000	40.52	2.91
6. 8,000-9,000	40.65	2.93
7. 9,000-10,000	40.41	2.91
8. 10,000-	39.51	2.86
Average	41.06	2.94

Table 3. Intensities of Household and House Construction(1US$=105yen)

	Energy Intensity (MJ/1000 Yen)	CO2 Intensity (kg-C/1000Yen)	Reference (MJ, kg-C/1000 Yen)
Household Economy	32.7	2.42	-
Wooden House	22.8	1.90	17.2-21.4, 1.4-1.8
Non-wooden House	30.5	2.73	29.7-33.5, 2.8-3.2
Non-residential(Office etc.)	30.9	2.75	32.0-44.0, 3.0-4.2

kg-C/1000yen in Japan. The total CO2 emission in Japan may be decreased by increasing wooden house construction, and the intensity of reinforced concrete multi-family houses should reduce 15% of their CO2 emission to achieve the environmental loads due to the construction being canceled by decreasing household expenses. It appears to be possible to reduce 15% of the CO2 emission by the greening method and recycling materials which are being developed now.

Conclusion

Particularly wooden houses are ecological products from the viewpoint of energy consumption and CO2 emission, therefore it may be possible to decrease the total quantity of energy and CO2 and keeping the economy level in Japan by increasing the investment in houses.

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PAVILIONS: NEW SYDNEY SHOWGROUND
Homebush Bay, Sydney Australia

"IMAGINATION AS NATURE"

Robert Perry - Director
John Ferres - Associate Director
Scott Carver Pty Ltd
12 Berry Street, North Sydney
NSW Australia 2060
Email: mail@scottcarver.com.au

INTRODUCTION

This paper describes the design process for the Pavilions at the New Sydney Showground in 1996, which led to a commendable outcome in terms of Ecologically Sustainable Development and also, since we think we all want the 2000 Olympics and their legacy in Sydney to mean something, we would like to speculate a little on what this exercise might mean for the future. The Pavilions will also be the venue for the Main Press Centre during the course of the Olympic Games, following an interior fitout Covering 40, 000 sq. metres.

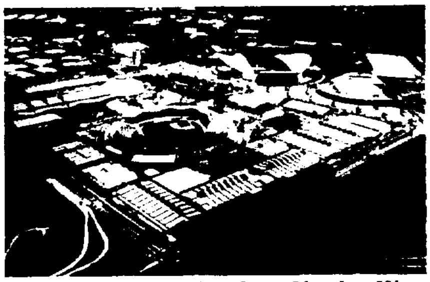


Figure 1 – Aerial View from North – West, with Pavilions in foreground

INTER-DISCIPLINARY TEAM

Pavilion Architects was established as a joint venture between three architectural firms solely for the purpose of winning and implementing the design commission for the Livestock Pavilions and Sports Centre on behalf of the Olympic Co-ordination Authority. We won the project, because our stated design methodology was the most sensitive to the task at hand. We appointed Environmetal Consultants to overarch and manage the design process to fulfil ESD objectives. The commission comprised fifteen buildings with a total area of about 65,000 square metres.

The Masterplan had imagined and cost planned large portal framed sheds with ridge ventilators. One of the first things we did was amend the Masterplan as much as possible to introduce some smaller building widths and a variety of building sizes and orientations.

DESIGN PROCESS

As designers nonetheless we had to adopt a philosophical position that we would proceed as a team, each expert contributing his or her understanding of forces and limitations which might contribute to the form of the solution, and that cultural precepts such as visual style expectations, would be set aside so that a solution might reveal itself free of preconceptions, particularly architects' preconceptions.

The design solutions were to become the result of group imagination where components are multi-purposed to embrace forces necessary for the comfort and functionality of the buildings.

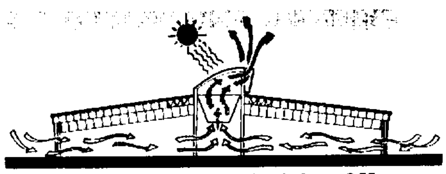


Figure 2 - Ventilation Principles of Horse and Cattle Pavilions

The ultimate outcome of this process was the publication of an 'Environmental Management Plan - Design' (EMP - Design). This document created an auditable trail of decision-making around the following key ESD elements:

- Passive energy
- Waste management
- Materials selection
- Water conservation

In part, these elements represented directions of investigation for which the pavilions had a natural aptitude, each representing nevertheless an enormous amount of work before we could start jumping to design conclusions.

Goals were set for each ESD element and teams of various appropriate disciplines were set tasks and followed predetermined strategies for achieving design and conceptual outcomes. Finally commitments were made in the context of environmental and economic sustainability.

Materials were chosen on the basis of their total lifecycle cost and their suitability to construction processes and built conditions. We, the architects, had to make a balanced choice of materials.

Holding onto the ESD goals under the pragmatic glare of cost planning and the few weeks of design program available to us proved, initially, to be very frustrating. It's not easy to fine tune costs on a 65,000 sq. metre project where $4 a square metre represents a $250, 000 in the end. Ultimately, however, when we all thought we had run out of ideas, it was budget imperatives which forced the final inspiration for our solution. We found that a cheaper way was also a better way.

Figure 3 – Rendered 3-D Model of N-S Pavilions

KEY OUTCOMES

The core of our pursuit emerged as a search for the best shape for the sheds. We hoped that a fresh iconography for ESD architecture might appear, a type of environmental modernism where form follows function, acknowledging that the 'function' would include the 'capturing of the day' or the 'harnessing of the sunlight and air' for the use of the buildings, merely by virtue of the shape of the buildings.

Figure 4 – Dynamic roof forms, creating a fifth façade

Some of our buildings were extremely large measuring 76 metres wide by 110 metres in length. This was twice the width of the largest of the existing, poorly ventilated cattle pavilions at Paddington. Our research had uncovered recommendations from authorities in Kansas City that the deepest naturally ventilated cattle pavilions should be 15 metres.

The determination of these shapes required an iterative process between our Environmental and Daylighting Engineers, our Fire and Safety Engineers and Architects. Within the time available and the requirements for reporting to the multiple stakeholders, this process would not have been possible without computers.

DIGITAL PROTOTYPING

It strikes us that there is a remarkable and important convergence of human endeavors going on at the moment through the coincidence of advanced computer modelling techniques with the urgent need for ecologically sustainable development.

Five years ago we could only have presented our ideas to our clients as hunches reasonably informed conjecture represented by reasonably crude diagrams. Now we are able to walk them through the finished building, show them pictures of what the air is doing in the building - how warm it is, how fast it is moving, we can show them how much daylight is falling on each part of the floor, where the sun comes in at any hour of any day in the year, how a fire will behave and where the smoke will go.

Digital prototyping could be fairly described as being applied to the following factors:

- Thermal analysis
- Solar trespass analysis
- Air movement analysis
- Form understanding
- Comfort assessment
- Fire modeling
- Lighting analysis
- Structural analysis
- Solar access analysis
- Communication to stakeholders

The outcomes of the process were buildings that were shaped for the multiple purposes of rainwater drainage, daylighting, inducement of air movement, tempering of thermal environment and management of fire and smoke.

PERFORMANCE

Analysis and testing of our final solutions gave encouraging results:

- Internal conditions are held at around 2 degrees Celsius above outside in the day
- No electricity is consumed by the buildings during daylight
- Internal conditions are held within perceived comfort zones at all times (Predicted Mean Vote <1, Percentage People Dissatisfied <20%)
- 15 air changes per hour achieved in the occupied zone during the day and not less than ten air changes per hour at night.
- Lighting levels of >300 lux in the occupied zone during daylight hours

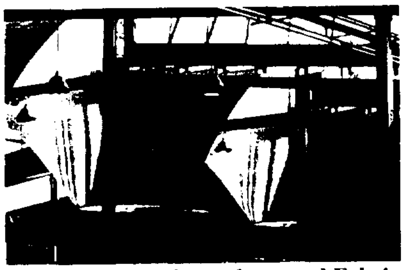


Figure 5 - Light from above and Fabric Ducts

CONCLUSION - ECOMODERNISM

The environmental agenda created by Sydney through our conspicuous Olympics could be the catalyst for a changing attitude towards development that is sustainable. We think that an approach of choreographed inter-disciplinary design could be the maturing of modernism.

It would be a pity if human imagination, because of its current alignment with technology, was a source of embarrassment and thought to be part of the problem. Imagination is human nature and will be the key to our taking long-term responsibility for our modifications to the planet.

We would like to see the emergence of 'Ecomodernism' as a style of architecture whereby form is derived from environmental performance, goals and the self-obsessed wallowing around in cultural precepts which has typified post-modernism, subsumed by the pursuit of beauty through the harnessing and filtering of each day to our diverse purposes on the ground

ENVIRONMENTAL ASSESSMENT OF A HIGHSCHOOL BY LIFE CYCLE SIMULATION

Bruno Peuportier
Centre d'Energétique, Ecole des Mines, 60 Bd St Michel, 75272 Paris Cedex 06, France

INTRODUCTION

Several regional authorities in France have launched programmes to improve environmental quality of high-schools. For instance an architectural competition was organised for the design of the “ Cité scolaire internationale ” in Grenoble. The study presented here concerns the evaluation of the environmental impacts of one of the projects, compared to a typical high-school in the same region.

LIFE CYCLE SIMULATION

Various methods are proposed to evaluate the environmental quality of buildings. We used the life cycle assessment -LCA- method (ISO, 1997) because environmental quality is the result of a global process integrating the whole life of a complex system. Also, the standardisation of LCA may allow future links between evaluations concerning materials and buildings.

This work has been done within the French EQUER project (Evaluation of environmental quality of buildings), gathering researchers and professional partners (Polster et al., 1996).

A general framework for applying LCA in buildings has been elaborated in the European project REGENER (REGENER, 1997).

The different phases considered for a building life cycle are: the fabrication of components, the construction, the use of the building, the renovation including the renewal of components, the final dismantling and the treatment after use of components. The possible reuse and recycling of components is also taken into account.

We consider here only the influence of buildings on the outside environment. Inside comfort and health issues are supposed to be addressed by other tools. Therefore the calculation of the inside air quality, illumination and noise level as well as the thermal comfort analysis are not dealt with in this article. They are however implicitly taken into account in the definition of the "functional unit".
The environmental impact of building components or processes (e.g. energy use, transport) can be evaluated on the basis of inventories, i.e. tables indicating the quantity of the used resources (e.g. rare materials, energy, water), the emissions into air, water, ground (e.g. CO_2 into air, ammonia into water, metals into ground), and the created waste (e.g. inert, toxic, radioactive).

Data collected in the REGENER project, or from the Oekoinventare data base (Frischknecht, 1995) has been used concerning the inventories corresponding to the different processes considered (energy, transportation, manufacturing of building materials).

Interpretation of results is hardly possible using such inventories. Hence, data is usually aggregated on environmental themes in order to present the final output under the form of an environmental profile. The definition of the profile considered here (cf. table 1) is partly based on a classification method published by CML (Heijungs, 1992). For some of the themes (e.g. energy and water consumption) an absolute value is calculated. On the other hand, themes like global warming or acidification can only be assessed by a potential, expressed as an equivalent quantity of a reference substance (e.g. kg CO_2 for global warming). The list of environmental themes and aggregation methods is still in evolution.

Table 1: Environmental themes considered

environmental theme	**PROFILE NAME**	**unit**
energy consumption	ENERGY	MJ
water consumption	WATER	m3
depletion of abiotic resources	RESOURCES	10^{-9}, used resources / known resources
waste creation	WASTE	tons
radioactive waste	RAD-WASTE	dm3
global warming	GWP_{100}	ton CO_2 eq.
depletion of the ozone layer	ODP	kg CFC-11 equivalent
acidification	ACIDIFICA-TION	kg SO_2 eq.
eutrophication	EUTROPHI-CATION.	kg PO_4^{3-} eq.
aquatic ecotoxicity	ECOTOX-W	m3 of polluted water
human toxicity	HUMAN-TOX	Kg, human weight
photochemical oxidant formation	O3-SMOG	kg C_2H_4 eq.
malodorous air	ODOUR	m3 of contaminated air

LIMITS OF THE APPROACH

There are still many uncertainties and limits to the present state of the art of LCA. The uncertainties concern both the data (inventories) and indicators : for instance, the global warming potential (GWP) of other gases than CO_2 is known with 35% uncertainty (IPCC, 1994). Indicators related to human or eco-toxicity are doubtful because the location of the emissions is not considered : air pollution inside buildings might have a much larger effect than diluted external emissions. Also, the processes occurring at the end of the building life cycle are difficult to foresee, particularly because buildings are generally long lasting (though it may be assumed that mixing materials -concrete with polystyrene or wood for instance- will make the future waste management more difficult). Variation of the physical properties of materials in time are not considered (e.g. thermal conductivity of insulation materials).
Accidental risk analysis is not included as we assumed that this topic is accounted for in safety and work legislation. Esthetical aspects are neither included.

Some intercode comparisons have been performed in order to increase the confidence in the tool. A workshop has been organised by the French Ministry of Dwelling, in which 4 tools have been compared in the case of a single family house : TEAM (ECOBILAN), ESCALE (CSTB), PAPOOSE (TRIBU) and EQUER. Another exercise has been performed in the frame of the International Energy Agency (programme : Energy conservation in Buildings and communities, Annex 31). Numerous tools have been compared, also in the case of a single family house : ECOPRO (IFIB, Germany), ECOQUANTUM (IVAM, The Netherlands), EQUER (ARMINES et al., France), OPTIMIZE (Canada), SBI-tool (SBI, Denmark), BEE (Finland), BRI-LCA (Japan), BEES (USA), etc.

CASE STUDY : CITE SCOLAIRE INTERNATIONALE, GRENOBLE (France)

To illustrate the approach, we present hereunder an application in the case of a high-school project in Grenoble (French Alps). The general shape of the building is a set of 4 buildings around 3 patios, cf. figure 1.

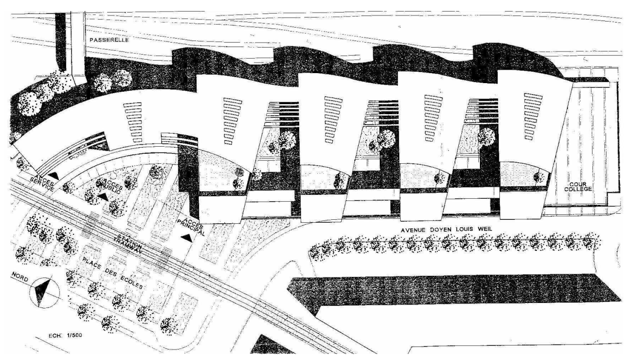
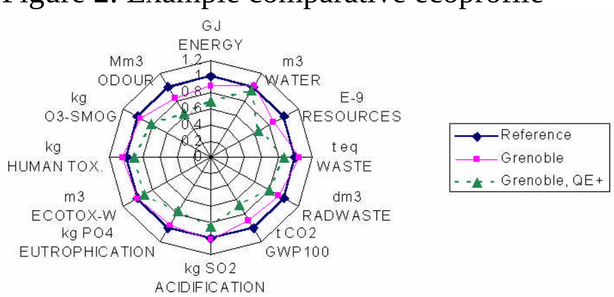


Figure 1: Plan of the studied project, Cité Scolaire Internationale, Grenoble (Groupe 6 Architectes)

The glazed areas (standard double glazing) are mainly facing south and south west, the aperture is reduced on the north east facade. This project, called "Grenoble" in Fig. 2, has been compared to a typical high-school in the same region, constituting a reference. In a first phase, identical materials and components are considered for the two buildings : the aim is to perform a comparison only on architectural aspects. Mainly due to a higher solar aperture, the heating load (64 kWh/m2/year) is lower by 25% compared to the reference value (84 kWh/m2/year).

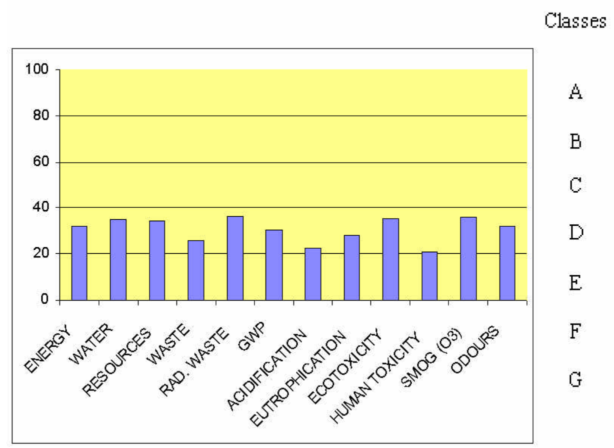
In a second phase, the reference insulation has been replaced by the material selected in the project (mineral wool instead of polystyrene) and the thicknesses were adapted. We also defined a "best practice reference" called "Grenoble QE+", by replacing standard by low emissivity double glazing, integrating wood panels on the north facade and preheating the ventilation air in a heat exchanger. The comparative ecoprofile is given in the next diagramme. To each axis corresponds an environmental theme (cf table 1), and the impacts of alternatives are represented in relative value : e.g. compared to the reference, the GWP is reduced by 30% in "GrenobleQE+".

Figure 2: Example comparative ecoprofile



A ranking similar to the energy labelling of domestic appliances has been derived : for each environmental theme. The A class corresponds to the highest performance (+80 to 100% compared to the reference, 100% being the best pratcice) and G class to a low performance (-20 to -40% compared to the reference). The evaluation of the studied project is given below.

Figure 3 : Environmental profile of Cité Scolaire Internationale, Grenoble



The functional unit being one m^2 of high-school, the studied project could be rated as a D class.

CONCLUSIONS

The main limits of the present knowledge concern the environmental data on material fabrication, the environmental indicators, the durability of the materials and possible variation of their performances, the processes which will occur in a far future (renovation, demolition in e.g. 100 years). Despite of these questions, some trends can be identified and sensitivity studies provide information on the most important parameters. The overall conclusion is a confirmation of the relevance of energy efficiency and use of solar gains in buildings, assuming attention is paid to summer comfort.

ACKNOWLEDGEMENTS

This research has been supported by the European Commission (D.G. XII, Programme APAS), ADEME (French agency for environment and energy efficiency) and Plan Construction et Architecture (French ministry of dwelling). The application presented above was supported by Territoires 38 in relation with Region Rhône Alpes (DPMG, Service des Constructions des Lycées).

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WHEN SOCIAL HOUSING AND SUSTAINABILITY MEET... IN PETIT-COURONNE

Alain PIERRE[1], Luc TABARY[1], Erick FAURRE[2]
[1] EDF - Research and Development Division, Electricity in Buildings Branch (ADEB)
Les Renardières, BP1 route de Sens 77818 Moret-sur-Loing, France
[2] Société d'Economie Mixte de Petit-Couronne, 80, place de la Libération
76650 Petit-Couronne, France

ABSTRACT

In the outskirts of Rouen (100 km from Paris, France), at Petit-Couronne, the local authorities have decided a construction program in a place where they want to mix different construction styles (individual and collective housing) and various social categories in order to vitalise this part of the town. The requirements for the first 24-dwelling-building were:

- access for all categories of people (disabled, elderly,...),
- limited investment costs, leading to affordable rents for inhabitants,
- moderate exploitation costs,
- easy-to-use, simple, safe and clean energy.

Without modifying the initial architectural choices, insulation was moved from the inner side to the outer one. So, the energy performance was increased - 22% better than the regulation requirement -, the comfort was improved and the living area has been extended in the dwellings without any over cost. In those conditions, electricity has been retained as a satisfactory energy.

A measurement campaign has been achieved between summer 1998 and spring 1999 and has confirmed the good performances of the building.

Both building and measurements campaign will be presented in the paper.

This operation:

- is an example of social integration,
- points out that the social housing can be comfortable and energy efficient,
- shows that energy efficiency is achievable without over-investment.

INTRODUCTION

Figure 1: "Côte d'Albâtre" residence in Petit Couronne.

Petit Couronne is located in the district of Rouen (100 km from Paris, France); due to its close proximity to the Madrillet technological centre and its university centre, there was a need for residential zones and housing estates to be built.

In 1997, Société d'Economie Mixte (SEM), whose main shareholder is the Town, decided to start up a program of 68 social dwellings divided into three 4-storey blocks on a semi-buried basement.

The first apartment block built, the "Côte d'Albâtre" residence (figure 1), contains 24 one to four-roomed units.

The "Côte d'Albâtre" residence, the first phase of the 68 dwellings program, is part of the development plan for Plateau Lacroix. The town's policy is to offer a range of housing diversified both in terms of type of construction (apartments, houses) and of social category, creating the momentum for the schools and shops necessary for the Plateau's everyday life.

The project owner, SEM, represented by Mr. Faurre, wanted energy which is clean, safe, flexible and easy to use, hence the final choice of electricity. It should also be pointed out that this program had to cater for disabled people.

These dwellings are designed for an average-income population, not entitled to big housing benefits. The combination of rent + service charges must therefore be controlled. SEM's objective was that the final rents should be no more than 20% higher than those of conventional social housing, and operating costs completely controlled.

PRESENTATION

Technical options chosen: external insulation with insulation of cold bridges on balconies and terraces.

The final rent depends on the investment made. The architectural choices of the initial project (in particular, wood decoration on approximately one third of the building) meant that it was possible to change from insulation from the inside to insulation from the outside (IFO) at little extra cost (7,013 euros), recouped in four years thanks to the increased living area gained using IFO (a total of 31.48 m^2). The choice of electricity combined with a quality structural framework (insulation 22% better than the regulatory level) resulted in no change in investment costs (767 euros/m^2 inclusive of taxes, VAT 20.6%). It was thus possible to limit monthly rents to a very reasonable level of 5.5 euros/m^2 inclusive of taxes (365 euros per month inclusive of taxes for a dwelling of 64.9 m^2).

The main technical options chosen are as follows:

- Insulation:
  - walls: from the outside, thin coating on insulator (10 cm expanded polystyrene) or wood facing in front of 10 cm of semi-rigid mineral wool;
  - floor on basement: insulation on under side with a 9.5 cm flocking of mineral wool;
  - loft: 20 cm of glass wool;
  - balconies and terraces: cold bridges interrupters.
- Outside fittings: PVC windows with 4/12/4 double glazing and shutters.
- Heating: radiating panels in the sitting room and Elexence convectors in the other rooms.
- Ventilation: type B hygro-adjustable (air inlet and extraction hygro-adjustable).
- Tariff: individual 6kVA or 9kVA.
- Hot water for bathrooms: individual storage tanks.
- Programming: daily 1-zone timer in one-room dwellings, 2-zone in the other dwellings.
- Lift: space and energy-saving model.

Results: a residence which lives up to its promises

The EDF Research and Development Division monitored this operation by a series of measurements, on the one hand and a sociological survey of tenant satisfaction, on the other hand.

The series of measurements gave a full picture of the technical results of the operation (consumption and costs for the different electricity uses and temperatures in the dwellings). The results of the measurements taken between 1 July 1998 and 30 June 1999 are shown in figure 2.

These results come completely within the cost control objectives set by the project owner: the total electricity bill is less than 9 euros/m²/year.

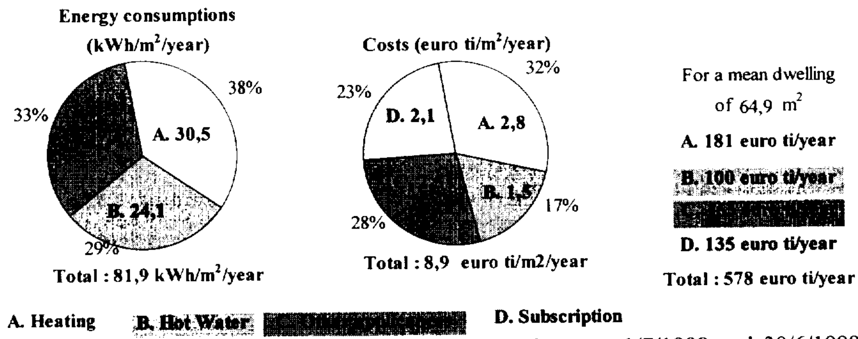


Figure 2: results of the measurements taken over a year between 1/7/1998 and 30/6/1999 (8 °C mean outside temperature between 10/1/1998 and 5/31/1999) in 10 representative dwellings of the "Côte d'Albâtre" residence in Petit-Couronne.

The comfort factor is very good, both in winter: average temperature of 20.5°C, and summer. The thermal inertia provided by the insulation from the outside is fully effective in offsetting variations in the outside temperature.

The satisfaction survey carried out by a sociologist shows that the residents display a high level of satisfaction in terms of the neighbourhood and the building. They consider the dwellings pleasant, practical, bright and spacious. Their opinion is generally very positive.

The residents are satisfied with the heating and consider they enjoy the level of comfort expected. The radiating panel in the sitting room is very popular. However, the timer, thought to be complicated, is little used.

Conclusion

This project is a text-book example in many respects:

- on a social point of view: it contributes to the development plan of Plateau Lacroix, near the Madrillet technological centre - 150 hectares in the process of being serviced by the district of Rouen. It is remarkably well integrated into the neighbourhood and provides an average-income population with comfortable housing with low service charges;
- on an economic point of view: construction of this building, while achieving good thermal performances ensuring low electricity bills, has kept strictly within the project owner's financing plan. In addition, the technical options chosen guarantee the return on the project owner's investment over time (preservation of the structural framework thanks to outside insulation, for example).
- control of energy consumption: thanks to its good thermal performances, heating the residence takes only a small amount of energy, which helps protect the environment.

BUILDING INTEGRATION OF PHOTO-VOLTAICS
ECN - BUILDING 42 PETTEN (NL)

ir. Tjerk Reijenga, dr.ir. Henk Kaan
1. BEAR Architecten, P.O. Box 349, NL-2800 AH Gouda, The Netherlands,
   tel.: +31 182 529899, fax: +31 128 582599, e-mail: tjerk@bear.nl, internet: www.bear.nl
2. ECN, Renewable Energy in the Built Environment, P.O. Box 1, 1755 ZG Petten,
   The Netherlands, tel: +31 224 56 4689, fax: +31 224 56 3214, e-mail: kaan@ecn.nl,
   internet: www.ecn.nl

The new office- and laboratory building of the Netherlands Energy Research Foundation ECN in Petten is a good example of the building integration of photo voltaic energy. Besides, the new building demonstrates and increases the know-how and experience of the company on the sustainable use of energy in the built environment.
The building lay-out is designed to maximise the use of daylight. The glass-covered corridor on the first floor, with its entrances to the office-modules, will be the connecting element between the existing laboratory building 31 and the new building 42. The use of photo voltaic in the curved glass roof prevents overheating in summer and provides diffuse lighting. The capacity of the PV system is about 40 kWp. A webcame can be found at http://www.ecn.nl/unit_de/dego/object42/index.html

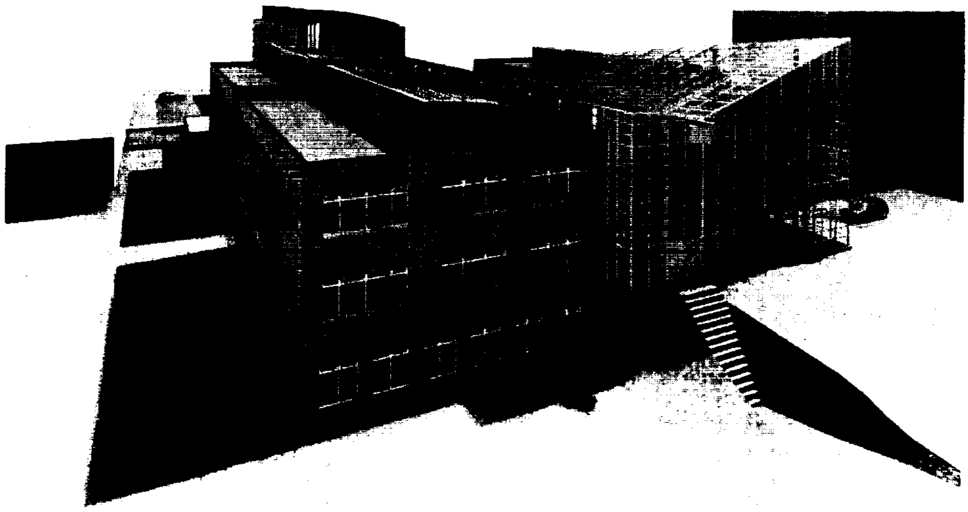


Fig. 1: The new office-building 42

INTRODUCTION
A new building for ECN
The Netherlands Energy Research Foundation (ECN) in Petten has a shortage of working place. Besides energy-research in the Netherlands became more complex. Also, nowadays, a lot of attention is paid to sustainable energy. As a result a new office building is needed. The new building has to be flexible in future use. While in former days the office was determined to be the same for years, nowadays the research programs have a short term and there is a need for a different lay-out. In fact today one cannot predict how to organise

the working space for tomorrow.
The architecture of the new building has to be similar to the adjacent office building 31, an existing building which is being renovated at this moment.

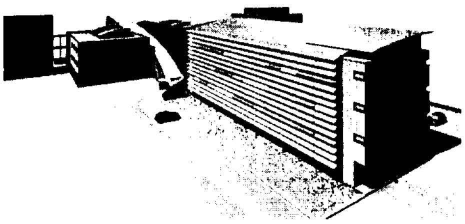


Fig. 2: ECN building 42 and building 31

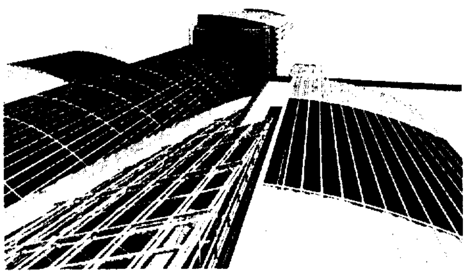


Fig. 3: The roof of the building 42

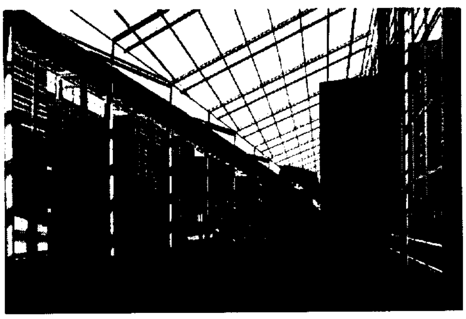


Fig. 4: The serre of the building 42

Purpose
The new office- and laboratory building of the Netherlands Energy Research Foundation ECN demonstrates and increases the know-how and experience of the company on the sustainable use of energy in the built environment.
The building is situated in the dunes near Petten. The building respects this worthy natural beauty, and fits its surroundings.

The existing building 31 will be connected with 3 new office- and laboratory buildings (number 42.1, 42.2 and 42.3) by a conservatory. Construction of these buildings started in 1999. The concept of the new building has good potentialities to fit all kind of alternating organisations in the future.
In this flexible office, separated spaces can be created by using flexible separation walls.

Fig. 5: The inner street of the building 42

APPROACH

Integration of photo voltaic
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, will be the connecting element between building 31 and building 42. In the roof of this unheated and strongly ventilated conservatory, 400 m^2 of PV modules are integrated (21 kWp). In-between the multi crystalline cells a transparent free space of 1 à 2 centimetres provides lighting of the conservatory. In this way the use of photo voltaic in the curved glass roof prevents overheating in summer and provides diffuse lighting. The glass roof is like a parasol for the building behind it. The (total) capacity of the PV system, including the photo voltaic system on the roof, is about 40 kWp.

The use of daylight
The building lay-out is designed to maximise the use of daylight and to minimise the use of artificial light. Therefore the structure of the

building is compact and efficient. The building has several light-courts allowing a maximum use of daylight, all working places are situated in the daylight zone. The artificial lighting reacts to the amount of daylight and the system is divided in small units. When the office is closed, all artificial lighting can be switched off automatically.

Energy use

According to the Dutch building code at that time (1999) an energy performance (EPc) = 1,9 is obliged for office-buildings. This building achieves a much better energy performance. Without taking the photo voltaic in account the energy performance (EPc) is 0,92. When one takes account off the photo voltaic system the energy performance (EPc) is even 0,46. This demonstrates the low energy character of the building. This building will be one of the most energy concious office buildings in the Netherlands.

Fig. 6: A light-court of the building 42.1

Also a lot of attention is paid to the ventilation system. In wintertime the mechanical system uses heat recovery. The conservatory will be an intermediary between inside and outside. In summertime during the night the ventilation system is used to cool the office, therefore windows open automatically.

No CO_2 emissions

The building is supplied with a total energy system. When the co-generation station uses biological materials, there will be no CO_2 emissions at all. A study, carried out at this moment, will show whether this possibility is attainable or not, both technically and financially.

Fig. 7: A flexible office

FINANCIAL CONSTRUCTION

The conservatory and parts of the roof are supplied with PV modules. For credit facilities ECN buys so-called 'green-power' from the energy company NUON for a period of 15 years. In return NUON takes care of the installation of 200 m^2 PV on the roof of the conservatory. This is the same amount of money that ECN pays for the 'green-power' during the 15 years. These 15 years NUON will be the owner of the system, after this period ECN owns the system.

RESULTS

Scientific innovation and relevance

The PV system is architecturally integrated in the building. The PV system gives a better quality of indoor space. A shading system is avoided because of the lower irradiation and heat-load.

Results

By integrating the PV system in the building, a better quality/cost ratio will be attained. The architectural integration has a high relevance.

CONCLUSION

This design is a good example of building integration of photo voltaics.

Construction has started in 1999 and the building will be finished in 2001.

A webcam is available at www.ecn.nl and www.bear.nl.

4 AUSTRIAN GREEN BUILDINGS

GEORG W. REINBERG
Architekturbüro Reinberg
Lindengasse 39/10, A-1070 Wien
Tel: 0043-1-524 82 80
Fax: 0043-1-524 82 80-15
architekt.reinberg@aon.at/
www.reinberg@archin.at

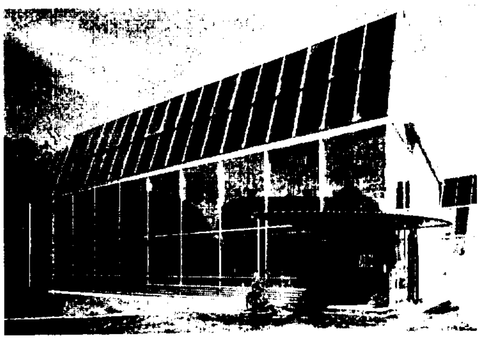
INTRODUCTION

The autor found relatively good conditions in Austria to realize low energy houses. 4 examples realized between 1998 and 2000 should demonstrate how the energy aspect leads to a very specific architecture. Within those projects there were realized for example: PV systems, automatic passiv solar use, warm water collector roofs with storage-tanks for heating purpose as well as for warm water use, earth-to-air-heat-exchangers, solid wood construction with controlled air ventilation systems with heat recovering and so on.

„Aspern at the sun", Vienna

Salzburg Gneis-Moos

Vienna Sagedergasse

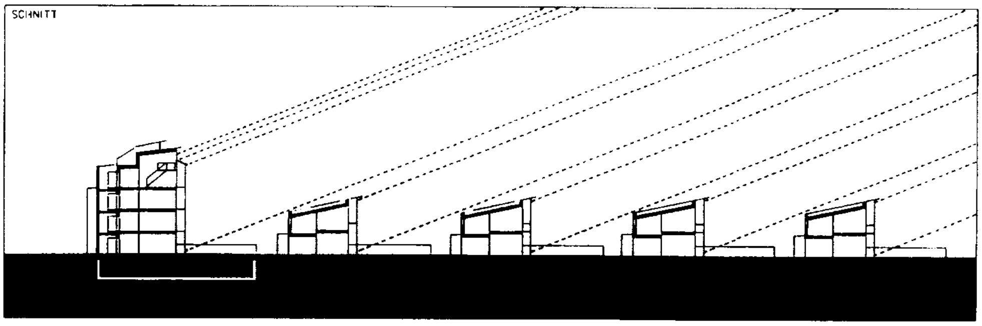


Gleisdorf

1. ASPERN AT THE SUN, VIENNA

A housing project built by the city of Vienna (as developer and owner) for low income tenants.
90 housing units, room for communal activities, garbage collecting points - designed as social meeting places in the center, bycicle garages, 1 shop, deep well for water supply, the entire rain water is oozed away on the side.

Solar use: PV (11 kWp), extensive passive solar use, sun deal.
Finished: February 2000

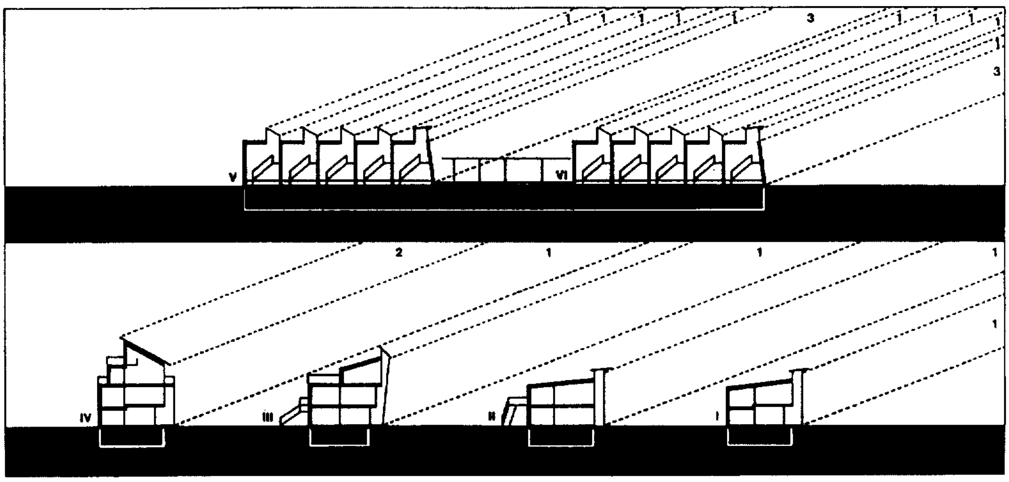


2. GNEIS-MOOS, SALZBURG

Social housing project with 64 units. Rooms for communal activities. Rain water drained to a river.

Solar use: passiv solar use through wintergardens and controlled air ventilation (through the wintergardens) and heat-exchangers. Active solar use by a warm water roof collector (410 m²) and a water storage tank (100.000 liter) serving warm water and heating.

Finished: December 1999 and February 2000



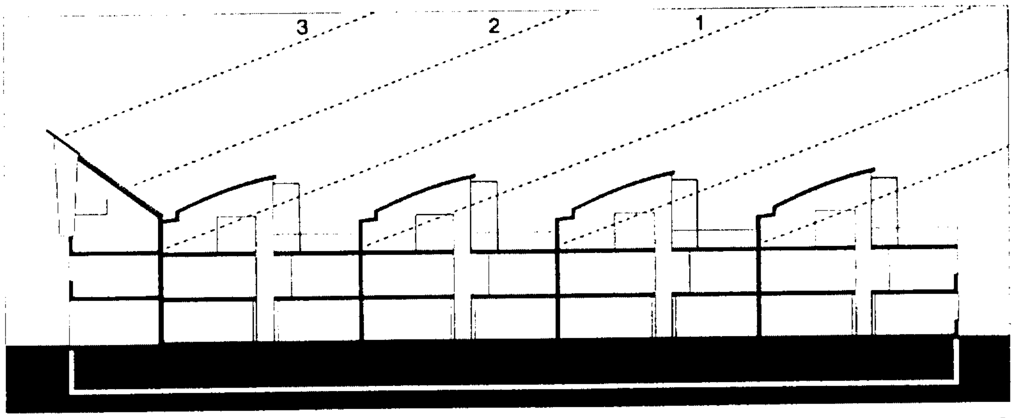
1 passiv solar, 2 aktiv-thermisch solar, 3 Photovoltaik

3. SAGEDERGASSE, VIENNA

A social housing project with 9 units, one office and one shop. Rainwater collecting system (for toilets and gardens), heat recovering ventilation system with earth-to-air-heat-exchangers and incooperated into the wintergardens.

Solar use: Passiv through wintergardens (with automatic ventilators) and active solar use by a collector-roof (about 56 m² and storage tank) for warm water. Space is given for lateron to be mounted PV.

Finished:1998



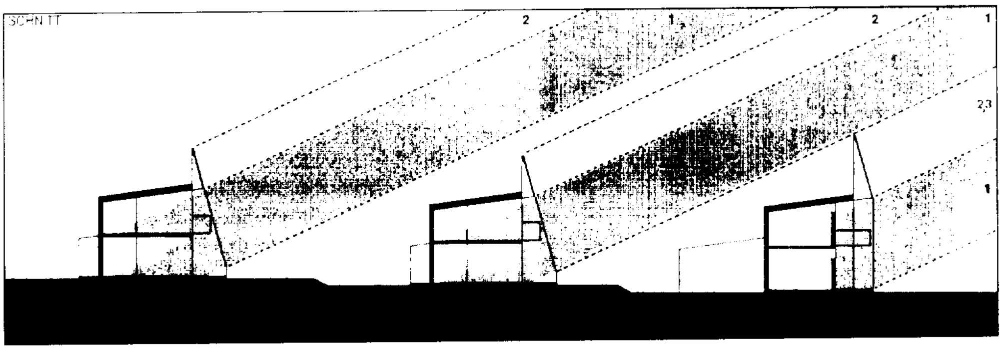
SCHNITT N-S

4. GLEISDORF

Office building and 6 housing units. Solid wood construction with wood isulation and further wood materials. Biomass heating (for a demand of 8kWh/m²/a).

Solar use: Extensive passiv solar use through wintergardens incooperated in a controlled air ventilation system (with earth-to-air-heat-exchangers). Active use by 240 m² of warm water collectors with a water storage tank (14.000 liter) for warm water and heating, PV.

Finished: office 1998, homes: 1999



LITERATUR

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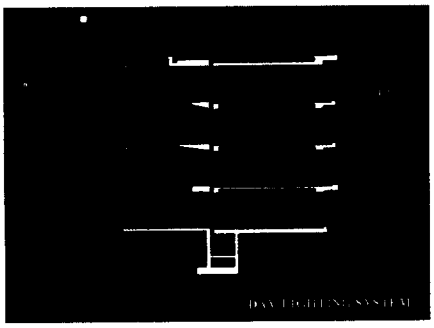
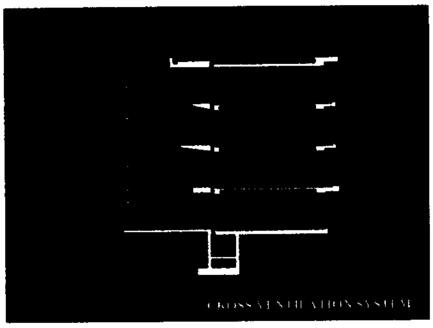
SUSTAINABLE AND BIOCLIMATIC OFFICE BUILDING ON PARCBIT PALMA DE MALLORCA, ILLES BALEARS, SPAIN

Company:	ParcBIT Desenvolupament S.A.
Address:	Camí de Can Manuel s/n 07120 Palma de Mallorca, Illes Balears, Spain
Telephone:	+34 971435006
Fax:	+34 971435070
e-mail:	parcbit@juniper.es
Architect:	Jaime Sicilia
Design team:	Boris Pena (architect) Javier Oliver (architect) Jaume Mayans Mónica Lanzón
Address:	Calle Reina Esclaramunda 15, 3-2 07003 Palma de Mallorca, Illes Balears, Spain
Telephone:	+34 971727734
Fax:	+34 971722256
e-mail:	spa@deazul.com

INTRODUCTION
ParcBIT: THE MASTERPLAN

In 1994 the Government of the Balears, within the context of a global strategy based on the development of new technologies in the islands, decided to promote a sustainable development to house this new activities in collaboration with the university. The principal objective was also to demonstrate the possibility of making compatible two antagonic concepts such as development and preservation of the environment.
Richard Rogers Partnership won the international competition for the design of the Masterplan, presenting a scheme with special concerns for the use of energy, water, ecology and landscape, on a sustainable development.
The Masterplan is actually under construction.





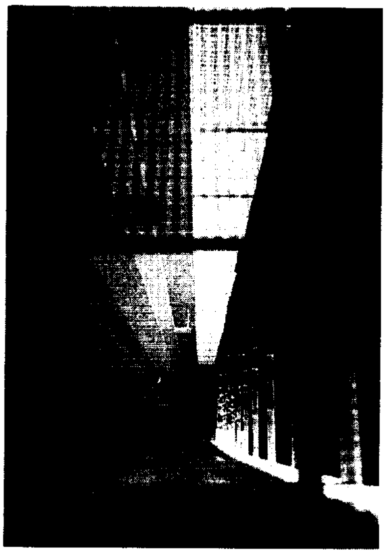
PRESENTATION:
THE OFFICE BUILDING

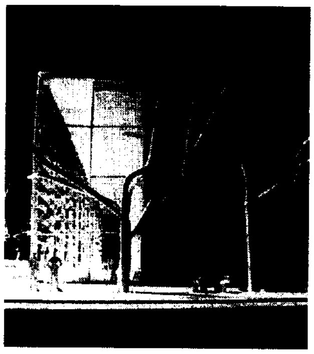
This office building has been designed to house the activities of companies related to the information society sector, within ParcBIT (sustainable development by Richard Rogers Partnership). The concept design of the building is based on the Masterplan specifications and on the commitment of ParcBIT to produce an exemplary construction, combination of mediterranean tradition, bioclimatics, sustainability and modernity as a demonstration of the new spirit of this innovative project.

The building has been developed with a strong sense about efficiency in terms of function, construction, budget and aesthetics, and a very special concern about energy consumption and environmental response.

About energy consumption, it is important to note that this building participates on the Thermie Program, where consumption on heating and/or cooling, has to be under 50 kW/sqm. hour year, only achievable by applying different series of passive systems permitting to control climatically the building and guarantee thermal comfort throughout the year. In this sense, the key issues have been:

· Sensitivity towards the orientations
· Use of prevailing winds for passive cooling on summertime.
· Control of solar radiation.
· Application of a controllable system of crossed ventilation.
· Use of the thermal mass of earth.
· Application of a system of ventilated roof with passively chilled air.
· Use of maximum natural light.





It is important to highlight the high amount of energy saved, which is up to 40% and the proportional reduction of CO_2 emissions.
The building has been designed following a strict sustainability criteria regarding the use of materials and the election of the different construction systems.

CONCLUSIONS AND RECOMMENDATIONS

ParcBIT, with this building which is the first one to be built, demonstrates that it is possible and highly recommendable to produce sustainable buildings within standard budgets.
Local tradition in terms of tipology and elements of construction generally provides of the best solutions to implement passive systems for heating and cooling. A good understanding of tradition is a key issue into the process of designing a sustainable building.

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SUPPORTING SUSTAINABLE DECISION IN SELECTION OF WINDOW TECHNOLOGY

Dr. Marjana Sijanec Zavrl, M. Sc. Miha Tomsic
Civil Engineering Institute ZRMK, Dimiceva 12, SI-1000 Ljubljana, Slovenia,
Tel.: +386 1 5888 342, Fax: +386 1 4367 451, E-mail: msijanec@gi-zrmk.si

ABSTRACT - A set of actions on the national level has been executed in Slovenia recently in order to support building owners in implementation of building components that primarily reduce energy consumption, exhibit high quality in other relevant technical domains and are environmentally friendly. A market analysis of window production and use in Slovenia has shown that the implementation rate of out-of-date glazing and window technology in Slovenia is still too high. Therefore a national scheme of incentives for implementation of energy efficient windows and glazing technologies, supported by the "National quality sign for energy efficient windows", has been established. These programmes supported by various other information activities have raised awareness and knowledge of the building owners and increased the interest in energy efficient and environmentally conscious products, thus contributing to the idea of sustainable building.

INTRODUCTION

On the way to the strategic goal – sustainable building and building refurbishment – two main approaches can be found, the first one giving priority to "green solutions" in buildings and the second one emphasising the importance of low energy & intelligent buildings. Each new building, no matter how energy-efficiently and environment-consciously designed and operated, gives rise to global energy consumption and emissions. Using state-of-the-art technologies can only help to keep these figures as low as possible. Installation of energy-efficient windows in new buildings is one of the important measures to achieve this goal and to follow the principles of sustainability.

On the other hand energy savings resulting from replacement of old windows can reach substantial values. Bearing in mind that these measures are usually taken in the framework of necessary maintenance and renovation work, the incremental investment in improved window/glazing technology is relatively low (+10%) and the payback period very acceptable (2-3 years).

CURRENT SITUATION

Buildings

A prevailing part of Slovenian public and apartment buildings is characterised by use of energy inefficient windows. Especially in the apartment building sector these windows also lack in regular maintenance. Insufficient air-tightness and poor thermal properties of glazing result in a high heating energy demand and low level of thermal comfort in such buildings. Double-glazing is most commonly used in existent windows. Typically, older buildings are equipped with double or coupled windows while for the last two or three decades single windows are being built in. Mainly the so-called double insulating glazing is used in single windows. Its advantage is that the condensation on the inner glass panes is prevented, but the thermal characteristics remain the same or even worse compared to double-glazed coupled and double windows.

In a public opinion survey (1) more than one third of residents in apartment buildings complained about draughts resulting from poor air-tightness of their windows. 7% of residents in single-family houses and 9% of residents in apartment buildings have consequently already invested in additional draught proofing of existent windows. 9% of residents in apartment buildings and 17% of residents in single-family houses have already replaced old windows with energy-efficient ones. Over 20% of apartment owners, both in single-family and apartment buildings, intend to replace existent windows with new ones during the next five-year period.

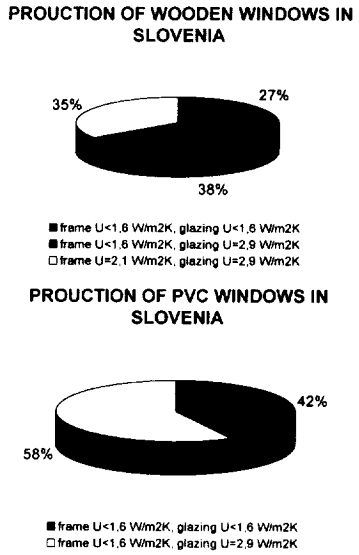


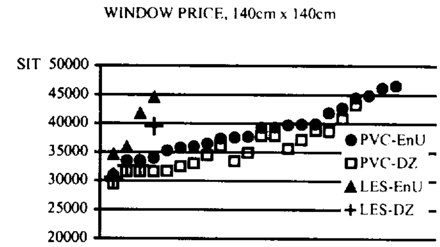
Figure 1: Current production of timber and PVC windows in Slovenia.

Slovenian market of windows and glazing

The national producers of glazing and windows that sell about 309,000 m^2 of windows (50% of total) on the Slovenian market (ca. 70% PVC frames and ca. 30% timber frames) and about 162,000 m^2 of glazing, reported the frequency of use of energy efficient glazing and windows within particular categories of buildings to be too low (2,3). Nearly 60% of the windows are sold with ordinary double glazing and not with low-e technology (Fig.1).

Investment-savings ratio

On the Slovenian market the cost for a window with an energy-efficient double-glazing is on an average only 10% higher compared to a window with an ordinary insulating double-glazing (Fig.2). Taking into account 2.7-times smaller energy losses and consequent notably lower heating costs, the calculation shows that an average payback period for the difference in price, i.e. for the additional investment in energy efficiency is 2 to 3 years. Measures introduced in the building sector with a payback period of less than 10 years are considered to be economically viable in Slovenia.



PVC-EnU = PVC frame, energy-efficient glazing
PVC-DZ = PVC frame, insulating double-glazing
LES-EnU = timber frame, energy-efficient glazing
LES-DZ = timber frame, insulating double-glazing

Figure 2: Window prices on the Slovenian market (100 SIT = 0.5 EUR).

SUSTAINABLE CHOICE CRITERIA

The following criteria for description of energy-efficient windows and glazing have been adopted: for windows, an overall U-value of less than 1.6 W/m^{2}K according to the ISO/DIS 10077, and meeting the demands for category C according to the national standard SIST 1018 regarding air- and water-tightness, and for glazing, a U-value of less than 1.4 W/m^{2}K. To upgrade and expand these parameters and thus create integral sustainable criteria for choice of windows, the National quality sign for energy efficient windows has been established in 1997.

The "National quality sign in Civil Engineering" (4) has been awarded also to energy efficient windows, produced by companies that concern about the environmentally friendly production and quality of their service. The evaluation scheme covers different criteria pondered according to their relevance to Slovenian situation. The evaluated criteria are:

(a) measurable technical criteria (U values, air-permeability, water tightness, mechanic characteristics),

(b) not measurable technical criteria (convenience of technical solution, functionality of the product)
(c) environmental criteria
(d) efficiency and quality of production processes
(e) satisfaction of buyers
(f) fulfilment of the company's business plan,
(g) global impact on the society and environment.

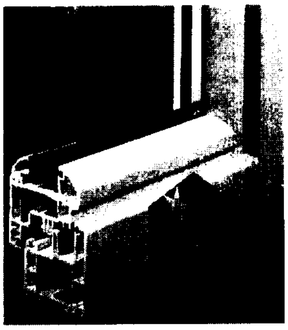


Figure 3: National quality sign for energy efficient windows.

Technical criteria (a) and (b) are pondered with prevailing weight, so that they have more than one half of the total impact. They implicitly represent the importance of energy efficiency and the effect on reduction of emissions. The environmental criteria (c) focus the influence of all phases of window life cycle on the environment and human health, comprising: availability of raw material, grey energy, life time of product, emissions from the product, recycling, damage to ecosystem. The environmental impact of the production process itself is evaluated separately, within (d). As a basis for the evaluation of environmental impacts of the window product the "environmental preference method" (5) was used. It was implemented to rate window components: frame, glazing, sealing and protective coatings. The results were transformed in the points and weighted according to the relative importance.
In last four years twelve best window types and their manufacturers were awarded the »Quality Sign in Civil Engineering«. The sign has a role of not obligatory certification sign of a national character and it supports identification of energy efficient windows on the market as well as the governmental incentives programme. In 1998 and 1999 880 households received state subsidies for sustainable choice of windows, and energy savings of approximately 2300 MWh/year were initiated (2).

CONCLUSION

Several barriers for implementation of sustainable windows were detected in various target groups: insufficient knowledge about contemporary window technologies, low economic interest in EE investments, insufficient interest for technological upgrade among salesmen, omitting testing of windows due to intense competition among small window production companies, transformation of technical regulation on building physics, insufficient environmental consciousness.
These programmes supported by various other information activities (3) have raised awareness and knowledge in the market and increased the interest in energy efficient and environmentally conscious products, thus contributing to the idea of sustainable building.

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AN EXPERIMENT ON PASSIVE DESIGN IN TROPICAL CLIMATE

Uno Tomoko[1)], Hokoi Shuichi[2)], Funo Shuji[3)], Yamamoto Naohiko[1)], S.Nastiti[4)]

1) Graduate Student, Graduate School of Eng., Kyoto University, Yoshida Honmachi, Kyoto 606-8501, Japan

2) Prof., Graduate School of Eng., Kyoto University, Dr. Eng.

3) Assoc. Prof., Graduate School of Eng., Kyoto University, Dr. Eng.

4) Faculty of Civil Engineering and Planning, Institute of Technology 'Sepuluh Nopember'

INTRODUCTION

In developing countries like Indonesia, the cooling energy conservation is expected to increase. The contribution to the energy conservation and the improvement in our surrounding is required by the utilization of passive cooling systems suitable to particular climates.

This paper reports the results of a survey on the thermal environment in an Eco-House[1)-3)] built in Surabaya, Indonesia. The performance of the passive solar technologies introduced into this house is analyzed and evaluated.

FEATURES OF THE ECO-HOUSE

Surabaya is situated 7° N and 135° E in a tropical rain forest climate. The first floor of the Eco-House is suspended on pilotis. On the second and third floors, there are four private sections around a semi-open common space. The exterior wall structure on the second floor is bricks and others are wooden. The rooms on the third floor have no ceiling.

In this house, several passive techniques are introduced, such as solar shading by a double layered roof[1),2)] with a thermal insulation layer made of coconuts fiber and an air layer, cross ventilation[3)] in the common space through the horizontal and vertical channels, cold storage in the RC structure, and a radiant cooling[2),3)] in the private section by the circulating water through the floor slab.

PROCEDURES AND RESULTS OF MONITORING

The monitoring was conducted in the dry season from July 27 to Aug. 7 in 1998, and in the rainy season from Dec. 13 in 1998 to Jan. 17 in 1999, in order to verify the effect of the installed passive cooling system and influence of living styles.

Outdoor temperature

The ambient temperature rises from 6 am and peaks at 2 pm. The ambient temperature in the daytime varies from 26 to 31[deg.C], and the humidity is about 60[%]. The temperature in the nighttime ranges from 26 to 27[deg.C]and the humidity is about 85[%]. During the monitoring period, the maximum ambient temperature, which was 32.7[deg.C], occurred on 25th December.

Private sections

Fig.3(a) shows the measured air temperatures and the humidities of the northeast corner on the second and third floors, when the openings are kept open from 8 am to 5 pm. During daytime,

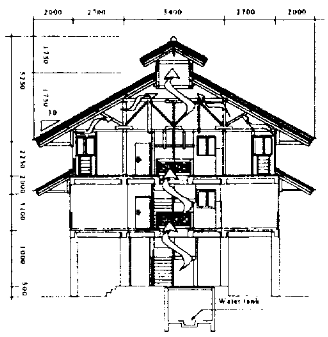


Fig.1 Section of Eco-House

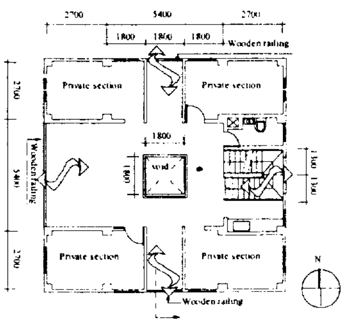


Fig.2 Plan of Eco-House (2Fl.)

the room air temperature rises up as the ambient temperature rises. It is over 30[deg.C] at 10 am. In the opposite case (Fig.3(b)), the room temperature on the second floor is lower than the ambient temperature by 2-4[K]. To keep the room temperature low, closing the openings during daytime is effective.

CALCULATION OF INDOOR THERMAL ENVIRONMENT

Simulation model

The simulation model calculates the room and the mean radiant temperatures (MRT), the humidity and PMV[4)] in the private sections on the second and third floors. Fig.4 shows the meteorological conditions used in these calculations and the calculated room air temperature.

In order to check the accuracy of the calculations, the simulated results were compared with the measured result in the case I (Fig.4). The difference between the simulated and the measured results is within 0.39[K] except at about 5 pm when the ambient temperature fell down sharply. The MRT is higher than the room air temperature by 0.34[K] during daytime and almost the same in the nighttime.

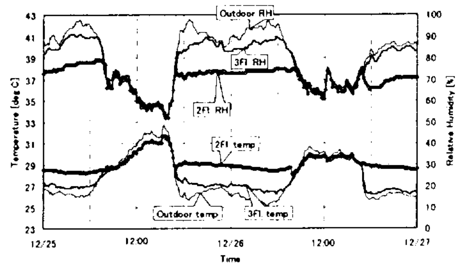
Effect of changing openings pattern

In a typical Indonesian style, the openings are kept open during daytime and closed during nighttime. First, the case IIA was calculated. The ventilations with the outside and the common space were set at 20[times/h], respectively. The wind velocity in the room was assumed to be 0.4[m/s]. The maximum room air temperature and the MRT during daytime are 31.1 and 31.7[deg.C], respectively (Fig.5). The maximum PMV is about 2 when the wind blows through the room, while that is about 2.5 in the calm case. The thermal condition in the room is rather hot. In the night, both the room air temperature and the MRT are between 27 and 28.5[deg.C], and the PMV is about 1.

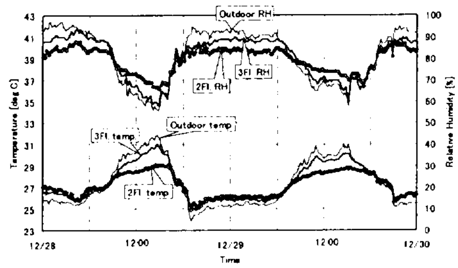
The opposite case (IIIA) is calculated (Fig.6). The maximum room air temperature and the maximum MRT in the daytime are 29.2 and

Table 1 Simulation case

Simulation case	Opening		Wind velocity [m/s]	Blind
	Daytime 8:00-17:00	Nighttime		
Case I	Close	Close	-	-
Case IIA	Open	Close	0.4	-
Case IIB	Open	Close	0.0	-
Case IIIA	Close	Open	0.0	-
Case IIIB	Close	Open	0.2	-
Case IV	Close	Open	0.0	Installed



(a) 8:00-17:00 open



(b) 8:00-17:00 close

Fig.3 Measured air temperature and humidity of the private sections

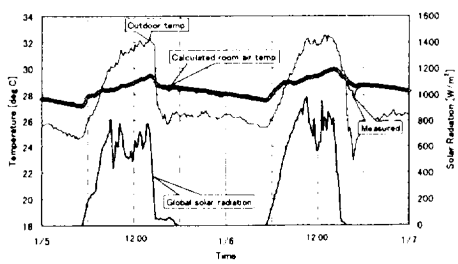


Fig.4 Ambient temperature, global solar radiation and calculated result (case I)

29.7[deg.C], respectively. In the night, the room air temperature is close to the ambient temperature due to night ventilation, and that is from 26 to 27[deg.C]. Therefore the maximum PMV is about 1.5 and almost the same as the case where the windows are open. The PMV in the nighttime is around −0.5.

Effect of Solar Shading by blind

In order to buffer the influence of the solar radiation, blinds (which are assumed to shade half of the solar radiation) are installed and their influence is examined. They are lifted up at night for the ventilation.

With the blinds, the average room air temperature is lower than in the case without the blinds by 0.29[K] and the maximum is 28.7[deg.C] during daytime. The average MRT is lower than that by 0.52[K] (Fig.7).

CONCLUSION

An experimental building "Eco-House" built in Surabaya, Indonesia, which introduces several kinds of passive techniques, was measured in order to examine the effect of these techniques. The room air temperature was reproduced by a simulation model and the improvement in the room thermal environment by changing lifestyles was considered.

When the opening are kept open during daytime and closed during nighttime, the PMV becomes about 1.5 with 0.4[m/s] wind velocity (IIA), and about 2 in the case (IIB).

When the openings are kept closed during daytime and open during nighttime, the maximum room air temperature is lower than that in the case II by 0.9[K], while the PMV is 1.5, same as the case IIA with wind velocity.

The PMV in the case IIIB is much lower than that in the case IIA (Fig.8).

With the blinds installed on the openings, the air temperature and the MRT during daytime are lower by 0.29 and 0.9[deg.C] on average, respectively. As a result, the PMV during daytime becomes about 1 (Fig7).

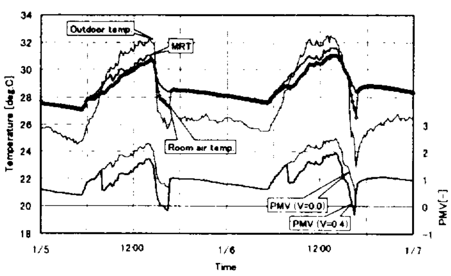


Fig.5 Calculated result in case IIA and IIB

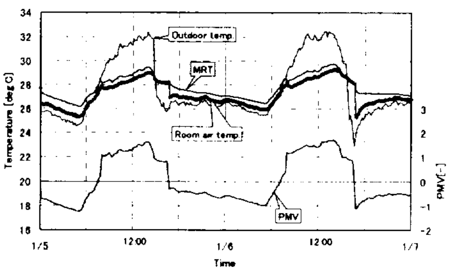


Fig.6 Calculated result in case IIIA

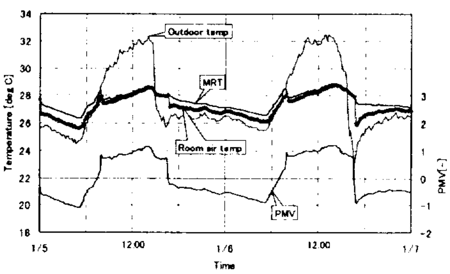


Fig.7 Calculated result in case IV

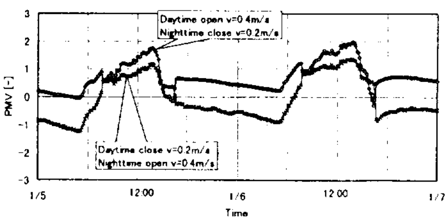


Fig.8 Compared PMV in case IIA and IIIB

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Sustainable Construction in Practice

Dr Sally Uren[1], Andrew Brown[2] and Fiona Gooch[1]

INTRODUCTION

Sustainable development forms a process which meets 'the needs of the present without compromising the ability of future generations to meet their own needs' (Bruntland 1987) and sustainable construction is the contribution which the construction industry can make to sustainable development. Sustainable construction therefore involves conducting business in a socially and environmentally responsible way, while generating a good economic return. This paper presents how a major construction to services company, Carillion, is embedding sustainable construction into its business both at corporate level and in practice in its many projects and sites.

Carillion is the new name for Tarmac Construction Services and is one of the UK's largest construction to service companies. Carillion is involved in every aspect of the built environment, has a turnover of £1.9 billion and over 10,000 employees. Since 1992, Carillion has been implementing a leading edge environmental management programme, which has won several awards. As an extension to this programme, Carillion has begun to address sustainability by implementing initiatives designed to integrate social and environmental issues into mainstream business. Stanger Science and Environment provides strategic consultancy to support this sustainability programme.

CARILLION'S ADOPTION OF SUSTAINABLE CONSTRUCTION PRACTICES

The main goal of Carillion's environmental, and now sustainable development, strategy has been to ensure it creates business benefits, and to implement actions that will embed sustainable development considerations into business practice. To support this goal, Carillion developed corporate objectives for 2000 as follows:

Financial and economic success
A: Develop and implement an environmental cost accounting system
B: Utilise the environmental cost accounting system or any other appropriate tool to explore the relationship between environmental and sustainability performance and financial performance
Employees and management systems
C: All Business Groups to implement an Environmental Management System by 2002
D: Extend EMS ownership to all Carillion Head Office functions
Stewardship & Supply Chain
E: Develop stewardship of Carillion's Supply chain across all Business Groups
F: Increase the purchase of materials and products from sustainable and well managed sources
G: Increase use of Life Cycle Analysis within Carillion projects
Consumption of natural resources
H: Develop measures to reduce consumption of natural resources (use of energy, water & raw materials)
Pollution of the environment
I: Implement a programme to reduce emissions produced as a result of Company activities (waste, CO_2, emissions to air and to water)
J: Introduce "green" fleet management
Suppliers and Stakeholders
K: Raise the profile of sustainable construction within Strategic accounts
L: Increase knowledge of environmental / sustainable issues and best practice across all Business Groups
M: Widen the scope and nature of stakeholder dialogue

These objectives have been put into practice for a number of sites within Carillion. For example, at Dartford and Gravesham Hospital an Environmental Financial Statement has been produced showing total environmental savings to be £181,500, which was 57% of the environmental costs. As

[1] Stanger Science and Environment, Lansdowne Building, Lansdowne Rd, Croydon CR0 2BX, UK

[2] Carillion plc, Carillion Building Special Projects, PMH Relocation, Coate, Swindon, SN3 6AA, UK

this PFI hospital becomes operational, it is considered that the savings are likely to increase. Another example is the work that Carillion is undertaking with its stakeholders, such a Sustainability Briefing for clients and staff and a stakeholder dialogue workshop with representatives from all Carillion business groups to develop programmes for engagement. There are also many examples of local stakeholder initiatives at project sites.

SUSTAINABLE CONSTRUCTION AT PRINCESS MARGARET HOSPITAL, SWINDON

At a project level, Sustainability Action Plans (SAPs) can be used to integrate sustainability considerations into a construction project. To date, SAPs have been developed for two Carillion projects, a social housing project in Bradford and a new hospital for Swindon[3].

Carillion is the lead partner in the PFI consortium developing this £148 million 486-bed hospital project for the client, Swindon and Marlborough NHS Trust, that is due to be completed in 2002. The project was accepted by the Movement for Innovation (M4I) as a demonstration project for innovation in 'Partnering in the Supply Chain'. Carillion's project team made an early decision to design and construct the new hospital in a way that embraces the principles of sustainable development.

Working with The Natural Step, an international movement for sustainable development, all members of the project team have participated in workshops to generate an SAP for the new hospital. The plan identifies short, medium and long-term actions to be taken to increase the sustainability of the design, construction and operation of the hospital. The Action Plan links nine design, process and operation topic areas, and the actions current at the time of this paper are outlined below.

the NATURAL STEP

THE FOUR SYSTEM CONDITIONS	Don't:
Substances extracted from the Earth's crust must not systematically increase in nature.	Overwhelm
Substances produced by society must not systematically increase in nature.	Poison
The physical basis for the productivity and the diversity of nature must not be systematically diminished.	Liquidate
We must be fair and efficient in meeting basic human needs.	Waste

Sustainability Topic	Example Actions
Materials Selection	• Use timber from sustainable sources • Reduce use of PVC and develop alternatives • Encourage suppliers to offer technological developments • Favour suppliers developing 'green' products.
Energy Use	• Incorporate energy efficient features in the design, including solar glazing, effective insulation materials, low energy lighting.
Plant Equipment and Specification	• Select equipment with high efficiency
Wildlife	• Develop habitat management plan • Native tree planting • Protect resident populations - e.g. provision of bird boxes
Local Nuisance	• Good communication, • Partnerships on initiatives • Conform with the Considerate Contractors Scheme, • Minimise road usage near housing, • Minimise dust • Minimise out of working hours operations
Transport	• Route planning to minimise disruption • Minimisation of vehicle movements by maximising vehicle loads • Provide transport for staff to reduce vehicle movements.

[3] Details of the project team are available on http://www.general-hospital.co.uk

Community Relations	• Appoint a Community Liaison manager • Support "New Deal" • Employ local trade contractors • Become member of local Chamber of Commerce
Waste Management	• Recycle all waste material on site. • Procure materials from suppliers able to take back and recycle packaging • Landscape to minimise waste soil on site - soil to be reused on site wherever possible • Purchasing policies to favour recycled materials and those with a long life
Landscape and Visual Impact	• Plant local species • Use organic materials, • Minimise the importation of soil • Minimise the use of herbicides and fertilisers

Application of the SAP to this project predicts significant, and measurable, positive impacts on energy use, carbon dioxide emissions, waste, safety, sustainability of materials and local employment, during both the construction phase and throughout the life of the hospital. The targets for lifetime savings are 30% in carbon dioxide emissions and 50% in waste generation. In addition, the value of the asset at the end of its predicted life as a hospital will be enhanced because the buildings and their services have been designed for flexibility in re-use.

Business costs/benefits of the this approach include the following:

- 7% saved on the cost of the building envelope procurement.
- Net saving of £219,000 resulted from the Energy Action Plan, which doubled the U-value of the roof insulation leading to savings on capital cost of the top floor radiant appliances and in the running costs over building life.
- Net saving of £809,000 resulted from the Materials Action Plan, which uses different timber and wood soap to avoid the use of paint and varnish.
- The only quantifiable cost to the company from the SAP was the investment in initial training, at about 1 day per team member.

CONCLUSIONS AND RECOMMENDATIONS

From Carillion's experience, the success factors for the application of sustainable construction practices on new projects are:

- Engage with the sustainability agenda at the earliest stages of a project
- Generate a clear understanding of the fundamental issues at stake
- Gain commitment from senior management
- Establish a shared vision
- Converse with as many stakeholders as possible
- Listen to what people want and can offer
- Be flexible
- Be open to innovative ways of doing things
- Learn from mistakes
- Use measurement systems to chart progress

The challenge for the building industry's engagement with sustainable construction will be to fully understand its social impacts, as well as the linkages between the social, environmental and economic aspects of its work and to embed the implications of this understanding into business practice. In addition, sustainable development should be used as an opportunity to innovate, and create new business opportunities.

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THE DESIGN OF A HEALTHY DWELLING FOR SENIORS

Author; August A.M.van Vliet, MSc.
Department of architecture, building and planning
Eindhoven University of Technology, building HG11.14, PO-box 513,NL 5600MB Eindhoven

THE AGEING SOCIETY AND HEALTH INTERVENTION

The Health Aspect and the Ageing Person

Older growing persons face the consequences of their life, including diseases and impairments, which threaten the quality of life. The philosopher Seneca defined ageing as an incurable disease, which reflects the common sense. It combines both the statement of the simultaniously relation between ageing and prevalence of diseases and the statement of impossibility to cure ageing diseases.

Dwelling Related Diseases at Growing Age

The dwelling itself is regarded to be the third skin, protecting mankind from the several outside physical dangers and health threats. As older persons with their high rate of impairments suffer increasing immobility, they stay up to 95 percent [1]of time in an artificial indoor climate. Most expensive diseases like osteoporosis and Falling Accidents in Home and diseases with highest prevalence like Asthma and Falling Accidents[2] are related to the particular physical conditions in the artificial living environment for humans, called dwelling. The social environment narrows with growing age, resulting in a decreased need for movements and outdoor stay. Impairments lead to immobility, which indicates a lower metabolism level, thus inducing the need for a higher thermal comfort. The health status of the old grown persons, who are more sensitive to allergens and more house bound, ultimately shows the impact of a long lasting exposure to unhealthy Indoor climate conditions in the dwelling.

Temporary by Sustainability provoked Dwelling related Diseases

Sustainability is invented to maintain a new sane human environment through another economic Profit[3] principle, in which individual Personal interests and the use of the limited resources on Planet Earth on the long turn are in balance. Extreme reduction of waste of energy sources in building material production under condition of an equal- or improved comfort level not automatically implies a healthy physical environment. Health status however shows to be the most important personal interest for the group of old grown persons. Regarding the modern Health definitions,[4] the change in individual ambitions of the older growing person has to be taken in account. Loss of health and vitality status generates a high demand for medical treatment and additional care. In order to prevent for waste of human resources, the appeal on remaining physical capacities has become Public policy.

The Actual Health Situation of Ageing Persons

The actual situation in the Netherlands, a country with a fairly well health reputation, shows a score of 134 patients with chronic diseases for each 100 persons over 65 years old. Combined with an average healthy life expectance of 60,3 years, we conclude that especially the Dutch women with their average life length of 80,3 years spend up to 25 percent of life ill-healthy.[5] The ill- healthy status provokes a high demand on Public offers for medical treatment and additional care. Regarding the demographic changes in the near future up to 2030, both Public Housing Policy[6] as well as Public Care[7] policy have formulated a vision. In this vision the theme Independent Living for Live Time in the own dwelling is developed. Besides an decrease of nursing home beds with intrinsic intensive care from 400.000 in 1980[8] to 103.000 beds in 2010.is foreseen. Increase of health status and vitality become limiting factor.

The Inevitability of Diseases with Growing Age?

Dwelling related diseases form a hughe part of health threats for older growing persons. Since indoor climate is artificial, the indoor physical conditions in the dwelling are the result of manipulation and mutation. Under condition, that the relation between attendence of an health risk and the physical environment conditions, is proven, unhealthy conditions are avoidable through health risk reduction. Concluded in another way, dwelling related diseases are the result of errors in the dwelling design and dwelling use by the inhabitants.[9] Seneca was not rigth , but the architects will have to avoid mistakes. How to manipulate physical conditions into a healthy living context?

HEALTH INTERVENTION AND THE DOMAIN OF BUILDING ENGINEERS

An Architect is not a Physician

Architects are occupied with design decisions, which optimise functional aspects of the built material context, meanwhile intervening as well in the health preventive interval of physical conditions. An expert knowledge on the impact of design decisions on physical medical- gerontologic and biologic aspects lacks for architects. How is this knowledge to be implemented in architect's design practice? Primary concern of physicians and medical caregivers is the health status of individual clients and the eventual deficits in individual living conditions. The demand for changed living conditions however gets an indirect answer, a mutation proposal for the dwelling. The plan actually represents a changed material context. A simple straight relation between an individual health risk and the application of an unique individual building component mostly is not present.

Ambition of Research

Research aim is to develop knowledge module gerontology within a design decisions support tool for the healthy dwelling of the older growing person, which is adaptive to the wishes and capacities of older grown individuals. The tool aims to generate health intervention proposals within the design.

HEALTH INTERVENTION POSITIONED IN THE DESIGN PROCESS

Health Intervention by Health Risk Reduction

Historic evidence for the preventive role of architects within Public Health Care is available i.e.in the provision of drink water installations and sewer installations in the 1880 urban town planning, which brought the comfort of available individual fresh water, and disconnected in the same time the chain of causes and effects for several bacterial infections.

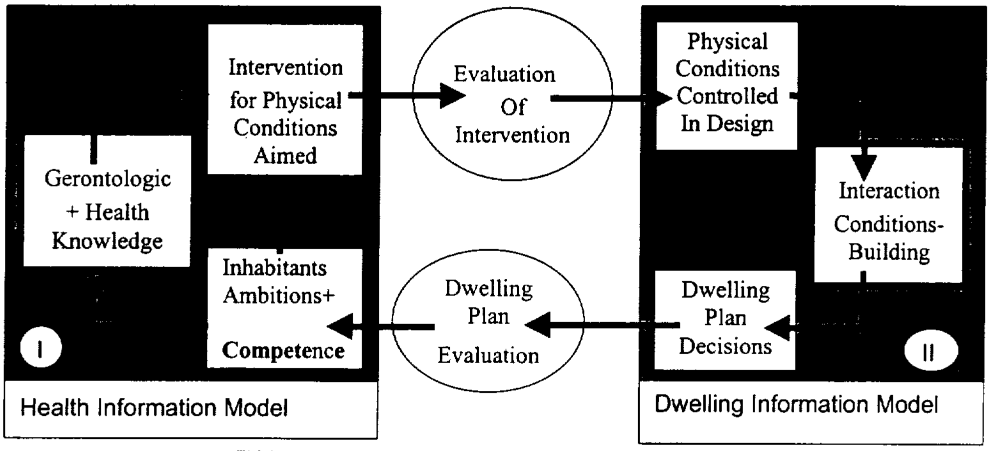
Medical and Biologic knowledge is needed to understand the mechanisms behind the growth of the risk level and the possibilities to intervene in the chains of causes and effects. Gerontologic knowledge is needed to understand the heredity for- and the impact of actual exposure on health agents with growing age. Intervention proposals can be generated for each element in a chain of causes and effects.

In our example, to stop drinking fresh water, to stop the inlet of toilet water in the river etc.

The Health Demand and Dwelling Plan Offer

Architectonic designers develop a dwelling plan according to criteria and demands from the principal. The design process becomes an interaction between the demand for healthy conditions by owners and inhabitants versus the offer of a material dwelling context by the designer. The growing group of ageing inhabitants is also growing in importance as a political factor. To reach the wished complete health , their individual personal aspirations must be identified and realised.

Gerontologic knowledge provides several chains of disease causes and health effects, which offers the data for possible interventions and gives the markers for an interval of aimed physical conditions. The intervention proposal grows to be a criterion for the aimed conditions. Physical conditions themself are starting point for the dwelling design of the material context. The materialised combination of building materials and constructions as a whole has an interaction with the indoor physical conditions. Building Technology offers the knowledge of the interaction between the physical conditions and the material context. The material context, formulated in a dwelling plan, itself is subject of evaluation by both the principal and the proposed inhabitant. In this way a circle of decisions can be formulated.



Healthy OLDD Dwelling Model (A.v.Vliet 17-5-2000)

Within this general scheme for 1 design decision loop, two domains are defined; the health information domain for the older growing client with its care advisors and physician next to the dwelling information domain with the principal and its advisors the architect and the constructor. Step by step the decisionloop is executed during the several phases in the Life cycle of the dwelling.
Sustainability criterion is, that all foreseen mutations of use within the planned use period of the dwelling must be possible, without a mutation of the building structure or move home itself.
This criterion implies a dwelling for lifetime, regarding the interests of the impaired 68 percent of the 14 percent ageing persons above 65 years old in the Dutch population.

Further Forseen Development

Within the Eindhoven University of Technology context the chair Biotic Agents of the Built Environment and the former Institute of Gerontechnology provide biological and gerontologic data. Further development is focused on the labeling of aimed qualities on the conditions and on building components. A second point of interest is the way, physical conditions can be measured and controlled by application of building components, which is within the domain of Building Technology Research.

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DEVELOPMENT OF THE FIRST SUSTAINABLE ELEMENTARY SCHOOL OF THE NETHERLANDS.

Prof. Dr. J.C. van Weenen;
IDEA- International Design and Environment Activities,
Tulpenveld 48
1901 LA Castricum,
The Netherlands.

Ing. W.J.M. Dettmers, Ir. M.S.J. Overtoom;
BBHD- Bakker Boots van Haaren Dijkhof, Architektenburo B.V.,
Koperwiek 3,
1742 GR Schagen,
The Netherlands.

Ir. H.G.J.M. Poldermans MRE,
Lithos Bouw bv,
Wihelminastraat 12,
3771 AR Barneveld,
The Netherlands.

INTRODUCTION

Against the background of international developments with regard to sustainable education and sustainable building, this paper deals with the new concept of a sustainable educational facility. It presents examples of sustainable schools from around the world, among which examples of sustainable elementary schools. Then the paper discusses the Dutch national context and Dutch examples of sustainable school buildings. Finally it deals with the development of the projected first sustainable elementary school of The Netherlands.

Background

One of the basic requirements for the realisation of the process of sustainable development, is sustainable education. All around the world initiatives have been taken to integrate sustainable development into the activities of existing educational institutions such as universities and professional schools [1]. Also the integration in secondary and elementary education is emerging [2, 3]. In the United Kingdom, a Sustainable Development Education Panel was established with the aim to consider issues on the subject in its broadest sense, in schools, further and higher education, at work, during recreation and at home; and to make recommendations for action in England [4]. With respect to sustainable building of educational facilities, the focus has mainly been on energy saving [5, 6], although also educational buildings have been realised on the basis of a broader scope [7]. In the last few years some Ph.D. studies on sustainable school building have been set up [8, 9]. Some totally new approaches can be found as well, in which the development of sustainable education is integrated with the building of a new school or a new educational facility. Examples of that are the Great Notley sustainable school in Essex, United Kingdom [10,11,12], the Östratornskolan in Lund, Sweden [13,14], the sustainable elementary school of McKinney, Texas, U.S.A. [15], the Van Hall Instituut / AOC Friesland, in Leeuwarden, The Netherlands [16], and the Adam Joseph Lewis Centre for Environmental Studies of Oberlin College, in Oberlin, Ohio, U.S.A.[17]. Overviews of examples of sustainable school design have also been published [18, 19], indicating that experience is increasing.

PRESENTATION

Dutch national context

In the Netherlands sustainable building is a well-established policy area in which many programmes have been organised and initiatives have been taken, from 1990 onwards [20]. In 1996, the programme on National Demonstration Projects for Sustainable and Energy-saving Building of NOVEM and SEV began. Sustainable school buildings resulting from that framework are: the Van Hall Instituut mentioned above, the Educatorium in Utrecht, the Peuterpalet in Leiden and the Hogeschool Limburg in Heerlen [21]. In addition, some schools were built that could rather be considered environment friendly schools, with a focus on health, energy and flexibility [22, 23]. The interest in similar approaches is increasing, both in the affluent and in the developing world [24, 25].

Sustainable elementary school

In November 1997 the municipality of Castricum decided to build a new school building for the public elementary school De Sokkerwei because of the deplorable state of its two old school buildings. In March 1998 ICS consultants were commissioned to write a discussion note for the schoolteachers, management and board on the characteristics, vision, mission and requirements of the school. At that time it had become clear that for the realisation of the school building other building partners would be required. Contacts were made with the local organisation for after school care (NSO), and with local housing associations. In May all the children were involved in an exhibition about the new Sokkerwei, which was well attended by parents, family and friends.
In February 1998 the School Board asked Hans van Weenen as a parent and former member, to investigate the possibilities of sustainable building of a new school. In February 1999 he completed a discussion report on the sustainable elementary school De Sokkerwei, which would be the first school of its kind [26]. He defined a sustainable elementary school as a sustainably designed, built and used school building in which sustainable education is being developed and provided. The building and its surroundings serve as an educational tool for illustration, demonstration, exploration, experimentation and discovery.

Project developer Lithos Bouw B.V. was chosen to build the whole plan consisting of a school, school apartments, an apartment building and free standing houses. An agreement indicated that an additional budget of 5-10% of the buildings costs of the school, resulting from the exploitation of the area, would be reserved for the sustainable building of the school. The municipal council finally approved the plan on October 4th 1999, unanimously supporting the sustainable building of the plan, and especially of the school. Then the architect BBHD was selected and the design process began in November 1999.

IDEA was appointed sustainable building advisor. The Netherlands Energy Research Foundation (ECN) became involved to do research on a zero-energy concept for the school, with support of NOVEM. The Dutch Governmental Building Agency (RGD) decided to give the project the status of National Demonstration Project on Sustainable Decision-Making. It provides support for maintaining and if possible upgrading the formulated ambition level. The Province of North-Holland nominated the project for the National Future Prize 2000. A web-site with national and international information relevant to sustainable elementary school building was developed. Lectures have been given on sustainable school building [27] and a regional TV broadcasting company presented a documentary. In June 2000 TNO-Centre for Timber Research began to investigate a timber frame building system for the school, the application of renewable resources-based materials, and the reuse of constructions and materials from the two existing school buildings. NOVEM and the provincial company PWN are involved to detail the water concept for the plan.

CONCLUSIONS AND RECOMMENDATIONS

Essential to the whole development process up to June 2000 has been the wish of the School Board to investigate the building of a sustainable school. The unanimous decision of the municipal council to support the sustainable building of the plan has been very instrumental. Both in the selection of the project developer and of the architect the criterion of experience and empathy with sustainable building has proved to be crucial. The endeavour to realise the first sustainable school in The Netherlands is well supported by additional budgets from the plan and from the RGD-project 'Sustainable Decision-making'. Time will tell whether or not the objectives will be achieved. The building of the school will begin in October 2000.

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DUFLEX PRONOVATIE

Ir. W. Zeiler
Kropman B.V. Mechanical & Electrical Contracting
Verrijn Stuartlaan 36
2288 EL RIJSWIJK
Tel. : 070-3401401
Fax. : 070-3999351
E-mail: w.zeiler@ry.kropman.nl

Sustainable building will be the major guiding principle for renewal of building and spatial planning practice. As one of the major Dutch mechanical and electrical contractors Kropman is aware of this fact. It is of this that the company puts effort towards knowledge transfer and networking with the major Dutch knowledge institutes. In the planning of a new building for the Kropman-Utrecht establishment the principles of sustainable building within the IFD (Industrial Flexible Dismountable) building concept are applied. The project is innovative and has reached the status of demonstration project within the IFD programme of SEV (Stichting Experimentele Volkshuisvesting [Groenedijk et.al. 2000]). Also the building itself is a source of energy. The project is being developed with TNO Bouw and the architect Van den Broek en Bakema. The integration of building elements and climate conditioning elements has reached a maximum level. Target is to design and build an office building with a flexible construction and notable sustainable innovations [Zeiler 1999]. Also the design process itself has been a topic of study. The results of this new approach is called **Du**urzaam **Flex**ibele **Pro**ces In**novatie**, sustainable flexible process innovation. [Zeiler et.al. 2000].

Introduction
Industrial, Flexible and Demountable (IFD)-building is seen as a expedient for an optimal useable and efficient buildingprocess. The IFD-programme is an joined initiative of the Netherlands Ministry of Economic Affairs and the Netherlands Ministry of Housing, Spatial Planning and the Environment. The project must show the possibilities of the new IFD-technology. Kropman is developing a new office for their Kropman-Utrecht establishment. The differentiation of organisational styles has created requirements and wishes concerning housing that are becoming both more diverse and more difficult to foresee. Adaptability is thus important. This implies a means of building for universal applicability with respect to use and organisational styles, as well as the ability to respond to the highly specific needs of different users. Flexibility and adaptability are considered as desirable qualities that can be achieved through industrialised building. IFD-building is strongly related to 'Open Building'.

Open Building
'Open Building', based on the ideas of N.J. Habraken can be seen as an attempt to integrate industrial building and user participation in housing. It approaches the built environment as a constantly changing product engendered by human action, with the central features of the environment resulting from decisions made at various levels. The levels of city structure, urban tissue, support, and infill are usually distinguished. Open Building entails the idea that the need for change at a lower level, such as the dwelling, emerges faster than at upper levels, such as the support. Open Building aims at a situation where decisions made on upper levels leave the contents of the decisions made at lower levels open. The basic idea of Open Building, the different levels of decision-making, is in concerning their placement.

The underlying idea is that users have the right to participate in the modification of their living environment and the decisions affecting its formation and modification. Habraken describes dwelling as an act where the occupant takes possession of the living space through participating in its creation and alteration. Open Building does not give a direct answer to the question as to who the genuine participants at the various levels are, and indeed it is seldom easy to name the decision-makers. In any case, decisions concerning the built environment and office buildings will never affect only the first occupants of the building.

A central idea in Open Building is to respond to the various needs of individual users through phasing of the design, decision-making, and implementation process. Some decisions are postponed until the stage at which future users can be identified and involved in the planning and decision-making. In order to provide subsequent occupants with the opportunity to influence their office, the elements decided by the resident must be easy to change. Thus adaptability is nog merely a means for modifying the office during use; it is first and foremost a strategy for enabling the fulfilment of individual wishes without compromising the rights of the succeeding occupants.

Installation technology

Incompatibility of installation systems causes many problems in construction. These problems can arise in additional use of space, use of time or extra costs. All installation systems are usually replaced when building is totally renovated. Installation systems in renovation require more work than in new buildings.

Renovation causes problems for working and living conditions and for building owners. Working and living comfort diminishes. Often people are moved to other places during the work. Construction and installation times related to renovation are prolonging. Owners loose income from rents and also investments costs are raising. To make the renovation work more effectiveness one target is to remove work from the building site to the factory. Today's demands and services require development of new solutions for the installation technology. Single easy-to-install products by single companies have been developed, but a complete building system have not been developed before. Main hindrance for development is disintegration of different fields of installation and even competition between them. This is the reason why there has not been common research and development in large scale. Ecological regulations will be better realized with prefabricated systems especially in the field of ecological installation and building systems.

Construction is developing towards more industrial process and pre-production in factories. This sets requirements also for installation systems to be developed so that common module and compatibility can be found. New methods for planning and installation have to be researched and an industrially realized. During the next 10 to 20 years indoor, removable space in buildings will be a major consideration.

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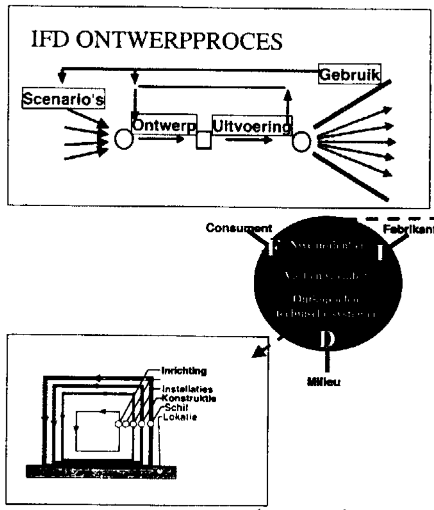

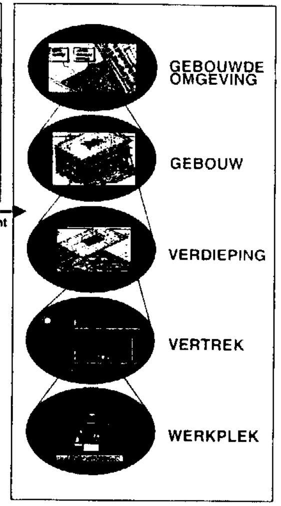

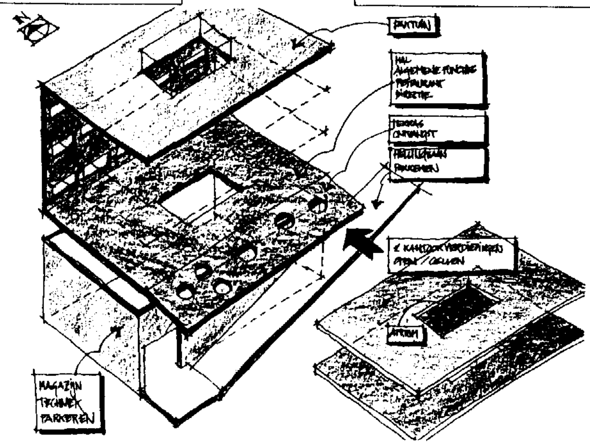

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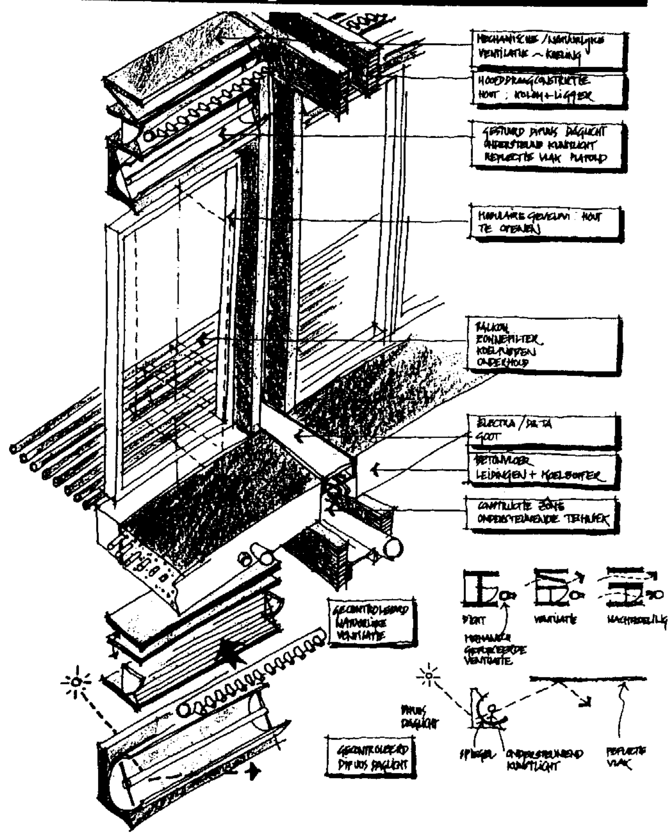

Ecological Urban Dynamics:
A Spatial Modeling Approach to Sustainable Design

Brian Deal
Construction Engineering Research Laboratory
and the Building Research Council
University of Illinois
1 E. St Marys Rd
Champaign, IL 61820

Introduction

Although the current literature includes discussions relating to the sustainability of the built human community, planning professions have focused their attention on continued technological solutions to environmental problems. These interventions attempt to stabilize the problem at hand through further technological infusion increasing the gap between the origination of the problem and ecologically sound solutions. Ecological sustainability, however, involves the identification of ecologically sound alternatives to current practices. In the urban ecosystem this means the identification of the processes of urban change.

Recent technological and computational developments have altered the basic assumptions of spatial analysis as it relates to urban growth. Recent work by Batty (1992), , and Landis (1994) have begun to utilize a cellular automata (CA) approach to integrate socioeconomic and environmentally based information into a dynamic and spatially oriented urban analysis and visualization tool. Along with advances in dynamic spatial modeling techniques currently used to analyze ecologically based systems, (Deal et al. 2000), are being developed to advance a modern Urban Ecology approach to urban systems modeling (Deal 1997)). The application of these techniques can help improve our fundamental understanding of the dynamics of the urban form and the complex interactions between urban change, climate change, and sustainable systems. These tools, used with Spatial Decision Support Systems (DSS) and Geographic Information Systems (GIS), are improving the long term viability of urban growth modeling.

A spatial urban growth model of the San Francisco Bay Area (Clarke 1997), is another example of using relatively simple rules in the CA environment to simulate urban growth patterns. The four types of growth as defined by Clark: a) spontaneous neighborhood growth, b) diffusive growth and spread of a new growth center, c) organic growth, d) road influenced growth. Each cell, at each time step has a defined propensity to change from an existing landuse to a modified landuse based on the three characteristics of growth.

Once the landuse has been defined for a cell, then its impact on a whole host of environmental issues can be estimated. Impact factors can be developed based on cell archetypes that can define growth in energy and water use, materials requirements, and their associated impacts. Also, alternative growth scenarios may be developed based on redefined cell archetypes, different social forces, and varying cell impacts.

ADVANTAGES OF THE NEW CONCEPT

The new concept has several advantages. The most illustrative advantages are:

- Closing the material cycles for concrete and masonry within the own chain. This fulfils one of the desires of the Dutch government, in the framework of sustainable development. It also fits into the policy of the industry, from the viewpoint of producers responsibility and long term raw materials availability.
- The production of high-grade raw materials for the production of new concrete and ceramic bricks. This means most probably higher profits for the C&D waste treatment industry and / or reduced rates for the demolition firms, in case undiluted concrete or masonry debris is delivered (thus promoting separation at the source). It also reduces the extraction of virgin materials, as sand, gravel, clay and marl.
- Utilising the combustible fraction of demolition waste as a fuel. This doubles the environmental profit, namely the reduction of the amount of waste to be disposed of and the reduction of the amount of fuel that is required for the thermal treatment of the concrete and masonry rubble.
- Benefit for the environment (less extraction of virgin materials and less waste disposal).
- The integrated character of the process furthermore implies a reduction is transport kilometres. This means less fuel consumption and because of this less exhaust gases.

CONCLUSIONS

The development of integrated technology for the sustainable production of raw materials for construction from demolition waste leads to closed material cycles for concrete and masonry. This has several environmental benefits, and most probably also economical benefits.

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The Model

An application of the CA urban growth modeling approach was applied recently to the Mill Creek watershed in Kane County, Illinois, a fast growing collar county of Chicago. The main goal of the simulation is to evaluate the influence of urban growth on the overall water quality of the watershed and to provide a basis for a dynamic decision support system.

The initial phase of the model emphasizes urban landscape transformation as a result of human activities. The spatio-temporal land transformation processes are examined from a variety of perspectives and scales using a variety of indicator parameters and variables. These processes work under a set of rules simulated using CA that utilize a growth probability function. During each simulation time step, predicted results for new households, commercial landuse, and open space requirements are compared with modeled simulation results. If there is a surplus or shortage, a self-adjusting mechanism of the model is kicked in, slowing or speeding the growth rates to more closely simulate the predicted results.

The model also evaluates the influence of land use changes on surface water quality using land use imperviousness factors and average annual rainfall events. The output describes pollutant levels for nitrogen, phosphorus, and suspended solids based on simple landuse characteristics and their associated multipliers. Once the spatial analysis has been calibrated and tested, scenario results can be used to evaluate landuse policy decisions for environmental and societal impacts based on ecological sustainability criteria developed.

The Mill Creek watershed model follows some of the fundamental principals of the Clarke model with some additional work and modification. Most important is the resolution of the model. The Mill Creek model represents a 30 meter x 30 meter resolution to simulate the parcel by parcel decision making that influence urban growth patterns. Another significant deviation from the Clark approach is the development of a Markov chain approach to determine the probabilities of development within any given cell in the landscape. For any developable cell in the landscape there is probability of landuse change associated with that cell. This probability is based on a set of criteria that is evaluated by the model at each time step. Each variable in the chain affects the overall probability (ΔP_R) of landuse change.

Model Results

The spatial dynamics of the changing landuse patterns in the Mill creek watershed in Kane County Illinois provides an interesting picture. Figures 2 and 3 displays four maps produced from the full 25-year run of the model showing the spread of development among the original mostly agrarian landscape. The following (figures 3-4) display an example of the Mill creek watershed model that was run for 25 years (starting at a 1995 data point). The outcome from time steps taken the simulation at t=5, t=10, t=15 and t=25. Roads were inserted (brown) to simulate subdivision growth.

Although one would expect the subdivisions seen at time 5 to be entirely built out and occupied by time 10-15.

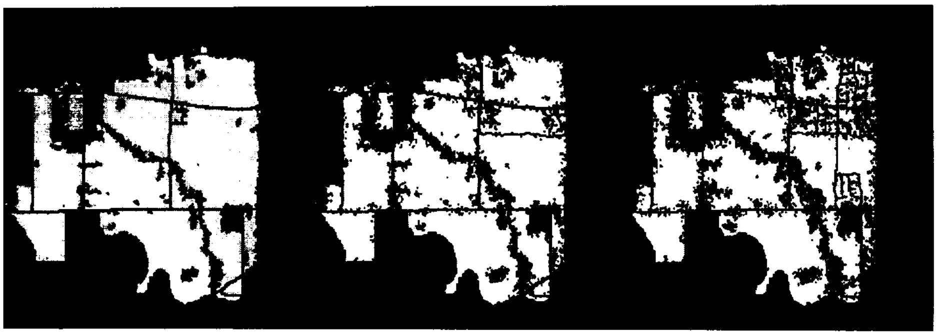

Figure 1. Mill creek watershed model run example. Existing development (dark) and roads (black) attractive new development. Existing agriculture development is the base grey and protected agricultural uses a lighter shade.

Conclusions

Dynamic models of complex and interconnected ecosystems enable scientists to experiment with and thus come to understand the interactions of dynamic system components. Dynamic models give valuable insights into the critical and sensitive components of those systems. While good progress has been made in the development of physical and biological system models, there have been fewer attempts and less success at developing urban ecological models. One of the most important locations for applying dynamic system modeling is at the study of urban/rural interface - where the built environmental and the natural environment directly interact. The application of these techniques the fine scale that this model provides can improve our fundamental understanding of the dynamics of the urban form and the complex interactions between urban change, landuse change, and the associated environmental impacts that affect sustainability. These techniques for evaluating urban change can also incorporate other sustainability-related concepts to form the basis for a comprehensive landuse DSS. Sustainability impacts and landuse assessment tools already developed can easily be incorporated into the dynamic landscape change model.

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A Study on comparison of modified weighting value of BREEAM, BEPAC and GBTool in JAPAN

Dr.Eng. Noriyoshi Yokoo, Dr.Eng. Tatsuo Oka,
Utsunomiya University,
7-1-2 Yoto Utsunomiya Tochigi 321-8585 Japan

INTRODUCTION

Environmental issues are increasing and various programs and tools are being developed to assist architectural community. In this decade, some environmental assessment methods for building have already been developed and used in practice in Europe and North America. On the other hand, there is no comprehensive building assessment method and no development of assessment method in Japan.

The purpose of this study is to determine how Japanese building designers and engineers think about assessment criteria of BREEAM, BEPAC and GBTool and how to modify the weighting value of assessment criteria to suite the Japanese context. The questionnaire survey was done in several Japanese building design firms to decide appropriate weighting values. And also the energy conservation building was assessed. The modified weighting value was used. Although the main criteria in BREEAM and BEPAC are assessed individually, in this study the weighting value of main criteria were decided according to the questionnaire survey and main criteria were compared each other like GBTool. According to this survey, Japanese designers and engineers think that the assessment criteria like “Global issue and resources”, “Environmental impact of energy use “ and “ Environmental loading” are important, so these criteria will be introduced easily into Japan and should be included in assessment method.

QUESTIONNAIRE SURVEY ON WEIGHTING VALUE

In this paper, the weighting value of assessment criteria of BREEAM, BEPAC and GBTool are decided based on the questionnaire survey in Japan. The180 Japanese building engineers of design firms, constructor companies and utility companies replied to questionnaires for BREEAM and BEPAC. The 20 people replied to the questionnaires for GBTool.

Although the issues of BREEAM and the assessment topic of BEPAC are assessed individually, in this paper the weighting value of the issue level and topic level are decided to compare with each other as GBTool. The results of questionnaire are shown in Table1, Table2, Table3. The total amount of weighting value are decided to be 1.0 in each issue of BREEAM, in each topic of BEPAC and in each performance area of GBTool. The weightings of detail level criteria are also decided to be 1.0.

The weighting value of “Global Issues” of BREEAM is 0.4, “Environment Impact” of BEPAC is 0.3 and “Environmental Loadings” of GBTool is 0.24. These are highly weighted than the other criteria. CO2 emission, Ozone depletion are also highly weighted. On the other hand, the weighting value of “Site and Transportation”, “Longevity” and “Process” are low weighted. It shows that the Japanese building engineers don’t consider these issues today so much .

Table1. Assessment Issues and criteria of BREEAM
And surveyed weighting value for existing offices

Issues, Criteria	BREEAM Credits	Surveyed Weighting Values
Global Issues and use of resources		(0.40)
• Global warming:carbon dioxide emissions	12	0.60
• Acid rain: oxides of nitrogen	1	0.10
• Ozone depletion: CFCx, HCFCs and halons	5	0.20
• Recycling of materials	1	0.10
Local Issues		(0.30)
• Water conservation	2	0.40
• Legionnaires' disease arising from wet cooling towers	1	0.20
• Transport	2	0.40
Indoor Issues		(0.30)
• Lighting	1	0.20
• Air quality	3	0.30
• Hazardous materials	2	0.20
• Radon	1	0.10
• Indoor noise	1	0.10
• Legionnaires' disease arising from domestic hot water system	1	0.10

( ) is weighting value of issue level

Table2 Assessment Topic and Criteria of BEPAC and surveyed weighting value

Assessment Topic, Criteria	BEPAC Weighting Value	Surveyed Weighting Value
Ozone Layer Protection		(0.20)
•Ozone Layer Depleting Substance Inventory	0.60	0.50
•System Design and Installation Standards	0.20	0.20
•Provision for future Retrofit to Non-Ozone Layer Depleting Equipment	0.20	0.30
Environmental Impact of Energy Use		(0.30)
•Annual Greenhouse Gas Emissions Avoidance	0.35	0.30
•Annual Regional Air Pollution Avoidance	0.10	0.10
•Annual Electrical Energy Conservation	0.15	0.20
•Peak Electirical Demand Reduction	0.10	0.10
•Building Envelop Design	0.10	0.5
•HVAC Systems	0.05	0.5
•HVAC Equipment	0.02	0.5
•Energy Management Control Systems	0.02	0.5
•Lighting & Electrical Systems	0.10	0.5
•Service Hot Water Systems	0.01	0.5
Indoor Environmental Quality		(0.25)
•Indoor Air Quality		0.40
•Lighting Quality		0.40
•Acoustic Control		0.20
Resource Conservation		(0.20)
•Preservation of Building and Landscape	0.2	0.20
•Reduced Environment Impact of Materials	0.2	0.20
•Wood Conservation	0.10	0.10
•Site Water Control	0.15	0.20
•Building Water Conservation	0.15	0.10
•Waste Recycling Facilities	0.20	0.20
Site and Transportation		(0.05)
•Site Use	0.5	0.50
•Building Design and Transportation	0.5	0.50

( )is weighting value of assessment topic level

Table 3 Assessment Area and Category of GBTool and surveyed weighting value

Performance Area , Category	Average Value of 14 countries	Surveyed Weighting Value
Resource Consumption	(0.22)	(0.21)
R1 Energy	0.39	0.47
R2 Land	0.19	0.10
R3 Water	0.21	0.27
R4 Materials	0.22	0.17
Environmental Loadings	(0.2)	(0.24)
E1 Airborne Emissions	0.36	0.42
E2 Solid Waste	0.22	0.24
E3 Liquid Waste	0.22	0.24
E4 Other Loadings	0.2	0.10
Quality of Indoor Environment	(0.19)	(0.19)
Q1 Air Quality	0.28	0.23
Q2 Thermal Quality	0.2	0.28
Q3 Visual Quality	0.16	0.18
Q4 Noise and Acoustics	0.18	0.13
Q5 Controllability of Systems	0.17	0.18
Longevity	(0.16)	(0.17)
L1 Adaptability	0.46	0.45
L2 Maintenance of Performance	0.54	0.58
Process	(0.11)	(0.10)
P1 Design and Construction Process	0.51	0.42
P2 Building Operations Planning	0.49	0.58
Contextual Factors	(0.11)	(0.09)
C1 Location and Transportation	0.5	0.42
C2 Loadings on Immediate Surroundings	0.5	0.58

( )is weighting value of performance area level

CASE STUDY

Case study building

The energy conservation building in Japan was assessed by BREEAM, BEPAC and GBTool as case study. The case study building was designed to be one of the best energy saving office building and constructed in suburb of Tokyo in1982. This building has 98 energy -conservation techniques. The main conservation techniques are Solar Heating and Cooling, Double Skin, Thermal Storage Tank, Ductless Ceiling, Underground Duct, Solar energy storage in underground soil, Task and Ambient Lighting, Daylight Utilization and Solar cell.

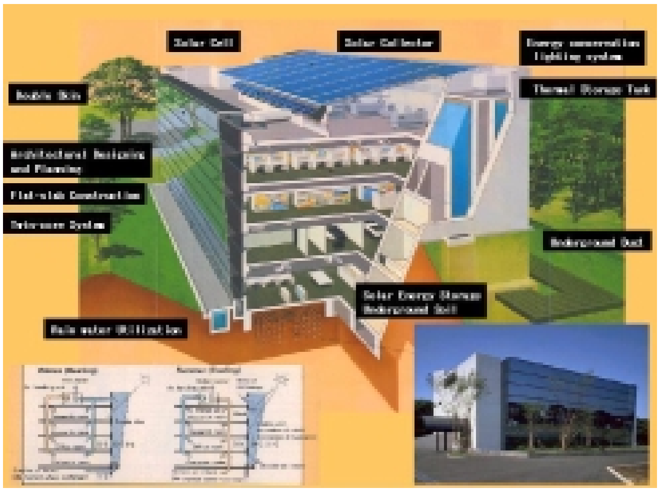

Fig.1 Summary of the case study building

Assessment Results

Assessment results of the case study building by BREEAM, BEPAC and GBTool are shown in Table4.

Table 4 Assessment result of case study building

	Surveyed Weighting Value	Score of criteria level	Weighted Score
BREEAM			
Global Issues and Resources	0.40	94	37.6
Local Issues	0.30	73.3	22
Indoor Issues	0.30	76.7	23
Total	1.00		82.6
BEPAC			
Ozone Layer Protection	0.20	75	15.0
Env. Impact of Energy Use	0.30	97.7	29.3
Indoor Environmental Quality	0.25	65.6	16.4
Resource Conservation	0.20	41	8.2
Site and Transportation	0.05	86	4.3
Total	1.00		73.2
GBTool			
Resource Consumption	0.21	67	14.1
Environmental Loadings	0.24	47.8	11.5
Quality of Indoor Environment	0.19	49.6	9.4
Longevity	0.17	15.4	2.6
Process	0.10	36	3.6
Contextual Factors	0.09	33.8	3.0
Total	1.00	-	44.2

The final score are obtained by using weighting value and full score is modified to be 100. The final score of the case study is 82.6 by BREEAM, 73.2 by BEPAC and 44.2 by GBTool. The final score of GBTool is different from the score of BREEAM and BEPAC because the different benchmarks and standard were used at assessment process and GBTool includes new and various assessment criteria which were not considered at the design stage of the case study building, 16 years ago.

The user and designer of the case study building commented that the assessment result is similar to their impression of the case study building.

CONCLUSION

The weighting value of assessment criteria of BREEAM, BEPAC and GBTool were decided based on the questionnaire survey to Japanese building engineers. They think that the assessment criteria like “Global issue and resources”, “Environmental impact of energy use “ and “ Environmental loading” are important, so these criteria will be introduced easily into Japan and should be included in assessment method.

It is important to establish appropriate benchmarks and calculation methods for assessment tool in Japan. And it is also needed to ensure the objectivity and validity of the assessment process.

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COMPARATIVE ASSESSMENT OF GBC 2000 AND LEED: LESSONS LEARNED FOR INTERNATIONAL AND NATIONAL SYSTEMS

Joel Ann Todd
The Scientific Consulting Group, Gaithersburg, Maryland, USA
Gail Lindsey, AIA
Design Harmony, Wake Forest, North Carolina, USA

INTRODUCTION

One of the primary goals of the Green Building Challenge, both in 1998 and 2000, has been to provide a framework for building assessment systems that can be used by government agencies and other organizations to develop more powerful systems for use within their countries, regions, or cities. Within the United States, the U.S. Green Building Council has developed a building rating system called Leadership in Energy and Environmental Design (LEED™). GBC 2000 and LEED™ use different approaches to building assessment, although the two systems address many of the same topics. This paper compares these two systems; in addition, the U.S. National Team for GBC 2000 will compare the application of these two systems to several buildings and will present the results at the Sustainable Building 2000 Conference on October 2000.

OVERVIEW OF GBC 2000 AND LEED™ ASSESSMENT FRAMEWORKS

Overview of GBC 2000

GBC 2000 has been developed by an international committee and is intended to be tailored to respond to national and/or regional differences. It assesses buildings in four categories: resource consumption, environmental loadings, indoor environmental quality, and quality of service. It also includes environmental sustainability indicators, absolute measures that permit comparisons among countries, as well as several categories that are optional in the current framework, including economics and pre-operations management. Within each category, there are specific criteria, and sometimes sub-criteria, that are assessed and assigned scores ranging from –2 to +5. Individual items are weighted to indicate their importance; scores are multiplied by these weights and the resulting values are summed. The GBC framework has been refined and simplified based on its use in GBC '98 as well as further discussions by the international framework committee.

Overview of LEED™

LEED™ was developed by the U.S. Green Building Council, a voluntary association of architects, builders, product manufacturers, environmental groups, and building owners. It awards ratings of certified, silver, gold, and platinum. To obtain a rating, a building must meet seven prerequisites and then obtain points for credits related to sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. LEED™ also includes points for innovations and for involving an accredited professional in the design process. The LEED™ rating system, Version 1.0, was pilot tested and refined by the Council and outside experts. Based on this pilot test, 12 buildings received certification. Version 2.0 is now available.

COMPARISON OF GBC 2000 AND LEED™

Comparison of Overall Design

GBC 2000 and LEED™ have fundamental differences in design and approach which are discussed briefly in this section.

- **Approach**. The GBC 2000 framework is organized around environmental impacts or other effects of building design elements, such as atmospheric emissions or resource consumption. In this framework, for example, non-renewable energy use is viewed as both a resource consumption issue and an air pollution issue. LEED™ is organized around inputs – the areas in which architects, designers, owners, and builders must make decisions – such as site, water, energy, materials, and indoor environment. As a result, the LEED™ system is somewhat more "user-friendly" and is more readily used as a tool in the design process. On the other hand, the GBC 2000 framework demonstrates more clearly the effects of these decisions.

- **Scoring.** The GBC 2000 framework uses a scale, ranging from –2 to +5 for each element, indicating the level of performance on each criterion and subcriterion. This can include performance that is below average as well as performance that is above average to exceptional. In LEED™ , users only score the building on those elements for which they intend to get points toward a final total. If the building is below average on other elements, the final score is not affected. In LEED™, most criteria are not scalar – the building either meets the criterion and receives the point(s) or it does not. Thus, GBC 2000 provides a more complete assessment of the building and allows for finer differentiation of gradations of performance.
- **Metrics** Both systems include a mixture of performance-based criteria and prescriptive criteria. Both sponsoring organizations have attempted to move toward performance-based criteria to the extent possible. Both are based on pre-occupancy modeling and design, not on post-occupancy monitoring of actual data.
- **Non-Environmental Criteria**. GBC 2000 explicitly goes beyond strictly environmental criteria. A number of GBC 2000 criteria address the building in the context of its community or neighborhood, including effects of the building on adjacent properties. Other criteria address building amenities for users; for example, both GBC 2000 and LEED™ have criteria related to shading for parking lots – in GBC 2000 this is under Quality of Amenities and Site Development whereas LEED™ focuses on the use of shading to reduce heat island effects. GBC 2000 also includes economic criteria, although they are not included in the scoring for the 2000 assessments.
- **Benchmarking.** The GBC 2000 framework assesses levels of performance against a similar "benchmark" building or accepted standards and codes. This permits the definition of "above average" and "exceptional" performance in terms that are relevant to the conditions in which the project is located. LEED™ criteria are uniform nationwide and for various types of settings, such as urban, suburban, and rural. Users of LEED ™ have noted that this approach results in many criteria being not applicable or not attainable at any cost for specific projects. Because of the ability to tailor the GBC 2000 criteria, ratings of buildings are generally not comparable; to address this issue, the framework has added the universally-applicable environmental sustainability indicators.
- **Documentation**. LEED™ specifies how the design team must document all prerequisites and credits to receive points. GBC 2000 does not require external verification of data.
- **Weighting** The GBC 2000 framework includes weights that are intended to indicate the importance of various criteria and subcriteria. National teams can modify the default weights to reflect conditions in their countries or in specific regions. LEED ™ does not include a weighting system and, therefore, weights all items equally. The U.S. Green Building Council took this approach due to the lack of an agreed-upon methodology for selecting weights among disparate categories.
- **Communicating Results.** The GBC 2000 system produces a visual representation of the assessment results, with histograms indicating the scores in each category and for each major criterion. LEED™ has a checklist that indicates the credits received and then produces a rating – based on total points.

Comparison of Specific Elements

Page limitations for this paper preclude a comprehensive comparison of these two systems. This section presents a few highlights of areas in which LEED™ criteria differ from GBC 2000 criteria.

- **Resource Consumption**. LEED™ includes criteria such as minimum and optimal energy performance, reduced site disturbance, site selection, brownfield redevelopment, water efficient landscaping, water use reduction, building reuse, resource reuse, and recycled content of materials that correspond to GBC 2000 resource consumption criteria (energy, land, water, materials). LEED™ also includes credits for use of local materials (included in GBC '98 but deleted from GBC 2000 due to difficulty in gathering data), use of rapidly renewable materials, and use of certified wood. GBC includes several criteria not found in LEED™ that relate to planning for recovery and reuse or recycling of materials during future building renovation, refurbishment, or demolition.
- **Loadings**. This area illustrates one of the significant differences between the systems. LEED™ does not explicitly address environmental loadings, although certain credits equate to the intent of GBC 2000 loadings criteria, such as CFC reduction, elimination of HCFCs and Halons, storage and collection of recyclables, stormwater management, and innovative wastewater treatment technologies. Further, LEED™ does not address impacts on adjacent properties that are included in GBC 2000. LEED™ does include the reduction of light pollution, which is not addressed in GBC 2000, as well as construction management to reduce waste, which is included in the GBC 2000 framework but is not scored.
- **Indoor Environmental Quality**. Both GBC 2000 and LEED™ have a separate category of criteria for IEQ. GBC 2000 contains a far more detailed list of criteria and subcriteria, in terms of moisture control, pollutant control, ventilation, thermal comfort, and noise and acoustics. LEED™ contains criteria on environmental tobacco smoke, monitoring, and construction management not found in GBC 2000.
- **Quality of Service**. Most of the GBC 2000 criteria in this category are not addressed in LEED, including flexibility and adaptability of the building, controllability of systems, maintenance of performance, and quality of amenities and site development.

CONCLUSION

Overall, the different approaches used by GBC 2000 and LEED™ both have significant strengths that are not present in the other system. Each could, perhaps, benefit from considering how these strengths could be incorporated. Specifically,

- GBC 2000 provides a complete assessment of the building, including both strengths and weaknesses, whereas LEED™ only addresses those areas chosen by the design team, assumed to be strengths. In other words, LEED™ is silent on areas of weakness or poor performance. As a result, the picture given of a building by LEED™ is certainly incomplete and does not necessarily reflect overall green (or high) performance.
- LEED™ provides a relatively straightforward checklist of credits which are linked to design strategies. It can be used as a tool by the design team to identify potential strategies for a project and to encourage green design. GBC 2000 is not designed to be used as a tool and does not function well in that role. As a result, its use will probably be limited to researchers and organizations that are attempting to design or improve assessment systems and design tools.

In summary, the GBC 2000 approach is more effective in defining and evaluating a green or high performance building overall, whereas the LEED™ approach is more effective in encouraging and assisting a team to design and build a green or high performance building. The presentation of this paper at the Sustainable Buildings 2000 Conference will include a comparison of the results of applying these two systems to several buildings in the United States.

GREEN BUILDING CHALLENGE
LESSONS LEARNED FROM GBC '98 AND GBC 2000

Raymond J Cole[1] and Nils Larsson[2]

[1]University of British Columbia, Vancouver, Canada
[2]Natural Resources Canada, Ottawa, Canada

INTRODUCTION

Green Building Challenge is an international collaborative effort to develop a building environmental assessment tool that exposes and addresses controversial aspects of building performance and from which the participating countries can selectively draw ideas to either incorporate into or modify their own tools. The *Green Building Challenge* process is an ongoing one of exploration and refinement that has now gained experience through two cycles of developing and testing a comprehensive assessment method – GBC '98 and GBC 2000.

The development and testing of the *GBC Assessment Framework* and the attendant *GBTool* during the *GBC '98 process* exposed numerous detailed technical issues and more fundamental conceptual weaknesses. In addition to addressing these concerns, the assessment framework for *GBC 2000* has been reviewed and applied by seven new participating countries from a wider geographical and cultural pool than in the first iteration.

This paper compares and contrasts the significant characteristics of the *GBC '98* and *GBC 2000* frameworks. The specific intention is to identify the lessons gained through this extensive process and to offer a series of possible directives on the structuring and content of future building environmental assessment tools. At the time of writing this paper, the National Teams were in the initial stages of using the new version of *GBTool* perform assessments on the case-study buildings and there was little direct application experience or feed back related to the new version of the system. This paper therefore focuses on the evolution of the underlying arguments related to *GBC'98* that have led to significant shifts in the versions of *GBTool* created for *GBC 2000.*

COLLABORATIVE DEVELOPMENT PROCESS

In the rapidly evolving field of building environmental research and practice, many players have different agendas and requirements. Unlike environmental assessment tools that are developed within confines of a single organisation, *GBTool* derives from an international collaborative process. This involved seeking a consensus among a variety of different cultural viewpoints and the need to reconcile different expectations of an assessment tool by National Team members who consisted of academics, researchers and practitioners.

Earlier discussions related to the potential use of *GBTool* as a design tool or assessment tool. Although still an issue, this has been subsumed by the related issues of "complexity-simplicity." Although the primary role of *GBTool* has been its application in assessing the GBC case-study buildings, it validity as a market tool has become more evident in the discussions. Several of the new countries entering the GBC process do not have a domestic assessment method and see *GBTool* as the logical starting point for developing one.

GREEN AND SUSTAINABLE AGENDAS

The distinction between "green" and "sustainable" agendas and their implications for the development of *GBTool* has been a continuing issue. Assessing "green" performance is more fundamentally rooted in the practicalities of current building delivery and is therefore perhaps more readily acceptable to building owners and practitioners. This is clearly both an advantage and a limitation. There is an implicit assumption in existing methods that "green design," by continually reducing resource use and ecological loadings, is charting a sustainable path. Although recognizing the ultimate shift required to position building environmental assessment under the umbrella of sustainability, *GBTool* remains directed at assessing green performance. The *GBC 2000 Assessment Framework* provides a measure of both:

- the environmental building performance of a case-study building relative to typical practice for that building type and region ("Green" performance), and
- the absolute performance in a selected set of performance criteria to contrast with other buildings in different regions ("Environmental Sustainability" performance).

Green Performance
Green performance is defined in six general *Performance Issues:*

- The first four - *Resource Consumption, Loadings, Indoor Environmental Quality* and *Quality of Service* - are considered "core" requirements in the *GBC* assessment. These contain the more direct and widely accepted environmental issues that are evident in all building environmental assessment methods. Conceptually, it is useful to consider the resource consumption and loadings as the environmental cost of providing "services" such as human health and comfort and other amenities such as adaptability, controllability etc. As in *GBC 98*, criteria and sub-criteria in these performance issues will be scored using the –2 to +5 assessment scale.
- The remaining two – *Economics* and *Pre-Operations Management* - will not be scored but simply be reported as text descriptions.

Sustainability Performance
Environmental Sustainability will necessitate absolute measures of resource use and environmental loadings associated with buildings, both individually and collectively. As such, *GBC 2000* will include the presentation of *Environmental Sustainability Indicators* (ESIs) along with the relative assessment profiles. ESIs are measures that characterize sustainable building practices and that would facilitate international comparability, including: Net annual consumption of primary energy for building operations, Annual GHG emissions from building operations, Net area of land consumed for building and related works, and Net annual consumption of water from building operations.

BENCHMARKS AND SCALES
Assessment implies measuring how well or poorly a building is performing, or is likely to perform, against a declared set of criteria. One of the significant contributions offered in *GBC 98* was the explicit declaration of "benchmarks" against which performance of the case-study buildings were assessed.

All performance criteria and sub-criteria assessed in *GBC* are set within performance scales ranging from –2 to +5. Performance scores are presented in a consistent manner all relative to an explicitly declared benchmark- the zero (0) on the performance scale. In *GBC '98* National Teams were expected to establish a "reference building" – one of the same size, shape, use, and operation schedule as the case-study building, designed assuming minimal industry norms in the region – as the basis for setting benchmark performance levels. Though the notion of having explicit benchmarks as an essential requirement of an assessment method was unanimously accepted, the use of a *Reference Building* proved universally problematic, both conceptually and in practice. National Teams typically chose benchmarks derived from national databases and other statistically based sources.

Benchmarking is now an accepted approach in *GBC 2000* and National Teams are left to determine and justify-suitable and defensible industry benchmarks bearing in mind the overall intent of the *GBC* process. In defining appropriate benchmarks, quantifiable issues (energy use, water use etc.,) are assumed to be either minimum code requirements or typical practice, depending on access to reliable data. For many of the qualitative criteria considerable judgement will be required. The default benchmarks for these are simply a declaration of what would be considered to be a typical condition or typical practice for the building type in the region. Moving away from the notion of a reference building as the basis for deriving all benchmarks has made the process simpler.

NORMALISING DATA
Using a common assessment scale offers the advantage of structuring the range of possible performances in a consistent and explicit manner. Comparing performance against a declared benchmark also requires the use of consistent performance measures for each assessed criterion, i.e., performance data for the case-study building is in the same units as the benchmark performance. Some

level of normalizing is necessary to enable this comparison. Many environmental issues in other assessment systems are expressed per unit are of the building, e.g., energy in GJ/m^2 or kWh/m^2 to account for variations in building size (e.g., between the case-study building and the benchmark.)

GBC 2000 uses a further level of normalization to account for variations in building occupancy patterns. Appropriate criteria are normalized for occupancy; in most cases the annual person-hrs of occupancy but in a few cases, the number of occupants. This is an important new emphasis in that it clearly offers a more appropriate basis for comparing the performance of a *building design.* However, increasing the number of variables included in the normalization can also diminish the validity of performance score, i.e., an estimated value of annual operating energy will be divided by an area, then by estimates of annual occupancy hours. Since this is repeated or inherent in the benchmark, the accuracy of scores based on the relative differences can quickly diminish.

WEIGHTING

Weighting has emerged as an important issue in building environmental assessment and there is considerable interest within the IFC on weightings, the protocols for deriving them and their inclusion in building environmental assessment methods. Analysis of the *GBC '98* performance assessments confirmed the significant role that the selection and application of weightings had on the overall building performance profile and score. Weighting is intimately linked with the summarizing and communicating of performance results. *GBTool* assesses approximately 100 individual sub-criteria and criteria and it is therefore necessary to reduce the assessment scores to a manageable number in the output profile.

Unlike *GBC 98*, which offered summary scores at four levels, the output profile at *GBC 2000* shows the aggregated scores only up to the *Category* level. This entails only two levels of weightings and thereby considerably reducing amount of subjectivity that was criticized in *GBC '98.* However, the lack of declared weighting differentials at the Category level means that their relative significance of energy, land, water and materials within Resource Use, or between resource use, loadings and indoor environmental quality, will not be explicit in *GBTool.* Although it will not be applied in assessment of case-study buildings in *GBC 2000*, National teams have been requested to report on the relative importance of the various categories to gauge international priorities on environmental issues.

ACCOUNTING FOR CONTEXT

The issue of *context* has emerged as an explicit part of the GBC assessment framework – and indeed, this may ultimately prove to be next significant conceptual advance in building environmental assessment.

The *GBC '98* framework recognized that the environmental performance of buildings extend beyond their physical envelope, and included a *Contextual Factors* performance area with categories dealing with *Location and Transportation*, and *Loadings on Immediate Surroundings* to represent these broader implications. These have been relocated in other categories within the *GBC 2000* framework. *GBC 2000* begins to explicitly acknowledge that the relative importance/significance of both the scoring scales and the appropriate weightings for the various criteria/sub-criteria are also contextually bound (i.e., the scoring scales and weightings are made relative to declared information about the 'environmental context' in which the building sits.)

CONCLUSION

Some aspects of *GBTool* have been improved over the initial version used in *GBC 98* – change to an *Excel™* platform, reduction on number of weightings, non-requirement of reference building for benchmarking etc. However, continuing to reconcile and satisfy different requirements and expectations (detailed assessment to be comprehensive/simplicity in use etc.) diminish the conceptual clarity of the resulting tool. Further developments of *GBTool* and indeed the *GBC* process must ultimately sharpen this focus.

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RESULTS OF IEA-ECBCS ANNEX 31 WORK ON ENVIRONMENTAL ASSESSMENT OF BUILDINGS AND RELATED TOOLS

Roger Baldwin [1], Peter Russell [2], Dr Sylviane Nibel [3], Chiel Boonstra [4], Dr Thomas Lützkendorf [5]

1. Ex-Director of Centre for Sustainable Construction, Building Research Establishment, 15, Harford Drive, Watford, Herts WD1 3DQ, UK, Tel : +44 (0) 1923 226863, E-mail : RogerBaldwin1@compuserve.com
2. PRA (Peter Russell Associates), 12, Mowat St., Gloucester, Ontario K1J 6R2, Canada, Tel: +1 613 744-8062, Fax: +1 613 744-8873, E-Mail: prussellassoc@home.com (ex CMHC)
3. Centre Scientifique et Technique du Bâtiment (CSTB), 84, av. Jean Jaurès, Champs-sur-Marne, BP 2, F-77421, Marne-la-Vallée Cedex 2, France, Tel : +33.(0)1.64.68.83.01, Fax : +33.(0)1.64.68.83.50, E-mail : nibel@cstb.fr
4. Ex W/E consultants sustainable building, P.O. Box 733, 2800 AS Gouda, The Netherlands. Currently employed at DHV Accommodation and Real Estate, Amersfoort, The Netherlands, E-mail : chiel.boonstra@aib.dhv.nl
5. Bauhaus-University, Department of architecture, Bauhaus -Str. 7b, D 99421 Weimar, Germany, Tel : +49 3643 58 3435, Fax : +49 3643 58 3438, E-mail : thomas.luetzkendorf@archit.uni-weimar.de

INTRODUCTION

This paper presents a brief overview of the results of a three-year collaboration between international experts on the environmental assessment of buildings, components and materials under the auspices of the International Energy Agency (IEA-ECBCS), Annex 31. In this project, 14 countries were gathered, with Canada as a leader.

The aim of the Annex was to provide building sector researchers with information to improve methods and data for measuring the energy-related effects of buildings on their interior, local and global environments. The Annex thus provides a resource book from which others can generate methods, software, guidelines, data bases etc. that have direct applicability to their own countries and audiences.

The work has been divided in three sections : Theory, Application and Resources. The results are presented in the form of a summary book, accompanying a CD which gives a full presentation of the Annex report [1]. Further information is also available on the Annex 31 Web-Site [2].

The work has been concerned with the environmental impacts of buildings, focussing on :

- Individual buildings and groups of buildings
- Energy-related impacts, but also examining other types of impact
- All phases of the life cycle of a building from "cradle to grave"
- The way assessment tools operate

The main results of the collaboration are :

- A review of the decision-making process
- A discussion of key theoretical issues in the development of assessment tools
- A catalogue and typology of major tools in current use internationally
- A methodology for the assessment of building stocks
- An up-to-date review of data bases, particularly those relevant to buildings
- A review of benchmarks and target values
- A comparison of major tools when used to assess two typical buildings
- Case studies of environmental assessments carried out in the real world
- A glossary of terms in common use

CONTEXT AND SCOPE

Tools are intended primarily to aid decision-makers, so that they can make informed decisions about environmental matters within their area of responsibility. A key role for tools is to provide appropriate and timely information on the nature and volume of these impacts, so that rational choices can be made. It follows that careful consideration must be given to the output of the assessment to ensure that it is relevant, understandable, user-friendly and of an appropriate accuracy.

Tools have to link the decision-making process with the technical system or object being assessed and the environment (or the "technosphere" and the "biosphere"). It must fit the phases of the construction life cycle, and decisions that are made at each stage (actors' framework). At the same time it must model the physical reality of the environmental impacts (physical framework). This is represented schematically in Figure 1.

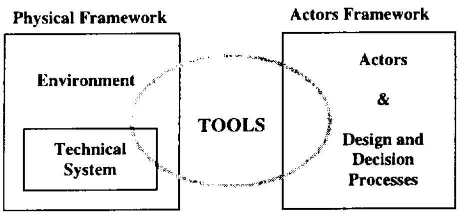

Figure 1 : Scope of Annex 31 work

In its Theory section, the Annex 31 final report describes the different entities of Fig. 1 : the decision-making process, the technical system (building on its life cycle) and the environment, with their interrelations.

MAIN ISSUES IN DEVELOPING TOOLS

As far as tools are concerned, they were studied from a methodological point of view, ending with recommendations targeted at advisors and tool developers. The work focused of the following key theoretical issues :

- Users of the tool (expert, end-user) and their needs
- Interaction with the design and decision-making process
- Output sets (list of relevant outputs) and indicators (requirements)
- Scope and scale of assessment (object to be assessed, system boundaries, phases of the life cycle, part of the infrastructure)
- Assessment methodology (LCA and other approaches)
- Input Requirements (amount, quality, format, availability of data)
- Benchmarks and target values (low-level, high-level, survey, use)
- Aggregation and weighting (difficulties, different approaches)
- Sensitivity and uncertainty analysis
- Presentation of results (and their interpretation)
- In addition, specific issues e.g. « adaptability » and « recycling potential ».

SURVEY OF TOOLS

Two types of tool have been distinguished:
- **Interactive tools,** provide calculation and evaluation methods which enable the user or decision maker to take a pro-active approach (to explore a range of options in an interactive way)
- **Tools as instruments**, are passive aids to decision-making, of a more general nature, which do not allow an interaction with the user.

An international survey was carried out on interactive tools (27 tools from 12 countries). Details of the tools and the survey are on the Annex Web Site; details of the analysis are in the main report on the CD, taking advantage of a work on tool typology.

The Annex report reviews a number of general types of instrument often used in the planning, procurement and design processes. These instruments typically provide guidance, advice and benchmarks of a more general nature (e.g. guidelines, checklists, element catalogue, products labelling, etc.).

DATA NEEDS AND SOURCES

A specific chapter reviews the needs for data to support tools and the decision making processes and the sources and quality of such data. A survey was carried out of existing data bases and their availability (20 databases from 10 countries, see full details on the Annex 31 Web Site). Key recommendations for databases users and developers are given in the final report, in terms of flexibility of inventory data, documentation of data, sensitivity analysis, transparency, metadata and existing formats.

STOCK AGGREGATION

Stock Aggregation is a technique used to analyse the environmental impacts of a stock of buildings together with their infrastructure.

The Annex 31 Report describes a bottom-up method which enables one to model the impacts that technological changes at the building level might have when introduced into the entire stock.

Stock Aggregation methods calculate total energy and resource statistics by analysing empirical data on buildings and infrastructure. In order to characterise the entire building stock, the method described in the Annex 31 Report employs *building archetypes*.

The Annex Report reviews the benefits and limitations of Stock Aggregation methods, and offers recommendations on how to maximise their usefulness and accuracy.

APPLICATION OF TOOLS

The Annex report contains the results of the application of a dozen different tools to two buildings, a domestic building and an office building. The aims of the work were to demonstrate available tools for the assessment of energy-related impacts of buildings and to show how the tools provide guidance on improvements to environmental performance.

Results were analysed and compared, but not deeply because it is a difficult task. Differences appeared in the results. Clearly, system boundaries are not always the same, and regional differences, for example in transport, or in electricity mix, lead to significant variation. It is clear that the application of tools outside the country of origin should be undertaken with caution.

From this application of tools it can be concluded that :

- Transparency of a tool is one of the most important characteristics. Not every user has to be able to see the ins and outs of a tool, but experts need that information to be able to draw conclusions
- Further research is necessary to compare and judge the quality of tools
- Uncertainty analysis and variability analysis are necessary because they are very important to interpret the results of the tools
- It is desirable to develop tools which can be used early in the design and planning process, and then throughout the whole design

CASE STUDIES

Case studies of the application of environmental assessment tools to actual construction projects have been identified and documented in six of the countries represented in the Annex.

IEA ANNEX 31 WEB SITE

The web-site has been set up to include detailed information on the results of the Annex [2]. It contains the following chapters:

- Surveys (Interactive tools and tools as instruments, Evaluation methods, Calculation methods, Benchmarks, Data bases, Decision-making)
- Sources (compilation of works)
- Glossary
- Dictionary
- Contacts

CONCLUSIONS

Annex 31 results show a wide panorama of methods, tools and databases dealing with building environmental assessment, with particular attention given to energy-related impacts. Conclusions and recommendations have been drawn. This panorama is both theoretical and practical, illustrated with exercises and examples of actual use. Furthermore, the technical work has been linked to the decision-making process. The work took advantage of synergies with other national or international projects.

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MCDM-23: A MULTI-CRITERIA DECISION MAKING TOOL FOR BUILDINGS

Dr. J. Douglas Balcomb and Adrienne Curtner
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, Colorado 80401 USA

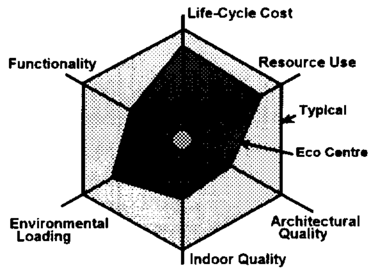
a. Introduction

To achieve a design for a building that will be sustainable, the design team must consider a multitude of criteria. Typically the team reaches a point in the schematic phase of the design process where two or more design options have been proposed. A decision must be made - which option should be pursued? A similar situation is reached in a design competition, where a jury must choose between alternative design proposals. This paper describes a tool that will help in making the best decision.

The tool is a computer program called *MCDM-23*. It has been developed at the National Renewable Energy Laboratory within the context of the twelve-country International Energy Agency Solar Heating and Cooling Task 23, which concerns *Optimization of Solar Energy Use in Large Buildings*. The tool automates many tasks involved in using the multi-criteria decision-making procedure being developed within Task 23. The end products of the program are worksheets and associated star diagrams that quantify how two or more design schemes stack up according to six main criteria, *Life-Cycle Cost, Resource Use, Environmental Loading, Functionality, Architectural Quality, and Indoor Quality*. Some of these criteria are inherently subjective in nature and others are objective in that they are amenable to quantitative evaluation. Each of the main criteria includes 3 to 6 sub-criteria (which can be renamed).

The diagram shows the final diagram, printed directly from the program.

Multi-Criteria Building Performance Chart



b. Presentation

The *MCDM-23* program does not reduce the building design process to a prescriptive procedure. Rather, it provides a framework within which to carry out the several tasks inherent in a partly subjective decision-making process. It facilitates rather than dictates. The key 8 steps are: (1) vote to determine weights and sub-weights, (2) evaluate a reference building and enter scores, (3) consider two or more design schemes, (4) calculate scores for objective criteria, (5) vote on subjective criteria, (6) enter scores for each scheme, (7) print a worksheet and star diagram for each scheme, and (8) select the winning scheme. The star diagram, such as the one shown here, is a compact way of displaying the whole picture in one graphic that can be easily interpreted by anyone—architect, engineer, client, energy analyst, building official, reporter, or layman. A smaller footprint is better on this diagram.

The *MCDM-23* process uses a simple weighting scheme to determine the 6 main criteria scores and to combine these 6 scores into an overall building score. The weights are determined by having the participants vote their preferences. The Analytical Hierarchy Process (AHP) is then used to calculate the weights. The objective criteria sub-scores must be determined by some independent tool, such as the *ENERGY-10* building simulation program. The subjective criteria sub-scores can be determined by having the participants vote. These scores are entered into *MCDM-23*. Calculations are carried out in a worksheet format programmed within the tool.

MCDM-23 is inherently different than a rating tool; such as the GBC tool, LEED, or BREEAM; in that it is designed as an aid for decision making *prior to* final design rather than a means of scoring a completed building. An additional major advantage of the *MCDM-23* tool is that it provides a compact and readily understandable means for documenting how decisions were made. This is particularly important in public buildings.

In MCDM-23, six major criteria were identified. This selection was done within the IEA Task-23 group, which includes a mix 25 highly knowledgeable and experienced designers, engineers, and analysts. However, the criteria may vary from case to case. The *MCDM-23* tool therefore offers the possibility to change or exclude some of the criteria

The design team will probably not agree on these criteria and weights. However, the weights can all be changed and the names of the sub-criteria under architectural quality and functionality can all be changed to better reflect the team's perspectives. With this flexibility, the choice of criteria should be acceptable to most teams. Gaining acceptance at the beginning is very important.

The 5 steps in using *MCDM-23* during the preliminary design phase are as follows:

The design team determines their preferences for the relative importance of the six main criteria. The process is repeated for the sub-criteria for architectural quality, indoor quality, and functionality. The Analytical Hierarchy Process (AHP) can be used to calculate the weights. For the quantitative criteria, life-cycle cost, resource use, and environmental loading, the sub-weights can be calculated. In the case of life-cycle cost, the program incorporates the life-cycle cost equations – the user enters the relevant financial parameters (discount rate, building lifetime, mortgage interest, discount rate, etc.) and the program calculates the three weights (coefficients).

The energy analyst enters performance values of the reference case the *MCDM-23* program. The energy, operating cost, and operating environmental loading associated with operation have already been calculated using *ENERGY-10*. The added construction cost is zero by definition. The only other values required are the environmental loadings associated with construction of the reference case. These must be estimated somehow. Scores for the qualitative criteria are usually all 5s (indicating typical performance).

The energy analyst calculates the performance of each of the schemes being proposed and enters these numbers into the *MCDM-23* program.

The design team determines the scores for the qualitative criteria using the 0-to-10 scale, and the results are entered into the *MCDM-23* program.

Print the worksheets and star diagrams. The team studies these results and makes their recommendations to the client.

An additional major advantage of the *MCDM-23* tool is that it provides a compact and readily understandable means for documenting how decisions were made. This is particularly important in public buildings.

The *MCDM-23* program automates the calculations, enters the results into the worksheets, and plots the star diagrams for each scheme. The design team than makes their selection based on all the information available, including the *MCDM-23* results.

There is no mystery to the process. All the intermediate results are displayed on the worksheets and are easily be verified using a calculator. The star diagram is simply a nice graphic representation of the performance of a scheme compared to the reference.

Users can quickly compare the performance of each scheme for each of the main criteria by visual inspection of its star diagram. At this point, the importance of the reference case is diminished because the star diagrams can be compared side-by-side. If the schemes do not exhibit evident differences, then they are probably not significantly different.

By its nature, preliminary design is an iterative process, cycling through a series of steps until the design meets all criteria. Each cycle typically involves design, evaluation, review, and revision. Both *MCDM-23* and *ENERGY-10* lend themselves to the evaluation step in each cycle. Again, emphasis must be placed on using the tool quickly so that the evaluations do not hold up the designers unreasonably.

Another use of the tools during preliminary design is performing sensitivity analyses. Because these are computer tools, they can be run repetitively incrementing single parameter over a range of values. The parameter can then be set to achieve the best performance. In this context, "best" could be the overall score, taking into account all effects captures in the evaluation. Historically, most such optimizations have been done on the basis of minimizing life-cycle cost. Having a tool such as *MCDM-23* available can broaden the nature of the optimization, quite possibly leading to significantly different choices.

c. Conclusions

Widespread use application of well known energy-efficiency measures and attention to other factors that affect building sustainability will require streamlining these considerations during the design process. A vital point in the process is the selection of one "best" design scheme from among alternates. The *MCDM-23* tool helps in making a good selection.

The stakes are enormous. Energy consumption, the single most important factor affecting sustainability, can typically be reduced by 50%, compared to conventional contemporary construction. This can usually by achieved without increasing the construction cost because of reductions in the installed capacity of heating, ventilating, and air-conditioning equipment, which typically accounts for 15 to 20% of the initial cost. These reductions often amount to 40% of the HVAC cost, paying for the added cost of all the other improvements that make the HVAC down-sizing possible.

The process described in this paper ensures that the most important issues that will affect building sustainability are considered equitably as vital decisions are being made during design.

Development of *MCDM-23* is a work in progress. Already, several countries have tried the process and made recommendations for changes. These are being implemented and the program will be updated when agreement is reached on the final procedure. The program will be made generally available when it has been finalized.

d. Acknowledgements

Thanks are due the 25 members of IEA Task 23 team who have all contributed in various ways to the development of this process. Anne Grete Hestnes is operating agent of Task 23. Inger Andresen contributed significantly. The *MCDM-23* tool was programmed in Visual Basic by Jun Tanimoto while visiting NREL on a post-doctoral assignment. Funding for the development of both *ENERGY-10* and *MCDM-23* is from the United States Department of Energy, Drury Crawley, Program Manager.

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VAMP - VALORIZATION OF BUILDING MATERIALS AND PRODUCT - A LIFE ENVIRONMENT PROJECT

Mr. E. Antonini, Mrs. A. Grossi
QUASCO -via Zacconi, 16 - 40127 Bologna (I) - tel.+39 051 6367811 /fax +39 051 6337814
ICIE-via Ciamician, 2 - 40127 Bologna (I) - tel+39 051 243131 /fax +39 051 243266

INTRODUCTION

Vamp is a project financed within the Life Environment Programme (LIFE 98 ENV/IT/00033). The prime proposer is Regione Emilia Romagna and its partners are:
Research Institutes (Quasco; Icie); Energy , Water, Waste and Environment local Authorities (Meta; Agac); Building Firms (Coopsette; CMB); Social cooperatives (Coopquarantacinque; Aliante).
The VAMP project aims to build an effective and innovative information system able to manage the waste flows produced by and/or recoverable in the construction and demolition sector as well as to test it in two Italian medium size towns and their surroundings.
The following presentation will describe the contents of the information system and the result of the first 16 months of research which will be completed at the end of 2000.

PRESENTATION

The Vamp management system goals are the quantity reduction of non-differentiated wastes, the reusable and recyclable parts valorization, the efficiency optimization of the local recovery activity networks existing in the area, the new employment opportunities promotion.
VAMP has planned to reach these objectives by implementing 4 main actions:

- establish a code of practice to help architects and builders to choose the most "environmentally friendly" techniques when carrying out the dissassembly activities;
- design and develop a "distributed information system" based on the existing municipal telematic network. and able to manage the waste flows produced by and/or recoverable in demolition/construction sector.
- test on field of the entire system functions, tools and operational performances. The test will run in real territorial situations and it includes the creation of two building sites pilot installations for the dissassembly methods;
- dissemination of the achieved results (to inform and to stimulate the system application in other areas) by whole actions including technical seminars; training programmes; folders, brochures and CD-Rom.

In the first 16 months of research the Vamp project achieved the following results:

- the dynamic(evolving) map of testing areas, which reports on the waste, the recycling and the treatment plants, the building and construction sites, the material and component collecting areas, as the part of the information system able to be connected with the territorial physical dimension and the transformations on it;
- the system model (Fig.1) in which the entities of the project ("the player's system"and the users system), the relationship between them, and the interesting Vamp system scenarios are defined, such as:
    - the life cycle assessment of the C&D materials
    - the physical flow (C&D materials flow) description
    - the logical flow (information flow) description
    - the IN/OUT model and the management of the materials flow

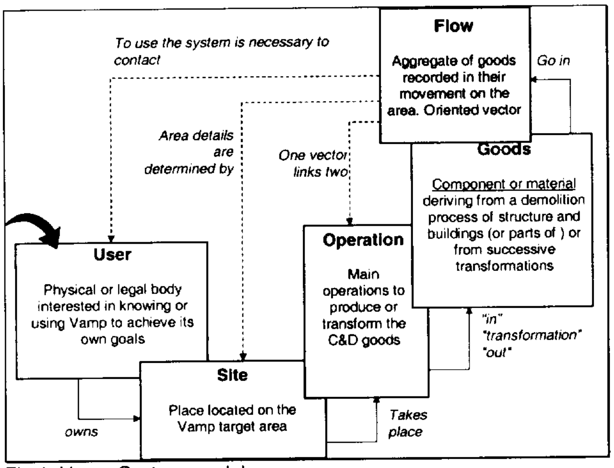

Fig.1: Vamp System model

- The tool with which Vamp is trying to make the best use of the flow of goods coming from C&D is a decision support system(DSS). This is a system of analysis of the information to help the decision making process, using information from a data base and applying a decision model to give useful advice for the formation of strategic plans. The Vamp decision support system must help users with their choices: :
  - for the dissassembly and/or demolition of buildings or parts of and
  - for the disposal and supplying of materials and components

The **Demolition Decision Support System (D- DSS)** is a useful tool for the deconstruction of the buildings on the site into reusable / recyclable parts. The aim of this part of the system is to help the user form the demolition plan containing: the assessment of the dissassembly and demolition feasibility, the bill of quantities which contains the work time and costs estimate and a code of practice to choose how best to carry out the dissassembly using environmentally friendly techniques. Five databases are the knowledge base of the D-DSS:

- building deconstruction model with the relationship between building components and the extracted materials of each one;
- assessment criteria of residual performance requirement and technical feasibility of component dissassembly
- assessment criteria of the possibility of separating and recycling of fragments and materials
- code of practice of dissassembly and demolition techniques for building deconstruction
- criteria of quantity estimate of extracted materials from building components.

The **Valorisation Decision Support System (V- DSS)** : the aim of this model is to provide support for the environmentally friendly and cost effective disposal/ supply of C&D materials and components produced by any users. This system indicates which recycling / disposal sites of C&D goods best meet Vamp system environmental requirements. The assessment is based upon two different kinds of criteria:

- economic criteria: waste management must be convenient for Vamp users. The first coeffients introduced in it are the disposal and the transport costs;
- environmental criteria: waste management must be 'environmental sustainable' to achieve the aim of the system. The coefficient of environmental assessment introduced in the system is defined for each activity in it.

During the designing of the Vamp model system it was decided to adopt the Web technology to create most of the parts of the software (fig.2), because it reaches more users than any other technology and gives a centralized solution to the management of the whole goods flow information and the local activities. The result is an exchange web site with a decision support system helping users in the demolition and valorisation processes of C&D goods.

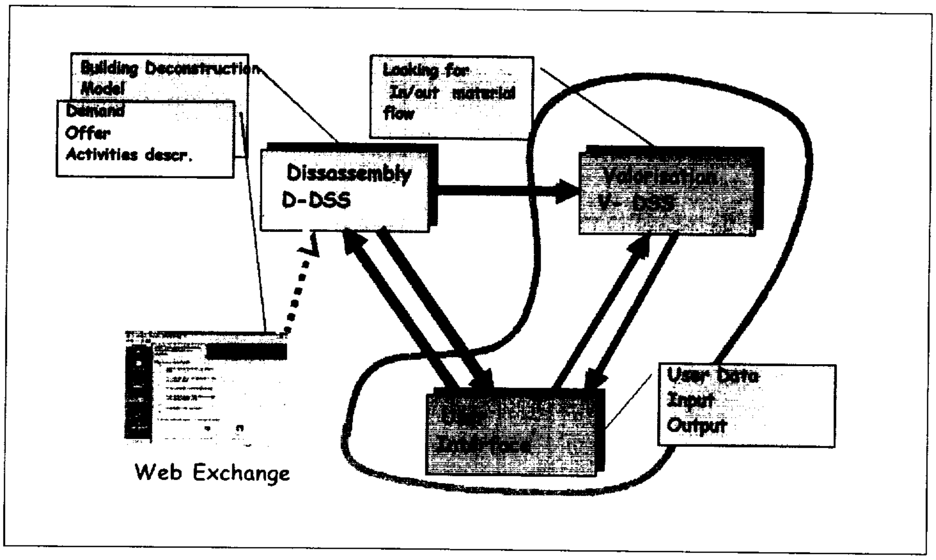

Fig. 2: Vamp web site.

CONCLUSION AND RECOMMENDATIONS

The 'theoretical result of the C&D material flow management should be to follow a life cicle model that , from the construction site through the different treatment and transformation passages, enables these materials to be reused in the construction field. But Vamp is a non-coercive system so it's not possible to oblige the users to bring the C&D materials to the most sustainable destination. Moreover the life cycle is due to several users and each one of these could decide to go out of the model piloted flow before the 'end of the cycle'.
Vamp system helps to choose the most sustainable destination but it is the users who take the decisions and the test is giving us the result that a completely pilotage of C&D materials could be better done by optimizing the life cycle model for a local network.

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IMPLEMENTING ENVIRONMENTAL PERFORMANCE ASSESSMENT METHODS: THREE INTERNATIONAL CASE STUDIES

Robert Lowe, Jaap Kortman, Nigel Howard

1. Centre for the Built Environment, Leeds Metropolitan University, Leeds, LS2 8BU, UK
2. IVAM Environmental Research, University of Amsterdam, Netherlands
3. Centre for Sustainable Construction, Building Research Establishment, Watford, WD2 7JR, UK

INTRODUCTION

As experience with Environmental Performance Methods grows, it is becoming clear that different implementation strategies may be required in different countries. The purpose of this paper is to report on a comparative study of the history of implementation of EPA in three countries, the UK, the Netherlands, and the US. The study has attempted to identify the objectives of each method, the specific constraints under which it was implemented and the stakeholders and decision makers involved in its implementation. We have attempted to relate the implementation route to prevailing political and regulatory structures, to stakeholder objectives, and to the wider structure of the construction industry in each country, and to explore the relationship between these external factors and the structure and methodology of each EPA method. The case studies have been chosen to span a wide a range in these variables.

UK - BREEAM

The first version of BREEAM was developed by the BRE in collaboration with ECD Partnership in 1990. BREEAM 1/90 led to a family of versions, covering existing offices, superstores and supermarkets and new homes. These have been updated periodically over throughout the 1990s.

Development of BREEAM has been funded by a combination of public and private bodies. The main goal of BREEAM 1/90 and subsequent versions has been to provide a tool to stimulate market demand for green buildings by providing transparent and credible information on environmental performance. Such information was rarely available for buildings designed before 1990 – indeed in many areas, BREEAM 1/90 was the first attempt to formulate a system of categories for environmental information. The BREEAM initiative was also an effective response to the political situation in the UK in the late 80s and early 90s. The general election of 1979 had brought about a profound change in the political climate. While an initial determination to dispense with building regulation completely was quickly softened, the government remained sceptical on the merits of regulation. For many years official energy policy was that there was no energy policy beyond ensuring that free markets were able to do their job as effectively as possible (DEn 1982).

Patterns of use reflect this approach. A survey of corporate BREEAM users in 1996 indicated that in most cases the method was applied with the aim of achieving direct corporate benefits – improved working environment, marketing advantages, lower running costs etc.

BREEAM has been most successful in the commercial building sector. BRE estimates that 25-30% of new office accommodation constructed since 1990 has received a rating using the method. Much smaller fractions of dwellings and existing commercial buildings have been rated. Extension of EPA into these sectors is the greatest challenge now facing BREEAM.

NL - Eco-Quantum

The development of Eco-Quantum started 5 years ago. The four year development was mainly funded by the Stichting Bouwresearch, SEV (Steering Committee for Experiments in Public Housing) and VROM (the Ministry of Housing, Planning and Environment). The programme was developed by IVAM Environmental Research, W/E Consultants, DuBo (Foundation for Sustainable Building) and Prisman.

The initiative was, in part, a response to frequent public discussions and legal battles between industry, organisations such as SEV and local governments over the environmental performance of building products. Local governments had and applied their own assessment instruments, which were not standardised. Suppliers of building products in the Netherlands found this diversity difficult.

The main goal of Eco-Quantum was to provide various actors in the building industry with one standard language to exchange information about the environmental effects of buildings. At the beginning there were serious doubts among building industry organisations that it was possible to develop a method to determine the environmental effects of a whole building based on a detailed LCA. Lack of data and variations in methods used by various institutes were reasons for these doubts.

The first prototype of the Eco-Quantum Residential computer program was finished in 1997 and has been extensively tested by architects, local governments and the building industry. On the basis of an evaluation of this test, the programme was adjusted to the practical needs of the potential users (Kortman et al. 1997). Attention was paid to the balance between the need for a quick, practical instrument and for a rigorous method giving reliable and robust results. The program was launched on the market in November 1999.

Two developments are important for Eco-Quantum. Firstly, 3 years ago, NVTB (the Dutch Confederation of Building Materials Suppliers) initiated the extensive MRPI (Environment-relevant Product Information) project to collect LCA data for building products through about 20 branch organisations in the Netherlands. This year the LCA methods for Eco-Quantum and MRPI have been harmonised in order to stimulate the exchange of data, and the incorporation of verified LCA data from industry into Eco-Quantum. Secondly, the Dutch Government has initiated the MMG (Material-related Environmental profile of Buildings) project. This is aimed at the development of a standardised assessment method to determine the material related environmental impacts of a building. The idea is to introduce a requirement for an MMG assessment into the Dutch Building Regulations (Scholten et al. forthcoming).

Factors affecting the widespread application of Eco-Quantum are:

- the successful development of MMG by the Dutch Government and Standards Institution, and its successful incorporation into the Dutch Building Regulations
- the motivation of local governments to substitute earlier instruments by Eco-Quantum in advance of a regulatory requirement.

US – LEED™

In recent years, a number of EPA systems have emerged in the US. Of these, we have examined one, LEED. This has been developed by the US Green Building Council, an umbrella organisation set up in 1993. Financial support has been received from industry and from federal agencies such as DOE and the Environmental Protection Agency. LEED is voluntary and market-driven. Assessments are through a self-assessed checklist, based on notions of good practice, implemented wherever possible through existing codes and standards.

The origins and style of LEED are similar to those of BREEAM, though subsequent development and content differ. LEED 2.0 was launched in March 2000. Factors that are likely to affect the uptake of LEED include the adoption by Navy and State Departments of policies requiring the greening of their building stocks, state and municipal initiatives requiring energy and environmental rating of new buildings, and the movement toward corporate accountability, including environmental accountability by business.

COMPARISONS

There is a clear difference in the origins of Eco-Quantum and the other systems, which reflects the polarity between the strong social democratic tradition of the Netherlands and the overtly free market philosophy of the US and the UK. In Holland, impetus and funding for development of Eco-Quantum came from the Dutch Government and two national institutions – SEV & SBR – and the proposal to incorporate the method into the Building Regulations is likely to ensure the universal adoption of the method for housing in the near future. In the UK (not withstanding the part played by BRE) and in the US, the private sector has been dominant in the initiation and development of EPA, and there is no prospect of either country incorporating EPA into national regulatory systems.

This is however not the whole story. In the UK, a range of strategic initiatives are likely to act indirectly to expand the role for EPA in the future. These include the Climate Change Levy and the introduction of enhanced capital allowances on energy efficient products and technologies. The on-going review of Part L of the Building Regulations may also lever additional interest in EPA by raising requiring regular reporting of energy use in commercial buildings. The resulting penalties, even if procedural rather than financial, are likely to increase market demand for energy efficiency and environmental performance in new and existing buildings.

An important factor in both the US and Holland has been the existence of powerful political structures below the level of national government – municipalities (gemeente) and, in the US, state governments and federal agencies. These decentralised structures have made it possible to introduce a wide range of EPA (and other tools) locally (Johnston 1998). While this complexity and competition can impede has impeded the uptake of Eco-Quantum in Holland, it has also allowed the gradual familiarisation of both the Dutch and US populations with the concept of environmental performance rating, and has allowed a range of approaches to be developed and evaluated in parallel. In the UK, where local government is essentially powerless, the development of EPA has been more centralised than in either the US or Holland, This situation may however change with the introduction of devolved government for Wales and Scotland.

Market size is an over-riding property of the US. Within their own sphere of operations, agencies like the US Department of Defence can regulate as effectively and intrusively as any European social democracy, and often at a larger scale.

CONCLUSIONS

This study set to explore the relationship between the nature and structure of societies and governments – the ecology of EPA methods – and the detail of their development and implementation. It became clear from a detailed examination of systems in the UK, Netherlands and US that these relationships are complex and sometimes counter-intuitive. It appears likely that they do affect both the methodology and objectives of methods - though methodologies may also converge. External leverage mechanisms are important in all three countries, and in some sectors may be crucial to the uptake of EPA. However, the nature of these mechanisms differs widely between the three countries studied.

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CRITICAL REVIEW OF ENVIRONMENTAL ASSESSMENT OF BUILDING MATERIALS

Hal Levin
Bulding Ecology Research Group, 2548 Empire Grade, Santa Cruz, CA 95060, hlevin@cruzio.com

INTRODUCTION

Many interests and issues compete for professional building designers' attention and priorities. Indoor air quality and "sustainable design" have been increasingly among these interests in recent years. While neither has yet gained widespread acceptance or general use in the building design professions, both are now being used more frequently in the United States and certain parts of Europe. The tools available to designers include several directly using or derived from life cycle assessment (LCA) software and concept approaches.

Many diverse methods are available for assessment of the environmental performance of building materials and products. These methods are distinct from those used to evaluate whole building environmental performance or energy consumption. Product manufacturers, governments, building design professionals. and other decision makers are relying increasingly on such product assessments in making important decisions. Most of these assessments are dominated by analyses of embodied environmental impacts and fail adequately to address in-use performance. This is partly due to the complexity of the interactions among building components and between buildings and the environment during the use phase. A review of the most prominent of these methods shows them to be highly diverse in their focus, approaches, and intended uses.

Major shortcomings are the lack of comprehensiveness and the failure adequately to treat uncertainties. Methodological issues that should be addressed include integrating data uncertainty into decision analysis, rating the relative importance of various environmental impacts, and integration of indoor air quality, building energy performance, and life cycle assessment. Tools are needed that are focused on specific intended audiences and applications.

NEED FOR TOTAL LIFE CYCLE PERFORMANCE ASSESSMENT

While many LCA's have been performed on building materials, few have been extended over the whole product or material life cycle including the use phase. Among the most important but frequently neglected aspects of the use phase are 1) the operational energy implications of using one product rather than another and 2) the chemical or other product and process requirements for the maintenance, cleaning, repair, refinishing, and finally the removal and replacement of products at the end of their service lives.

Analysis or comparison of products that do not take into account the use phase will ignore energy consumption that may be many times that involved in the production, installation, and end-of-life disposition of a product or material. The longer the building life, the more important the use phase environmental costs and the less important the embodied environmental costs.

NEED FOR PRODUCT SPECIFIC ENVIRONMENTAL ASSESSMENTS

The practice of conducting LCAs on product categories ignores the large differences that can exist among products in a given category. However, designers and other decision-makers must compare and finally select specific products rather than product categories. Therefore, data on specific products and processes rather than generic product or process types are essential to increasing the relevance and applicability of product environmental assessments. There will usually be a range of product performance within a product category.

For example, when comparing two products from a single category, e.g., floor coverings, it is quite possible that the worst product in the best category performs worse environmentally than the best product in a less-highly rated category. Thus, by simply assessing product categories, the information provided by LCAs and other environmental assessment methods may mislead decision-makers and result in poorer environmental decisions.

Need for product specific data

One of the primary reasons environmental assessments are done on product categories rather than on specific products is that data are difficult to obtain on specific products. By including a whole industry, the variations in actual data versus reported data can be easily ignored. Manufacturers assert product proprietary information as an excuse for not divulging details of the materials and processes involved in production of their products. But the use of industry averages or aggregates can be very misleading when there are large differences among products.

Products vary over time. Feedstocks for chemical products can change from batch to batch where manufacturers change suppliers for cost or quality control reasons. Processes can vary from one factory to another within a company. In the U.S., one major composite wood product manufacturer standardizes its operations in all its plants while another does not. Even so, the products are labelled identically from the later company so that the purchaser does not know what materials actually went into the product or where it was produced. Different species of wood used in particle board results in different VOC emission characteristics, an important consideration in total life cycle assessment of product environmental performance.

LCAs that have been done on building materials have either ignored indoor air quality (IAQ) or have actually stated that integration of IAQ into LCA practice is either impractical or infeasible . Their assertion hinges around their perception of the relative availability of data and the complexity of its analysis for general environmental impacts and for IAQ impacts . Generally LCA practitioners lack awareness of the methods and practices available to evaluate or compare products' IAQ performance. This issue is addressed and methods for integrating IAQ into LCA practice are presented in a separate paper submitted for presentation at Sustainable Buildings 2000.

Selection of Building Materials is Product Specific.

Many materials require periodic surface treatments and cleaning in order to perform well. For example, many non-textile flooring products require lacquer and wax applications to protect their material surface and improve their appearance. The total life cycle emissions from such products can easily exceed those from the material to which they are applied. Therefore, emissions from products routinely used with a given material should be included in analysis of Life Cycle IAQ. They should also be used in building material selection processes based solely on IAQ. So-called "green" paints that are not easily cleanable result in more frequent painting and, therefore, potentially larger emissions over the life cycle.

NEED FOR INCLUSION OF UNCERTAINTY

The uncertainty in environmental assessment of building materials and products can be quite large. Many LCA's ignore this uncertainty. In fact, it is not uncommon to see impacts reported with three, four, or even five significant digits. In fact, variations in data reliability and accuracy suggest that two significant digits is often the best accuracy that can be obtained. Yet the precision of the reported values misleads the user into believing that there is appropriate accuracy to justify the precision. On the contrary, plus and minus value calculations or estimates ought to be included in order to convey more correctly the accuracy of the reported data.

Furthermore, data uncertainty can result in incorrect or inappropriate decisions. Where some factors or indices of environmental performance are well-characterized and others are less-well characterized, decisions should not be based on the less reliable data. By explicitly identifying the data uncertainty, appropriate emphasis can be placed on the more certain data. Decisions should be avoided on the basis of uncertain data where the differences among products or materials is small based on the more certain data.

NEED FOR INTEGRATED DESIGN AND OTHER DECISION TOOLS

Designers and other product specifiers are not likely to perform LCAs on products if they must enter extensive data on their building in order to understand the implications of selecting one product or another. The most likely scenario is that LCA-based analyses will be transparently and seamlessly integrated into computer aided drafting and design (CADD) software so that data are automatically available to the program for the analysis. If designers can simply do what they are used to doing and be given data and other feedback on the environmental implications of the choices they make, they are far more likely to consider environmental consequences of selecting one or another product or material.

DISCUSSION

There are many shortcomings of the environmental analyses available to date on building materials and products. Yet there is a large demand for information in order to make "environmentally-correct" decisions. It is important to improve the methods and processes for evaluating building materials and products so that decision-makers do not draw inappropriate conclusions and select products without more reliable environmental impact assessment.

CONCLUSION

When more accurate, reliable, and easier-to-use environmental assessments are available, they will enhance designers' and other decision-makers' abilities to make sounder environmental decisions. Meanwhile, we must work to improve the accuracy, reliability, and transparency of environmental data on building materials by acquiring product specific data, including uncertainty in the analyses, and reporting the results with proper characterization of the inherent uncertainties. Furthermore, there is a need for integration of the environmental costs of the use phase of a product or material's life cycle including energy and indoor air quality performance. In the future, integration into design professionals' normal software of environmental analysis tools for comparing building materials and products will facilitate the more widespread acceptance and use of the data produced by environmental analyses such as life cycle assessments.

ENVIRONMENTAL LIFE CYCLE ASSESSMENT OF BUILDINGS AND THEIR ELEMENTS

M. Aygun
Faculty of Architecture, Istanbul Technical University, Taskisla, Taksim 80191 Istanbul, Turkey

INTRODUCTION

The environmental life cycle performance of building elements is obviously influenced by the attributes of their components. This indicator describes the level of utility from production to disposal or recycling phase of the elements. This paper attempts to compare element alternatives in terms of their utility over discrete phases or the whole of the life cycle therefore allowing phases and environmental criteria to be ranked as well as element alternatives. Consequently the alternatives can be appraised methodically. Weibel presents the cumulative normalized environmental effects of building materials to allow comparative appraisal [Weibel96]. Kohler and Klingele apply the life cycle assessment model in terms of energy and mass flow to the building as an object consisting of elements and phases [Kohler96]. Haas presents the TWIN model, an environmental calculation method as performance concept based on a double layer system where the first layer quantitatively uses all available life cycle assessment results and the second qualitatively compliments the other [Haas98]. Aygun makes a proposal for quantifying the effects of various energy and mass flow attributes of buildings on their relative environmental performance [Aygun98]. Aygun evaluates the life cycle performance of functional building elements by means of enhanced aggregation over phases using a conceptual building model [Aygun00].

BUILDING MODEL

The proposed model for representing the building as a product as well as a processs consists of two interrelated hierarchical subsystems. The first is concerned with notional entities and the other with physical. They are based on object oriented modelling in line with the principles of inheritance and encapsulation. Each entity in these subsystems is related to its successor as anchestor or to its predecessor as descendant. Consequently the instances of each entity at any given level of the hierarchy interacts with any number of the instances of the predecessor or successor. The notional subsystem comprises the entities of life cycle phases, exogenous or endogenous constraints (climate, location, surroundings), domains (safety, health, comfort, ecology, cost) and participants. The physical subsystem encompasses the entities of site, building, space and elements. For instance each element in turn consists of any number of components described herein by one or more attributes. The environmental criteria in each phase of the life cycle measure the effect of the attributes on element performance. Thus this method allows phases to be compared as well as element alternatives and performance criteria.

EVALUATION PROCEDURE

Each phase of the life cycle involves any number of environmental criteria that may be either medium or effect oriented. While some of the criteria in any given phase may be in accordance with each other, others may be in conflict. This procedure allows the effects of the element attributes on comparative performances to be investigated on the basis of aggregation over criteria and phases. The procedure is accomplished in three consecutive stages. First the actual criterion values are ascertained for each element alternative included at each life cycle phase. Subsequently since the criteria mostly have different dimensions, these values are standardized prior to converting them to weighted utility values which are then aggregated to obtain a single parameter for each phase of all element alternatives and presented in tabular form. Then the overall utility values of elements and phases can be determined and rank-ordered as a result of row and/or column aggregation of the values obtained in the penultimate stage. The conventional aggregation process is therin enhanced by considering the supplementary statistical parameters of standard deviation and coefficient of variation beside the mean for any array of relative values. Thus the distribution of criterion values for each alternative is accounted for so that the most synthesised alternatives can be ascertained

APPLICATION

In order to demonstrate the presented method a set of 18 element alternatives have been generated as instances of the element model described earlier and are valuated by means of 3 criteria, i.e. energy, waste and cost shared by the consecutive phases of manufacture, construction and occupancy. In the case of this application the element under consideration is the paved flat roof of an hypothetical building that is asumed to be located in an urban area with a moderate climate. The heat transmittance coefficient of all the roof alternatives is maintained as a constant value, ie. 0.4 W/kg m^2. The main components in the form of layers are the external finish/layer, thermal insulation, waterproofing and core/carrier. The viable alternatives are configured by combining different orders of layers with different materials of these layers. While some of the criteria are in accordance with each other, e.g. energy and waste, others can be in conflict, e.g. waste and cost. The utility functions of the criteria are deemed to be linear and relative weights equal. The implemented consecutive stages are described as follows. Table 1 displays he actual criterion values of alternatives at each phase, providing the input data for the subsequent evaluation process. Then relative values are obtained through standardization. Utility functions and weights are applied as linear and equal respectively. The statistical parameters for these values, i.e. arithmetic mean, standard deviation and variation coefficient are calculated for each phase as given in Table 2. They are then converted to relative values to obtain an overall statistical performance indicator. Table 3 presents the final results that rank-order the alternatives that attain above-average utility values at each phase and over the complete life cycle respectively. Individual phases are also ranked.

CONCLUSIONS

The approach presented above enables rank-ordering of element alternatives, environmental criteria and life cycle phases by means of value aggregation so that the entities deemed as most synthesised in terms of life cycle performance can be ascertained. While the proposed method is conceived primarily for the benefit of researchers, professionals are also envisaged to to apply the proposal in practice. Subsequent work may be undertaken to generate complete building assemblies or use data from real buildings consisting of many elements in order to explore life cycle performances. As far as the shortcomings of this work are concerned caution must be exercised by the user if weighting factors are intended to be applied since these are phenomenological variables and rely on subjective judgement. Furthermore some of the quantitative data processed in the method may be difficult to obtain in practice due to insufficient records at each phase of the life cycle.

ACKNOWLEDGEMENT

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Table 1: Actual values of performance criteria for roof alternatives at each phase

Roof	Manufacture			Construction			Occupancy		
	Energy (kwh/m^2)	Waste (kg/m^2)	Cost (ecu/m^2)	Energy (kwh/m^2)	Waste (kg/m^2)	Cost (ecu/m^2)	Energy (kwh/m^2)	Waste (kg/m^2)	Cost (ecu/m^2)
R_1	3.9	2.1	205	0.9	0.5	47	0.49	0.4	9
R_2	3.2	3.3	170	1.3	0.3	63	0.14	0.6	11
R_3	4.1	3.6	120	0.8	0.4	53	0.46	0.3	7
...	...	...	...	...	...	...	...	...	...
R_{16}	3.5	2.9	175	1.3	0.2	60	0.34	0.4	10
R_{17}	4.2	2.1	170	1.1	0.3	52	0.54	0.3	9
R_{18}	4.6	1.8	145	0.7	0.4	41	0.37	0.2	8

Table 2: Actual values of statistical performance indicators for roof alternatives at each phase (Sta.D: Standard Deviation, Var.C: Variation Coefficient)

Roof	Manufacture			Construction			Occupancy		
	Mean	Sta.D.	Var.C.	Mean	Sta.D.	Var.C.	Mean	Sta.D.	Var.C.
R_1	5.35	3.74	0.70	3.76	2.84	0.76	5.63	3.45	0.61
R_2	6.84	2.56	0.37	6.24	4.83	0.77	6.32	1.64	0.26
R_3	5.45	3.14	0.58	4.52	3.08	0.68	4.69	2.27	0.48
...	...	...		...	...		...	...	
R_{16}	5.22	3.47	0.66	5.88	3.85	0.65	5.47	2.83	0.52
R_{17}	4.46	1.55	0.35	3.28	2.24	0.68	6.20	4.85	0.78
R_{18}	5.06	2.28	0.45	5.43	4.25	0.78	7.44	1.27	0.17

Table 3: Ranked alternatives and phases with above-average utility values

Rank	Manuf.	Constr.	Occup.	Life cycle	Phase
1	R_7 9.16	R_5 9.36	R_6 9.74	R_{12} 8.43	Manuf. 7.75
2	R_{10} 8.54	R_{13} 8.75	R_{15} 9.55	R_6 7.69	Occup. 5.52
3	R_6 8.12	R_9 7.43	R_{12} 8.44	R_{16} 6.47	Const. 5.64
4	R_3 7.74	R_7 7.45	R_9 7.56	R_7 5.80	
5	R_{16} 6.58	R_6 6.84	R_{17} 5.88	R_{14} 5.32	
6	R_{12} 5.66		R_{10} 6.06		
7			R_{14} 5.90		
8			R_5 5.64		

A SUITE APPROACH FOR DEVELOPING ENVIRONMENTAL PERFORMANCE ASSESSMENT TOOLS

Harvey Bryan, Ph.D., FAIA
School of Architecture
Arizona State University
Tempe, AZ. 85287

Jiri Skopek, AA Dipl, RIBA
ECD Canada
165 Kenilworth Avenue
Toronto, ONT. M4L 3S7

Simone Pertuiset
ECD Canada
165 Kenilworth Avenue
Toronto, ONT. M4L 3S7

INTRODUCTION

A building assessment system can help fulfill a range of functions, such as serving as a design tool, providing continuity of the building process from design to O&M, identifying environmental management priorities, benchmarking improvements, comparing the performance of several buildings, or marketing high performance buildings. Given that different clients will require different focuses, it is neither likely nor desirable that one system will satisfy all. Yet a proliferation of systems can result in confusion. This paper will describe a solution to this dilemma.

A SUITE APPROACH

One solution is to produce a suite of assessment tools that meets the various needs of the marketplace but have a common basis, can be built on as well as "talk to one another".

There are four conditions that need to be met to ensure the integrity and credibility of such an approach. First, these tools should be based on sound science, a common set of issues, objectives and targets, and should reflect similar principles of eco-efficiency and sustainability. Second, stakeholders' concerns should be addressed. Third, the program should be capable of third party verification from an independent, recognized body such as a standards institution. The system should be evolving and able to demonstrate continuous improvement that reflects new data and continuous research. Finally, it should be practical, thereby capable of improving the environmental performance of buildings.

To date, several methods for assessing the environmental impact of buildings have been developed. Of these, according to the most recent survey of existing environmental assessment methods, BREEAM was found to be the most widely recognized international method.[1] BREEAM was launched in 1990 by the Building Research Establishment (BRE), the principal building research organization in the U.K. BREEAM's widespread acceptance, its sound research, comprehensive approach, and applicability to a range of building types make it a suitable core document upon which to build specialized applications.

The BREEAM structure is based on three sets of environmental issues. The first set is "building performance" which applies to all buildings. Next is the "design and procurement" which applies only to buildings at the design stage. Finally, there are the issues which apply to "management and operation" of existing buildings. It must be stressed that the assessment of a building's management is important, because it is possible to have an older, building that is so well managed that it more than makes up for performance limitations. Using BREEAM as a basis, two other products have recently been developed in the suite of assessment tools representing various degrees of cost and levels of effort: Green Leaf and a building module for ISO 14001 implementation. The three documents can serve a wide range of applications, and most importantly, can relate to one another.

BREEAM

BREEAM development was started in the UK in 1988, when the BRE, Stanhope Properties plc., and ECD Energy and Environment Consultants joined forces to develop an environmental assessment method for new offices. The BRE was an excellent source of technical and scientific knowledge on environmental issues in buildings and a highly credible organization. Soon, versions of BREEAM were adapted to other parts of the world. In 1995, BREEAM was introduced to Canada by ECD Canada, where it was published by the CSA International Standards Association. In 1997, the Canadian federal government adapted BREEAM to assess all federal buildings. As a result of these global applications, U.S. and Canadian committees, under the umbrella of the CSA International Standards Association, are currently drafting a BREEAM North America document.

Since its inception, R&D has continued with the development of BREEAM for different building types. In 1998, the BRE undertook a major upgrade that represents a substantial improvement over earlier versions by including a more comprehensive list of issue categories.[2] The importance of each issue category is determined by consensus-based weighting, and all items are then summed to arrive at the overall rating for the building being assessed.

GREEN LEAF

Green Leaf was developed in response to a market need for an inexpensive methodology that could be partially self-implemented. It provides a simplified approach over a broader range of issues. In its design, the principles of affordability, efficiency and credibility were paramount. This makes it an ideal introductory product for building managers who need a baseline for their buildings. The current program so far covers offices, high-rise residential buildings and hotels. ECD Canada and TerraChoice Environmental Services Inc. in Canada developed the methodology. The original design and implementation of the Green Leaf Eco-Rating methodology was directed by the Hotel Association of Canada (HAC) with support from Environment Canada, Public Works and Government Services Canada, Natural Resources Canada, and Heritage Canada. Under license from the HAC, TerraChoice developed and launched the Green Leaf Eco-Rating Program. The Program was a natural extension of the work Terra Choice had been doing in with the Environmental Choice Program, which applies the EcoLogo to products and services throughout Canada.

Green Leaf is similar to BREEAM in that it covers similar issues. As with a BREEAM assessment, the Green Leaf also uses a questionnaire as well as a walk-through survey. The Green Leaf deliverables include a comprehensive report, which include recommendations for operational savings, due diligence and occupant health and comfort. The Green Leaf price cannot cover such an extensive verification as BREEAM and consequently Green Leaf would be considered a rating, rather than certification system.

ISO 14001

The final suite-based tool is the ISO*soft 14001* that can be used in the implementation of an environmental management system and can lead to ISO 14001 certification.

In tailoring BREEAM Canada for use by large organizations, and in developing Green Leaf, it became increasingly clear to ECD Canada that any system it develops should have the capability of being a cross referencing tool for companies who might in the future want to implement ISO 14001. It therefore became essential to develop an environmental building management tool based on the ISO 14001 that provides guidance with regard to the activities, aspects and impacts that are found in buildings.

There are many reasons why such a tool lends itself to a software format. Although the principles of ISO 14001 are simple, the management system itself can be complex, depending on the size of the organization. A software tool allows users to be exposed to as much or as little information and complexity as needed. Finally, given the sheer volume of procedures and data, as well as the task of document control, using software provides a highly centralized approach to do the job.

ISO*soft* was an existing ISO 14001 product developed by Intelex Technologies, an international leader in the development of Windows-based applications for managing Environmental, Health and Safety, and Quality Systems. With Intelex, ECD Canada developed a building module for ISO 14001 implementation to help organizations to identify aspects, impacts, legislation and some objectives and targets related to best practices. The ISO*soft* 14001 tool makes it possible to develop a system for ISO 14001 implementation and certification using in-house expertise, thereby reducing the need for consultants. This makes it suitable for small and medium sized enterprises, which are very cost conscious.

One key requirement of ISO 14001 is to identify those aspects of the organization that affect the environment. The ISO*soft* building module helps organizations to identify the key aspects that impact the environment, and to then manage these impacts by developing worksheets based on sample conditions. These only require review, adjustment and fine-tuning for them to be applicable to implement ISO 14001. One limitation of ISO 14001 is that it does not lend itself well as a benchmark to compare buildings. Because the building owner or manager sets objectives and targets, it is possible that a relatively poorly performing building could claim to be ISO 14001 certified by setting very low targets. Another weakness is that ISO 14001 does not consider Health and Safety issues.

A BREEAM assessment can be used in conjunction with ISO*soft* to overcome these limitations as well as to help companies define objectives, and target "best practices." Many of these practices are simple management activities that do not require capital outlay. In addition to conservation measures for waste and water, energy management is a concern; BREEAM can also greatly improve human productivity. Savings in this area are increasingly being documented, and perhaps do not need ISO 14001 to be implemented. However, since owners want to control their energy costs and tenants increasingly demand high productivity workplaces, ISO 14001 can provide an additional vehicle to achieve continuous improvement in these areas. A system such as BREEAM can provide the benchmarks to gauge the quality of that commitment in terms of the building's performance before and after, and relative to industry best practices.

CONCLUSION

BREEAM, Green Leaf and ISO 14001 Building Module will provide a consistent and verifiable benchmark for environmental performance as well as provide, if desired, a gradual, long term migration to ISO 14001. They do this in two important ways. First, these tools promote an environmental management system, no matter how informally at the start, along the lines of ISO 14001. Second, they aim to make the environmental management system serve the organization and not the other way around. To illustrate this point, before Public Works and Government Services Canada chose an assessment protocol, they surveyed a number of systems. While at the time, PWGSC was not willing to make a formal commitment to ISO 14001, they wanted a system that would be flexible enough to address elements of ISO 14001. PWGSC chose BREEAM because it came closest to doing this,[3] thus avoiding the costly need of re-assessing their stock of over 400 buildings if they choose to get ISO 14001 certification.

The suite approach also interfaces well with the learning curve that is associated with any new learning. Initially a client is concerned about committing too many resources towards a new activity. Later, as learning increases more resources can be allocated and more sophisticated tools can be engaged. Thus, the suite approach grows with the client's understanding of environmental concerns. While not yet seamless, we believe the suite approach presented in this paper will make an important contribution to our understanding of the environmental performance of buildings.

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TOWARDS RATIONAL BUILDING PRODUCT ENVIRONMENTAL ASSESSMENT

P. CORTIJO – Ecobilan SA - Member of PricewaterhouseCoopers
pcortijo@ecobilan.com -http://www.ecobilan.com -
Tour AIG – 34, place des Corolles – 92908 Paris La Défense Cedex – France

G. OLIVE – GOIC
g_olive@club-internet.fr
Villa Pasteur – 83, boulevard MacDonald – 75019 Paris – France

INTRODUCTION

In France, most public buildings are rated as **"Haute Qualité Environnementale"** (HQE, High Environmental Quality). As the taking into account of environment in building is still quite recent, there is yet no criterion to describe what a HQE building is. One of the roles of the HQE association, created in 1996, is to define a system of reference. This association, which gathers most of the players involved in HQE construction, has already defined 14 targets to give concrete expression to this large concept.
One target "**Integrated choice of products and process**" has initiated intensive discussion between architects and environmental units to define the products and processes that could be used in HQE construction. As no evaluation method is available as yet, the risk has been great to base choices on some preconceived ideas, i.e. recycled, natural or traditional products far superior than "conventional" ones.

AIMCC BUILDING PRODUCT ENVIRONMENTAL COMMUNICATION

In order to rationalise the debate and to avoid biased comparisons between products, a group of industrial companies decided to create the Environmental Data Working Group (EDWG) within the Environmental Commission of the AIMCC (French Association of Building Product Manufacturers).
The objective of the Working Group is now to provide a common and recognised frame for all the industrials to communicate **complete** and **objective** environmental assessments of their products, based on verifiable data. "Complete" means that the evaluation deals not only with classical Life Cycle Assessment (LCA) results but also with more specific building issues such as inhabitant health or product contribution to water, energy or waste management during the building use phase. This goal will be achieved through key documents, finalised at the end of 2000.

AIMCC EDWG Environmental Communication Final Documents
• Form "Environmental Communication Form on Building Products"
• Guide "Common Rules to fill in the Environmental Communication Form on Building Products"
• Charter for Environmental communication on building products

Throughout the process, the EDWG has been helped by Gilles Olive, who is also the secretary of the French HQE association. Ecobilan has contributed to the definition of common methodological rules to ensure that "classical" environmental balances are performed in a consistent way from one product to the other.

In order to ensure its objectivity and its acknowledgement, this "classical" environmental balance is based on ISO **international standards**, dealing with this issue, which are:

International standards defining the frame of AIMCC Environmental evaluation	
ISO 14040	• Environmental Management – Life Cycle Assessment – Principles and Framework
ISO 14041	• Environmental Management – Life Cycle Assessment – Goal and scope definition and inventory analysis
ISO 14020	• Environmental label and declarations – General Principles
ISO 14025/TR	• Environmental label and declarations – Type III environmental declarations – Guiding principles and procedures
ISO 14048/CD	• Environmental management – Life Cycle assessment – Life cycle assessment data documentation format

DEFINING COMMON LCA METHODOLOGY RULES

The LCA international standards defined a methodology frame but choices remain to be done when a LCA is performed. Common LCA methodology rules ensure that these choices will be as close as possible for all forms that contain building product environmental information. The other goal was to choose common assumptions for some stages such as transportation or end-of-life for which accurate statistical data are seldom available.

Rule and assumption selection was performed by the industries involved in the EDWG, from Ecobilan's proposals. Some building products were selected as case studies. For some of them, LCA had already been performed. In this case, the EDWG adopted rules, which were as far as possible consistent with the ones selected in the existing studies.

Case Studies	Industrials present in EDWG	Existing study
Glass Wool	Fédération des Industries des Laines Minérales (FILMM)	X
Double Glazing	Saint Gobain Vitrages	X (partly)
Steel Covering	Usinor	X (partly)
Clay Brick	Fédération Française des Tuiles et Briques (FFTB) Centre Technique des Tuiles et Briques (CTTB)	X
Concrete Block	Centres d'Etudes et Recherches de l'Industrie du Béton (CERIB)	X (internal)
Cement	Association Technique de l'Industrie des Liants Hydrauliques (ATILH)	X
Floor Covering	Syndicat Français des Enducteurs Calendreurs et Fabricants de Revêtements de Sols et Murs (SFEC)	X
PVC gutter	ETEX	X
Plasterboard	Syndicat National des Industries du Plâtre (SNIP)	-

Some of the adopted rules are given in the following table as examples.

LCA methodology chapter	Examples of EDWH adopted rules
FUNCTIONAL UNIT	▪ The product environmental balance should be given for a **functional unit**, in order to ensure that, if products are compared for the same services, this is done in a rational way. ▪ For building product, this functional unit requires the definition of the product **Typical Life Span**, which corresponds to the usual life span in normal working conditions (cleaning and basic maintenance). The functional unit is expressed for one average use year (integrating average upkeep) ▪ **Example** of functional unit : ➢ Plasterboard: "To provide the function of an internal partition for 1 m² surface during 1 year, with an acoustic isolation to inside noises equal to 41 dB(A)".

LCA methodology chapter	Examples of EDWH adopted rules
	which corresponds to 0.736 (4*9.2/50) of BA 13 plasterboard (4 plasterboards / partition ; surface density: 9.2 kg/m² for one plasterboard ; typical life span: 50 years)
SYSTEM BOUNDARIES	▪ The system includes **all the stages** of the building product life cycle: production from resource extraction, distribution, installation, use phase (including maintenance and upkeep) and end-of-life.
	▪ To limit the **system extension**, the following **cut-off rules** have been decided: ➢ The weight of the inflows for which production stages are not included in the system should represent less that 5% of the weight of all the inflows (except water). Hence most (95%) of the inflows entering the Life Cycle System should be resources extracted from environment. ➢ The production from raw material extraction should be taken into account for all **fuels** (natural gas, coal, etc.) as data are available ; ➢ If a product is classified as toxic (T), very toxic (T+), harmful (Xn) or dangerous for the environment (N), its production should be taken into account.
SYSTEM BOUNDARIES	▪ For **coproducts and end-of-life recycling**, selecting a single rule does not appeared relevant, given the diversity of configurations. Each case is particular and needs a specific answer. What was agreed was however : ➢ To prefer the **stock scenario** for end-of-life recycling which means to allocate: (1) only fatal transportation to the upstream system generating the secondary material which is to be recycled and (2) the treatment and transportation stages due to the recycling processes to the downstream system using the secondary material. ➢ To be consistent from one building product LCA to another one: the methodological choice that has been applied to deal with a coproduct in a given study should be utilised in the future studies.
DATA REPRESENTATIVITY	▪ Data should be representative of the French situation. ▪ Common rules correspond mainly to transparency criteria. For the data specific to the building product, the following information concerning collected data should be provided: ➢ Market share of the sites included in the assessment ; ➢ Production year ; ➢ Covered technology ;
INVENTORY FLOWS	▪ The building product environmental balance will be the **life cycle inventory** (LCI). An LCI quantifies all the resources extracted in the environment and all the pollutants emitted to the air, water and soil. From this inventory, impact indicators can be calculated. ▪ A **list of inventory flows** was selected to provide the same level of detail for all the products. The criterion used to select these flows allowed the relevant information to be provided while taking data availability into account.

CONCLUSION

Building product manufacturers have chosen to base their product environmental communication on an internationally recognized methodology. They are now deeply involved in this process. At the same time they have defined common rules and assumptions, federations launched LCA studies on their products to fill in the definite form. This will provide rational and objective building product environmental balances, enabling each final decision-maker to choose according to their own environmental priorities.
Moreover, as the LCA methodology is also very helpful when defining an environmental strategy within an industry, carrying out LCA to fill-in the AIMCC form will also provide industrials with a tool that can be used to define and validate improvement objectives, to design new products or to compare alternative solutions.

FINDING THE MOST EFFECTIVE SUSTAINABLE MEASURES

ir. Andy van den Dobbelsteen and ir. Kees van der Linden
Delft University of Technology, Department of Civil Engineering and Geosciences, Building Engineering Division, P.O. Box 5048, 2600 GA Delft, the Netherlands - e-mail: andy.vandendobbelsteen@citg.tudelft.nl

in co-operation with prof.ir. Hans Cauberg, prof ir. Jón Kristinsson and dr.ir. Michiel Haas

Introduction

Since the introduction of the formula of Ehrlich, Ehrlich and Speth [1990] there has been better comprehension about the necessary environmental effort within 50 years:

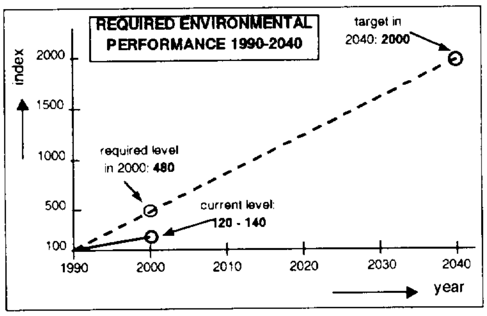
	EP	=	P	x	W	x	E
1990:	1	=	1	x	1	x	1
2040:	½	=	2	x	5	x	**1/20**

This "factor 20" (an improvement of 95% in E, environmental effects) has been chosen as a goal by five Dutch ministries and Delft University of Technology. Ways have to be found to achieve 95% improvement of environmental effects due to the building process as well. This is called the New Necessity [Kristinsson, 1997]. It means that, indexing 1990 as 100, in 2040 the environmental performance of buildings should be 2000.

Exact calculations of environmental effects have been made possible through environmental calculation models like GreenCalc and Eco-Quantum. In the presented research both models are used in analysing office buildings. By comparing the calculated absolute environmental load of the building with that of a reference building from 1990 (an apt reference year because Dutch environmental policy on the field of construction was implemented that year) the environmental index and factor can be appointed. The reference building is a fictitious office building based upon the same program of demands. Differing material use as well as energy- and water-consuming building services cause a difference in environmental effects and therefore, in the achieved factor. This method was pointed out in the "Easter Letters" [Dewever, 1996]. A more accurate calculation is necessary if there has been a significantly different approach in the building organisation or floor plan in comparison with a more traditional building lay-out. Such is the case with innovative office plans like in the "Dynamic Office" in Haarlem.

Analysis of case-studies

Through study of over 15 Dutch office buildings insight has been gained about the environmental effectivity of (sustainable) design solutions. As environmental cost calculations with GreenCalc show, constructing with no particular attention to sustainability leads to an index of not more than 120. With slight attention (the average level of sustainable building in Holland) an index 140 is possible. Building projects in which sustainability was an important aspect lead to an index 140 to 300.

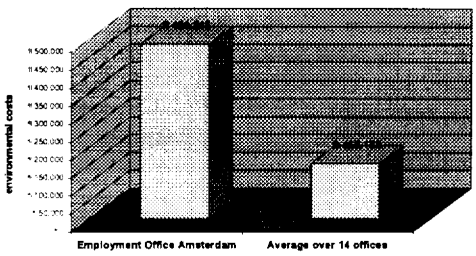


These results show that - in case of a linear path - we are behind schedule for 2040 and that in order to achieve the factor 20 a quick insight in the most effective measures is needed, as is an object of the presented research.

From the various case-studies experience is gained about the impact of decisions made in the building process. Analysis studies are still executed; not all results have been studied yet but first conclusions can be drawn with respect to the following aspects.

Reconstruction versus new building
Despite worse energetic conditions, reconstructing an old building generally achieves a better environmental performance than constructing a new one. This is due to the loss of environmental capital by demolition in combination with the assessment of new materials. In case of "energetic reconstruction" a big advantage is gained in comparison to new constructing.
Possible disadvantage of re-using old buildings is inefficient use of space, as can be seen in the environmental costs per employee of the Employment Office in Amsterdam.

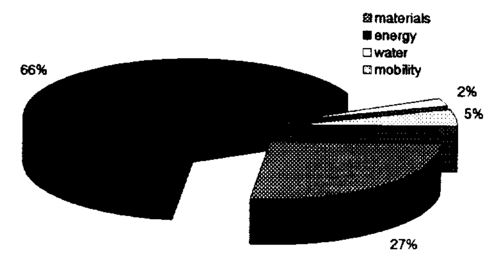
COMPARISON OF ENVIRONMENTAL COSTS PER FTE



The geometry (or shape) of the building
Compact buildings restrict the envelope area and thus the environmental costs of materials and energy use. However, office floors exceeding approximately 6.000 m^2 necessitate design solutions (glass houses, atria etc.) to maintain a compact structure. These interventions significantly add to increasing environmental costs, as can be seen with the building of IBN-DLO in Wageningen. In this building a lot of well-scoring timber is applied but the structure of glass houses between the office naves are a main contributor to the material environmental costs.

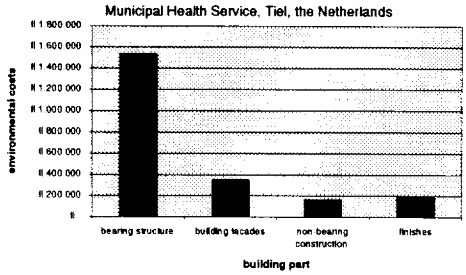
Main contributing elements
Considering a 75 years life cycle of buildings energy consumption of buildings is largely the most important factor in the environmental costs of buildings (approximately 2/3 of the total). The introduction of sustainable energy offers big opportunities in improving this situation, though within the system borders of a building further energy efficiency in the design remains effective.

DIVISION OF ENVIRONMENTAL COSTS OF OFFICES



Second contributor in the environmental costs of new buildings are building materials, in which the building structure causes 60-70 percent of the environmental costs, even with a timber bearing structure like with the Municipal Health Service in Tiel.

DIVISION OF ENVIRONMENTAL COSTS OF MATERIALS
Municipal Health Service, Tiel, the Netherlands



Building materials
Although there can be significant differences between the possible materials for building components (up to a factor 2 or 3), considering the contribution of these components to the total environmental costs the impact is limited. With the same technical requirements the differences between a timber, concrete and steel structure (in this order of increasing environmental costs) turn out to be small.

Building services
Because of the importance of energy within the environmental costs the choice of services can give significant changes in the total result, although the use of sustainable energy reduces the importance of these choices. Significant improvements can be made in water consumption, but perhaps tragically this element is a poor contributor in the total environmental costs.

Translation to the future

As can be obtained from the DTO-study by Van der Linden et al. [1999], with reasonable certainty we expect to easily achieve a factor 20 in energy use in 2040, provide sustainable energy is used. The inset of sustainable energy can stimulate ecological development of traffic. Water consumption is expected to be more of a problem, not to speak of the use of building materials. In that matter paying attention to building materials should go further than just choosing the right ecological materials. Even recent, very ecological office designs do not achieve better than an index 450. In order to make an effective leap forward a focus is needed on re-use of buildings, re-use of building materials and recycling, but even then the factor 20 will not be achieved, due to necessary energy for transportation and industrial processing.

The DTO-results are based upon the assumption that the surveyed office buildings reach a technical age of 75. Reckoning with the fact that most office buildings' period of use is not more than 25 years (reducing the duration of building use by one third) an improvement of even a factor 60 would be necessary. Hence, before zooming into possibilities of sustainable building design insight in future changes in lifestyle, work, workspace and mobility is needed. A more probable solution for rapid ecological improvements in office buildings is to be found in adaptability to the evolution of society, technology and office facilities.

Offices tend to be out-of-date before their technical life span. Most important reason for this is a lack of flexibility. Thus, attention needs to be paid to [Worthington, 2000]:

- technical flexibility, the physical possibility to make adjustments to a building and its floor plan;
- functional flexibility, reckoning with functional changes during the lifecycle of an office, not just changes from offices to apartments but organisational or ITC-related changes as well;
- more outside the builder's reach: financial flexibility in contracts.

The author would like to add development flexibility. A complete forecast of the future is impossible; flexibility in development of town enlargements makes adjustments possible whenever necessary.

Related to flexibility another solution to the problem of building materials can be found in more efficient use of buildings and space in general. On the level of office lay-out this demands intelligent new approaches of organisations (a shift from hierarchy based floor plans to functional work space allotment). On a broader scale spatial planning should concentrate on dynamic economy and mobility based nodes, thus leaving more space to nature, recreation and agriculture.

Conclusions and recommendations

From the first case-studies of office buildings the following conclusions can be drawn.

- Application of sustainable energy can make a factor 20 in energy consumption possible, but much effort can still be put into optimizing office building designs.
- Over-all, the required factor 20 will probably only be achieved by a combination of technical solutions and an innovative approach of office floor organisation and use of space. A focus on re-use of buildings and a flexible, multi-purpose set-up is necessary. One step back (larger, spacy buildings) might be necessary to make longer duration of use possible.

In October 2000 the case-studies will be completed. Further research, for instance on the influence of the office building locations, will also be applied.

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ECOEFFECT – A HOLISTIC TOOL TO MEASURE ENVIRONMENTAL IMPACT OF BUILDING PROPERTIES

Arch, D. Eng. Mauritz Glaumann, (glaumann@arch.kth.se)
KTH Infrastructure and Planning
Built Environment Analysis
SE – 100 44 Stockholm

INTRODUCTION

EcoEffect (ref. 1) is a method to calculate and assess the long-term environmental effects caused by the use of a real estate. It is developed for managers, consultants and contractors who need information about the environmental impacts associated with the built environment. Energy use, Materials use, Indoor environment, Outdoor environment and Life cycle costs are treated individually in the analysis. The assessment is based on life cycle analysis (LCA) for use of energy and materials and on criteria for indoor and outdoor environment. The result is presented as an environmental profile for each area with bars showing potential environmental effects for different impact categories. A possibility to aggregate this information into a few environmental load numbers for each area is offered to simplify a comparison between elements, buildings or estates. For use of energy and materials load numbers for ***emissions, waste*** and ***natural resource depletion*** can be calculated and for indoor and outdoor environment the load numbers that may be calculated represents ***ill health, discomfort, biodiversity*** and ***biological productivity.***

PRESENTATION

Impact on the exterior environment

In EcoEffect the environmental impacts outside an estate caused by erecting, use and demolishing constructions on the estate has been called impact on the ***"exterior environment"***. The methodology and effect categories are to a considerable extent taken from the Danish LCA methodology, EDIP (ref. 2), fig 1.

The impact scale expresses the relative impact of an average user of the estate in relation to the average impact per capita in the country. Since this normalisation brings all the effects into the same unit, if weighted with respect to their relative importance, they can be added. The weighting process used is inspired by the Analytic Hierarchy Process, AHP (ref. 3) and Green Building Challenge (ref. 4). The impact categories are compared pairwise with respect to one weighting aspect at the time. ***Extent, Intensity*** and ***Reversibility*** have been chosen as weighting aspects.

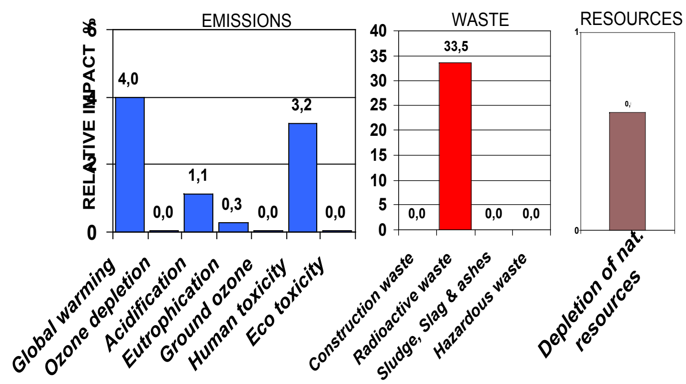

Figure 1. Environmental profile showing the relative effects caused by use of energy and materials. The same kind of profile can be calculated for building parts, elements and buildings.

Impact on the interior environment

The environmental state and the potential impacts occurring within the estate has been called impacts on the ***"interior environment".*** It covers comfort and health for people staying indoors and out of doors at the estate and the actual and potential state of biological life at the estate. The assessment is based on criteria giving scores between 0 and 3, where 0 means good conditions or low risk for impact and 3 means poor conditions or high risk for potential impact.

The assessment of indoor conditions in existing buildings is mainly based on a questionnaire to the users that has been applied to more than 10.000 dwellings in Stockholm (ref. 5, 6). Results from a building compared with the expected ones based on statistics give the scores of the indoor profile, fig 2. Assessment of future indoor conditions, i.e. an assessment made at the planning stage, is based on the target level chosen by the client and an evaluation of performance made from drawings and documents. This part of the method is still under development.

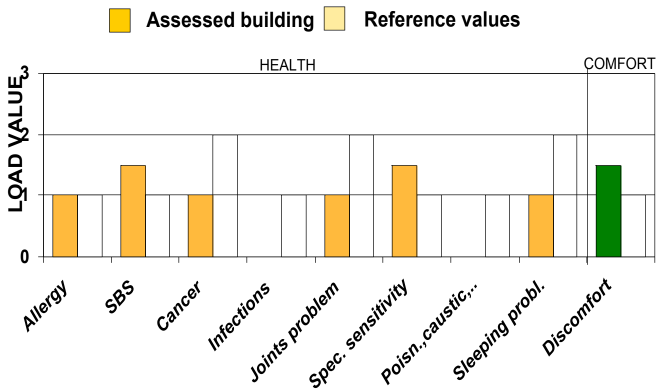

Figure 2. The indoor assessment profile covers 7 health effects and 2 comfort aspects.

The impact on health and comfort for people staying out of doors is assessed from the physical conditions of the surroundings, like distance to noise and pollution sources, exposure for high winds speeds etc., fig.3. The second impact group, biodiversity, is assessed from factors like access to free water surfaces, large trees, soil conditions etc.

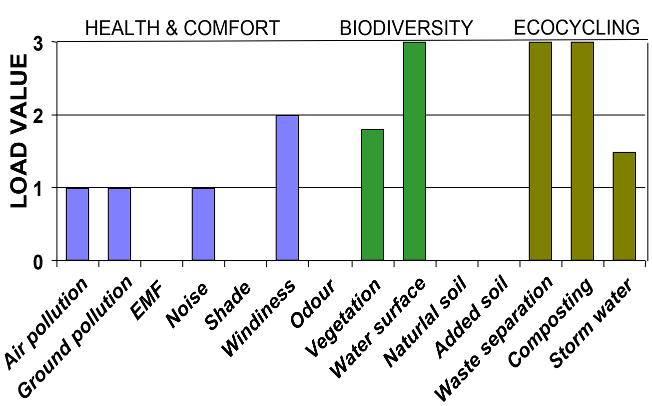

Figure 3. The outdoor assessment profile covers human health and comfort for people staying out of doors at the estate and ecosystems and eco-cycling.

The last impact group, ecocycling, gives credit to waste separation, composting and storm water infiltration at the site. This group represents actually a part of the mass flows cross the estate and will in the next version of EcoEffect be judged by its effects on the exterior environment. An exploratory study on how to calculate effects of stormwater is presented at this conference (ref 7).

The question of extra costs related to environmental improvements is always brought up. EcoEffect calculates the life cycle costs for issues, which give impacts on the exterior environment like energy, water and waste costs, materials costs, etc. The aggregated life cycle cost is shown for two standard scenarios. The first scenario is a steady state development, i.e. the cost relations in the society are constant. The second scenario shows an increased cost for energy, waste etc by 3% per year compared to other costs, fig. 4. A probable future is believed to lie in between these two examples.

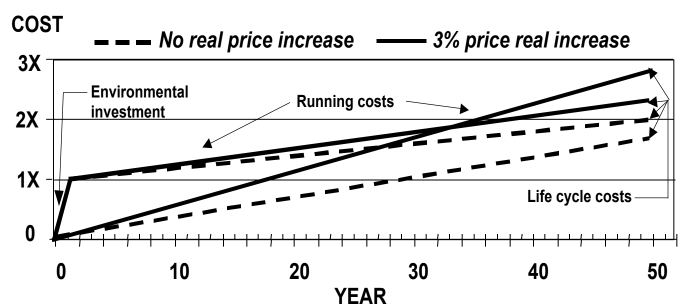

Figure 4. A possible prospect for an environmental investment that means lower running cost. If there will be no future increase in environmental related costs no action is needed. However, if the environmental costs will exceed the general inflation it is very advantageous to make this investment. In the latter case a future cost increase means less since the running costs are lower.

FUTURE WORK

The structure and the main contents of EcoEffect are settled. A beta-version of the EcoEffect-computer program has been developed in Microsoft Access. The layout of the program makes it easy to scroll between input data and information to find the reasons for any result. The suggested weights are default values that are easy to change.

New funding has been allocated from The Swedish Council for Building Research and the building sector to develop specific EcoEffect application tools for environmental management of buildings and design of buildings. The recent database will be complemented and checked for accuracy.

CONCLUSIONS

So far EcoEffect has only been tested on a few buildings. During the period of development the interest for environmental management of buildings and application of LCA based tools for choice of materials and energy sources has grown considerably. EcoEffect meet these needs and we will in the next stage develop practical tools for estate managers and building designers based on it.

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LIFE CYCLE COSTING (LCC) – A MANAGERIAL ENVIRONMENTAL ACCOUNTING TOOL FOR BUILDING PROJECTS?

Pernilla Gluch
Department of Building Economics and Management, Chalmers University of Technology,
S-412 96 Göteborg, Sweden

INTRODUCTION

The accounting concept, Life Cycle Costing (LCC), was a frequently occurring concept in literature during late '70s and early '80s. With the increasing focus on environmental issues the concept is currently having a renaissance. Why is that? Why would this concept regain its popularity, especially considering that LCC is simply a type of investment calculus that has an expanded life cycle perspective?

There are indications that many existing cost-accounting systems handle environmental costs in a way that leads to incorrect investment decisions (Hamner and Stinson, 1995; Kite, 1995). One way of solving this problem has been to include environmental consequences in LCC. However, how environmental consequences are incorporated in LCC is not clear (Zaring, 1996). "Traditional" LCC considers the initial capital and operating costs of producing, using and maintaining products, but ignores environmental costs (Cohan and Gess, 1994). Nevertheless, there seems to be an increasing interest in life cycle management and LCC in industry today (Freedman, 1998), which provides a good reason for discussing environmentally adjusted LCC and other, similar monetary managerial accounting tools.

The aim of this article is to investigate the use of LCC as a tool for making environmentally responsible investment decisions in construction projects. The use of discounting methods, the life-cycle approach and practical implications of conducting an environmentally relevant LCC are discussed. The discussion is based on literature studies of managerial environmental accounting tools and on experience from an application of LCC on a building project.

MONETARY MANAGERIAL ENVIRONMENTAL ACCOUNTNING

LCC can be traced back to the U.S. Department of Defence in the mid-1960s, where it was used in the acquisition of weapons systems (Epstein, 1996). LCC is a tool used in making a long-term prognosis considering financial results and is defined by Kirk and Dell'Isola (1995) as an *economic assessment of investment alternatives that considers all significant costs of ownership discounted over a lifetime of a product*. LCC is a type of investment calculus. Hence, LCC is used to rank different investment alternatives. It is also possible to use the results from a LCC as a measurement when setting requirements or to give priority to a certain building quality. From this it follows that LCC provides an indication of which strategic decisions should be made. Thus, according to Henn (1993) LCC seeks to optimize product performance and lifetime cost of ownership.

Several variants of the "traditional" LCC with a more or less stated environmental approach have been developed during this last decade. According to Schaltegger (1996) the emerging environmental accounting systems are the result of a change in goals and perspectives within business but also caused by critical stakeholders. By adjusting the variables in the equation, the tools become "environmental." The tools have different abbreviations but are nevertheless quite similar in their approach. The different methods share the life cycle approach and the idea of integration of monetary and environmental dimensions. Words like full, total, true and life cycle indicate that there has been an effort to develop traditional accounting approaches into environmental accounting tools. Examples are Full Cost Accounting (FCA), Full Cost Environmental Accounting (FCEA), Total

Cost Assessment (TCA), Life Cycle Cost Assessment (LCCA), Life Cycle Cost (LCC), and Full Cost Pricing. The purpose of LCC and other similar tools is to give the decision maker monetary measures of environmental performance, which can ease the integration of different dimensions. The driving force behind this development of managerial environmental accounting tools is the fact that current accounting techniques are inadequate for handling environmental issues (Bennett and James, 1997). Costs associated with environmental issues have long been underestimated by decision makers (Abraham and Dickinson, 1998), and it is easy to imagine that it is caused partly by a lack of monetary decision support tools that elevate environmental issues. It is also found that most companies do not properly identify or, even more seldom, measure their environmental costs nor identify their causes (Epstein, 1996).

In common for these modified managerial accounting tools is the fact that they attempt to integrate negative environmental impacts as costs into the managerial accounting systems. Managerial environmental accounting involves tracking and tracing environmental costs to the organization. The accounting approach also attempts to allocate where a resource is used and to measure it (Baumann and Cowell, 1999; Wycherley, 1997). In other words, detecting costs hidden in overhead accounts (Kreutze and Newell, 1994).

CONCLUSIONS

A number of problems were identified. In evaluating managerial environmental accounting tools such as LCC, a conclusion is that several problems occur in the integration of environmental and micro-economic dimensions. The difficulty of estimating the life cycle of a building and its components, as well as the problems with discounting methods, implies that the reliability of results from LCC is poor. There are many techniques available, such as the hurdle-rate principle (Gray, Bebbington and Walters, 1993), but, when there are no commonly used rules, the results cannot be compared and are thus unreliable. Continuously shifting environmental regulations and rules further contribute to this problem. The difficulty of implementing managerial environmental accounting tools such as LCC is that estimated future costs are not included in a company's current costs and prices. Thus, it is difficult to measure the environmental costs attributed to a company.

The relevance of the results from a LCC is often questioned because of the poor quality of data and a lack of industry standards that describe the life cycle behaviour of facilities (Abraham and Dickinson, 1998). The research found that, except for energy data, the data provided from the construction and real estate industry's standards and internal business accounting systems provided insufficient information. Thus, it was difficult to differentiate environmental costs from other costs. This can be a consequence of continuously changing accounting systems, unsatisfactory handling of the discounting problem, and negligence in bookkeeping. Another limitation is that the environmental impact of the building is not adequately identified. It is important to consider that a prerequisite for integrating environmental dimensions in managerial accounting systems, is that the environmental impact must be identifiable. This lack of identification means that the result of the calculated LCC can not be used to support environmentally responsible decisions.

The similarity between the concepts of different managerial accounting tools and the multifaceted grouping of environmental costs means that the concepts are difficult to apply in practice. Current definitions and groupings bring confusion to users and do not ease the implementation of the tools. This confusion implies ambivalence in deciding how and which kind of environmental accounting should be used to make environmentally responsible investment decisions. Since ambiguity is one reason why individuals make bad or at least irrational decisions (Hogarth, 1994), there is an obvious need for standardisation if practitioners are to use the tools.

It is possible to make two conclusions about future development of environmental accounting tools: (1) either_we continue our effort in developing tools that integrate environmental and micro-economic dimensions. But in order to avoid ambiguity a joint platform of definitions and groupings must be developed. (2) Or, we develop and use tools that complement each other. It is possible that instead of developing decision support tools, that integrate environmental and micro-economic dimensions, the future task is to raise manager's knowledge of environmental dimensions and thus change their social values. Because of the insufficiency of LCC as an environmental decision support tool this paper propose the latter approach as a more efficient way of making environmentally responsible investment decisions in building projects.

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BREEAM™

BRE

A practical method for assessing the sustainability of buildings for the new millennium

Matt Grace, Centre for Sustainable Construction, BRE, Garston WD25 9XX United Kingdom Website: www.bre.co.uk

What is BREEAM?

BREEAM (BRE Environmental Assessment Method) was the first commercially available environmental assessment tool for buildings and has been the benchmark for methods for assessing the environmental aspects of sustainability of buildings since the first version for offices was launched in 1990.

Why do we need BREEAM?

BREEAM provides the opportunity to benchmark the performance of all new and existing buildings using proven and effective, self financing methodologies.

In order to make progress towards sustainable development, a practical, easy to understand measure of sustainable construction is of paramount importance. The urgency of the need to address buildings should not be underestimated. In the UK, buildings are responsible for almost half of all carbon dioxide emissions as a result of their energy use, the construction industry consumes 6 tonnes of material per person per annum and creates 30–40% of annual waste, and a typical UK citizen spends approximately 90% of each day indoors, and is therefore potentially at risk from any hazardous materials within the fabric of the building.

How does BREEAM work?

BREEAM has been developed to provide a simple, cost-effective way of evaluating and improving the environmental performance of buildings. It brings real benefits for Developers, Designers, Landlords, Facilities Managers, and the environment as indicated by the continual and growing use of the method.

BREEAM covers the following areas of environmental impact:

Issue	Description
Management	Overall policy, commissioning and procedural issues
Energy Use	Operational energy and CO_2 issues
Health and Well Being	Indoor and external issues affecting health and well being
Pollution	Air and water pollution
Transport	Transport related CO_2 and location related factors
Land Use	Greenfield and brownfield sites
Ecology	Ecological value of the site
Materials	Environmental implication of building materials
Water	Consumption and water efficiency

For each of the categories set out above, the building is assessed against performance criteria set by BRE and awarded "credits" based on the level of performance against each criteria. The percentage of credits achieved under each category is then calculated and environmental weightings are applied to produce an overall score for the building. The overall score is then translated into a BREEAM rating of:

PASS

GOOD

VERY GOOD

or

EXCELLENT

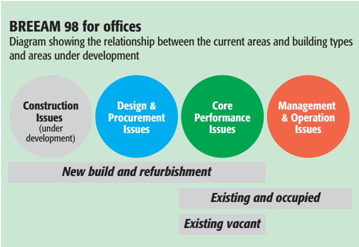
The BREEAM rating achieved will be presented on the BREEAM Certificate, which can be used to verify and promote the environmental credentials of an organisation.

How can BREEAM be used?

To date, over 500 buildings have officially been BREEAMed. Many more are in the process of being BREEAMed, and BREEAM versions have already been developed for Canada, Hong Kong, New Zealand and a BREEAM derivative scheme in Norway.

Types of buildings that are covered at present are Offices (new and existing), Homes, Superstores and Industrial Units.

Market surveys have shown that the perceived client benefits of BREEAM include environmental, benchmarking, productivity, marketing and health and well being. It is essential for BREEAM to stay in tune with client wishes and market forces as well as technical development aspects.



Latest developments and the future of BREEAM

EcoHomes

In order to distinguish itself from other systems currently available, BREEAM must continue to be developed, reviewed and updated to ensure that it takes into account the latest research, technological developments and legislation. The version of BREEAM that applies to Offices has been revised three times, the latest version having been launched in 1998. EcoHomes (the version of BREEAM for houses) was launched on 6th April 2000 and BREEAM is currently being developed to cover more building types.

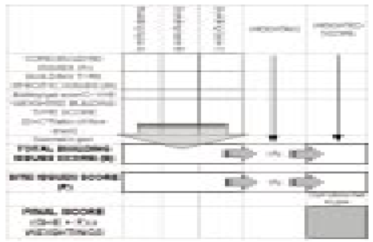


Figure 1 Multi building type assessment concept

BREEAM must also continue to expand to cover new building types and to explore new assessment techniques. Figure 1 shows a new concept, which can be used for the assessment of a building containing a number of different end uses or separate building types. At present, this is a prototype and has been successfully used to assess one major development. It is an example of one of the new developments that BREEAM is embracing for the future.

Recent revisions of the versions for both offices and homes have resulted in a significant growth in the range of issues covered. This reflects the broadening of the sustainability debate in general.

Maintaining the highest possible level of consistency and quality across all assessments is essential to maintaining the success of BREEAM as a benchmarking and reviewing system for the environmental sustainability of buildings. Assessments are carried out by a network of trained, licensed assessors.

Figure 2 shows an outline the system that has been established to maintain quality and consistency.

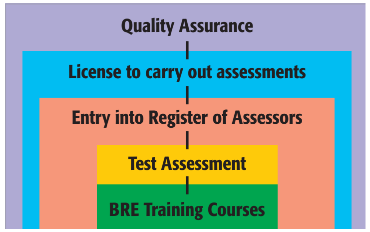
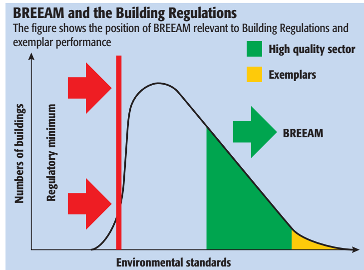


Figure 2 Structure for maintaining quality

Conclusions and recommendations

For more than a decade, BREEAM has now been at the forefront of benchmarking, reviewing and improving the environmental performance of the built environment. It has been and will continue to expand to embrace wider issues of sustainable construction as the debate becomes more informed from the results of ongoing research. The discussion and diagrams presented here illustrate and demonstrate the importance of maintaining close contact with the clients, through the use of market surveys, as the scheme must be self financing. The role of continuing development has been discussed. This is essential, as it will ensure that BREEAM takes into account relevant research and legislation and continues to expand to cover more building types. Lastly, quality was discussed and the mechanism installed for maintaining quality within BREEAM was described.



EXTENDED LIFE CYCLE ASSESSMENT OF BUILDING ELEMENTS - TO MATCH THE PLANNERS DESIGN-CONSIDERATIONS

Dipl.-Ing. Karin Gruhler and Dipl.-Ing. Clemens Deilmann,
Institute of Ecological and Regional Development, Dresden, Germany

INTRODUCTION

Life Cycle Assessments (LCAs) depend by definition on the interests of the user and the product. Therefore the framework can not be defined for each LCA in the same way. The framework and so the most important criteria and aspects depend on the specific product and the interests and goals of the user (fig. 1).

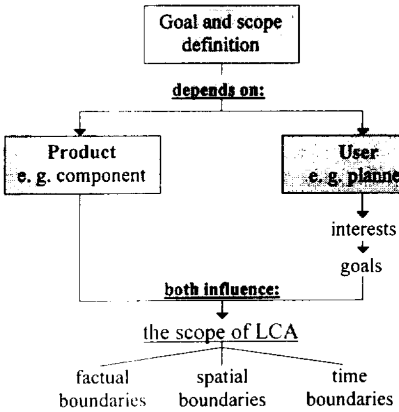


Fig. 1: Factors of influence in the first step of LCA

Although LCAs exist for different building materials and buildings, they are only to a certain extent a support for the planner in his decision-process. For comparisons between building elements of the same function it is first of all necessary to make sure that the boundaries of LCAs are the same within a specific and clearly defined framework. Otherwise it is difficult to find out the most favourable variation within the given variations.

Second, the LCA gives primarily information about environmental impacts associated with the life-cycle of a product (EN ISO 14040, 1997). But the planner requires beside ecological information those about functional, technical, economical and health issues. Thus it is necessary to define a specific framework which allows to describe a specific building product (e. g. external wall - EW) from a broader perspective of a planner. On basis of such an assessment-framework it should be possible, to evaluate and compare all the different variations of the building element "external wall" in a closer link up with the decision making process of the designer.

ASSESSMENT-METHOD OF BUILDING ELEMENTS

Selection of the assessment-approach

Within the scope of ecological evaluation the analysis of assessment tools shows, that there is a wide variety of possible assessment-approaches (DeMan 1995, Corino 1995, Wagner 1992, Rubik, Teichert 1997). Fundamentally one distinguishes between two assessment approaches, the product-related assessment (LCA, "work-piece calculation") and the environmental accounting ("period calculation").

To determine the right assessment-approach for a building element, the characteristics of the buildings themselves must be taken into consideration. Building elements and buildings are not consumer goods but products which are continously used. Compared with other products they have to guarantee a long phase of use. The running expenditures for maintenance and repair during the phase of use can be fairly high in comparison to the expenditure for first setting up (construction). These running expenses substantially depend on the decision for building materials and details taken during the planning phase (Kohler, Klingele 1995). On basis of the methodical investigations about assessment-approaches and the specific issues related to buildings, it becomes clear, that the building elements can be evaluated during their phases of production and disposal as a product. For the assessment of the phase of use, however, it is crucial to include aspects of an environmental accounting.

Definition of the specific assessment-framework

The specific assessment-framework was designed on bases of the results of investigations about goal, scope and operational steps of product-related assessment and environmental accounting respectively and about the relevant aspects of the building element "external wall" and the special interests of the planner respectively (Blum, Deilmann 1997).

To help the planner in the decision-process the LCA of building elements must be broadened by aspects about function, health and costs (fig. 2).

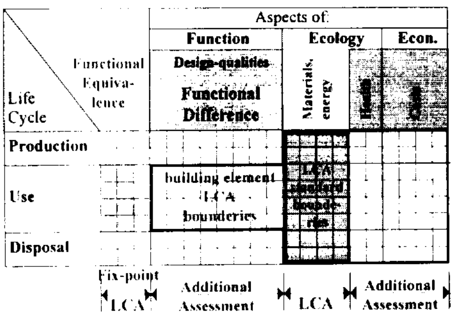


Fig. 2: Specific assessment-framework "external walls"

Function / Design-qualities

The production but also the functioning of the building elements and the building itself re-spectively and the running expenditures produce material and energy flows. When a building presents a poor performance or one that undergoes fast ageing, when mistakes in planning and construction come to surface or when changes in interests of user necessitate modifications, then the maintenance, repair, reconstruction, reorganization, conversion will produce great flows of materials and energy. These steps of change and modification are reflected in further consumption of material and energy. So the design and function of building elements will prove their efficiency mainly in the phase of use. But the impacts of the decisions taken during the design-phase should be reviewed more carefully at the beginning by a description of functional aspects like durability, weather protection, parasites resistance, easy cleaning, easy repair, risk for planing mistakes, building mistakes, heat gaps, thermal capacity, design constraints or aesthetics.

Ecology / Health

Furthermore the planner is interested not only in environmental effects and impacts. Questions related to health like indoor air quality, working conditions, risks and accidents are of great importance, because the builders as well as the users of the building are directly affected.

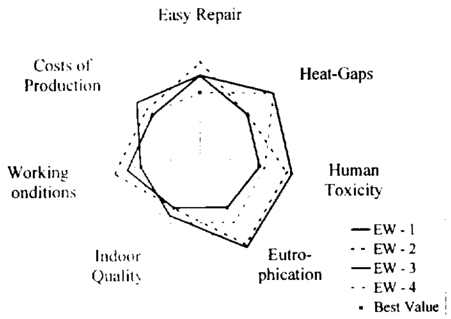
Economy / Costs

After all the cost aspect plays an important role. In this context it is not only important to reduce building costs, but for example the question to what extent high-quality construction necessarily is more cost producing, to what extent the running costs are effected. In this sense information about costs (time expenses, human labour, single, running and external costs) should try to integrate a total cost accounting.

Assessment - example

The practicability of the assessment-method (combination of specific assessment-approach and specific assessment-framework) was tested with the help of four different external wall-constructions. Seven criteria were selected to the describe the areas function, health, materials/energy and costs (fig. 3).

In order to compare the impacts of different criteria it was necessary to invent operation points with the same calibration. The chosen assessment-method is therefore a relative assessment. This assessment produces no absolute figures, but relational ones. These are appropriate to compare the different constructions along the very different aspects. The presentation in the „spider's web"-grafic shows the planner visually which of the external wall-constructions is the most favourable. The „spider's web"-grafic offers the planner a decision-support, but it does not reduce his assessment-conflict and responsibility for his final choice.



EW-1: brick and insulation plaster
EW-2: brick and rockwool
EW-3: calcium-silicate and polystyrol
EW-4: wooden frame and cellulose

Fig. 3: Relative assessment – „spider's web"-grafic

CONCLUSIONS AND RECOMMENDATIONS

Building elements are products which are characterized by a long phase of use. During this phase expenditures for the use of building elements include servicing, maintenance, redevelopment and reconstruction. These expenditures must be analysed and evaluated in ecological, functional and economic terms by an environmental accounting. Therefore the assessment for a building element is not only a product-related assessment (LCA), it must include aspects of an environmental accounting.

The LCA evaluates the environmental impacts of a product on basis of material and energy input-output-data. In a scientific view the LCA is informative, but it corresponds only partially with the interests of the planner. Information about durability, easy repair, building mistakes, indoor air quality as well as costs, are in general of greater significance for the planner. So the LCA should be broadened by functional, health and economic aspects.

A cost-effective, functional and ecological building along the complete life cycle means not only reduction in single expenditures for production but also reduction in running expenditures during the phase of use. So the environmental accounting of the building element should be in the centre of any approach.

In the decision-process, the planner must balance out the different aspects and effects. The results of a broader assessment can support his decision-making, when the information can be well illustrated in such a way, to allow the most favourable construction to be pin pointed. The relational assessment of different aspects in form of a „spider's web"-grafic is one possible way. Although no absolute, irrefutable final results are given, the planner can make comparisons in a visual way. Nevertheless it does not set him free from the assessment-conflict. In the end he has to decide himself, but on a higher level of thorough information.

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Building Deconstruction Assessment Tool

Bradley Guy, Associate Director
Center for Construction and Environment
University of Florida, Gainesville, Florida 32611-5703, USA

Abstract

Deconstruction is a means to "un-construct" buildings for the maximum recovery of reusable and recyclable building materials in a cost-effective manner. It also provides feedback for the design of new structures to extend their longevity through cost-effective maintenance, repair and adaptation. In order to make deconstruction feasible under real-world conditions, a model for use as a computer-based estimating tool is described. The tool may also be used for modeling economic variables to assist in determining labor and disposal costs, and salvageable and recyclable materials values, to make deconstruction cost-effective on a regional basis. The tool is for use with wood-framed one and two-story structures and will provide a template for other kinds of structures, including masonry residential structures, multi-family residential structures and eventually commercial structures, as more real-cost data is available for those building types.

Key words: deconstruction, selective dismantling, design for environment (DFE), design for disassembly, reused building materials, pollution prevention, assessment tools.

Introduction

The purpose of this model is to aid anyone from a home owner to a building or demolition contractor to estimate costs and revenue potential from the deconstruction of a wood-framed residential building. As further data is developed, the model will be adaptable to a commercial building. The basis for the default data in the model and the structure of the model came from the Center for Construction and Environment's (CCE) experiences deconstructing six (6) residential structures in Alachua County, Florida, USA. Deconstruction was determined to be economically feasible with salvage revenues and a contract price competitive with demolition. First costs were 21% higher than demolition over the average of the six (6) of the deconstructed houses. The net cost of deconstruction with salvage was 37% lower than demolition and 10% lower using "wholesale" prices. The net cost includes the retail used materials prices, which are 50% to 25% of equivalent new materials. Wholesale used building materials prices are in turn one-half of the retail used material prices.

The six (6) buildings used to develop baseline data were not selected based on a bias towards their more cost-effective deconstruction, as such, they provide a range of costs and revenues per square foot. The deconstruction assessment process that is presented in the model was developed from experience and was augmented by research on other projects and interviews with a long-time deconstruction specialist, Pete Hendricks from Chapel Hill, North Carolina, U.S.A. Another computer-based estimating tool for "selective dismantling", as it is called, has been developed at the French-German Institute for Environmental Policy - University of Karlsruhe, Karlsruhe, Germany (Ruch, et al, 1997).

The net cost of a deconstruction is the expression:

(Gross Deconstruction + Disposal + Processing) – (Contract Price + Salvage Value) = Net Deconstruction Cost.

The net cost for demolition is:

(Demolition + Disposal) – (Contract Price) = Net Demolition Cost.

Figure 1 - Economic Equations for Demolition and Deconstruction

The key factors in the feasibility of deconstruction are labor costs, which is both an independent variable and dependent on the number of deconstruction tasks and the efficiency of each task, and local disposal costs.

Salvage materials values are extremely variable, from dimensional lumber (which may be much less valuable than new lumber) to high value architectural salvage (which may have a unique value). The savings in disposal costs between gross deconstruction and demolition were on average 41% per house of the six (6) houses that were used to develop the model baseline data. Net savings from salvage were on average 53%. Therefore, there is less opportunity to increase salvage value (100-53 = 47%) than in reducing disposal costs (100-41 = 59%). Attempting to increase salvage per building will always have a point of diminishing returns as the more valuable items are stripped more efficiently than harder-to-access materials, and as less damaged materials give way to more damaged materials (Guy, 2000). Based on this analysis, the typical disposal fees in a geographic area are an important "indicator" of deconstruction potential and will encourage more "whole house" deconstruction in lieu of selective "cherry-picking" of materials.

Description of Model

The building deconstruction assessment tool begins with a preliminary assessment (Figure 2) based on building age, deterioration from water, termite, and fire damage, the relative costs of disposal, and whether the building uses higher grades of wood for finish materials, wood structure. This preliminary assessment uses a series of "indicators" of the building' s deconstructability, which are compiled into a score.

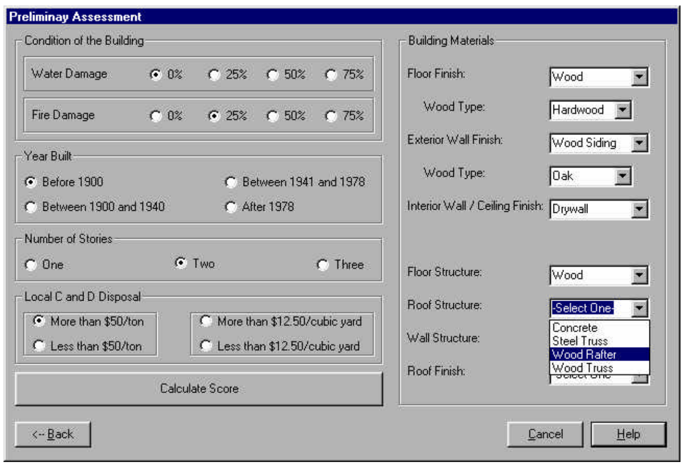

Figure 2 - Preliminary Assessment Using "Indicators" of Feasibility

Bonus points are given for a high local disposal fee and use of high-grade species lumber in the structure. Upon determining that the building has a high "score" for deconstruction, (Figure 3) the user will proceed to a more detailed quantification of the materials of the building and assign a base dollar value on the salvageable materials. The building is broken into major and minor components, under these categories, the specific elements and materials types are listed for the user to increase the specificity of the assessment as they wish. The main element categories are:

1. Appliances and Equipment
2. Hardware and Fixtures
3. Windows and Doors
4. Interior Casework
5. Interior Walls
6. Roof
7. Exterior Walls
8. Floor
9. Foundation
10. Site

The building is assessed in two ways, by the entire building and each subsequent addition to the original building, and then by room. For some elements such as exterior siding, the perimeter exterior walls can estimated as a component of the entire building. For other elements such as interior finishes, each room is assigned up to 6 wall surfaces, 2 ceiling surfaces, and 2 floor surfaces, and the finishes are estimated by room.   Element sub-categories include for example:

5. Interior Walls
    5.1 Wall structure
        5.1.1 2 x4 wood 24" on center
        5.1.2 8" Concrete masonry unit
    5.2 Wall Finish
        5.2.1 Gypsum drywall
        5.2.2 Wood paneling

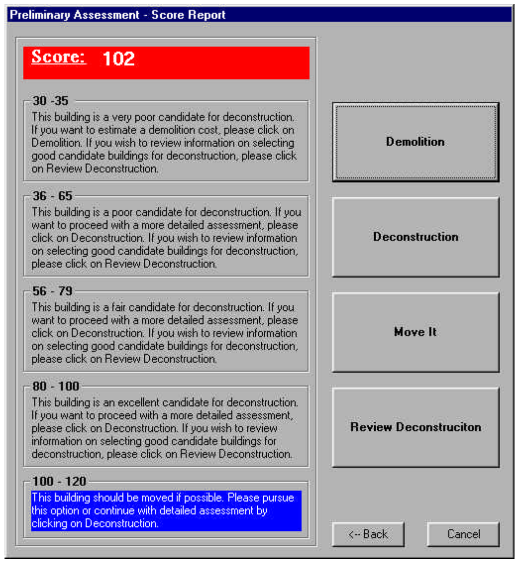

Figure 3 – Preliminary Scoring Summary

Upon completion of the materials quantity estimates, a salvage rate or percentage is assigned to each sub-element category to estimate the actual salvage value that can be expected. The salvage factor will first be based on the general level of deterioration as determined in the preliminary assessment, and then further refined with each element of the building. For example, in the case of a window or door, the user will assign a salvage factor of 1, since the window only has value as an entire unit. For a wood framed wall, the salvage factor will be a percentage of the wood in the wall.

Upon completion of the detailed materials and salvage estimate, the user will then be able to estimate costs based on unit deconstruction rates, estimated labor costs rates, estimated disposal and disposal costs, permitting and environmental assessment costs, and asbestos abatement costs if required. The final report will combine these estimates and variables to determine the cost-effectiveness of a deconstruction. In addition, the user will have the flexibility to change any variable such as salvage values for components, labor rates and disposal fees, in order to understand macro-level costs and specific materials revenues which most effect the economic viability of deconstruction in a particular geographic locale. This modeling capability will have use for determining local policy options to increase the feasibility of deconstruction within a particular municipality.

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ENVIRONMENTAL BUILDING INDEX AS A TOOL FOR THE MANAGEMENT

dr.ir. Michael Haas

Nederlands Instituut voor Bouwbiologie en Ecologie (NIBE)
P.O. Box 229, 1400 AE Bussum, The Netherlands
e-mail: m.haas@nibe.org

INTRODUCTION TO THE ENVIRONMENTAL INDEX

A hundred and one different factors play a role in the decisions we make about real estate projects (financing, architecture, location, and so on). If we also want environmental aspects to play a major role, this can only be done if those environmental aspects are presented in such a way that makes them crystal clear. We do just that with our 'environmental (building) index': a single number that represents a building's environmental quality.
We present results of the calculation of hidden environmental costs as an index. Just like the Dow Jones on Wall Street. Everybody understands what it means when the Dow Jones falls, but just a few know how the Dow Jones really works, what the figures behind the Dow Jones mean. When interpreting the environmental index, 100 indicates the zero (0) level (the lawful minimum). The index rises as more measures are taken above this minimum.
As you can see in the results of the environmental index , without much explanation you will understand which building is most environmental friendly.

ENVIRONMENTAL INDEX EXPLANATION

The daily practice in 1990 was index 100. The way we build today has an index of approximately 110-120. While the Dutch Government Building Agency builds with an index of about 140-160.
In the United Nations Brundtland-report is spoken of the factor 20, which means an index of 2,000 in the year 2040. The best buildings we build today have approximately index 300, with one exception. Technically, approximately 400-600 is conceivable, but we are not willing to pay the price.
As you can see there is still a lot of work to be done if we want to reach index 2,000. But at least we now have the instruments to calculate the stage of sustainability we reach. And there is hope, because today we can already build offices with an index of nearly 400. These buildings need to be built, because otherwise we'll get behind on our schedule in the realisation of index 2,000.
I will now explain the instrument we use for these calculations, its called GreenCalc. For the time being we have GreenCalc version 2.0.

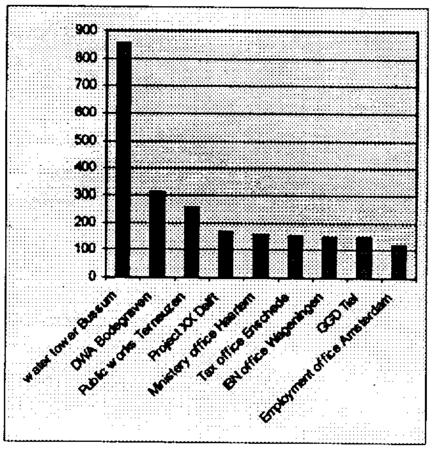

Figure 1: The environmental index is shown here. When interpreting the environmental index, 100 indicates the zero (0) level (the lawful minimum). The index rises as more measures are taken above this minimum.

GREENCALC AS A SMART CAR

GreenCalc is a combination of existing products; comparable to the Smart car, which is also built using products manufactured by a wide range of other companies.
GreenCalc is a computer programme having different modules. We choose the best we could find for the different modules.

building materials:
The building materials module is the TWIN-model from the NIBE. The TWIN model they developed is an excellent system for charting environmental impact based on LCAs. As we'll soon see, the TWIN model is a hybrid system.

energy use:
The energy module was developed by DGMR, one of the Netherlands' best-known offices in this field.

water use:
The development of the water module was based on a system produced by opMAAT and BOOM. This is used to calculate water consumption during the period of use.

commuter traffic:
The environmental impact of commuter traffic was developed by Bouwinfo Koster.

use of space:
The space module is based on a doctoral thesis by Ferdi Beetstra at the Technical University of Eindhoven.

monetary valuation:
Monetary valuation has largely been developed by the Erasmus University in Rotterdam, in cooperation with the Technical University of Eindhoven and the NIBE.

TWIN-MODEL (BUILDING MATERIALS MODULE)

The TWIN-model stands for two pairs of twins:

1. the matrix, comprised of an environmental element and a health element

2. the ability to incorporate quantitative and qualitative data

The assessment criteria of the TWIN-model are, generally, the same as those of the LCA methodology. The environmental matrix of the TWIN-model shows environmental interventions and environmental effects. These interventions are: resources, pollution, waste, nuisance, visual effects on landscape, energy, reusability, and life expectation. Pollution, for example, is listed as: acidification, effect of fertilisers, greenhouse effect, ozone layer breakdown, etc. etc. Various life phases of the resource exploitation lead to the demolition of the building and disposal of waste. The health matrix of the TWIN-model, again subdivided by primary criteria and secondary criteria: physical agents, chemical agents, biological agents, ergonomic factors, safety. Biological agents are listed as: bacteria, viruses, parasites, and fungi. Actually, these are only important during the use and maintenance phase of a building's life.
In the TWIN-model, the LCA method has been supplemented with a method, which also takes qualitative data into account. This is a method I developed as a part of the work I carried out to earn my PhD.
Comparative analysis is possible with this method, which is based on quantitative data to the extent possible, supplemented with qualitative data.

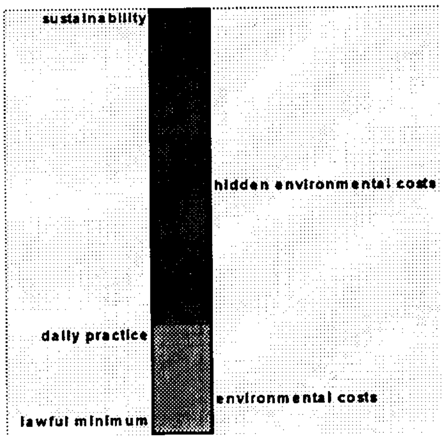

Figure 2: By 'environmental costs' we mean those costs that we incur in practice in order to protect the environment. They include the costs as insulation and double glazing. Although these measures reduce environmental damage, their effect is not so great that we can talk about a sustainable situation. If we really are serious about

sustainable building, we need to take much more far-reaching measures. Everything would then become that bit more expensive, and by current standards, in fact, too expensive. We therefore choose to forget those extra environmental measures. The environmental costs that we choose at the moment not to incur, but that are essential to sustainable solutions, we have called the 'hidden environmental costs'.

GREENCALC, CALCULATION IN FOUR STEPS

GreenCalc calculates what it would cost to prevent the environmental damage caused by a building's construction and use. In summary, GreenCalc is a calculation having four steps:

1. The calculation starts with a quantification of the environmental effects.

2. This environmental impact is then converted into a monetary value referred to as the 'hidden environmental costs'.

3. We then carry out calculations to reach a total figure for the environmental impact of a building and its use. In doing this, we take into account the expected life of building components, the use of the building, and its age.

4. A building's hidden environmental costs are compared to the hidden environmental costs of the reference building. The relationship between the hidden environmental costs of the building and the hidden environmental costs of the reference building determines the building's index, which unambiguously expresses the building's environmental quality.

CONCLUSIONS

Approximately eighty projects have been calculated up to this point. It is our experience that the calculations of environmental cost really do support the discussions on sustainable building. The decision-makers in the building industry think about the bottom line. Our approach in following this line of thought seems to be successful. Talking in terms of environmental costs communicates easily and encourages managers to search for a balance between environment and economics.

The reason it works so well is because it's simple. Everyone understands how it works and mutual comparisons are made possible. Another important reason why it works so well is because although it is easy to understand, people are confident that the underlying system is very well researched and is a reliable way of clarifying environmental costs. All the partners involved back the good quality of this information.

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WEB-BASED BUILDING PERFORMANCE ASSESSMENT:
FIRST STEPS WITH THE CBIP SCREENING TOOL

Curt Hepting and Diane Ehret, EnerSys Analytics Inc.
Maria Mottillo, Natural Resources Canada

INTRODUCTION

To encourage energy-efficient design practices and to bring about lasting changes in attitudes and practices in the Canadian building design and construction industry, Natural Resources Canada (NRCan) has implemented the Commercial Building Incentive Program (CBIP). CBIP offers a financial incentive for the incorporation of energy efficient features in new commercial/institutional building designs. An eligible building design must demonstrate a reduction in energy use by at least 25% when compared to the requirements of the Model National Energy Code for Buildings. To help building owners determine whether or not their building is a good candidate for the program, NRCan has developed a web-based building energy performance modelling tool. This tool gives the user information about their building's anticipated energy use, energy costs, and emissions savings from implementing energy-efficient technologies.

HOW THE TOOL WORKS

The screening tool is designed to give users rapid feedback, based on a select but key set of inputs. It allows users to enter values for their proposed design's construction, limiting the inputs to the characteristics of the building that most affect energy use. Inputs include:

- Building location, building type, and HVAC system type, selected from 2,500 possible combinations;
- Building envelope characteristics, including insulation and window performance characteristics;
- Mechanical system information, focussing on elements that typically have the greatest impact on energy savings;
- Lighting levels and type of controls; and
- Marginal utility rates.

Figure 1: Sample Inputs

Building Shell

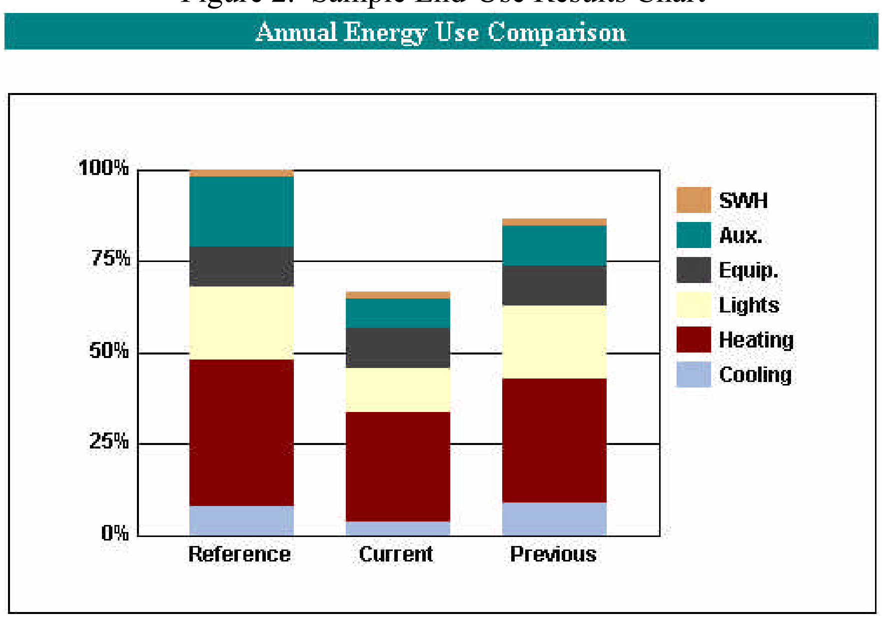
	Reference Building	Your Design	
Average window-to-wall-area ratio:	**20.50%**	20.50	%
Overall window U-value:	**3.20**	3.20	W/m_°C
Window shading coefficient:	**0.74**	0.74	
Overall wall R-value:	**1.82**	1.82	m_°C/W

To serve as a guideline and for quick comparison, each input displays the corresponding "reference case" value for a similar building if it were built to just meet the code, as shown in Figure 1.

The tool provides almost instantaneous feedback, including:

- A clear indication of whether or not the building design is likely to qualify for a CBIP incentive, and an estimation of the incentive amount;
- An estimated percent energy savings vs. the code-compliant reference case building;
- An anticipated annual energy cost savings, as compared to the reference case;
- Possible emissions savings as compared to the reference case;
- An end-use breakdown of the total energy consumption for both the proposed design and the reference case (Figure 2); and
- A summary page of the inputs and results that can be easily printed.

Figure 2. Sample End-Use Results Chart



In addition, the tool allows users to return to the input screen, change their input values, and view the difference in the results between the new inputs and the last iteration, as shown in Figure 2. Thus, the screening tool can serve as an educational device by allowing the user to investigate how various building characteristics impact energy use, energy costs, and emission savings.

BEHIND THE SCENES

The screening tool stores data derived from thermal, hourly energy performance models using the DOE2.1e software and encompassing more than 70,000 hourly simulations. While the interface intentionally limits the number of input data, the database contains default values for approximately 80 different building characteristics. The default values are based on standard practice design or prescribed energy code values, but can be assigned a full range of possible values as is appropriate.

Unlike most macro-based building analysis approaches, our calculational approach does not make use of statistical correlations, which typically use a relatively small subset of discrete building characteristics. In other words, the screening tool does not simply draw upon the relationship among easily quantifiable characteristics to predict energy savings, such as building size, HVAC system type, and if air conditioning is present. Instead, the screening tool's engine derives its calculations from engineering practices and thermodynamic principles which are embodied in hourly energy performance simulations.
The calculation engine embodies a unique process for rapidly accessing the results from a vast range of building energy simulations such as DOE2.1e. More specifically, it makes use of response factors produced from performing dozens of simulations on a specific building project. Each simulation represents a discrete change to a building characteristic (roof insulation, for instance). By also applying the engineering principles of how the discrete change affects energy use, the tool can calculate the end-use impacts from changing a building characteristic by nearly any amount. The results from this approach agree closely with actual DOE2 simulations (Hepting et al, 1996). Meanwhile, the approach has the advantage of taking less than 1% of the time—an important factor for an Internet application.

In comparison to econometric "top-down approaches," this engineering-based "bottom-up approach" allows more flexibility. Rarely, if ever, are there enough building characteristics data available to make statistically valid correlations to monthly or hourly end-use energy by fuel type. With the tool's approach, key building characteristics can be changed to calibrate the model to known energy and demand requirements. Users can then modify any characteristic to immediately observe the impact the change has on energy performance—as if they had run a full building energy simulation but in a fraction of the time.

CONCLUSION

The screening tool is widely used both by people interested in the Commercial Building Incentive Program and by NRCan program administrators. Building owners and developers can determine whether or not their building is likely to qualify for an incentive before undergoing the time-consuming and often expensive task of building performance modelling. In addition, they receive valuable information about the key characteristics that influence energy use and thus about the possible modifications to their design that can lead to an energy efficient building.

The screening tool has been a useful resource for NRCan staff as well by enabling them to conduct preliminary reviews of program submissions. NRCan is considering expanding the tool to create simulation input files that can be used in a more detailed energy compliance software to further facilitate program participation and administration. With its flexible and powerful core engine, there is a potential to apply this application to other programs and functions. For instance, the application is currently being modified to serve as a aggregation and policy analysis tool for existing buildings across Canada. The core system could also be used to facilitate a consistent energy rating service for existing buildings.

The screening tool has become an important component of the Commercial Building Incentive Program, and has the potential of helping to meet NRCan's goals of reducing energy use and emissions through its application to future programs.

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COMPREHENSIVE AND SCALEABLE METHOD FOR LCA-, COST- AND ENERGY CALCULATION.

Manfred Hermann, Niklaus Kohler, Daniela Schloeßer.
Institut für Industrielle Bauproduktion - Universität Karlsruhe, Germany

Introduction

Research on energy and environmental performance optimisation as well as basic research on design optimisation has shown the complex nature of the design process with incomplete knowledge, a multitude of iterations and a great number of involved actors [PAP93]. Taking into consideration sustainability objectives and the life cycle of buildings adds supplementary degrees of complexity to the design process. Existing LCA methods do not support the design process efficiently for several reasons: They generally are stand alone solutions which do not share the data with other design tools like CAAD systems. For this reason they cannot establish interactive relations showing e.g. the interdependence of energy consumption and cost. Furthermore these methods are generally adapted for one specific design situation; in most cases they are therefore either too detailed or too general. To cope with the changing degree of differentiation, different methods are used successively from checklist type tools through energy balance calculation to labels for specification. The results are a disproportional effort of repeated data input and an inconsistent framework of functional units, target values etc.

Basic requirements for LCA methods supporting the design, construction and management of buildings

The basic framework of the method should cover

- all life cycle phases (from design brief to facility management and deconstruction) ,
- the most important performance criteria like resource consumption (energy, costs,materials), impacts (on the ecosystem, on human health) and comfort .

The data should be retrieved either from a database or directly from other design tools (CAAD, element catalogues etc.). The functional units (reference units) should be adapted and adaptable to the different life cycle phases. It should be clear if data are hypotheses, design values, experience values, measured values etc.

The LCA methods should support a constraint based type of optimisation. Simple optimisation functions (like linear programming), multicriteria decision methods, rule- or case-based approaches do not allow to take into consideration the complexity and the scope of the design task. For this reason design optimisation research has moved to assisting methods with a high degree of interaction using extensive visual control. These methods try to assist comprehensive design teams in different situations, storing and retrieving simultaneously design step, contextual data and the relevant performance s.

All LCA methods more or less explicitly relate material causes (mass flows from the biosphere to the antroposphere) to effects on the ecosystem or on human health. Even if the existing physical energy and massflow approaches do not yet model all process in sufficient depth, there is no alternative to this general, system-ecological approach. The main issues are to decide where the best trade offs are and how reliable the results are as a basis for design and management decisions. There can be no doubt that all future LCA methods will be based on physical energy-massflow basis. The available computing and storage power allows to model the upstream, downstream and the building specific process in a detailed way even if only a small part of the possible results are used in the design process. The principal data issue is not LCA calculation but the description of the building. In the present professional practice (and design teaching) the geometric presentation of buildings through two-dimensional plans and sections and increasingly three-dimensional CAD models are still dominant. These representations are well suited for presentations to clients and to a lesser degree as production information. They do not allow any conceptual relation both with technical or simulation data and with historic or social context information [HAS00]. It is therefore difficult to bridge the gap between multidisciplinary scientific research and architectural practice as long as the geometric models did not have any relation to the knowledge based semantic representations of building product models.

The ongoing digitalisation of the design, management and production process and the international division of labour need some type of general, common, machine readable description of manufactured objects. The problem cannot be solved by the addition of interfaces between different applications. A product model is the attempt to model all information concerning the life cycle of a product. A product data model structures the different geometrical and semantic information and allows specific users determined presentations (views). [BJÖ92],

Efficient LCA tools which support the design, construction and management of buildings must be based on a generic framework which combines a state of the art modelling of physical mass and energy flows with a building description based on a product model which covers the life cycle of a building. This allows to continuously link the different performance aspects on a basic simulation level and to present automatically appropriated, phase- and actorspecific views. The specification of a life cycle oriented building product model [KOH97] and its implementation in software tools has been described in another contribution on the German LEGOE system. The structural components of this tool are

- a database with element and process specifications and reference buildings
- different simulation tools (energy, life cycle analysis, comfort, costs calculation, scheduling etc.)
- a tool which stores the data of a specific design stage from simulation, from the CADD system, from databases etc. The tool can retrieve a multitude of specific views from the basic data.

The two principal characteristics of this method are scalability and the modelling of default values.

Scalability

Research in the field of energy simulation and to a certain degree cost planning has shown that in the design process the same questions are asked several times during the advancement of a project, but that the level of accuracy and the granularity change. Furthermore, additional specialists enter the design process later on. One of the problems is that for each stage (and specialist), new conceptual models (and their corresponding software) are used. These models have different assumptions, different system limits and different mathematical resolution techniques. One way to overcome this dilemma is to use scaleable methods where the same complex model is used from the very beginning of the design process. Very few inputs are open in the beginning, most of them being occupied by default values (average values). When the process advances and new evidence or new specialists appear in the design process, the default values are gradually replaced by resulting design or dimension values. At the end the measured values can be used allowing improvement of the model for further applications [KOH97].

The basic idea is that the common model for the life cycle of building can only be the "building as built". The "building as built" is the starting point of the life time of a building and of its induced mass, energy, work and monetary flows. All planning steps, which precede the "building as built" can be considered as a temporarily uncompleted building or as not yet instantiated structure. The design process reveals the building (it discovers and fills the underlying structure). The questions of functional units is crucial because as long as a functional unit has not been given a specific value through a planning decision, it must take a default value, which can be the average value of similar buildings. This allows to produce a large number of simulations of possible design outcomes, which are of course not exact, but which are plausible.

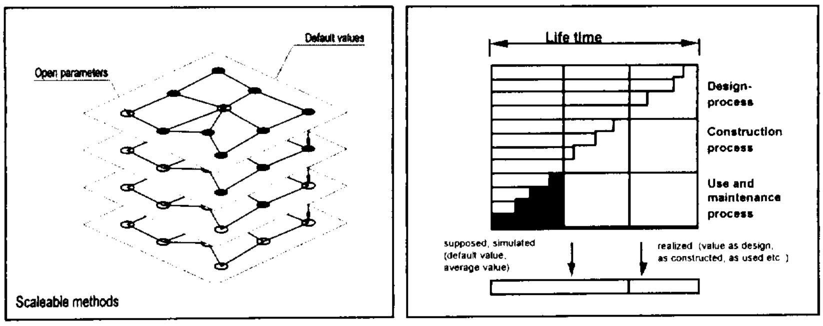

Fig. 1: Scalable methods in design

The basic assumption of this approach is that buildings of a certain function (housing, office buildings, hospitals, factory etc.) are much more similar than we generally think. Their cost and environmental impacts during their life time can already be determined during the design brief and through performance specification by associating performances and functional units. It also implies that simulation techniques can be used very extensively to verify if the performance targets are reached during the ongoing planning phase. The impacts of the building during the life cycle phases after construction (building as maintained, refurbished and demolished) can be simulated the same way, taking into account the upstream and the downstream processes. If we consider the "building as built" as the central representation, then the planning and use process of a building can be considered as the gradual replacement of average or default values by actually realised values. In the beginning a building is therefore described by 99 % of average (default) values and 1 % really planned (realised) values. This principle can be applied through the use of different (common) functional units. The advantage is that the whole building is considered and nothing is forgotten. It is therefore possible to represent buildings as combinations of planned and not planned parts, of realised and supposed parts, of real and virtual parts, of past, present and future parts.

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LEGOE – A COMPLEX DESIGN AND VALUATION TOOL

Manfred Hermann, Niklaus Kohler, Daniela Schloeßer, Universität Karlsruhe, Germany
Holger König, Ascona GbR, D-82194 Gröbenzell, Germany
Thomas Lützkendorf, Bauhaus-Universität Weimar, Germany

INTRODUCTION

The design world of architects and engineers is changing. In addition to the still dominant investment orientation, costs arising during the whole life cycle of the building are being taken into account as well as ecological and technical requests for objects produced from building products. Therefore there is a high demand for complex tools to support design decisions. They must guarantee that previous evaluation criteria, like function, form, and economy are met and not negated by environmental and health protection aspects.

The goal of the German LEGOE project was the integration of an ecological evaluation into normal work routines and tools (CAD, specification and quantity surveying) used by architects and engineers. This integration has taken the form of complex integrated design and construction tools. In addition to usual building cost rates and performance certifications, the designers will be provided with additional information about economic data (investment and running costs), ecological data (resource consumption and environmental impact), energetic data (observance of national laws and ordinances) and health data (comfort) during the design process which will allow a direct feedback.

Unlike in conventional design tools, the whole life cycle of a planned construction ought to be represented. The usual work flow in building design will be maintained to keep the adaptation difficulties to additional problems as low as possible.

STRUCTURE AND PROCEDURE

Basic data on energy, transportation, materials, and waste elimination

The life cycle analysis of energy and mass flows of building products, building parts and buildings as a whole requires data about resource consumption and the environmental impact resulting from the preparation of final energy, transportation services, the extraction and production of materials and waste elimination. The data for the life cycle inventory and life cycle impact of building products are obtained by recording the process chains and not simply by taking data from literature. This allows for a standardisation of assumptions and a regular update of the data. In the framework of LEGOE, basic data of the Öko-Institut Darmstadt (GEMIS) [GEM95] as well as that of the ETH Zurich (ECOINVENT) [FRI95] are used.

Database for ecological and technical qualities of building products

Ecological data for building products (building materials as well as building parts, composite building parts and manufactured components) are provided for the level of life cycle inventory analysis and life cycle impact analysis. These are calculated by using uniform basic data stored in a DBMS. Since the linking of the process steps is maintained within the DBMS, an update of the data stock (due to changes in the process chains) is possible. The system limit of the data acquisition is the finished building product at the production site corresponding to the approach "from cradle to gate". Building products carry information, which can only be realistically evaluated in the final context of the building on its site. There is no continuous evaluation of the life ("from cradle to grave") on the level of building products.

Evaluation procedures of environmental impact

LEGOE is not limited to one particular evaluation method. It allows the possibility to choose between several methods. The module "evaluation procedures and evaluation data" consists of a selection of known evaluation procedures including the required basic data. Basic evaluation data are method-specific evaluation factors for single elements of life cycle inventories as well as weighting factors of aggregation methods. At present the following evaluation possibilities are available: mass flow, primary energy consumption, effect-oriented impact categories, full aggregation (eco-indicator).

Energy prices are managed separately to allow different present and future economic evaluation methods.

Building elements and building specifications

LEGOE uses a catalogue of building elements whose attributes contain all necessary life cycle specific information. This is the basis for the analysis of the economic and ecological consequences of certain design decisions building over the entire life cycle of the building. In current practice building elements describe material and constructive solutions. They allow the estimation of the building costs and the plausibility of a solution already in early design stages. The life cycle evaluation is made possible by the introduction of energy and mass flow data, impact categories, health aspects and life cycle scenarios. Usual data like technical information and cost rates are maintained.

The building elements of this catalogue are composed of building process specifications. On the level of the building process specifications, it is possible to identify the single material processes needed and to describe them by the necessary quantities of materials used (including all auxiliary materials and waste) and of tools and machines used (including their energy consumption and their maintenance). Since the building process specifications are assigned to building elements, the basic quantities can be calculated for the building elements and then linked to the evaluation data. [BAR95]

In order to reflect the life cycle of a building element, additional information is needed about the life expectancy, maintenance and cleaning cycles, energy consumption during use, recycling behaviour and appropriate elimination paths. Through this method, the traditional construction elements for building parts and technical equipment are complemented by cleaning, maintenance and refurbishment elements with their specific set of evaluation data

Building description

The attributes of the building element catalogue can be used to describe buildings composed of building elements. However, this description is not sufficient for certain life cycle calculations. They need topological information and neighbourhood relationships which cannot be derived from the element catalogue attributes. LEGOE is based on a CAAD system using a building model which serves as an input module which is able to store, to manage and to interpret geometrical and semantic building information. The user can associate elements of the catalogue to the elements of the design in the CAAD system. By this procedure, all building element-specific data of the catalogue are available and can be used in combination with data at building level. In the case of topologically independent criteria, the quantities of different building elements and classes of elements of the design are immediately available and can be transferred into the project-specific database (PDB). The building specific topological data are used as input for calculation methods which require attribute values of the building elements as well as data derivable only from the spatial and space enclosing structures of the building. The interpretation programs use a combination of building-specific and element-specific data.

Scenarios and rules of calculation

The resource consumption and resulting environmental pollution due to the production of materials and the construction process can be considered as an accomplished process which is "reviewed". The appreciation of the life cycle can only take the form of a simulation of use, maintenance, refurbishment and waste elimination cycles. It is a "forecast" using scenarios and assumptions concerning the future.

Within LEGOE, a set of scenarios is available for the user. In addition, specific assumptions can be formulated. In modelling the assumed life cycle, the following criteria must be established: utilisation including a standard-use-scenario, considered time period, trends in cost development, levels of equipment, cycles of cleaning and maintenance, cycles of refurbishment and waste elimination.

In order to determine the energy and mass flow due to utilisation, life cycle inventory analysis and life cycle impact analysis is necessary, corresponding to the evaluation of the construction phases. It is necessary to provide rules of calculation for the determination of the present consumption of heating, lighting, air conditioning as well as service and maintenance. Whereas the determination of the running energy consumption of room heating and hot water can be performed according to national standards or internationally acknowledged methods of calculation, new procedures had to be found for service, maintenance, and the use of auxiliary energy.

Building simulation

Specific calculation programs are developed or extended to simulate the life cycle of a building with regard to costs, energy, comfort and environmental impact. The life cycle calculations require the mentioned specific description of a building related

to rules of calculation and pre-configured scenarios. The calculation programs require this description of the building, extracted from the building model of the CAAD system, as well as the data from the building element catalogue as input data. For each calculation program, the required data are prepared from the building model data and stored in the central data repository PDB. The element-specific data are available for each calculation program through the specific labelling of the building elements. In detail, the following calculations depending on the chosen scenarios for the life cycle phases of new construction, utilisation, refurbishment and demolition are executed:costs, ecological indicators, energy consumptions for room heating and hot-water, electric energy consumption, water consumption.
The data generated by the different calculation programs are stored in the PDB and are available to the other modules.

Room simulation

The ecological construction approach (estimation and evaluation of energy and mass flow during the lifetime) is completed by an assessment of the comfort conditions of the users. The estimation of the energy and mass flow can be done for the building as a whole. The assessment of the thermal comfort or, for example, the room acoustics can only be realised for specific rooms. In the present version of LEGOE, the thermal comfort in winter is evaluated on the basis of the average value of the internal temperatures and the temperatures of the bounding surfaces. The evaluation of the summer comfort condition is realised by calculating the probable number of days of utilisation with undesirable high internal temperatures.

Evaluation and interpretation

For evaluation, interpretation and, if necessary, modification, a comparison of calculated data and target values is performed. The different modules offer the possibility to define target in the form of legally fixed values as well as values taken on reference by literature, and to compare them visually to the calculated results. In order to create an overview of the calculated data, another module serves exclusively to produce the graphical representation of a subset of these data. This subset includes all aspects (costs, heat requirements, energy requirements, water consumption and ecological indicators) during the entire life cycle of the building.

Production of documents

The approach of LEGOE incorporates the coupling of the production of documents like object descriptions, evaluation of resource consumption and the resulting environmental pollution and energy certificate into the evaluation and interpretation. Based on a central object and data administration, information can be generated, evaluated and assigned to the necessary documents afterwards.

CONCLUSIONS

In the R&D project LEGOE, the calculation of costs, energy requirements and ecological evaluation is integrated into the design process. The entire life cycle of a planned building is taken into consideration.
A first complete application of the LEGOE concept based on the catalogue of building elements and integrated tools for selection of building elements, calculation and interpretation of costs, energy and LCA without using a CAAD system will be developed this year.

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ESCALE, ASSESSMENT METHOD OF BUILDINGS ENVIRONMENTAL PERFORMANCE

Dr Sylviane Nibel [1], Dr Nadège Chatagnon [2], Prof. Gilbert Achard [3]

1. Centre Scientifique et Technique du Bâtiment (CSTB), 84 av. Jean Jaurès, Champs-sur-Marne, BP 2, F-77421 Marne-la-Vallée Cedex 2, France, Tel : +33.(0)1.64.68.83.01, Fax : +33.(0)1.64.68.83.50, E-mail : nibel@cstb.fr
2. EDF / Division Recherche et Développement / Dépt. Applications de l'électricité dans les bâtiments, Centre des Renardières, Route de Sens, Ecuelle, 77 818 Moret sur Loing, France, E-mail: Nadege.Chatagnon@edf.fr
3. LGCH (Laboratoire Génie Civil et Habitat), ESIGEC (Ecole Supérieure d'InGEnieurs de Chambery), Université de Savoie, Campus Scientifique, 73 376 Le Bourget du Lac Cedex, France, E-mail: Gilbert.Achard@univ-savoie.fr

INTRODUCTION

This paper presents the results of a French Ph.D. managed by CSTB and University of Savoie, dealing with the development of an assessment method of building environmental performance, usable at the design stages [1]. The method, named ESCALE, has been designed to be adapted to the iterative design process, to speak the decision-makers language and to provide understandable and interpretable results. It is structured by 11 main criteria, declined in sub-criteria. To each sub-criterion corresponds an assessment module. The final result is a partially aggregated profile, giving performance scores.

As part of this Ph.D. work, the methodological framework of ESCALE has been defined, and various modules have been developed in an operational way, demonstrating that different assessment approaches can coexist inside a single method. This research work took advantage of the Green Building Challenge project and also provided substance to this project. The work on ESCALE is currently going on, with the development of new modules and preparation of software.

The paper gives a brief overview of the work done. It emphasises on methodological choices and is illustrated by the presentation of different module types.

METHODOLOGICAL STRUCTURE

Environmental profile

The tree structure is schematically presented in Table 1, showing the main criteria and the first level of sub-criteria.

Environmental criteria
1. Energy resources *
2. Other resources . water resource * . materials resources °
3. Waste ° . construction waste . operation waste . demolition waste
4. Large scale pollution . greenhouse effect * . acid rains * . ozone depletion ° . radioactive waste *
5. Local pollution . air pollution + . water pollution ° . soil pollution °
6. Contextual fit + . landscape and architectural integration ° . respect for neighbours . users' local outdoor comfort . respect for the ecology of the site . adaptation to networks
7. Comfort . thermal comfort * . visual comfort * . acoustic comfort * . olfactive comfort °
8. Health . indoor air quality + . water quality °
9. Environmental Management *
Indirect environmental criteria
10. Maintenance *
11. Adaptability *
** : operational model + : partly developed model ° : undeveloped model*

Table 1: Hierarchical criteria structure

Two levels of assessment modules

Two levels of assessment module are defined for each criterion. Each one is adapted to the level of detail of the available design data. These modules are:

- a simplified module suitable for the upstream design phases (Sketches and Preliminary Design),
- and a detailed module adapted to the Detailed Design and Project phases.

Assessment according to individual criterion

The assessment according to an elementary criterion is made up of two stages. The first stage consists in giving a value to the indicator associated to the criterion. The second consists in positioning this value on a performance scale.

This performance scale is defined by a reference value (0, equal to a statutory value or one frequently met in practice); a upper limit also called target value (5, equal to a best possible value); a lower value (-1, equal to a non-statutory value or below normal practice); and by a performance function that makes the link between the value of the indicator and a numerical value from -1 to +5.

In the ESCALE method, the assessment based on each criterion (or sub-criterion) is the aggregated result, by weighted sum, of the assessments of the previous levels of the tree structure. However, complex and incomparable criteria are not aggregated.

Hierarchical presentation of the results

The final environmental profile is a 24-component multi-criteria profile which, in the form of bar charts, represents the performances of a project according to different assessment criteria or sub-criteria.

The output profile can be broken down into explanatory sub-profiles in order to explain the results of the performances obtained (see Figure 1).

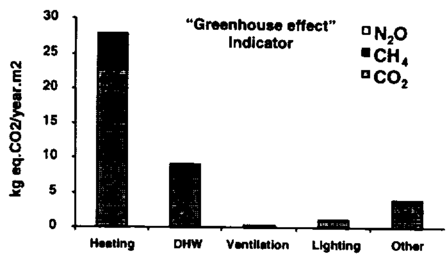

Figure 1 Example of sub-profile

PRESENTATION OF SEVERAL ASSESSMENT MODULES

The three criteria presented hereafter have been chosen because they represent the diversity of the issues and the models used in the method. Indeed, these three criteria are structured differently and their indicators are of different types (quantitative, qualitative, results-oriented, means-oriented, etc.

"Acoustic comfort" criterion

Two modules have been recently developed: a simplified module applicable in the preliminary design phase (qualitative), and a detailed module applicable in the detailed design phase (quantitative and qualitative). It has to be noted that the acoustics concerning the block plan (position of buildings, infrastructures, etc.) are taken into account in the "Contextual fit" criterion.

The structure of the detailed module is made of 3 elements :

- sound-proofing (indoor / outdoor noises)
- sound correction
- architectural organisation (qualitative)

The performance function finds its inspiration in the different perception thresholds of acoustic ambiences: indifference threshold, preference threshold, etc.. It takes account of French and European regulations (the score 0 corresponds to the statutory level).

"Large-scale pollution" criterion

The main environmental source of the "Large-scale pollution" main criterion is the energy which is used during the life cycle of the building. For the time being, only the preponderant use phase has been modelled operationally. This main criterion breaks down into four sub-criteria concerning the environmental effects:

- "Greenhouse effect" (indicator: GWP),
- "Acid rain" (AP),
- "Radioactive waste" (volume),
- "Ozone layer" (under development).

As a first step, in order to calculate the indicators, the energy consumption of the different uses of a building have to be estimated.

Lastly, the performance scale is sensitive to both the type of energy and the energy consumption.

"Maintenance" criterion

Indeed, the quality of maintenance will considerably affect the future environmental performances of the building and its service life. The structure of the module is presented in Figure 2.

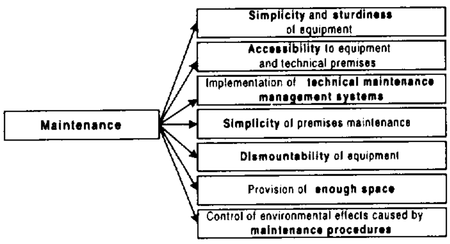

Figure 2 : Maintenance criterion

Check lists are used to perform the assessment. This makes the evaluation procedure simple and quick and also may orient the design.

Does ESCALE have decision-making characteristics ?

For example, despite the aggregations made, the intermediate results remain readable and accessible. The fact of being able to move with transparency inside the tree structure of the results assists the user in results interpretation, that is a preliminary step to take any decision.

CONCLUSIONS

This assessment method of the environmental quality of a building project, based on criteria which are directly or indirectly environmental, is a first stage in a decision-making tool. The environmental information produced may form a common basis for discussion and negotiation with involved parties.

The first applications of the method to a real project have demonstrated its feasibility and presented a few of its potential uses in decision-making.

The missing modules are under development according to the same principle (diversity of issues and modelling), and new tests will take place when these are entirely operational.

Once completed, the method will then provide a wide range of environmental criteria, useful to decision-making, which will avoid a design solution being chosen according to a single environmental criterion, while ignoring its performance according to the other ones.

However, it would be worth while coupling this environmental assessment to other assessments, especially economical, functional and social ones.

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IMPLEMENTATION AND COMPARISON OF FOUR BUILDING ENVIRONMENTAL ASSESSMENT TOOLS

Dr Sylviane Nibel (1)
Anne Rialhe (2)

1. Centre Scientifique et Technique du Bâtiment (CSTB), 84 av. Jean Jaurès, Champs-sur-Marne, BP 2, F-77421 Marne-la-Vallée Cedex 2, France, Tel : +33.(0)1.64.68.83.01, Fax : +33.(0)1.64.68.83.50, E-mail : nibel@cstb.fr
2. Innovation Energie Développement , 46 rue de Provence, 75009 Paris, Tel : +33 (0)1.48.74.62.15, Fax : +33 (0)1.48.74.50.52, E-mail : a.rialhe@ied-sa.fr

INTRODUCTION

In the framework of ATEQUE, (French working group for building environmental quality assessment), French assessment tools have been described and analysed, according to a format specifically developed for this task. But the most interesting part of the work was the implementation of 4 tools, EQUER, ESCALE, PAPOOSE and TEAM for Buildings, on a case study, and the comparative analysis of the results [1].

OBJECTIVE AND APPROACH

The objective was to study on a concrete case existing French tools, in order to show the way they are operational and to analyse the results, in their overall consistency and also more in detail.

Indeed, considering professional external demand more and more exacting and supply too partial, it seemed necessary to demonstrate what can provide the assessment methods developed by the ATEQUE teams.

The case study was a single-family house belonging to a Green pilot project (REX HQE near Toulouse). The exercise was performed on the house as it was built and on two variants. Term to term comparisons have been performed, intermediate results and assumptions have been studied.

PRESENTATION OF THE 4 TOOLS

EQUER, developed by a team led by Ecole des Mines de Paris, is an LCA oriented tool. It contains product data bases of Swiss and German origin. It is coupled with a energy analysis software, Comfie. Equer calculates 12 environmental indicators. Outputs are presented by an eco-profile, with the possibility to display the contribution of each phase of the building life cycle, and to compare variants.

ESCALE, developed by CSTB and University of Savoie, is a method able to assess the environmental quality of a building along its design phases. 11 main criteria have been defined, representing for instance impacts on outdoor environment at different geographic scales, users' comfort and health, environmental management. Two levels of models exist, simplified and detailed, in order to square with the availability and accuracy of data. The final profile is expressed in terms of performance scores, complemented by explanatory sub-profiles.

PAPOOSE, developed by TRIBU, is defined as a decision-aid tool, targeted to building owners. It covers the various design stages, by different calculation levels. It deals with a dozen of environmental themes, with a particular attention to energy and to the users, and include cost aspects. Results are presented in numerical and graphical form, given among other things performances expressed in percentage.

TEAM for Buildings, developed by Ecobilan, is a variant of the TEAM LCA software, adapted to the building sector. It includes the DEAM data base covering numerous industrial fields. It enables the user to model graphically complex systems thanks to the nesting of systems and sub-systems. The user has the choice between different methods to translate flow inventories into impact indicators.

EXERCISE ORGANISATION

For this exercise, three cases were defined: the house as it was built (basic case), a first variant with a slight increase of glazed area, and a second one with an economical and ecological user's behaviour.

Developers implemented themselves their tools, and the results were analysed collectively by a working group, including developers. The analysis was managed by CSTB and IED.

Initially, when looking at the results given by the tools, it could be noticed that the 4 tools had not all assessed the same phases of the building life cycle, that they did not exactly deal with the same environmental themes, and that they used different assumptions, units and indicators.

The comparison was carried out only on the results comparable between at least two tools. Only quantified results were analysed, after expressing them in a common unit. It has to be noticed that the exercise does not reflect the variety of outputs of each tool.

Comparative analysis has dealt with the following issues:

- Eco-balance of material and product manufacture
- Water consumption
- Energy consumption
- Airborne emissions
- Waste production

SUMMARY OF RESULTS

ECO-BALANCE OF MATERIAL AND PRODUCT MANUFACTURE

The variations, often consequent, noticed at the level of the material manufacturing phase are due to an insufficiently accurate description of the project on certain materials, to variable assumptions of density and lifespan, and to life cycle inventory data bases of different origins, sometimes little adapted to the current French context. The limits of the system considered, including more or less industrial processes, are an additional factor of variation, in particular on energy consumption. It is currently lacking recent, validated and transparent French data bases.

WATER CONSUMPTION

The study of water consumption emphasises the strong prevalence of the use phase (which accounts for 99% of consumption). The assumptions differ according to the tools, and the significant influence of the efficiency of the water supply network and of water consumption due to the cooling of the nuclear or thermal power stations could be appreciated.

ENERGY CONSUMPTION

A rather complete analysis was undertaken on energy consumption, expressed in primary energy. There too, the assumptions differ, with regard to the limits of the system (processes related to the infrastructures such as transport, waste processing, water supply networks) and to final consumption of certain domestic uses as lighting, domestic hot water or cooking, very dependent on the occupant's behaviour. Primary energy is dominating in the use phase (91 to 95% for a 80-year lifespan of the building). Primary energy related to the renovation is about equivalent to that related to manufacture / construction of the house. The variants have shown that the results evolve in the same direction. The "window" variant made it possible to check the sensitivity of the tools to small variations.

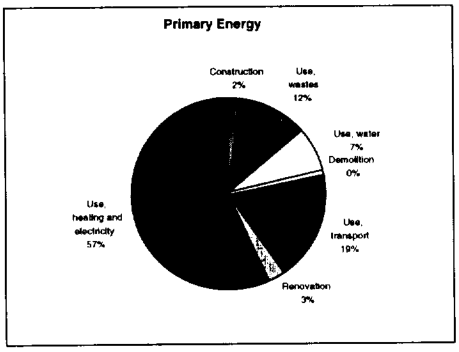

Fig. 1 : Energy consumption sources

AIRBORNE EMISSIONS

As far as the emissions are concerned, this is mainly the airborne emissions that were studied, the comparison being more limited for the emissions in water. The greenhouse effect and the acidification were analysed. The greenhouse effect calculated in the use phase is approximately 20 times greater than the one of the manufacture / construction phase. The airborne emissions in the use phase are not only due to energy and its infrastructure, but also to transport (of the users and materials), to water pumping and treatment, to domestic waste processing. These last three items are not taken into account by all the tools.

WASTE PRODUCTION

The way of calculating and presenting the results on waste is not always very transparent, and it would be advisable to distinguish the various types of waste in the results, in addition to a distinction per phase. The radioactive waste related to electricity production is calculated separately and is expressed in volume in three tools out of four. The differences observed in the results come especially from the conversion coefficients used.

IN BRIEF...

Finally, the results were considered as globally coherent between the tools, and these appeared sensitive to the variations of design, even to slight variations (study of variants).

GENERAL REMARKS

Other lessons have to be drawn:

- The definition of the system limits is a fundamental problem; the developers must justify the system limits according to their objectives (the latter may differ from one tool to another).
- The question of the taking into account of the users' transportation is not the subject of a consensus, certain tools taking it into account, others not.
- The occupants' behaviour is very influential but difficult to forecast and model, which brings to suggest the definition of various scenarios of behaviour applicable to a same building design, in order to better determine in the results the behaviour-related part.
- The assessments privilege the effects on a broad geographic scale, with the detriment of those on a local scale, on which work remains to be made.
- The sources responsible for the environmental effects must be indicated most clearly possible, and the results must be able to be disaggregated consequently, enabling the decision-maker to understand on which sources he must act to reduce the effects.
- The sources generating significant environmental loadings are not obvious to identify at first sight. That implies a systematic study of the sources included in the system, before carrying out simplifications (e.g. for energy and water consumption, and for the emissions).
- It would be useful to supplement the environmental assessment by an analysis of the cost of the solutions considered.

At the end of this work, the working group tried to define some specifications for the assessment of building environmental quality, in terms of users' needs, object to be assessed, system limits, and relevant outputs (see [1]).

CONCLUSIONS

This work enabled us to better understand each tool, to show what kind of results can be brought by current environmental assessment tools, to explain discrepancies observed in the results, to draw lessons and recommendations and to suggest improvements. This exercise constituted a sort of inter-model validation.

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Cost Benefit Analysis of a LEED™ Model Building

Paladino Consulting LLC, Tom Paladino
6815 32nd Ave. NE, Seattle, WA 98115 USA
info@palcon.com

INTRODUCTION

This paper examines the costs required for a building to achieve a LEED rating, a USA metric for measuring building performance, and analyzes those costs against the economic and environmental benefits provided. Based on early results of the LEED™ Pilot Program, conclusions regarding the financial results of investing in different green building features are offered.

THE LEED™ APPROACH

The LEED Green Building Rating System™ presents a qualitative indicator of relative building performance, awarding a building a Certified, Silver, Gold, or Platinum medal if the building incorporates the required number of green building 'measures'.

LEED™ (version 2.0) has grouped measures into five environmental goals. Under the headings of Sustainable Sites, Energy Efficiency, Materials and Resource Management, Indoor Environmental Quality, and Safeguarding Water, measures are designed at increasing environmental performance within each of these goals.

Up to now, designers have been limited to the CSI or UNI Format outlines for their cost estimates. Typically, building features or measures are studied on first cost basis as shown in figure 1. The result is that performance features can appear to have significant cost premium. This easy identification of high first cost attracts the attention of value engineers and contractors, with all to familiar results.

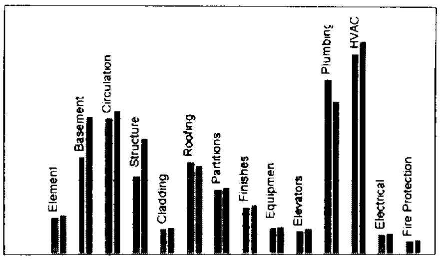

Figure 1 - Cost evaluation of green versus standard

With LEED™, a new organization, the five environmental categories, allows for a very different kind if cost estimate to be created; one based on performance rather than construction elements. Within each category, parametric studies can be made to determine the most cost effective set of environmental building features.

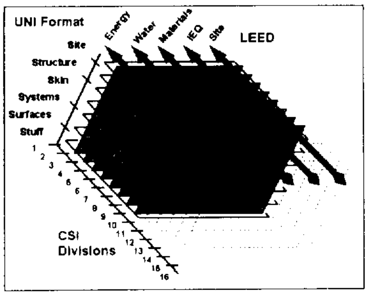

Figure 2 - Cost estimating systems

The simplicity of the system makes it a useful tracking tool to indicate how green your project is during design, providing a metric that even a layperson on the team can understand. This important new feature of the system affords a more rigorous cost analysis of the possible measures to be included in the project.

A LEED™ MODEL BUILDING

To study the strengths of the environmental cost evaluation approach, a computer model of a LEED™ building has been developed. The model is established by stating the design assumptions that influence the "environmental demand" associated with each measure. Such assumptions include the number of occupants, lighting levels, and fuel costs for example. The linkage allows a change in occupant load to influence both ventilation volumes and water consumption, for example.

Once the assumptions are defined, a parametric study of the LEED™ credits on a project can be made using the "principles of performance" to identify alternate, supporting measures. For example, reducing demand or increasing efficiency are both strategies useful in meeting the goal of Energy and Atmosphere protection. Under the strategy of "reducing demand", measures could include "reduced lighting power density," or "expanded comfort zone." Under the strategy of increasing efficiency "install T-5 lamps," or "use high efficiency boilers." These measures are specific performance improvements with measurable performance targets such as "8 watts/square foot," or 93% efficiency, and can be evaluated on a first cost and running cost basis. The ultimate decision can then be based on selecting for the least life cycle cost, or greatest net present value (NPV).

With green building, approach, the comparison of green versus traditional is avoided, and the discussion focused on the total cost of the measure. The "measure" becomes the basic building block of the cost estimate.

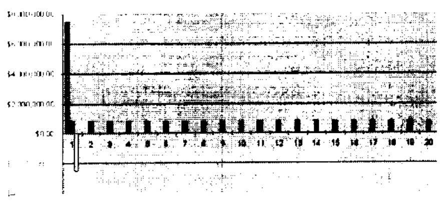

Figure 3 - Cost evaluation of green measure's NPV

ANALYSIS OF THE LEED™ MODEL BUILDING

As an example, energy will be discussed in detail. The other environmental categories can be treated in a similar fashion. Energy is a finite resource that must be conserved to achieve a sustainable pattern of development. Given the prediction of continued population growth, the most effective way to reduce demand is to lower our per capita consumption of electricity. Each new project should meet performance targets of reduced energy consumption through one or more energy conserving strategies that reduce demand, harvest site energy and increase system efficiency.

Using these principles of performance, different measures can be identified that meet the intent of the environmental goal. First cost and running cost predictions can be made and a financial analysis of the measures undertaken. Figure 4 is a sample from the LEED™ Model Building.

Credits & measures	First cost	Annual savings	Pts
Credit 1: Optimize Performance			
Design Criteria review (5%)	$0	$9.450	
Lighting density (-.25w/sf)	($350,000)	$12.776	1
Roof Upgrade (-2% of load)	($35,000)	$9.450	
Envelope Upgrade (-5% of load)	($187,861)	$18,900	1
Lighting controls	($56,358)	$1,583	1
Credit 2 Renewables			
Heat Recovery (5% savings)	($9,800)	$3,000	1
Credit 3: Commissioning			
Commissioning	($175,000)		1
Innovation Credit			
HVAC Upgrade (-.15 kW/ton)	($39,375)	$30,051	1
	$ (853,394)	$ 235,210	6

Figure 4 - Costs for energy category credits

After completing similar parametric studies for all five LEED™ categories, the measures can be combined in a variety of ways to arrive at the most cost-effective package for the client. For example, a client might elect to pursue measures that are conservative in nature and offer positive but not large returns on the "green building investment". Using the measures described in the figures above, and combining them conservatively yields the following results, with an equivalent Internal Rate of Return of 12%.

Category	Pts	First Cost	Savings	NPV
Sustainable Sites	5	$ (306,250)	$ 20,213	$ (54,358)
Energy & Atmosphere	5	$ (39,375)	$ 39,501	$ 452,895
Resources	5	$ (151,261)	$ -	$ (151,261)
Environmental Quality	7	$ (449,930)	$ 73,450	$ 465,419
Water Efficiency	4	$ (35,750)	$ 500	$ (29,519)
	26	$ (982,567)	$ 133,664	$ 683,176

Figure 5 - Certified Building Proforma

By combining more of the measures, and selecting for a high NPV, a second version of the same building can be arrived at that has a much higher first cost, but a better Internal Rate of Return of 16%.

Category	Pts	First Cost	Savings	NPV
Sustainable Sites	6	$ (1,201,250)	$ 188,650	$ 1,149,746
Energy & Atmosphere	6	$ (80,000)	$ 49,450	$ 536,256
Resources	8	$ 641,261	$ -	$ (641,261)
Environmental Quality	11	$ (970,663)	$ 278,501	$ 2,413,214
Water Efficiency	6	$ (274,000)	$ 3,500	$ (230,382)
	37	$ (3,167,174)	$ 520,101	$ 3,227,573

Figure 6 - Platinum Building Proforma

DISCUSSION

This cost analysis is preliminary, based on assumptions about fit and finish that could change the figures significantly. Nonetheless, using square foot estimates for the costs, and rule of thumb for the estimated benefits, the project goals can be developed to show some order of magnitude implications.

Initial investments of 1.5% - 4.5 % of the hard cost for the project both show positive net present values. This means that when you buy the green building, add all the future savings up into today's dollars (5% interest rate), subtract the initial investment (first cost), you have money left over. This money is over and above what you would have if you had simply invested the original dollars at the interest rate used in the calculation. In other words, if you don't buy the green building measure, that is the monetary value you lose by not making the investment.

The LEED™ Model Building raises some interesting questions. Is the point reward biased towards predicted environmental performance or first cost? Initially, the LEED™ points do not seem to reward the owner in proportion to the first cost of the measures. For example, the Bronze building required an investment of $38,000 per point. The Platinum building required an investment of over $85,000 per point. As these building were based on the same baseline and set of measures, there is a non-linear relationship between point cost and total point count.

On the other hand, the Bronze building produced a net present value of $26,000 per point, where the Platinum building produced a NPV of $87,000 per point. It is tempting to think of the LEED™ points as an investment indicator or measure of the green building investment portfolio. Future data from the Pilot Program will help develop investment strategies, and indicators representing the efficiency of a measure might be represented as an index or ratio.

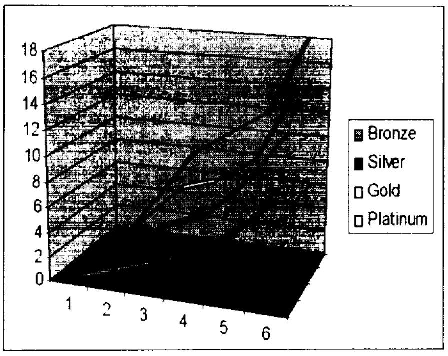

Figure 7 - Portfolio evaluation of LEED™ credits

The LEED™ Model Building should also help answer questions such as whether LEED™ should be weighted to reflect a measure's return on investment, or to reward the "low hanging fruit" which have the least first cost.

BUILDING ENVIRONMENTAL ASSESSEMENT TOOL – BEAT 2000

Ebbe Holleris Petersen, Senior researcher, Ph.D.
Danish Building Research Institute (SBI), Dr. Neergaards Vej 15, DK-2970 Hørsholm, Denmark

INTRODUCTION

BEAT 2000 – Building Environmental Assessment Tool - is a pc-program for performing life cycle based environmental assessment of buildings and building elements. It is developed at the Danish Building Research Institute (SBI), and consists of a database for systematic storing of all quantifiable environmental data, and an inventory tool for calculation of the potential environmental effects for buildings and building elements. The database contains data for most common energy sources, means of transport, building materials and building elements used in the Danish building sector. Data for most building materials have been collected by SBI directly from Danish producers insofar as the materials are produced in Denmark. Data from literature have been used for most imported products. BEAT 2000 can be used to perform environmental assessments for any type of product, but it is designed and structured specifically for performing environmental assessments for buildings and building elements.

PRESENTATION

BEAT 2000 is a relational database designed using Microsoft Access 97 and consists of the following three parts:

- A database with environmental data for typical energy sources, means of transport, building materials and building elements commonly used in the Danish building sector. Data for energy sources and means of transport are identical with those found in the EDIP-database [2].
- A user interface which allows the user to add, edit and delete units, emissions, raw materials, environmental effects, energy sources, means of transport, building materials and building elements in the database.
- An inventory tool which can calculate the consumption of raw materials, energy sources, building materials and the emissions for a building material, building element or building and convert these to normalised and weighted potential environmental effects.

Based on the data in the database BEAT 2000 can perform the necessary calculations, which form the basis for environmental assessment of building materials, building elements and buildings. BEAT 2000 can also calculate environmental effects, i.e. global warming, ozone depletion,

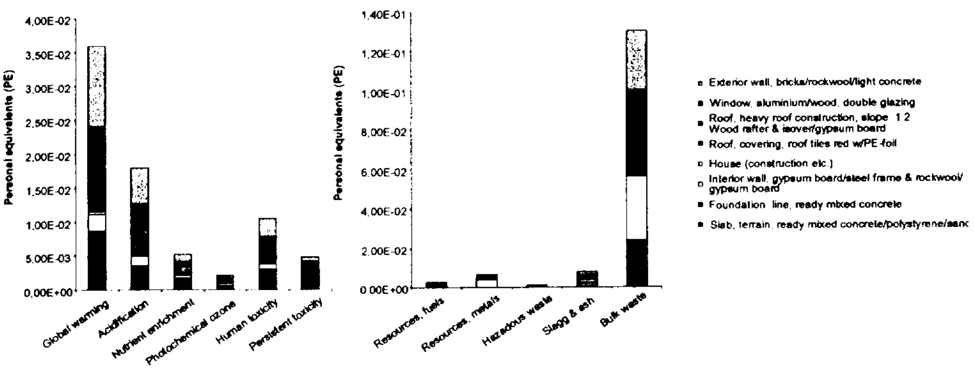

Figure 1. Environmental profile for a building, as presented by BEAT 2000 (slightly edited).

acidification etc. The environmental effects are calculated using the EDIP-method [3; 4] which has been developed at the Danish Technical University (DTU), at the Institute for Product development (IPU). All data and calculations can be printed both as tables and graphically in the form of environmental profiles (see figure 1).

BEAT 2000 can also handle uncertainty, by use of a method called Successive Estimating [1], which was developed at the Danish Technical University (DTU), at the former Department of Construction Management. Successive Estimating is based on Bayesian statistics and compared to e.g. Monte Carlo simulation which is iterative, requires less computing power, and consequently is significantly faster to use. However, the present version of the database only contains limited data on uncertainty.

Using BEAT 2000

BEAT 2000 can be used at different levels depending on the users' needs. It is possible to perform both very detailed environmental assessments based on product specific data from the actual producers of building materials and there subsuppliers, and very general assessments based on typical, most likely or average data.

When performing an environmental assessment for a building, the most efficient method is to start by defining the building using the predefined building elements in the database. If a building element cannot be found, it is often possible to find one that is sufficiently close which can be used instead. Alternatively it may be necessary to define a new building element in the database. Then a calculation for the building can be performed to identify the building elements which contribute the most to the environmental impact of the building. In this way the data (and consequently the assessment) can progressively be improved without wasting time defining building elements or collecting data for materials which do not contribute significantly to the environmental impacts.

The environmental impacts from operation, maintenance, renovation and demolition of the building can also be included in the assessment. The actual energy use for operation of the building e.g. heating, cooling, ventilation etc. must, however, be calculated using another program.

When the building has been defined in sufficient detail, a calculation can be performed. From the environmental profile can be seen how much each building element contributes to the environmental impact of the buildings, e.g. how much the exterior walls contribute to global warming, (see figure 1). This way the building elements responsible for the largest environmental impacts, and thereby also the largest potential for reduction of the environmental impacts, can easily be identified.

It should be noted that currently data for some parts of the lifecycle of a building are not available, and therefore not included in the database. These are mainly energy use for machines etc. on the construction site during construction, maintenance, renovation and demolition of a building. However, the few data available seem to indicate that energy use for these activities is of minor importance, and no significant error is therefore made by leaving them out.

After a building has been defined in the database, "what if" analysis can be performed. This is done by changing the data for the building, and then comparing the modified building with the original. In this way alternatives can be analysed and the building can be optimised. In this way it can be examined how large a change of a buildings environmental impacts can be obtained by e.g.:

- Substituting one type of building element for another.
- Substituting one building material for another.
- Substituting one building materials producer for another.
- Reducing transport distance by choosing producers of building materials located close to the construction site.
- Reducing energy consumption.

- Substituting one energy source for another (e.g. from electricity to district heating).
- Changing the geometry of the building and thereby material consumption and energy use for operation.

Additionally it can be determined e.g. how thick a layer of insulation or how many layers of glass can be used before the environmental impacts from producing the extra materials will exceed the savings from the reduced energy consumption for operation.

This way BEAT 2000 can be used to optimise a building which is being designed or renovated. It can also be used to document the environmental impacts from an existing building. In the same way BEAT 2000 can be used to analyse, improve and document the environmental performance of building elements and building materials.

CONCLUSIONS AND RECOMENDATIONS

Most of the Danish data in the database will only be of interest to Danish users since experience shows that there are often quite significant differences between countries because of national differences in available energy sources and raw materials. If BEAT 2000 is used outside Denmark, the Danish data for energy and products should therefore be replaced with corresponding national data.

BEAT 2000 is under constant development, and will in the future be improved in a number of areas, of which a few are (in no particular order):

- Integration with CAD-programs
- Integration with programs which calculate energy use for heating, ventilation etc.
- Implementation of a simple and fast way of defining new buildings based on a few key figures about geometry etc.
- Implementation of more ways for presenting results.
- Support for different methods for environmental assessment.
- Implementation of a method for handling total economy.

SBI intend to release new and improved versions of BEAT 2000 on a regular basis and to expand the database with data for new products and building elements. BEAT 2000 can be purchased from SBI for a price of approx. US$ 600. The price includes both a Danish and an English version of BEAT 2000 with a user manual (in the form of a standard help file), as well as a run-time version of Microsoft Access 97.

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ECOPROFILE - A SIMPLISTIC ENVIRONMENTAL ASSESSMENT METHOD EXPERIENCES AND NEW CHALLENGES

Dr. Trine Dyrstad Pettersen[1], Sigrid Melby Strand[2], Dr. Svein E. Haagenrud[3], Dr. Guri Krigsvoll[4]

Norwegian Building Research Institute, RTD-department Building Services, P.O. Box 123 Blindern, N-0314 Oslo

1. E-mail: Trine.Pettersen@byggforsk.no, Tel: +47 2296 5541
2. E-mail: Sigrid.Strand@byggforsk.no, Tel: +47 2296 5718
3. E-mail: Svein.Haagenrud@byggforsk.no, Tel: +47 2296 5843
4. E-mail: Guri.Krigsvoll@byggforsk.no, Tel: +47 2296 5550

ECOPROFILE METHOD

Ecoprofile is a method for simplistic environmental assessment of buildings and gives a good picture of the building's resource and environmental profile. A good environmental classification can lead to a market advantage in the sale and rental of commercial buildings. Ecoprofile can also be used as an internal management and steering tool for the building owner.

The Ecoprofile of a building is divided into the three principal components "External environment", "Resources" and "Indoor Climate". These components are then divided into sub-components with different consequences for the principal components, and therefore weighted. Several of the sub-components also have underlying sub-components. Each sub-component and underlying sub-component contains a number of parameters that are individually evaluated and given a grade. Figure 1 shows the structure for Ecoprofile for office buildings. For residential buildings there are some changes in sub-components, weighting, and of course in parameters.

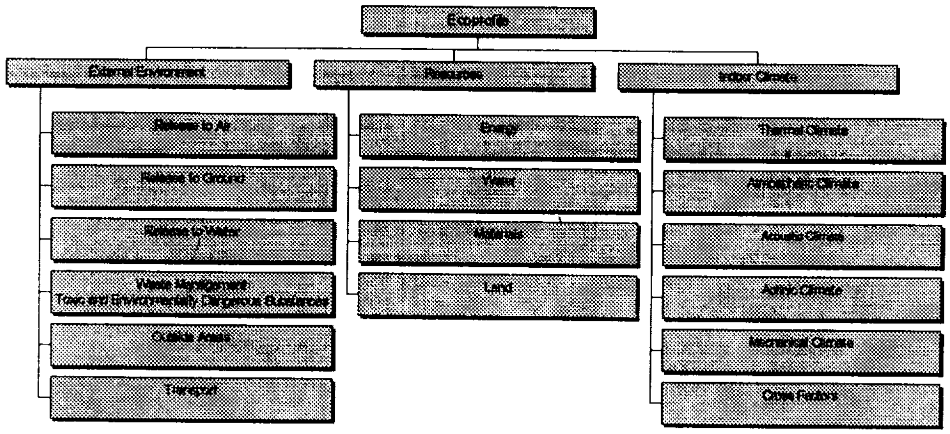

Figure 1: Structure for the three principal components of Ecoprofile, and their sub-components.

The component "Resources" has the sub-components "Energy", "Water", "Land" and "Materials", which harmonises with the structure in the LCA method and internationally recognised environmental evaluation methods such as Green Building Challenge '98 (GBTool'98).

The sub-components are given weight from 1 to 3, but "Energy" is given a weight of 10, based on experience of the importance of this component. Classification of "Energy Use" is defined in a separate matrix based on classification of "Condition of Technical Installations" and "Real Energy Use".

A building's Ecoprofile can be visualised in two ways. The principal components can be combined in a bar graph indicating to large, medium or small environmental impact for "External environment", "Resources" and "Indoor Climate" (Figure 2). Rose diagrams show more detailed results (Figure 3). High values represent a large environmental impact in both types of diagram.

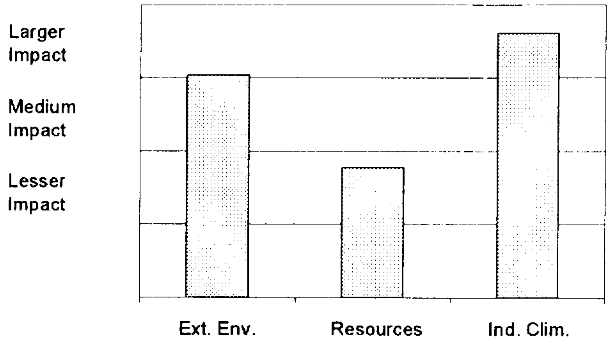

Figure 2: Graphical presentation of results at principal component level.

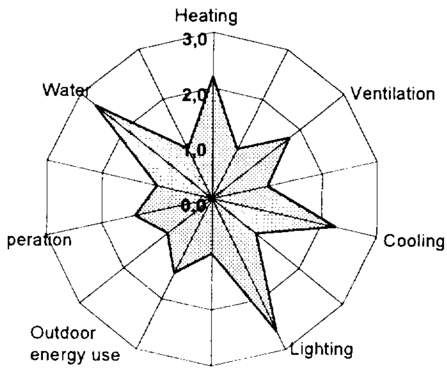

Figure 3: Graphical presentation of results as a rose-diagram.

EXPERIENCES WITH ECOPROFILE ON EXISTING BUILDING

Ecoprofile for commercial building has been in the marked since 1999, and the results for 18 buildings, 175 000m^2, are reported to the operating organisation to be included in a national database. From these results the Ecoprofile for an average building can be found, see Figure 4 which also shows the maximum and minimum values for each component. According to the figure the method gives a good idea of the buildings environmental impacts. The figure also shows that for the compound "Indoor Climate" no building has been categorised to have lesser impact.

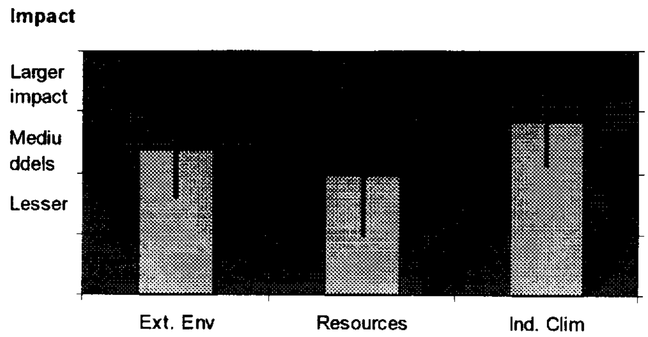

Figure 4: Average Ecoprofile results for the reported buildings also showing the maximum and minimum values.

FURTHER DEVELOPMENT OF THE METHOD

The method office building has been in the market for about a year, for rscidental buildings only a few months. Based on experience gained the methods will be further improved and developed, and the work to adjust and extend the method to other building types, such as Shopping Malls, Schools, and Hospitals has been started. The Ecoprofile methods are for existing buildings, but we are also working with another version for residential buildings; Ecoprofile as a planning tool.

Introduction of the sub-areas Land and Material in the method for office buildings

The Ecoprofile for offices do not yet include sub-components "Land" and "Material". When including these new parameters have to be described and classified, and some parameters may be moved from other sub-components.

Better weighting of parameters and sub-areas

In the first version of Ecoprofile all parameters have the same weight, even though we know they have different impact. Some functions or installations have many describing parameters, and the number of parameters makes them more important in the final result. For some sub-components only one parameter is described. Even though the weighting between the sub-components is "correct", these parameters might be to dominating in the final result. In the new version of Ecoprofile the weighting will be changed.

Introduction of the 0-level for sustainable constructions

Each of the parameters is classified according to a scale from 1 to 3 where:
- Class 1 = Lesser environmental impact
- Class 2 = Medium environmental impact
- Class 3 = Larger environmental impact

Eventually a class 0 is going to be included that will represent the sustainable construction, but there is currently little basis for defining such a level.

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INTEGRATED TOOL FOR ECOLOGICAL DESIGN AND ANALYZE OF BUILDING SERVICES

Erja Reinikainen, Markku Jokela, Tuomas Laine, Kimmo Liljeström
Olof Granlund Oy
Malminkaari 21, 00701 Helsinki, Finland

Introduction

Eco-efficient design of buildings and technical systems services is becoming an important design aspect in Finland. In many new projects building owners require their project designers to provide life cycle calculations and environmental assessments. Life Cycle Assessment (LCA) is one method to monitor the ecological perspective during design and decision making processes. During the design process it is necessary to compare different technical solutions and their ecological and financial properties during the life cycle of the building. From the building owners' point of view the assessment reports should be uniform, easy to read and comparable from project to project. A systematic evaluation of environmental impacts means, that the results of LCA calculations should be clear and transparent and also the inventory and evaluation methods in use should be commonly accepted.

During the last decade Granlund has put a strong effort on developing the design process, quality aspects and design software tools. Granlund has a clear vision of new concepts and software tools to be developed, having long experience and technical skills combined with R&D. The visions are strongly based on our clients' requirements, life cycle thinking, openness and the concept of life cycle data management. A direct database link from design through construction to facilities management has been reality for us for many years.

Granlund participates actively in the work of the International Alliance of Interoperability in IFC development. We have already developed IFC 1.5.1 compatible software tools offering open data exchange links between applications – such as a 3D modelling tool and an energy simulation tool.

The Integrated LCA-Tool

This paper presents **an integrated tool (LCA-tool) for ecological design** and analysis of building services that has been developed by Granlund. This LCA-tool is a database solution with a Windows interface and it handles the environmental impacts of the building envelope and the building services systems.

One of the Granlund objectives has been to develop both the design process and design software towards sustainable development. This means that ecological aspects are included already in the conceptual phase and the data, which is rough at first will become more specific during the design process. The integrated design process also means that the information created during the process will be available and utilised from design into construction and FM - on the other words during the whole life cycle of the building.

The **ecological design process** (Figure1) includes LCA-calculations for different purposes at different stages. In the conceptual phase the energy use and environmental impacts of different building shapes, orientations and structural solutions may be compared. In the following phase different technical systems are compared using more detailed energy simulations and life cycle analysis. When the project proceeds to detailed design it is possible to compare the environmental impacts of actual system components, equipment and even materials using manufacturer data.

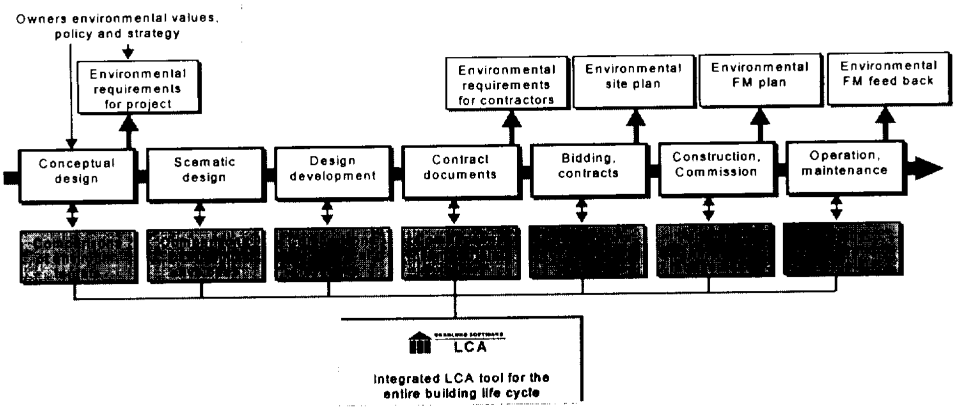

Figure 1 The Ecological Design Process

The aim of Granlund's software development has been to **integrate all design tools** so that they produce output data in a format that can be used as input for other tools. All information created in the design process is stored in the database – when updating this data during the design, all software solutions will use the same updated information.

Granlund's system design software forms a base for the LCA-software tool as shown in Figure 2. From the design software the LCA-software receives all information needed in the LCA-analysis. The LCA calculation uses the design data stored in the database during the design process.
The LCA-tool contains inventory calculation i.e. life cycle consumption of materials and energy, emission calculation, characterisation and valuation. In the first stage the tool has been developed for internal use in design projects and in environmental consulting.

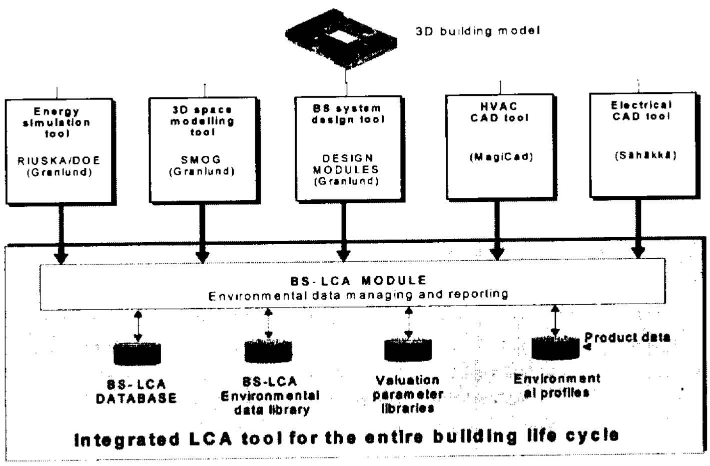

Figure 2 The LCA Tool Architecture

The Granlund **design database** includes information about the building and its technical systems. All the information is stored in a systematic hierarchy format, which makes it possible to analyse results on different levels, from building level to system and equipment level. All the software tools provide information needed in the life cycle assessment of the building envelope and its technical systems – very little additional work is required for the LCA calculation itself as most of the essential information already exists. The inventory of materials (building constructions and technical systems) is very laborious if done manually. The LCA tool, based on use of design database, does this inventory quickly and produces the LCI and LCA.

The 3D-modelling tool **SMOG** produces data on the building constructions and the building envelope. The simulation tool **RIUSKA** calculates the capacity and energy use of heating, cooling and electrical systems. The **DESIGN** tool manages the design data during design, including system and equipment capacity and dimensioning data. The data from the **MagiCAD** HVAC-CAD software (a new Finnish product model based on a 3D CAD tool for HVAC design) can be transferred to the LCA tool to produce a life cycle inventory of the ducting and piping networks.

The LCA-tool uses a library of the environmental profiles of different building materials and of mechanical and electrical system components and equipment. It is possible to do the calculation on various levels: starting at building level (using material-per-m^2-data) and going deeper into system details (using actual equipment data). Also the environmental data of various energy forms is included. The output from the LCA-tool are the life cycle environmental emissions from the building, classified and valuated according to a chosen method.

One of the ideas that make the use of this integrated LCA-tool very easy is the **hierarchical data structure** of the technical data. The user may navigate on different levels of this hierarchy by using a navigator which makes it possible to analyse the ecological impacts of alternative design cases on different levels. For example, if the life cycle impact of two different cooling systems are compared, it is possible to make changes in individual equipment dimensioning and observe the changes in the environmental loads (materials and energy) of the specific cooling system, of all cooling systems, of the whole HVAC system or of the whole building. This feature is a unique for illustrating the things that are important in ecological sense – what is the meaning from the whole building and the whole life cycle point of view.

Conclusions

The Granlund LCA-tool is the first integrated LCA-tool which uses a database containing data on building constructions and technical systems. The unique integrated software tools and the database including data of systems, equipment and material make it possible to use the LCA-tool for calculating the environmental impacts at the different stages of the design process as well as the whole life cycle of the building.

The LCA-tool prints out 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 help 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.

ENVIRONMENTAL EVALUATION OF A TYPICAL FRENCH ELECTRIC HEATED HOUSE : STRENGTH AND POSSIBLE IMPROVEMENTS

L. Tabary, N. Chatagnon
EDF Pôle Industrie / R&D Division / Les Renardières 77818 MORET SUR LOING Cedex France

Considering the lack of widely spread environmental design tools in France, a work was conducted in 1999 to a) evaluate the difficulty to ensure environmental satisfying performances without design tools, b) evaluate the environmental profile of a typical detached house heated by electricity and meeting the latest construction quality labelling proposed by EDF.

Results showed that

- EDF quality requirements can act as environmental promoters for constructions,
- some complementary requirements could be added to improve the environmental profile,
- a set of simple criteria is not sufficient : environmental evaluations require to have a close scrutiny of the objectives (energy consumption,...) but also of the means to reach them.

GENERAL LAY-OUT

As a national energy supplier, Electricité De France (the French National Utility) is looking for energetic solutions both environmentally friendly and pragmatic.

Environment-based-decision-making-tools are not widely spread in France and several works are carried out to improve the situation [1]. In real projects, one has often to rely on qualitative guidelines.

So it seemed interesting to analyse a typical building from this "paper based point of view". Through the case of a typical detached house heated by electricity, we tried to have a "green" look at VIVRELEC, the latest construction quality labelling proposed by EDF.

PRESENTATION OF WORK

The target building

The studied building is a typical French detached house [2]. Its surface is 102 m^2 and its thermal loss coefficient is 180W / K, i.e. 10% better than mandatory regulation value. It is considered as equipped with direct electric heating following EDF quality standards.

Environmental criteria considered

To evaluate the environmental performance, we adopted the 14 environmental targets proposed by the French association HQE (Haute Qualité Environnementale) [3] which are summarised in table 1. Anyway these targets are qualitative and therefore are not sufficient to evaluate the performance of our building.

Outside	Inside
Integration into landscape	Hygrothermal comfort
Building materials and technology	Acoustic comfort
Building site	Visual comfort
Energy management	Olfactive comfort
Water management	Sanitary conditions
Waste management	Indoor air quality
Maintenance	Water quality

Table 1 : The 14 environmental targets proposed by Association HQE

So we chose to proceed in 2 steps :

- refer to the more quantitative reference system proposed by the ministry of Housing (PCA) in a call to constructors for Environmentally friendly building projects in 1993 [4] (see below) and which has served to establish the 14 HQE targets,
- translate the obtained performance into the 14 targets reference system.

Evaluation of the target building

To proceed to evaluation, we considered 2 subsets of criteria (see table 2a and 2b): the ones concerned by energy (11 out of 25), the ones not influenced by the choice of energy.

Results:

The evaluation showed that 4 targets are rather well considered, 4 targets could be better processed and 3 targets are not considered.

The 4 well considered targets

- The minimum energy efficiency requirement (HPE 3*) is easily satisfied by the target building (its improved insulation induces in turn a better recovery of internal heat sources and lower heating consumption). To enhance performance, the building insulation or the heating system should be improved.
- The main requirement about domestic hot water quality is satisfied (storage temperature greater than 60°C).
- The building complies with the electrical part of the requirement called "sanitary conditions" (constituted of the French PROMOTELEC "Confort Plus" label).
- In terms of ventilation, the humidity based exhaust ventilation is satisfying, even if a dual flow system could improve the energetic performance and the thermal comfort level.

Construction phase
Integration into local environment (soils, available energy,...)
Noise of equipment (*)
In service management
Energy efficiency (*)
In service comfort
Hygrothermal comfort (*)
acoustic comfort (*)
visual comfort (*)
Health related
water quality (*)
Sanitary conditions (*)
Polluting construction products
Ventilation
Outside air pollution

Table 2a: Requirements from [4] concerned by electric solution (* indicates requirement with reference to existing labels or threshold values)

The 4 improvable targets

- VIVRELEC does not define maximum acceptable levels for the noise generated by equipment and uses : most electric heating solutions are noiseless and therefore do not need specific requirement. In the case of thermodynamical systems (potential sources of noise), guidelines are provided to ensure acoustic comfort of inhabitants. The possible improvement would be the prescription in VIVRELEC of a systematic maximum acoustic level.

Construction phase
Low grey energy products
Demolition waste
Eco products
External noise (*)
Construction waste
Construction nuisance
Energy consumption and air pollution due to construction
Water consumption and water pollution due to construction
In service management
Clean boiler
Water savings
Outside water management
Daily waste management
Health related
Indoor risks due to combustion process
Radon (*)

Table 2b: Requirements from [4] not concerned by electric solution (* indicates requirement with reference to existing labels or threshold values)

- Concerning protection against outdoor noise, no requirement is specified in VIVRELEC while the increased thermal insulation can act as a promoter of a better acoustic environment.
- About hygrothermal comfort, VIVRELEC focuses on winter comfort. Summer comfort is taken into consideration by the highest versions of VIVRELEC with thermodynamical systems. An improvement would be to systematically study passive summer comfort.
- Visual comfort interacts with thermal characteristics and recommendations are already given about windows' performance. They could be completed with a "lighting approach".

The remaining 3 targets

- The PCA requirement about the pre-analysis for the choice of energy is not in the scope of VIVRELEC which is a label about a technical solution once energy has been chosen.
- Construction products are considered in VIVRELEC as a mean to reach satisfying thermal performance. Considerations about Indoor Air Quality (IAQ) should lead to a preference for solvent free products,... assuming their performance are competitive.

• The consideration of outdoor air pollution caused by construction products should be analysed similarly to IAQ.

Back to HQE reference grid

We translated the above results into the HQE reference grid (14 targets constructed from 25 requirements). On figure 1, it appears that VIVRELEC acts as a promoter of energy efficiency, comfort and health related objectives. Due to its energetic specificity, it does not take into account considerations about other topics (e.g. waste management, construction nuisance,...). These ones can be either well considered or ignored depending on every particular operation.

CONCLUSIONS

About environmental evaluation

From this work it appeared clearly that

• quantified indicators are necessary to qualify a project,

• the means to achieve a given performance play a role in the overall impact of a project (e.g. potential thermal drawback of an increased glazing surface). In particular, one should be careful when working with energy efficiency because behind a same performance lay different impacts according to the energy used (renewable, electricity, gas,...).

About the VIVRELEC quality criteria

The study was the occasion to have a look at different ways to fulfil simultaneously the VIVRELEC and the green PCA requirements. VIVRELEC enforces clearly energy efficiency and acts as a promoter for an increased comfort. However some requirements could be widened to take into account complementary aspects (e.g. passive summer comfort) or deepened (to improve environmental performance). Finally other aspects not related to energy, comfort or health should be taken care of through another approach during building construction.

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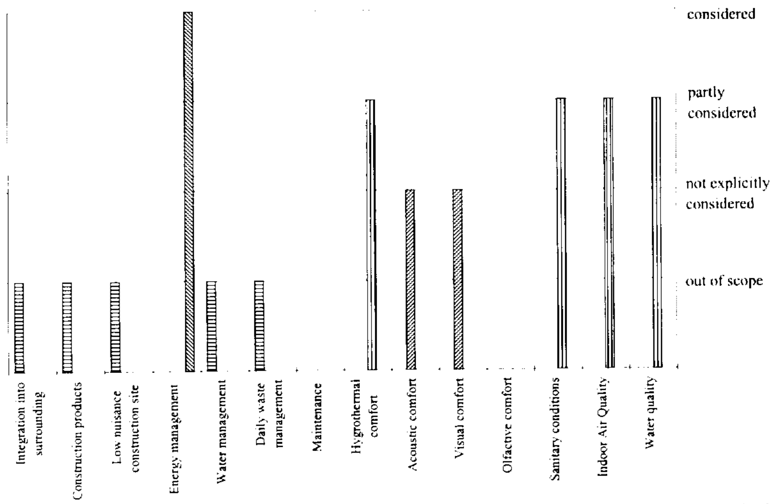

Figure 1: Positionning of the target building towards the 14 HQE environmental objectives (maintenance is not plotted for no objectives were associated to it within the PCA reference system)

LCA-HOUSE:" A TOOL FOR LIFE CYCLE ASSESSMENT OF BUILDINGS

Sirje Vares, Research Scientist
Technical Research Centre of Finland
VTT Building Technology
Box 1805
02044 VTT, Finland

INTRODUCTION

The ecological aspects of building material production and exploitation need increasing attention. This includes claims and decisions related to the use of land, material and energy in building process which are effecting the environment. According to the needs of users, business of owners and goals of society the designers and owners should be pre-determine building's performances so one could ensure environmental performance. The ecological aspects in material selection and energy uses should take into account the interior layout to fulfil a set environmental performance. Ecological building design means that demands will be executed with reduced environmental burdens by using less natural resources and have less released emissions.

LCA IN BUILDING SECTOR

Life cycle assessment (LCA) is a study which calculates and evaluates the environmental loading caused by a product, a material or a service during its life cycle. Life cycle assessment studies in the building sector can be focused on building materials, building structures and spaces, production and construction processes, and planning of HVAC equipments to improve environmental performance in the building industry. In the building process all requirements and decisions made concerning the building (including the building products' production, uses of land-, materials- and energy-resources) are directly related to their environmental impact.

In Finland, an environmental declaration procedure has been set to inform people of the environmental affects of materials (Finnish environmental declarations issued in www site - http://www.rts.fi). The declarations were result of co-operation with building-product producers and the Building Information Institute using established LCA methods (ISO 14040). The environmental affects addressed include climate change potential, acidification potential, photochemical oxidant formation and the use of renewable- and non-renewable energy. Prior to the declaration, use of resources and harmful emissions released the environment have been studied and calculated for raw-material acquisition and transportation, production, care, maintenance and custom transportation processes. Recycling and final location have not been directly calculated in LCA methods, but written suggestions are given separately for these items.

TOOL FOR DESIGNERS AND OWNERS

The computer program, LCA-House, was created at VTT Building Technology for property owners, constructors and building designers. LCA-House tool presented here is an excel-based and visual basic coded program for life cycle assessment of building structures and buildings.

This tool uses the environmental characteristics from the environmental declarations about building material production. The environmental characteristics are used as input data for assessing environmental parameters of building structure or for the whole building. Figure 1 shows the general appearance of the LCA-House tool.

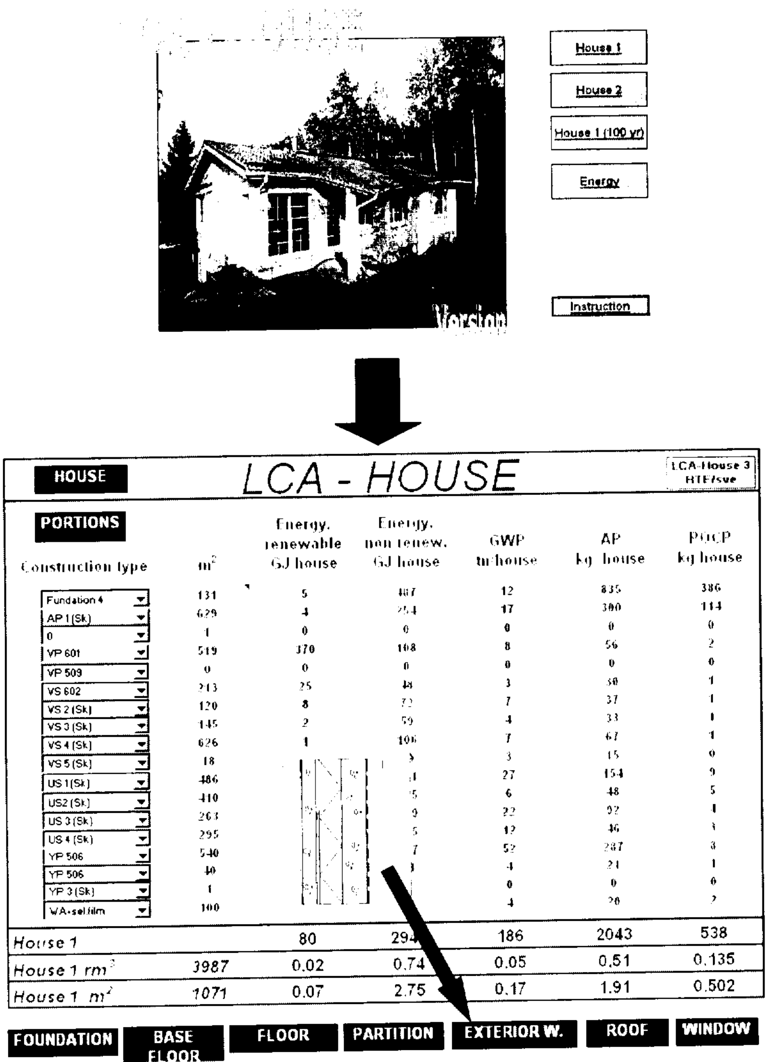

Figure 1. LCA HOUSE - tool for life cycle assessment of buildings.

In this tool optional structures, recommended by the Building Information Institute, were used for the background of the different LCA-HOUSE options. It is possible to choose structures for different houses like wooden, concrete or brick house. The result of the program is the plot of five environmental characteristics: two for energy use and three for describing emissions. These characteristics are the same as used in the building material environmental declaration: renewable energy, non-renewable energy, climate change potential, acidification potential and photochemical oxidant potentials.

For designers, there are two additional critical items to design for to provide environmentally friendly buildings. It is important to take into account the service life of materials so less maintenance is required.

Another criteria is to design structures with reasonable thermal conductivity (low energy houses) which can help save heating energy. This tool cannot determine how a designer makes this decision, as it must be done in practice. After a low energy house has been designed it is also possible to check the environmental profile for that individual design.

CONCLUSION

One of the focuses of VTT Building Technology during last years has been to develop computer aided tools to assist ecological building and product design at various levels. These include: requirements management in life-cycle, evaluation of energy consumption of buildings, evaluation of individual building products or an entire industry and evaluation of a building as a whole (same of the tools has been described in article Vares, S. et al).

The tool, LCA-House, was developed for environmental impact evaluation and for comparing or benchmarking buildings and different structure solutions. This tool can be used by researchers, designers, constructors, owners and material producers.

An important factor in LCA is considering the environmental burden, comprised of total energy consumption and emissions caused during the actual building use over many years. This is much greater than the burdens resulting from the production of the materials.

The LCA-House program can be used for different purposes:

*to examine the ecological affect of building choices related to materials used and service life of the whole building (designer and constructors use);

*for verifying environmental characteristics' fulfilment, if such has been demanded (designer use);

*for owners to examine their building's environmental profiles (owner use);

*for checking the affect of care, maintenance and repairing actions on the environment;

*for comparing environmental profiles of structures having the same functional units; and

*for comparing environmental impacts of produced- and competing materials in certain structure or building (use of building material producer).

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CONSTRUCTION RELATED SUSTAINABILITY INDICATORS – SETTING TARGETS & MONITORING PERFORMANCE IN THE BUILT ENVIRONMENT

Group Manager Pekka Huovila[1], Head of European Affairs Luc Bourdeau[2]
1. VTT Building Technology, P.O. Box 1801, 02044 VTT, Finland
2. CSTB, BP 209, F-06904 Sophia Antipolis Cedex, France

INTRODUCTION

The CIBW82 [CIB] project "Sustainable Development and the Future of Construction" studied the consequences of sustainable development to the construction industry in the future. That study concluded that the next step should be to reach a more consensus vision through a global common model and to set up indicators and policies to translate this vision into reality [Bourdeau et al. 1998]. A new CIBW82 project is now launched to define and validate construction related sustainability indicators for setting targets and monitoring performance in the built environment.

Decision-makers and policy-makers may use the indicators to evaluate economically viable and technically feasible strategies to improve the quality of life. Different actors in building processes may use the indicators as guidelines and tools to improve current practises and to improve the quality of construction. The indicators can be used for measuring the sustainability of building projects, the capability of different actors and the state of different regions or nations. Many ongoing efforts deal with indicators at some level, like in the planning and design process [Sunikka et al. 2000], forming the design brief [Leinonen et al. 2000], or assisting in the design decision making process [Nieminen et al. 2000].

OBJECTIVES

The project scope includes both qualitative and quantitative aspects together with social and economic issues of the concept of sustainability (Figure 1.).

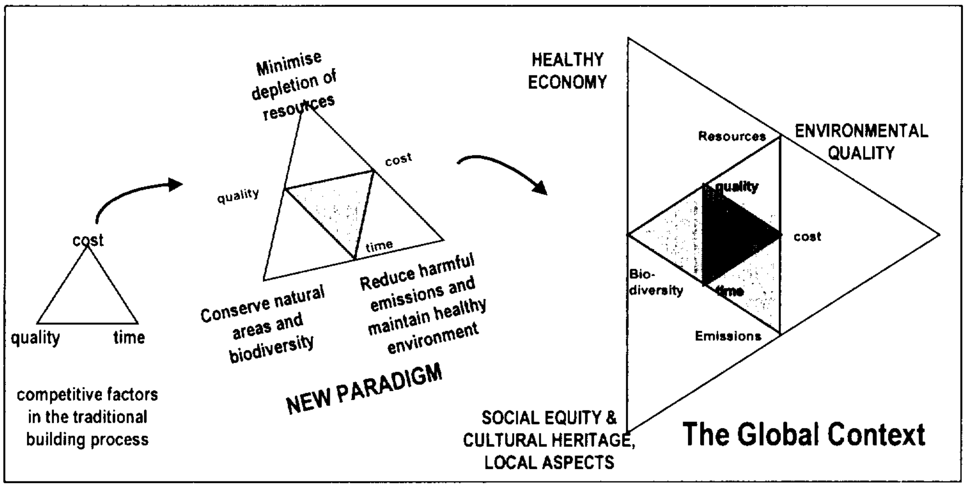

Figure 1. The concept of sustainable construction [Bourdeau et al. 1998].

The project will benefit the UN working list of sustainability indicators [UN], which is structured according to Agenda 21 Chapters, but is not construction specific. Recently launched European thematic network project called Construction and City Related Sustainability Indicators [CRISP] will cover the scope of the CIBW82 project. That three year EC project, starting in Summer 2000 under the specific Energy, Environment and Sustainable Development programme, gathers together experts from Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Norway, United Kingdom, Romania, Spain and Sweden.

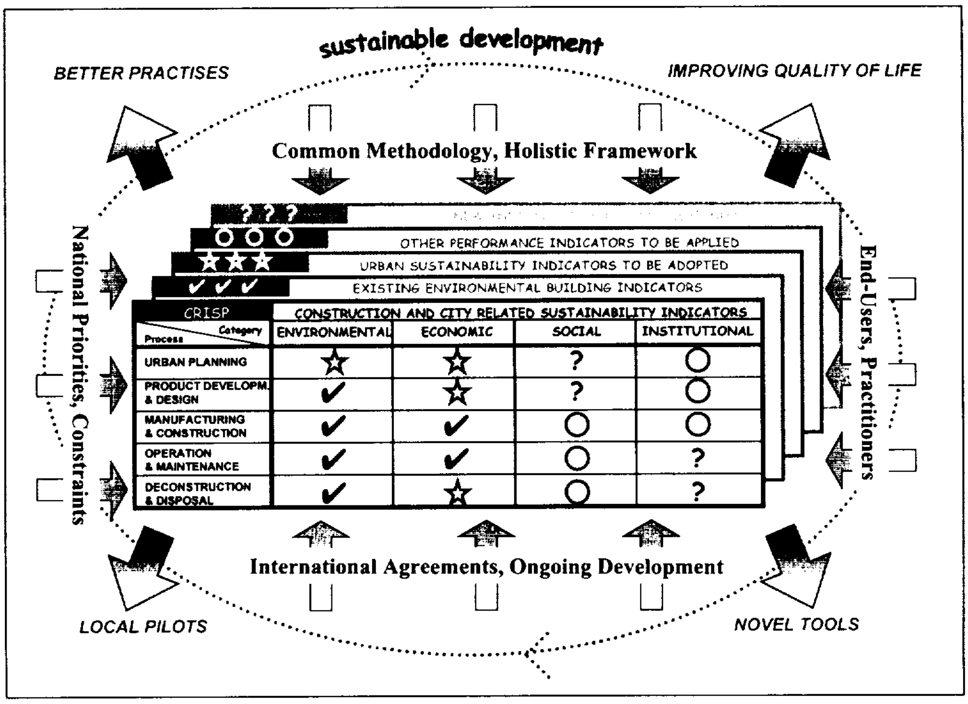

Figure 2. The Framework for Construction Related Sustainability Indicators [CRISP].

DISCUSSION

The building practise often faces situations where environmental loading of buildings cannot be precisely verified by calculation or testing. Simple indicators are needed to precede or to replace complicated calculations in complex systems. Indicators can be used to evaluate the capability of organisations to produce sustainable solutions. Indicators can also be used to measure indirectly aspects that cannot be verified directly, such as biodiversity. The objective is not to create long ad hoc lists of indicators, but rather to formulate a transparent framework to increase understanding and support implementation of many kinds of indicators that are valid in various occasions and environments.

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Developing an environmental performance standard for the materialuse in buildings for the Dutch Building Decree

Nico Scholten, TNO Building and Construction Research
Adrie de Groot-Van Dam, TNO Building and Construction Research
Jaap Kortman, IVAM Environmental Research
Gjalt Huppes, CML, University of Leiden;
Bernhard van der Ven, TNO MEP
Agnes Schuurmans, Intron
David Anink, W/E consultants sustainable building

Summary

The Dutch Government is co-operating with the building industry to prepare legislation and standardisation for environmental performance requirements [1,2,3]. These requirements, also known as "*dubo-eisen*" (requirements for sustainable building), will have to apply to all newly built dwellings and residential buildings in the Netherlands. The determination method will include the entire lifecycle of the various elements of the building and will be based on the internationally developed method LCA. The requirements will be based on an overall score for the "environmental performance" of the building as a whole (material based environmental profile (*mbep*)), which will allow designers and builders considerable flexibility in choices of building products and building methods.
An introductory study (stage 1) into the options for such an method has been completed and results have been discussed with the parties concerned.
The process of standardisation has been started recently (stage 2). "White spots" will have to be elaborated in an ongoing study, including a more detailed definition of the functional unit, the method of allocation, the integration of the themes of the environmental performance profile into a useful score for the overall 'environmental performance, the check of completeness and the maintenance scenarios.
The *mbep* is to be applied in addition to other environmental requirements, such as the energy performance coefficient (*epc*), which is already included in the Dutch Building Decree and reflects a building's energy efficiency during its exploitation.

Introduction
The inclusion of sustainable building measures in the Dutch Building Decree implies the general imposition of an agreed minimum level of sustainable building.
The introduction of new regulations must be based on a method for further defining the environmental performance profile. The main problem is that there is as yet no fully developed and generally recognised method that can be unambiguously applied. At present, various municipal authorities have introduced a range of local instruments, imposing environmental requirements on specific building projects, based on a variety of environmental not generally accepted analyses and evaluation models. Inclusion in the Dutch Building Decree, however, demands an unequivocal and generally accepted method. Although the ISO standards of the 14 040 series provide a framework, they do not include an operational and unambiguously applicable method. Certain models and databases which are currently being applied in building practice, such as Eco-Quantum, Greencalc and MRPI, differ to a certain extent in the methodologies and data on which they are based, and their methodology is as yet insufficiently explicit.

Aims and findings of the study (stage 1)

The aim of the study reported in the present paper was to design a prototype of a method to assess the materials-based environmental performance profile (*mbep*) of dwellings and residential buildings on the basis of LCA. In particular, the study established how and under what prior conditions an operational assessment method could be designed which might be applied in a legislative context. A process of interaction between researchers, national authorities and the building industry has led to the development of such a prototype method for assessing *mbeg [4]*. The development process took account of the conditions imposed by European law and of national legislative guidelines. It also attempted to link in with the customs and perceptions of the building industry as well as with existing private sector instruments for the environmental assessment of buildings and construction products. A further aim was to limit the costs and administrative effort involved in the method's application. The latter aim led to the development of two variants within the prototype, one more specific and the other simplified.

The proposed assessment method distinguishes between three stages in the life of a building:

- The **product stage**, i.e., from the extraction of the raw materials to the finished building products.
- The **building stage**, i.e., from the transport of finished products, through the actual building process, maintenance and exploitation of the building, up to and including the demolition.
- The **discarding stage**, i.e., from the transport of discarded and scrap materials up to and including the recycling or processing of end-stage waste.

The method does not assess the environmental effects, like consumption of energy during the lifetime of a building and waterconsumption during that lifetime, nor does it include pollution of the indoor air (by e.g. formaldehyde, asbestos, volatile organic compounds or radon), as these environmental aspects are already included in other clauses of the Building Decree. Its does include, however, the consumption of water and energy during the product stage, the actual building process and the discarding stage and during transport.

The assessment method can be applied to all construction elements for which permits are required, including foundations, walls and roofs, as well as to construction elements for which no permit is required, such as partitions and storage facilities, and to elements which are part of the furnishings and fittings of buildings intended for habitation, such as carpets and central heating systems. The proposed regulations also use these categories and allow the occupiers to make their own choices. The assessment method can also be applied outside a regulatory context, e.g. in sales negotiations. The method has been designed in such a way that minor additions can also make it suitable for other types of buildings than dwellings and residential buildings .

Obviously, the assessment method can only be usefully applied if its practical implementation results in a range of scores even for "good" houses, as this would allow the method to yield guidelines for building practice. These actual differences in *mbeg* are currently the subject of a follow-up study (stage 2) involving some one hundred different types of houses.

Steps in the assessment method

The environmental performance is assessed in 6 consecutive steps, which collectively constitute the "building model" and the "environmental model". The building model (steps 1 - 3) assesses the material flows required for construction and maintenance, allowing for the life-span of the various elements of the building. The environmental model (steps 4 - 6) models the environmental effects, analyses them and converts them to functional units. Step 1 involves subdividing the building into standardized elements. Step 2 classifies these elements into types relating to building regulations, viz. construction elements requiring permits, construction elements not requiring permits and other elements. Step 3 involves determining the processes in the three above-mentioned stages for each construction element. Step 4 assesses environmental interventions per unit of each element (e.g. per m^2 of apertures, per m^2 of roof surface, per m of roof gutter etc.) for each stage, and integrates them into an environmental performance profile score in terms of environmental themes, or integrates them further into a limited number of environmental scores. Step 5 involves the summation of the environmental performance scores of all elements. This yields an unconverted materials-related environmental performance profile (*mmg*), that is, one which has not yet been converted to the relevant functional units at the building level. The three types of elements are still treated separately at this point. Finally, step 6 processes the individual materials-related environmental performance profile scores for the building as a whole, resulting in three converted profiles, i.e., profiles converted to the relevant functional unit at the building level for the various types of elements in the building.

Future developments

The assessment method has not been fully worked out yet, but suggestions have been made for further development, which will be elaborated in stage 2.

In March 2000 the standardisationprocess has been started. The prototype will be translated to a Dutch standard. Parallel two complementary research projects are ongoing:

a. to solve the white spots in the de "building model" and in the "environmental model";
b. to get experience with the draft standard;
c. to get figures for supplying processes;
d. to get figures for the simplified method;
e. to get rules how to handle construction elements not needed a building permit, and
f. to get rules to convert the results to a functional unit at building level.

Because of the impact of introduction of legal sustainability requirements also a knowledge transfer project have been started up. So suppliers, designers and building industry will be well informed during the whole process of developing the standard and the regulations.

Perspectives

The introduction of materials-related environmental performance profile requirements into the Dutch Building Decree can be expected to have a series of attractive consequences.

a. Local environmental guidelines might be optimised to a more common language at the national level, which would allow more effective environmental policies.
b. Uniform national legislation to improve environmental performance would allow the construction industry in a large measure technical freedom, since the environmental performance requirements would only apply to the building as a whole. An innovation push can be expected.
c. All new dwellings and residential buildings will have to comply with minimum sustainable building quality requirements as regards the use of materials in the various stages of the lifecycle.
d. Environmental performance scores relating to the materials used in the fixed furnishings, such as floor coverings, bathroom fixtures and kitchens could become a significant factor in private sector choices, since this analysis is not only relevant for legislation but can also be used in wider discussions on environmental aspects of the construction industry.

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DEVELOPMENT OF BUILDING ENERGY RATING SYSTEM IN LATVIA

Andris Kreslins[1], Prof. Dr.habil.ing.sc. Olita Belindzeva-Korkla[2], M.sc.ing.
1,2. Institute of Heat, Gas and Water Technology.
Riga Technical University. P.o.Box 526,LV-1010, Riga, Latvia

INTRODUCTION

Sustainable development and buildings sustainability as part of it is invariably connected with effective use of energy resources. Of course estimation of buildings energy effectiveness should be based on building life cycle energy analysis taking into account embodied energy during all phases of the building life [1]. Although for the countries with cold climate energy consumption for heating purposes during the economical life of buildings is especially important. In Latvia heating of buildings takes at least 35% of primary energy consumption, imported energy sources contributes to about 80% of energy production and thermal resistance of building structures built during Soviet Union time is rather low (U-values for walls is ≈ 0,75 W/m^{2}K, for roofs it is ≈ 1,25 W/m^{2}K). All mentioned factors indicate the importance and necessity of energy management system for housing sector in Latvia. This paper is devoted to the development of building energy rating system as the first step of energy management system.

BUILDING ENERGY RATING

Results of the study on house real heat consumption

Building energy rating is impossible without reliable dates on buildings real heat consumption. Till 1998 only theoretical calculation of energy demand was possible, as building heat consumption was not metered. Now heat received from district heating systems is measured in one of three ways: with one heat meter for the whole house; with two heat meters separately is measured heat for space heating and domestic hot water; heat consumption for space heating is measured for each house, consumption for domestic hot water is measured for the group of houses.

The study on real heat consumption was made for the period October.01.1998-September.30.1999. Heating period of this year (October-April) had 3831,2 degree-days that is 1,7% more than degree-days of the same period in standard year (3766,8). Degree-days in both cases are calculated for the space temperature +18°C. Study included 349 houses in 5 different districts of Riga. There were mainly 5-16 storied apartment houses built in 1960-70ies. Some 2-4 storied houses of previous construction were included for comparison purposes. The aims of the study were to determine total specific heat consumption, q, kWh/m^{2}year; specific heat consumption for space heating, q_h, kWh/m^{2}year and specific heat loss, h, W/m^{2}K calculated for one square meter of heated built-in area of the buildings.

Results of the study showed that:

-real specific heat loss for the same type of houses vary ±25% and the rating scale cannot be based on calculated heat loss due to the big differences in quality of the construction;

-total specific heat consumption falls in wide range 160-350 kWh/m^{2}year with majority if cases 220-240 kWh/m^{2}year. Cumulative distribution of total heat consumption is shown as line 1 at figure1;

-part of space heating in total heat consumption is around 56% that is mainly 120-150 kWh/m^{2}year. Consumption for the space heating is not so high as may have been expected for the houses with the specific heat loss 1,2-1,6 W/m^{2}K. It is so due to the relatively short heating season (October-April) and the fact that houses generally tend to be heated to minimal acceptable temperatures. Such heating regime mainly suits people more than high payments. Some people who can financially afford it use additional energy sources (gas, electricity, stoves) when needed. The part of domestic hot water is few times bigger than it normally is in Northern European countries due to much smaller amounts of heated area per inhabitant (in our study mean level was 24,49 m^2/person).

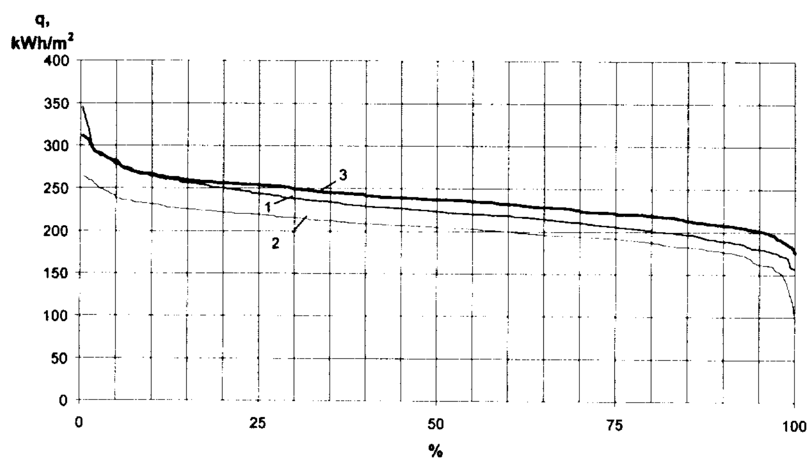

Fig.1. Cumulative distribution of real (1) and rating heat consumption in present (2) and favorable (3) economical situation

The rating scale

Two main considerations for the rating scale development were:

- the part of domestic hot water is rather high and has to be taken into account recalculated to the standard level of occupancy 30 m^2/person;
- the part of space heating has to be recalculated to 4688,3 degree-days of heating period in economically favorable conditions (heating period from September till May, mean outside temperatures of standard year, space temperature + 20°C).

Obviously rating scale cannot be based on the real heat consumption as it may depend on financial circumstances of inhabitants. Rating consumption is a recalculated one.

The formulae for the rating specific heat consumption of the house is:

$$q_{st} = q_{s.h.} D_{st}/D + q_{d.w.} F/30n, \qquad kWh/m^2 \, year \qquad (1)$$

where q_{st} - rating specific heat consumption, kWh/m^2 year

$q_{s.h.}$ - measured specific consumption for space heating in rating year, kWh/m^2 year

$q_{d.w.}$ - measured consumption for domestic hot water in rating year, kWh/m^2 year

D - degree-days of heating period in rating year

D_{st} - degree-days of standard year in favorable economical conditions

F - heated built-in area, m^2

30 - standard occupancy level, m^2/ person

n - number of inhabitants, persons.

Energy auditor calculating the energy rating has to evaluate real space temperatures during heating season and determine degree-days of particular year; to evaluate real number of inhabitants and the part of heat consumption for domestic hot water if the space heating and domestic hot water consumptions are not measured separately; to make preliminary audit analyzing most obvious reasons which had influenced the particular rating and note them in the rating statement.

The proposed rating scale (table 1) for total heat consumption which evaluate house energy effectiveness from the macro economical point of view is:

Table 1. Energy rating

Rating	A (excellent)	B (good)	C (fair)	D (bad)	E (very bad)
q, kWh/m^2year	≤160,00	160,01 - 190,00	190,01 - 220,00	220,01 - 250,00	> 250,00

Evaluating buildings energy effectiveness of the mentioned case study (figure 1 line 3) by this scale 30 % of buildings fall in category E, 45 % in category D, 22 % in category C, only 3% fall in category B and none in the category A.

Besides as the consumption for the space heating depends very much on the type of house (for example, it was for the houses of 103.serie 87-126 kWh/m^2 year, for 5-storied brick houses built in 1960-ies it was 154-176 kWh/m^2year), it is useful to show the place of the particular house in it's own group. It can be done by three indices: 1 (good), 2 (average), 3(bad) and would characterize possibilities for the improvements of energy effectiveness without reconstruction of the house. So rating C3 would mean fair total heat consumption but bad effectiveness of space heating for the house of this group.

Certificates of building energy efficiency

New building regulations for thermal resistance of building structures which has to be adopted in 2000 has new approach that U-value of individual structures can vary and be higher than normative if it does not exceed maximal value and total heat loss of the house does not exceed maximal limits. Maximal limit of heat loss is value calculated for the house of same size built with normative thermal resistance. For dwelling houses maximal heat loss may be calculated using maximal allowed specific heat loss (table 2). Table 2 also shows corresponding specific heat consumption in economically favorable conditions (4688,3 degree-days) and in brackets in present situation (3766,8 degree-days).

Table 2. Specific heat loss accordingly to the new building regulations

Number of stories	1-2	3-4	>5
Specific heat loss, h, W/m^2K	1,2	0,9	0,72
Corresponding specific heat consumption for space heating, q_h, kWh/m^2year	135,02 (108,50)	101,27 (81,36)	81,01 (65,09)

Annual heat consumption of the houses designed accordingly to these norms still is rather high. The idea of energy certificate is to praise the most energy effective houses. Mark "excellent" may be received if calculated heat loss of the new house is less than 60% of maximal allowed value, for the mark " very good" it has to be not more than 80%. Calculated values have to be confirmed in field study made by energy auditor.

CONCLUSIONS

Building energy rating gives possibility to classify dwelling houses by their energy consumption, to market "better" and "worse" dwelling hoses series and each particular house, to evaluate possible economical effect of energy saving measures, to indicate houses with extraordinary heat consumption and analyze the reasons of it.

Building energy rating will stimulate energy awareness of inhabitants indicating possibilities for improvements. It has to be done mandatory than selling property. An additional stimulus for energy rating may be reduction of real estate tax in the year of rating and the dependency of real estate tax on energy rating.

Certificate of building energy efficiency has to be received on voluntary basis. For the designing and construction firms it will serve as additional advertisement that proves the quality of works.

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Evaluation System and Policy for Green Building in Taiwan

Hsien-Te Lin, Chiang-Pi Hsiao, Jui-Ling Chen

1. Professor, Department of Architecture, National Cheng-Kung University, Tainan, Taiwan
2. General Director, Architecture & Building Research Institute, Ministry of Interior, Taipei, Taiwan
3. Director of Environment Control Department, Architecture & Building Research Institute, Ministry of Interior, Taipei, Taiwan

Introduction

This paper will introduce an evaluation system for Green Buildings in Taiwan, which emphasizes energy conservation, resource protection, low waste and low environmental impact for the life cycle of the building. This system has become a most urgent strategy for the building administration of Taiwan because the ecological environment is becoming worse and worse. Seven categories, which denote the environmental impact of buildings on resources, climate, water, soil and energy, are introduced, as shown in Table 1. Quantitative indices and strict criteria are set up for each category, described in the following.

Seven Categories for the Evaluation System

(1) green

Green is the first category of this evaluation system. It introduces the CO_2 absorption index as the conversion unit for different types of plantings, such as trees, shrubs, climbers etc. The CO_2 absorption index, which is evaluated over a building life cycle of 40 years, can quantified any type of green design because the total planting effect can be converted into a single CO_2 absorption index. As a qualified green design for Green Building, the total CO_2 planting absorption should reach a high level, with a planting rate greater than 50% of the open space and a CO_2 absorption efficiency higher than 600 kg-CO_2/(m^2.40yr).

Table 1. Categories and indices for Green Building Evaluation in Taiwan

Climate	Water	Soil	Energy	Materials	Categories	Evaluation indices and unites
*	*	*			1.green	CO_2 absorption (kg-CO_2/(m^2.40yr))
*	*	*			2. soil water content	water contentment of the site (-)
	*				3. water conservation	water usage(L/person), hygienic instrument with water saving (-)
*			*		4.energy conservation	ENVLOAD、Req、PACS、energy saving techniques
*		*	*	*	5. CO_2emission	CO_2 emission of building material (kg-CO_2/m^2)
		*		*	6. waste reduction	waste of soil, construction, destruction(-), recycling material(-)
	*			*	7.sewer and garbage	sewer plumbing , sanitary condition for garbage gathering

(2) soil water content

The second category, soil water content, is introduced for maintaining the site permeability performance. An index for the permeable ratio λ of a constructed site in comparison to a bare site is adopted to evaluate the water content capacity of the site. The calculation of this permeable ratio λ encourages permeable pavement, ponds, permeable lowlands, and gardens on impermeable floors or roofs in the site design. A building project can be qualified as a Green Building if the permeable site design is greater than 80% of the open space.

(3) water conservation

The third category, water conservation, is introduced for saving water resources. Many types of water saving hygienic instruments, such as water closets, bathtubs, showers, etc., are encouraged in this evaluation. Water recycling systems for used water or rainwater are especially encouraged in this calculation. As a qualified Green Building project, the calculated saving rate for water resources should be greater than 20% , or the adoption rate of water saving instruments should be greater than 80% .

(4) energy conservation

The fourth category, energy conservation, is the most sophisticated field in the Green Building evaluation system. This category focuses mainly on the energy performance of the building envelope, cooling, lighting, which occupies over 80% of the total building energy consumption. The building envelope energy performance evaluation is quite convincing because the evaluation method, ENVLOAD (thermal load of envelope) and Req index, has become the legal regulation in Taiwan. The PACS (performance of air conditioning system) method is also well established in the air conditioning field in Taiwan. The lighting energy can easily be evaluated based on the average illumination usage calculation per square meter of floor area. In the Green Building evaluation, the energy saving rates for the three indexes, the building envelope energy performance, cooling and lighting, should be greater than 20 % of the average energy consumption.

(5) CO_2 emission

The fifth category, CO_2 emissions, is an important tool for reducing pollution emissions through a clean building materials and construction design. A Green Building candidate should emit 10% lower than the average CO_2 emissions from reinforced concrete buildings through a more logical and efficient design for the structural system and low energy materials. This evaluation can especially encourage lower environmental impact structures, such as lightweight steel structured buildings, industrialized construction methods or wooden buildings.

(6) waste reduction

The sixth category, waste reduction, is introduced to evaluate solid waste and particle pollution, from basement cutting, construction and destruction in the life cycle of building. A Green Building qualified project is required to cut 10% of the soil waste, construction waste, destruction waste, and to reduce 40% of the construction particles, as compared to the average waste emissions from reinforced concrete buildings. This evaluation can encourage more natural site design with fewer landscape changes, less basement cutting, and low pollution construction, such as industrialized building methods and steel or wooden buildings. Recycled materials, such as recycled blocks, tiles, aggregate, are especially encouraged in the destruction waste evaluation.

(7) sewer and garbage

The seventh category, sewer and garbage, does not evaluate sewer and garbage biotechnology but focuses on the landscape design or detailed improvements for sewer plumbing and garbage holding area sanitary conditions. This category involves stringent regulations for correct sewer and daily use water plumbing, and evaluates the landscape environment and garbage recycling system in housing communities.

Conclusions and Recommendations

The above seven categories were evaluated independently in order to reply to the various environmental impacts upon the earth. Each category has some quantitative calculation equations and strict criteria for the evaluation judgment. This system has been simplified, quantified and localized for the subtropical climate of Taiwan and is regarded as a standard evaluation method for Green Buildings by the Ministry of the Interior of Taiwan. In order to promote Green Building design, the government has developed some encouragement policies. For example, a standard manual for Green Building evaluation was published and distributed widely to building designers, teachers, architects and contractors trained in Green Building design. A Green Building CAD program is being developed for future use.

At the same time, a Green Building Logo encouragement system has been set up and a Green Building Committee organized for Green Building evaluation. Any existing building or any new building scheme is encouraged before construction to pursue the Green Building Logo award, as shown in Fig.1. A Green Building is evaluated on different levels according to how many qualified categories are attained in the evaluation. However, the Green Building Logo award is given only to buildings, which have passed at least the "water conservation" and "energy conservation" evaluations among the seven categories. Three projects have received the Green Building Logo award as of June 2000. The Green Building evaluation is not compulsive at this time but the Taiwan government will require official buildings to undergo this evaluation in the near future. This requirement will be assigned to private buildings in the next step.

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綠建築標章
GREEN BUILDING

Fig1. The Green Building Logo of Taiwan Government

Eco-Labelling for Buildings - Examples and Requirements

Andreas Blum, Clemens Deilmann, Frank-Stefan Neubauer
Institute of Ecological and Regional Development, Dresden, Germany
Weberplatz 1, D-01217 Dresden, http://www.tu-dresden.de/ioer

WHY ECO-LABELLING?

It is a fundamental phenomenon that tangible or observable features of a product in general have a stronger influence on market decisions than more hidden characteristics. In consequence, buildings with extraordinary environmental characteristics often succeed in the market as they should do ("adverse selection" [1]). This problem is especially likely to arise in the case of 'innovators' marketing their products for the first time [2]. At the same time, however, 'innovators' are required for a development of the building stock oriented towards the concept of sustainability.
Therefore, at the centre of the research presented stand the questions as to what extent "Eco-Labelling for Buildings" schemes can contribute to solving this problem and which methodological demands are to be made of such an instrument. Analysed are existing examples and experiences as well as developing initiatives. Furthermore a survey concerning attitudes and demands of important stakeholders in Germany was conducted.

PRINCIPLES

Environmental labelling provides an opportunity to support voluntary ecological better practice in the building market. On the one hand, suppliers are given the opportunity to point up their particular ecological quality ("signalling"). On the other hand, the demand side acquires initial orientation concerning often invisible and rarely tangible qualities, which can thus be included in the decision-process ("screening") [2]. Nevertheless a variety of demands have to be fulfilled before eco-labelling can become effective.
Highly condensed information (the typical symbolic eco-label) presupposes the (blind) trust of the addressee in the judgement of the experts involved. Labels of this type are particularly suitable "for consumers with low involvement and for decisions concerning the purchase and use of products with low information requirements" [2]. Accordingly symbolic labels alone will not be sufficient for the purpose of representing extraordinary environmental performance levels of buildings. Rather, instruments are needed that are able to offer speedy orientation but at the same time keep detailed information accessible in the background if required. Documentation, Aggregation, and Communication are the three Columns of any eco-labelling approach for buildings. Nevertheless very often the discussion concentrates on the first column, the design of a suitable, or often rather practicable catalogue of criteria. However, all three columns are of equal importance for the acceptability and validity of the instrument and have to be discussed in conjunction with the organisational structure that links them together [3].
Generally we can say that any approach should fall mid-way between the poles of "no information" and "information-overload" by transforming *factually necessary* information input into *acceptable* information output. At the same time completeness of the recorded information is an important precondition for the acceptability of the instrument. Environmental labelling must therefore first of all record as comprehensively as possible materially relevant impacts. Although the main focuses of existing instruments appear quite similar (Table 1), there is a great difference in detail. In addition and since environmental impacts are by no means completely and finally recognisable, even a seal of environmental quality with comprehensive scope has to remain open for revision and adaptation. Furthermore "Completeness" of the scope of assessment is not only defined by the actual fact of scientific knowledge but also by the specific require-

ments of the target group concerning relevance and usefulness of the information.

Criteria based on UBA-Leitfaden[4]	LGA Gebäudepass D [5]	Grüne Hausnummer D [6]	Gebäudepass Sachsenhaus D [7]	BMBau Gebäudepass D [8]	AKÖH Gebäudebrief D [9]	Environmental Standard Award GB [10]	Nibe TWIN-Model NL [11]
Environmental aspects of building material	X	X	X	X	X	X	X
Recycling of building material			(X)		(X)	X	X
Indoor-pollution caused by building material	X	X		X		X	(X)
Concept of construction/ orientation of building	X	X	X	X	X	(X)	X
Thermal insulation	X	X	X	X	X	X	X
Energy-saving heating systems/technologies	X	X		X	X	X	X
Use of renewable energy resources	(X)	X	X	X	X	X	X
Water-saving technologies	X	X	X	X	X	(X)	X
Use of grey/rainwater	X	X			X	(X)	
Pavement of soil, Seepage, Waste-water purification	(X)	X	X		X	(X)	(X)
Waste management, composting		X	X	X			X
Noise abatement	X		X	X			X
Greening of buildings and housing areas	X	X	(X)			(X)	X

Table 1: Main focuses of selected different schemes [3]; other interesting approaches are existing or on the way for example with Eco-Quantum, NL [12], the international Green-Building-Challenge (GBC)-Tool [13] or the Norwegian EcoProfile [14]

ATTITUDES AND EXPECTATIONS OF INTEREST GROUPS

To gain insight in attitudes and expectations for example concerning criteria and procedural elements, a survey of major player and interest groups in the German building sector was conducted in the middle of 1999 [15]. The survey addressed itself to the associations of architects/ planners, owners/ clients, tenants/ users/ consumers, estate agents. In addition, major environmental organisations and numerous prefabricated house suppliers were surveyed, as well as financing institutions. A total of around 160 associations/institutions were contacted. Roughly a third were approached within the sample survey by phone, whilst roughly a quarter of institutions asked took part in the written survey (46 returns).

General findings

Although the findings from the exploratory investigation cannot claim to be representative in statistics terms, all in all the survey does yield a useful initial picture of the general mood amongst the various player groups in the building sector (Fig. 1).

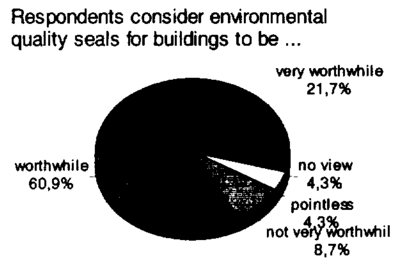

Fig. 1: General attitudes towards environmental labelling/certification for buildings (Percentages of participants in the standardised survey; IÖR 1999)

Methodological Characteristics

Among other questions respondents were invited to grade 19 possible organisational and procedural elements, derived from existing examples and literary sources, for an environmental quality seal. The question was posed as to whether the usefulness of an environmental quality seal for buildings is defined by a given factor. With regard to the "full approval" category, the following items are those in which the attitudes of respondents are most uniform in nature:

"Environmental quality seals/certificates as a means of denoting ecological building qualities only make sense if ...

... if the awarding procedure is organised independently of businesses."

... if the ecologically relevant characteristics of a building are comprehensively documented."

... if the entire lifecycle of the building is considered."

... if the catalogue of criteria is drawn up by recognised ecological-construction experts."

... if ecological qualities (including the criteria, procedures and findings taken into account) are comprehensively documented within a 'building passport'."

... if the certification test date is clearly discernible."

... if the criteria and procedures used are regularly revised and adapted."

Most decisively rejected was the item:

... if applicants for the seal can influence the procedure and scope of testing."

CONCLUSION

The studies show that Eco-Labelling for buildings that provides guidance for target groups (planner, clients, owner, user, financiers) and serves as a tool for strengthening the competitiveness of extraordinary voluntary environmental performance in building practice can hope for a certain degree of approval from players in the building sector.

At the same time, it also becomes clear that there are numerous conceptual and methodological questions to be clarified. Particularly an urgent task would appear to be the definition of specified procedural and organisational requirements within common conventions. This should be done by an impartial institution to increase comparability and credibility of existing (competing) labelling and certification schemes, at least concerning fundamental methodological characteristics. With the single European market taking shape also for the building sector, common basic principles for an environmental quality seal ideally need to be drawn up at European level, ensuring compatibility with international schemes and regulations.

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THE APPLICATION OF ENVIRONMENTAL PRODUCT DECLARATIONS FOR INNOVATIONS IN THE BUILDING SECTOR

drs. Agnes Schuurmans (asc@intronbv.nl), drs. Joep Meijer (jme@intronbv.nl)
INTRON B.V., the quality assessment institute for the building industry, P.O. Box 5187, 6130 PD SITTARD, The Netherlands

INTRODUCTION

How can environmental information of building products contribute to Sustainable Building? Although there is no clear definition of what Sustainable Building exactly is, it is agreed upon that Sustainable Building has to do with "environment" in all aspects of building: the building itself (materials and products, the design, the waste, etc), the building processes, the use of the building, the flexibility of the building, the location and surroundings, etc.. Sustainable Building may be a very confusing thing that seems to cover more and more. The subject of this presentation – building products - seems to be relatively easy: apply building products with a low environmental impact and you contribute to Sustainable Building. The only thing to do, is to take care that uniform environmental product information is supplied, so products can be compared. If it would be that simple ...
We show you in this presentation that supplying and using environmental product information for Sustainable Building is not that simple. The challenge is to overview the impact of building products on the whole building's life cycle, in all facets. The ones who realise this, will be the innovators in Sustainable Building. We explain how environmental product declarations can be applied to achieve this.

IMPACTS OF BUILDING PRODUCTS ON ALL FACETS OF SUSTAINABLE BUILDING

The environmental impact of building products is usually studied by LCA. In this respect we want to emphasise the importance of the so-called functional unit. The functional unit is much more than just describing the application of the product. The functional unit has to be defined on the building level instead of on the level of "subfunctions". Furthermore, the functional unit has to contain all requirements for obtaining a sustainable building. "Sustainable Building aspects" such as flexibility, adaptibility, durability, aesthetics, etc have to be defined beforehand. These requirements differ per situation. The product that is able to meet the requirements of the functional unit in the best way, is the best environmental option for that situation. It is our opinion that "fit for purpose" is the best equivalent of sustainable building products.
Some examples:

- Insulation material contributes significantly to energy saving in the use phase. The savings exceed the environmental impacts of production many times. Comparison of traditional LCAs of insulation materials is therefore not useful. Studying the insulating performance in the life of the building is a much more effective. Dynamic modelling in LCA is an option for this.

- Paints and coatings protect a.o. a material for deterioration. When assessing these products the maintenance phase of the building is the main phase to study. There are several examples known where "environmental-friendly" paints have been applied but had to be removed much too early because of dis-functioning.
- Stony materials are known as very durable materials. When durability is required, stony materials are a sustainable solution. When flexibility and adaptibility is required other materials such as steel may offer better solutions. Building monuments is other business than building dwellings or offices! Office XX in the Netherlands is an example of building a "non-durable" but fit-for-purpose application: the office has to function for no more than 20 years. Contrary, there are many examples of "environmental" housing projects that failed because of lack of durability. Who wants to live in a house where you are constantly repairing things?
- Aesthetics, comfort and perception are as important as durability. You probably know the examples where maintenance is not necessary from a durability point of view, but where aesthetics are the reason for preliminary maintenance or even replacement of material. Or the residential quarters where buildings that could have lived for 100 years more, are broken down.

Which environmental product information contains this type of information? Which producer dare to say in which situation his product is a sustainable solution and in which situation it is not? Which architect dare to claim an environmental solution by "fit for purpose" products only? When do we change our black-and-white perception of "green" and "not green" products? "(Not) green" products do not exist: it is the application and situation that determines the environmental performance.

CHALLENGES FOR INNOVATIONS

As long as we think in the traditional way – the producer produces a product, the architect designs a building, etc. – environmental product information can be no more than LCAs that can be compared or applied for LCAs of buildings. In our opinion sustainable building and sustainable innovations have to be achieved by "looking over the borders". From the perspective of building products this means:

- Producers have to take the responsibility for the whole life cycle of their product. Responsibility for the end-of-life stage is a well-known example, e.g. recycling systems and return systems. But what about the design, the building process, the maintenance? Think of performance contracts, leasing, etc..
- Co-operation between actors, horizontal (between producers) as well as vertical (between producers, architects, owners, etc) is required. Why thinking in products instead of solutions?

THE APPLICATION OF ENVIRONMENTAL PRODUCT DECLARATIONS

What is the link between the above statements and environmental product declarations? Is it necessary to have an official document that shows the environmental performance of a product, to reach innovations? The answer is yes.

Such declarations can be an impulse to realise the way of thinking we plead for, because innovations are market-driven. Product declarations are a tangible document for marketeers to show environmental effort, and a tangible document for buyers of products to have a critical look at products.
However, the current environmental product declarations are no more than a datasheet containing LCA figures (environmental profiles) and some explanation of the product. In figure 1 you see an example of the Dutch "MRPI®" declaration (In 1999 the Dutch producers of building materials introduced a product declaration system, called Environmental Relevant Product Information (MRPI®). This is a type III labelling system).

What can you do with the LCA figures? To be honest: nothing as such. It are just data, no information. Of course, they are the basis for benchmarking and implementation of product orientated environmental systems within companies. When product improvements are realised and can be shown by this declaration, the document will become much more interesting for marketeers. Then it can be used for image-setting. However, the most interesting application is data transfer, horizontal (combining LCAs of products) as well as vertical (the data will be the input for assessment tools for buildings such as Eco-Quantum). This opens the way of thinking we plead for: co-operation and life-cycle thinking. Producers made first steps to present the data in such a way that they help the designer to find a good design solution (e.g. aerated cellular concrete, paint, concrete). An official document can be the market-driven incentive.
In the Dutch MRPI®-system a first step in the "co-operative way of thinking" is made by using matrices as a functional unit, see figure 2. Furthermore, the producer has to supply qualitative information on other life cycle stages, if relevant. However, data transfer to Eco-Quantum is a further necessary step to stimulate the life-cycle thinking.

Functional unit wall (example)	Production phase	transport to site	building process	use and maintenance phase	waste treatment phase
part 1, outer wall	must included in MRPI®	can be included	can be included	can be included	must be included
part 2, insulation	etc				
part 3, inner wall	etc				

Figure 1. Matrix as a functional unit

CONCLUSIONS AND RECOMMENDATIONS

We conclude that environmental product declarations can the market driven incentive to realise sustainable innovations: life-cycle thinking and co-operation. We recommend that the declarations focus more on information about sustainable solutions than on LCA data only. "Fit for purpose" should be the central communication issue between actors in the building column.

The Environmental Declarations of Building Products in Finland

Mr Petri Neuvonen
petri.neuvonen@rts.fi
The Building Information Foundation RTS
P. O. B. 1004
00101 Helsinki
Finland

Which materials should be used in a sustainable building ? What kind of environmental impacts do building products have ? Many professionals and laymen alike wish to find simple and reliable answers to these central questions.

For many the various ecolabels provide a sufficient answer. The message of an eco label is simple: this product is in certain respects better than the other products used for the same purpose. The various labelling systems have also their limitations. The least of these is not the fact that, the diversity and incommensurability of environmental impacts continues to offer problems for those attempting to define criteria for a green building product. Where to set the limit of a green building product ? Which properties should be assessed ?

Well-informed professionals often want to set the criteria and limits themselves instead of relying on the judgement of others. What they need to achieve this are environmental declarations i. e. information on the environmental impact of building products compiled in a uniform way so that the reliable comparison of different products is possible.

Although certain guidelines exist, there is no universally accepted model for the environmental declaration of building products. In Finland the model for the environmental declarations of building products has been developed by the Building Information Foundation RTS and VTT Building Technology in collaboration with representatives of the Finnish construction materials industry. The project was a part of technology programme "Environmental Technology in Construction" organised by TEKES, the National Technology Agency in Finland.

The declarations provide information for the assessment of the environmental impact of building products over their entire life cycle – extraction, processing, use, maintenance and disposal / re-use. The information is based on the LCA data supplied by the producers. The declarations contain neutral information, the final assessment is left to the reader. Environmental declarations promote the development, manufacture, marketing and use of products, which will be less harmful to the environment than alternative products available. The ultimate goal of the system is to facilitate the selection of design solutions, which minimise the environmental impact of building. The information provided in the declarations is to be employed in the comparison between different building elements, such as external walls, fulfilling similar functional and technical requirements.

The declarations cover all the stages of the principal material's lifecycle through their extraction, processing, construction, use and maintenance, and their eventual demolition and disposal. The data presented are based on lifecycle inventory ISO 14040 and 14041. The declaration describes the features of the product in the stated application.

On each product the following the following data is presented:

- service life
  (based on the announcement of the producer)

- energy and raw material consumption

The energy of all flows belonging to the system is stated as HHV value (Higher Heating Value) per mass of the product and / or per functional unit. Energy is divided into non-renewable and renewable energy. The source of renewable energy can be stated if wanted. Also the statement of the share of energy stocked in the product can be added if wanted. The energy stocked in the product can alternatively be stated in the paragraph "Recycling and final location". The raw material consumption is stated as the raw material mass per mass of the final product.

- emissions to air
  (greenhouse gases, CO_2 stored in product, emissions causing acidification and emissions causing oxidants)

Emissions are stated as equivalent values, which should be calculated according to the table below. Equivalent values are stated per mass of the product and / or per functional unit.

Greenhouse gases	Weight
CO_2	1
CH_4	24,5
N_2O	320

Emissions causing acidification	Weight
SO_2	1,00
NO	1,07
NO_2	0,70
NO_x	0,70
NH_3	1,88
HCl	0,88
HF	1,60

Emissions causing oxidants	Weight
Ethane $C_2 H_4$	1
Methane CH_4	0,01
Others	0,4

- emissions to indoor air (M1 / M2 / M3 / no impact / emissions to indoor air not measured)

The chapter is based on the classification of finishing materials by the Finnish Society of Indoor Air Quality and Climate. Requirements for finishing materials in category M1, the best class in the classification, are as follows:

- emission of total volatile organic compounds (TVOC) is below	0.2 mg/m^2h
- emission of formaldehyde (HCOH) is below	0.05 mg/m^2h
- emission of ammonia (NH3) is below	0,03 mg/m^2h

- emission of carcinogenic compounds according
  to category 1 of IARC classification is below 0.005 mg/m^2h
- the material is not odorous

Category M1 includes also natural materials which are known to be safe in respect of emissions: brick, natural stone, ceramic tiles, glass, metal surfaces and wood. The classifications are granted by the Building Information Foundation. The full list of the almost 400 M1-classified products is available in the Internet (http://www.rts.fi).

- recycling and final location

- status of information

The declarations are compiled by VTT Building Technology from the data supplied by the producers. The Building Information Foundation RTS is responsible for the ratification and distribution of the declarations. The producers pay a fee for the compilation of declarations, but the use of the database of environmental declarations is free of charge. In June 2000 38 building products in Finland had a ratified environmental declaration. These materials included for example concrete, gypsum board and mineral wool. The database of environmental profiles is available in the Internet (http://www.rts.fi).

"CERTIFICATION OF ENVIRONMENTAL INSPECTORS - BUILDINGS"

SL, Manager of Energy, Environment and Technology. Solveig Larsen. THE SWEDISH FEDERATION FOR RENTAL PROPERTY OWNERS

Introduction

Even before it joined the EU, Sweden had implemented the principle that the polluter should pay. As a consequence of this, the Swedish Parliament took the decision to introduce producer liability, and the first area that was required to have a functioning recycling system was the packaging industry. After this, it was intended that the fields of electronics, tyres, cars and construction/demolition waste should assume producer liability. At the time, the construction and property industry chose to establish a voluntary network, " The Ecocycle Council for the Building Sector", including architects/consultants, the building materials sector, contractors and developers/property owners. The network's joint action plan included an undertaking to implement comprehensive training for people active throughout the building sector. Skilled people are required for all types of mapping and data collection work with regard to environmental conditions.

In 1999, the Swedish authorities carried out a campaign in respect of the indoor environment. Knowledge about the indoor environment in existing buildings proved to be lacking, while at the same time many tenants were extremely worried about the increase in allergies, particularly among children. We cannot rule out a possible link between indoor environment and allergies. A good indoor environment is fundamental for secure housing conditions. This led property owners and tenants to demand inventories of the indoor environment.

As long ago as 1995, Sveriges Fastighetsägareförbund [the Swedish Federation for Rental Property Owners] launched a project to look into the possibility of establishing a voluntary system, like the eco-cycle council, to investigate the indoor environment in existing buildings. The project aimed to carry out inventories of the indoor environment nationwide. As a result, fewer resources would be devoted to properties which had a healthy indoor environment, so that greater resources could instead be targeted at properties with sick building syndrome.

Presentation

The voluntary implementation of environmental inventories has a number of advantages for property owners and tenants. For example, they can be carried out at a time to suit the property owner. The results can be passed on to tenants, prospective purchasers, financiers and other market players in order to create goodwill and other market benefits. In addition, a well developed system of self-assessment can satisfy the objectives of the Swedish Environment Act as regards preventive environmental work that minimises negative environmental effects on people and the environment.

The inventories have to be carried out with an input of resources that only marginally increases living costs in Sweden. One cost-effective variant is to allow an environmental inspector to perform an overall assessment of the property. To help him, he can use questionnaire results and indication measurements. It is effective, both in terms of the environment and of resources, to choose an inventory model which involves the tenants by allowing them to express their experiences of the indoor environment through questionnaires. One way of quality-assuring the results is to stipulate demands as regards the skill of the environmental inspector instead of a quality-assured manual and process.

Society's requirements as expressed in the authorities' directives and general advice constitute the level of demands for the environmental inventory. In order to limit the room for subjective evaluations, the environmental inspector must have verified expertise which has been checked by means of tests carried out by an accredited certification body. Inventories of this type are known as Environmental Inventories in Existing Buildings. Three major Swedish housing organisations have pledged their support to this type of inventory.

Environmental education takes place at all levels in Sweden. Children are given basic information about the environment as early as their day-care centre. In later years, environment courses have been established at universities and colleges. In the consultancy field, there is comprehensive further education about the environment, primarily through individual courses and seminars. Property owners and property managers also undergo continual environmental training. Property managers who introduce business controls for quality and the environment have, as a result, established skills requirements and procedures for their personnel in order to ensure quality and environmental values in their properties. Further training is carried out in many different ways, with different aims and different educating bodies.

Clients ordering environmental services may find it difficult to get their bearings and stipulate demands as regards expertise. The need to test environmental expertise through an independent body and to certify individuals emerged both among clients and practitioners. Following the establishment of a type of inventory which included the precondition that it should be implemented by a person with verified environmental expertise, demand grew for the development of a requirement specification for basic skills as regards an environmental inspector of buildings.

The construction industry has been largely deregulated in Sweden. As early as the mid-1990s, detailed standards within building were replaced with functional requirements. Through legislation, the client was given specific responsibility for building and property maintenance. This has resulted in property owners to a greater extent striving to satisfy market requirements, as opposed to the previous situation where they primarily endeavoured to comply with social demands through official directives. Third party certification for people and companies is a suitable form for a deregulated sector. The official work in Sweden, performed by SWEDAC, takes place in the form of accreditation and ongoing monitoring of certification bodies. These bodies test people and continually monitor that those who have been awarded individual certificates are maintaining their level of skill.

However, the basis for this is that the skills requirements are included in a requirement specification. This document should balance the interests of the client and the practitioner. It is in the interest of the client that the requirements are not so stringent that the services of the certified practitioner entail too high a price. On the other hand, however, the requirements may not be so low that the results of the services are not good enough. Among practitioners, there is a group who would be happy to see stringent requirements. This group is highly skilled and feels that a lack of competition would be to their advantage. There is also a group of less than professional practitioners who consider that low requirements are to their advantage, and could imagine winning a share of the new market for inventory services without having any long-term aims as regards the results they produce.

As a result of the developments described above, a project was initiated whose goal was to create a requirement specification. The objective was to shape the demands for a basic level expertise among environmental inspectors.

Conclusions and recommendations

A working group comprising representatives of clients, practitioners and training bodies was established. The group produced a proposal for a requirement specification. It was given the name CMF-Buildings, from the Swedish abbreviation for Certification of Environmental Inspectors for Buildings. The Swedish requirements can be found in a publication called CMF-Buildings and are adapted to Swedish conditions.

The content complies with the standards and comes under the following headings:
- Introduction
- Definitions and references
- General directives for personal certification
- Knowledge tests
- Certificate's validity
- Knowledge requirements by subject

The following comments describe adjustments and standpoints under each heading.

Under the heading *General directives for personal certification*, there are demands for prior knowledge, professional experience and suitability. Depending on which demands are selected, some professional practitioners on the market will be excluded from certification. At the same time, it is these demands that determine the value of the certificate. The demands can be found in the publication CMF-Buildings mentioned above.

The *Knowledge test* stipulates the level of achievement that is required to gain approval. The working group decided that, in a written test, at least 70% of the answers should be correct.

The section on the *Certificate's validity* is mostly standardised and not specific to this area of expertise.

Knowledge requirements by subject comprises both theoretical knowledge and proficiency in the application of the theoretical knowledge. One fundamental approach which has permeated the demands is that it is impossible for certified people to be specialists in every area. However, their expertise should be so comprehensive that observations about negative environmental effects made during the environmental inventory should lead to more in-depth investigations in combination with measurements and laboratory studies. These demands are introduced with the words *Be aware of.* Environmental inspectors should be aware of the relevant legislation, as well as having specialist knowledge about land, buildings and installations with regard to toxicity, resource management, in particular energy usage, and the effects on health of the indoor environment.

When the demands were established after extensive referral work and workshops, SWEDAC decided that they should form the basis for personal certification. A group of experts has subsequently carried out an initial interpretation of the demands, as well as drawing up a list of relevant literature. Several educating bodies are now providing training towards CMF, and by June 2000 some 200 people will have been tested in respect of the demands and been approved.

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The standards SS EN 45013 and SS EN - ISO 14050.

EVOLVING APPROACHES TO EVALUATE SUSTAINABLE HOUSING PROJECTS

Fernando Murillo & Silvia de Schiller.
Centro de Investigaci6n Hábitat y Energía, FADU-UBA
Pabellon 3, piso 4, Ciudad Universitaria (1428) Capital Federal. Argentina.
fmurillo@fadu.uba.ar / schiller@fadu.uba.ar

INTRODUCTION

Methodological approaches to evaluate housing projects have changed significantly during the last decades. From the cost-benefit approach in the 60's to the United Nations Human Development Indexes in the 90's, a valuable range of precedents can contribute to the selection of a suitable approach to evaluate 'sustainability' in housing projects.

The emphasis on sustainable development expressed in terms of economic efficiency, social equality and environmental protection, particularly applied to low-income communities indicates the need for clear strategies to optimise natural resources through building construction, urban planning and design. Relevant benefits can be obtained in terms of better living conditions, lower operational costs and positive urban environmental impacts. These results can be promoted through the introduction of such issues during the process of project evaluation.

Paradoxically, government funded 'social' housing in the developing world tend to be designed with little consideration for optimising natural and climatic resources, such as solar, wind, land, water, vegetation, etc., in planning, design and construction. This situation can be partially explained as a result of the methods used to evaluate such projects, originally strongly influenced by economic and financial parameters first and the inclusion of aspects of social development and environmental impact later. However, a systematic environmental design and planning approach to evaluate such plans has been scarcely applied, due to the lack of suitable and locally available methodologies, scarcity of trained professionals, conditions of financial institutions and time limitations.

PRESENTATION

This paper analyses the incidence of evaluation approaches during the last four decades in Buenos Aires, Argentina in housing design for low-income groups. Particularly, it considers how evaluation lethods have evolved from purely economic evaluations to the challenge of considering many different dimensions integrated in the concept of sustainable development.

Case studies from Buenos Aires have been taken into account, where different evaluation criteria were applied, each one representing successive steps toward the evolving concept of sustainability. Preliminary results of the research demonstrate that housing projects evaluated positively according to the principles of sustainable development require implementation of bio-climatic design and construction guidelines without adversely affecting its affordability to produce favourable environmental impacts. On the other hand, development of new contents is required including design decisions integrated with economic, social and environmental variables, in order to evaluate the suitability of such principles.

These case studies consider public works carried out during different decades by the Municipal Housing Commission of the City of Buenos Aires. Housing complexes in the 60's, urbanisation by NGO's in the 80's and recent programmes initiatives based on public-private partnership, known as Programa Casa Propia are considered as emblematic case studies - GCBA, 1999.

During the 60's the local government had been coping with the housing deficit, through different strategies: Construction of high-density housing schemes, creating serious social and urban problems in social and urban terms, forming "ghettos", with many negative environmental consequences. During the 80's the local government strategy for habitat production moved towards funding non-profit initiatives (NGO's), which demonstrate efficiency in terms of minimising costs, but create conflicts. Firstly, it generates conflicts related to the criteria to distribute funds among the different NGO's working in the field of housing and many different CBO's (Community Based Organisations) competing for funding. Secondly, the benefits obtained by these initiatives tend to be minimum compared to the demand for social housing. During the last decade, the policy of local government to deal with the housing deficit has been to split the problem according to different incomes of the target groups. The idea is to encourage to the private sector to participate in housing projects for middle income groups, ensuring a proper payback. The concept of public-private partnership is based on the principle of "financial sustainability".

The housing strategies during the 60's and 70's reflect the ideology of cost-benefit evaluation methodologies, focussed on the economic and financial aspects of the projects, but without any regard to social or environmental impact. From the '80's, "alternative" methods, more oriented to community participation, more concerned with the issue of social development, working with qualitative indicators instead of quantitative and paying more attention to process than to final results -Cuenya, 1994-, support the idea of funding non profit organisations. Such projects definitively introduce design and planning principles as key elements to achieve positive evaluations. Social development of the target group and urban impact were particularly considered.

The Human Development Indexes of the United Nations -United Nations, 1992-, at the beginning of the 90's set up some more ambitious objectives incorporated in the evaluation framework of international donors, including globally social and economic issues in the context of environmental concerns. Although such indicators provides a certain framework upon which carry out more comprehensive and deeper evaluations, particularly relevant for the developing world, its application is still minimal, mainly as results of its complexity and high cost.

Simultaneously in the 90's, the idea of sustainable development appears in many different professional scenarios, but with very different meanings. But sustainable development has not a clear set of variables to evaluate, and particularly in the context of peripheral economies, sustainability is associated to governability, interpreted in financial terms, how the way to ensure a proper payback of the housing projects. It drives to a well-known social problem: Exclusion of the programs of an important percentage of the deficit: low income population without the possibility to have access to the still existing subsidised housing plans.

A second important consequence is the absence of encouragement to produce higher quality design. Energy efficiency is practically not considered at all in official plans, except basic regulations related to walls width and materials, without establishing any bio-climatic guidelines to optimise orientations, building typologies, designs details, etc.

The search for a sustainable housing policy implies the integration of economic-financial variables, oriented to an optimum equilibrium between public and private funds, but designing such partnership not only in terms of initial costs, but also in terms of running costs. It means that a sustainable housing policy must be efficient in reducing initial costs, optimising public-private partnership to finance the program, but also should foresee an efficient investments to minimise running costs, such as energy consumption, which depends a lot on design and construction details. The issues of social development and environmental protection are closely related to the concept of bio-climatic design as a crucial factor for sustainable development.

CONCLUSIONS AND RECOMMENDATIONS

Considering that different evaluation approaches strongly influence the concepts of housing design and planning, it is logical to acknowledge for the need developing new approaches of sustainability, integrating economic-financial, social and environmental aspects, applied to planning, design and construction principles. Such evaluation innovations are in a process of development: from many different contexts, different evaluation methodologies have been proposed in the last years. But very few applications can be identified in public programs, though new approaches to evaluate financial sustainability are already on the agenda of local government, especially in developing countries. The consequences of such situation can be measured in terms of non-sustainability, demonstrating the need to integrate financial, social and environmental factors in a unique evaluation approach. But although conceptually it is highly recommendable to create such integrated approach there are still important methodological and conceptual difficulties.

From a methodological point of view, a first difficulty is related to the dilemma between quantitative and/or qualitative indicators. A second difficulty is how to define the importance of each aspects to be evaluated: financial, social, or environmental and all the variables involved in each field. Both difficulties have been partially resolved by strategies developed in the field of environmental impact analysis. But what still remain as a problem is how to create an evaluation approach friendly enough to encourage public evaluators to become involved more comprehensively, but at the same time, promote strategic approaches. That means, evaluations that consider many different key aspects, always in an attractive framework to be managed for an evaluator with limited energies and resources to carry out his work.

From a conceptual point of view, it seems to be highly recommendable to clarify from the very beginning the type of sustainability under discussion, recognising that the same concept according to its particular interpretation can drive to opposite actions. An academic and at the same time operative way to classify sustainability is how "weak" or "strong" -Bell & Morse, 1999-. Weak sustainability is understood as related to a particular field, financial, ecological, etc; while "strong" sustainability means the paradigm proposed previously of integrating the many different dimensions of sustainable development. In the case of design for affordable housing it seems clear the need for "strong" sustainability.

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METHODOLOGICAL CONCEPTS AND RELATED DIFFICULTIES WHEN DEVELOPING BUILDING ENVIRONMENTAL ASSESSMENT TOOLS

Dr Sylviane Nibel

Centre Scientifique et Technique du Bâtiment (CSTB), 84, av. Jean Jaurès, Champs-sur-Marne, BP 2, F-77421, Marne-la-Vallée Cedex 2, France, Tel : +33.(0)1.64.68.83.01, Fax : +33.(0)1.64.68.83.50, E-mail : nibel@cstb.fr

INTRODUCTION

This paper briefly describes the theoretical concepts that underlie design and application of assessment tools for buildings. It also summarises many of the key issues and options that must be resolved in order to create an effective evaluation tool.

This text is a summary of a part of the IEA-ECBCS Annex 31 work [1]. It relies on a French Ph.D. [2], on an exercise led in the French ATEQUE working group [3], and on the Green Building Challenge project [4].

The organisation of the text follows the steps taken by a tool designer, beginning with a clarification of the tool's intended use, and ending with questions about how best to present the results. Between these two points, the paper explores the methodology leading to the "measurement" of the environmental potential effects or impacts induced by the "building system", (generally a building during its life cycle). This measurement method supposes how to structure the criteria to be studied, to define indicators and scales, to properly establish and delimit the causal chains (source ⇨ loading ⇨ effect ⇨ impact), and to elaborate calculation models and aggregation rules.

Indeed, the limited knowledge on the chains mentioned above, the necessity to make many assumptions, plus the difficulty to collect accurate input data on the building project, necessarily imply uncertainties in the final results. Consequently, each tool developer adopts his own framework and assumptions, leading to variation when comparing results from different tools.

Evaluation tools are primarily intended for decision support. For this reason, many of the issues related to tool design cannot be addressed without first clarifying the intended users, and the types of decisions for which they need support. Details are given in [1].

HIGH-PRIORITY ISSUES AND RECOMMENDATIONS

In the Annex 31 final report, many of the key theoretical concepts and issues that must be addressed by tool developers during the design of an assessment tool have been reviewed. It is clear that the difficulties faced by tool developers are substantial, given the large number of issues covered. Discussion of these issues has identified a number of areas where a special need exists for progress in tool development. These high-priority issues are summarised below.

Adequation with building design process

Paradoxically, an assessment tool can have the greatest impact in the early design phase, when the available information is the least precise. As a deduction from this paradox, it seems necessary that an assessment method can be used starting from a rough description of the building, and that it can then be adjusted to accommodate the increasingly detailed levels of available data. To this end, It may now be necessary for tool designers to establish new 'simplified' models from the existing detailed models.

Output sets

An assessment tool must be adapted to the decision-makers' needs, to their context, interests and areas of influence. This implies a close correspondence between the output set of a given tool (the information it generates) and what the decision-maker needs to know. A good compromise is to gather together on one hand the physical reality of environ-mental phenomena, and on the other hand concerns and decision criteria of involved parties.

In order to make output sets relevant, it is necessary for tool designers to avoid redundancy, to maximise the objectivity of outputs, to include the most significant environmental impacts attributed to the building sector, and to focus on those outputs which are amenable to improvement by the user (generally the building designer).

Often the number of the desirable or desired outputs is high. As it is necessary that output information is easily exploitable and readable, it should be structured and organised for easy reference and organisation. In this context, a key concept is the hierarchical framework. This framework generates a tree structure of outputs, implying a certain number of aggregations (see [4] and [2]).

Tool designers must pay attention to the way they structure the output set. The level at which an output is subsumed within another category will affect its profile relative to other impacts. Thus how to structure the framework is not a neutral decision, and can influence the final decisions made by actors. To some extent all hierarchical frameworks contain a kind of implicit pre-prioritisation of the environmental issues.

Indicators
An indicator must be expressed in clear and precise terms, relevant and effective. Some requirements and characteristics are associated to indicators [1].

The determination of an indicator, criterion by criterion, is generally not sufficient to give to decision-makers relevant information to make their choices. The notion of assessment includes in itself the comparison with reference values, implicit or explicit. That is what we call *performance assessment.*

Performance scales
The aim of the performance assessment is to position, by comparison to reference values, the results of assessments made according to each criterion. This assessment is made relative to a performance scale specified for each indicator.

The scale is characterised by:
- a lower limit, equivalent to a statutory value for the indicator, or one frequently met in practice,
- an upper limit, also called target value, equivalent to a maximum value for the indicator but currently achievable,
- a performance function (see Figure 1) that makes the link between the value of the indicator and a numeric value (or score) from - 2 to + 5 for example (as in GBC framework, see [4]).

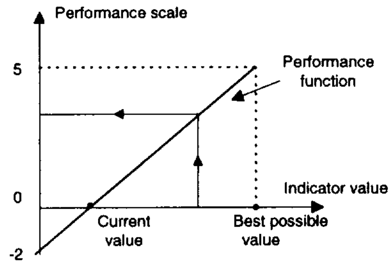

Figure 1 : Performance function

The calibration of the performance scale is a difficult task, it is not neutral because the judgement of the decision-makers will be based on the performance score. In addition, it is necessary to make the scale sensitive to variations of design characteristics, as well as avoiding saturation. The calibration of the scales must be consistent between the different criteria. In addition, the numerical value of all the indicators that exist behind the performance scores must remain accessible for the user.

System boundaries
Setting «system boundaries» is more difficult and critical than it appears at first sight, and tool designers must learn to describe boundaries in more explicit ways, and also must justify their choices. In order to do so, sensitivity analysis is useful.

Indeed, the comparative studies implementing various tools (see e.g. [3]) show that part of the variations observed in the results come from differences within the limits of the system.

In any event, if a source leads to non-negligible flows, if reliable calculations of flows are available, and if decision-makers can affect this source, it would be a mistake not to include it in the system.

Calculation models
Tool developers should inform users about the validation procedures and related results.

Aggregation and weighting
It is recommended that the weighting coefficients used within tools be more explicit and objective . Tool developers should justify them. These coefficients must remain apparent and logical for the decision-maker.

It may be a mistake to aggregate criteria that are difficult to combine.

Tool developers must be aware that aggregation methods - such as the weighted sum - present certain drawbacks, that can be limited if the tools are sufficiently « transparent ».

Presentation of results
The decision-maker should be able to identify the sources responsible for the environmental effects.

The decision-maker should be aware of uncertainties, and the tool developers should find adequate means to present them. In general, current tools do not present uncertainties well.

In addition and in parallel to the results, the main assumptions used may be reminded to the user, insofar as the results must be interpreted regarding the starting assumptions.

The decision-makers need reference values to be able to appreciate and interpret the results of the assessment. A performance scale is useful for this purpose (see Fig. 1). In addition, the scale allows a homogeneous presentation of the results according to various criteria.

In order to facilitate interpretation of the results, it is necessary that the tool enable the user to split up the final profile into detailed sub-profiles, so as intermediate performances and characteristics of the building responsible for the results become accessible to the user. That is what we called a *hierarchical presentation of the results*.

A list of specifications for well-structured output set has been suggested [1].

The user must not perceive the tool as a « black box ». Transparency is a strong requirement.

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APPLICATION OF ENVIRONMENTAL PROFILES FOR CONSTRUCTION MATERIALS AND COMPONENTS IN THE UK.

Suzy Edwards, Jane Anderson and Nigel Howard
Centre for Sustainable Construction, BRE, Watford, WD2 7JR. UK

INTRODUCTION

How can designers simply compare the *embodied impacts* with the *operational impacts* of a building?
How to combine *life cycle costs* of a building with its environmental impact?
These are just some of the applications of the Life Cycle Assessment (LCA) of construction products, a technique which provides a valuable starting point for many practical assessments of construction impact.
A standard LCA methodology has been established in collaboration with construction product producers in the UK, with support from the UK government. The BRE Environmental Profiles Methodology enables "level-playing field" LCA for all types of construction materials. The Environmental Profile information is presented in a choice of data formats:

- for *materials* presented as "cradle to gate" Profiles on a per tonne basis,
- for square metre of *elements* as they are *installed* in the building,
- for *elements* over a specified design life with maintenance, replacement and disposal included.

Only the latter gives the true "life cycle" of the products. It can be helpful however to apply particular replacement and maintenance factors, therefore the installed version is provided. "Per tonne" data, will be used to make comparisons of interchangeable materials provided by competing manufacturers. This use of the data is known as an "Environmental Declaration" and is described by ISO as a Type III label.
This paper describes further practical applications of Environmental Profiles data in the UK: the use of a single score assessment procedure, "Ecopoints"; whole life costing and LCA by the design team and in an initial design estimating tool called "ENVEST". The data is also used in preparing the Green Guides to Specification, including a version for housing. They are not described here.

ENVIRONMENTAL PROFILES

A Peer Review of the BRE methodology by five international experts in Life Cycle Assessment and Building confirmed that the choices used in this methodology conform to ISO14041.
Materials producers can display their data as an "inventory inputs and outputs. More frequently, the data may be presented as "characterised" environmental impacts (Table 1), which can then be normalised through comparison to the relative environmental impacts of one UK citizen.

Table 1 Characterised impacts shown on an Environmental Profile

Climate change ($kgCO_2eq.100yr$)	Eco-toxicity (m^3 tox)	Acid deposition ($kgSO_2eq$)
Ozone depletion ($kgCFC_{11}eq$)	Water pollution ($kgPO_4$ eq)	Minerals extraction (tonnes)
Fossil fuel depletion (t oil eq.)	Water extraction (litres)	Waste disposal (tonnes)
Human toxicity (kg.tox.)	Low level ozone creation potential (POCP) (kg ethene eq)	Transport Pollution and Congestion (tonnes.km)

ECOPOINTS

For the majority of users within the construction industry, a very simple method of comparison is required. For this reason, BRE developed Ecopoints. A UK Ecopoint is a single score measuring total environmental impact as a proportion of overall impact occurring in the UK. It is calculated by taking normalised data from Environmental Profiles, applying a weighting factor to each impact and adding all the weighted impacts to give the Ecopoints.

The weightings are from DETR funded consensus based research to weight sustainable construction issues. Building on other Eco-indicator methods, invited panels represented the perspectives of interest groups from the UK construction industry. It is intended that the weightings will be updated by ongoing research.

ENVEST: ENVIRONMENTAL ESTIMATOR SOFTWARE TOOL

To apply either Environmental Profiles or Ecopoints data to a design requires manual effort and data about the specification of different products. BRE has produced ENVEST[tm], to allow designers to evaluate the environmental impact of different options for a chosen design, with environmental impacts compared in Ecopoints. At the initial design stage, the user can identify the elements with the most impact and modify the design to reduce the environmental impact. Significantly, the tool includes the ecopoints of the operational energy demand to allow designers to investigate the trade-off between the life cycle impacts embodied in the design and operational impacts of building use.

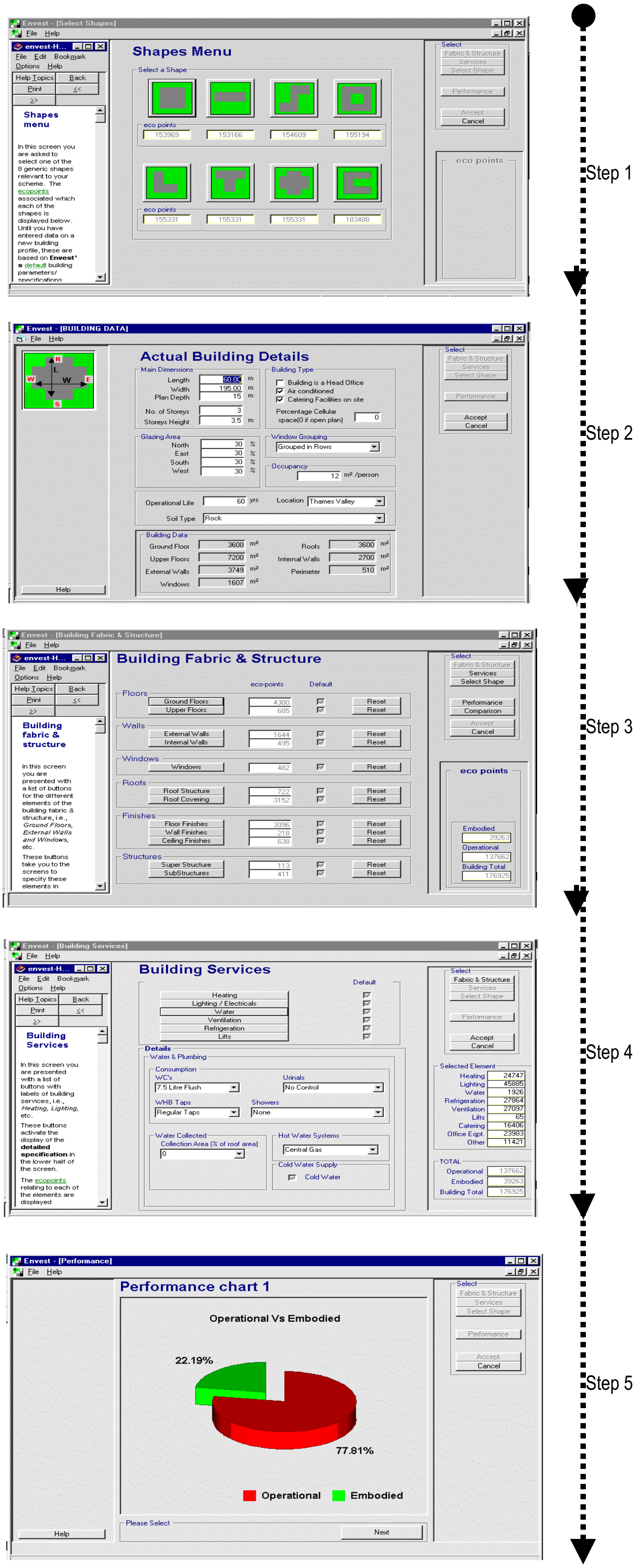


Fig 1 Selected stages in an ENVEST assessment:

step 1 choose shape,

step 2 change building details,

step 3 modify fabric,

step 4 modify services,

step 5 produce graphics (compare relative embodied and operational impacts, between buildings and between elements.)

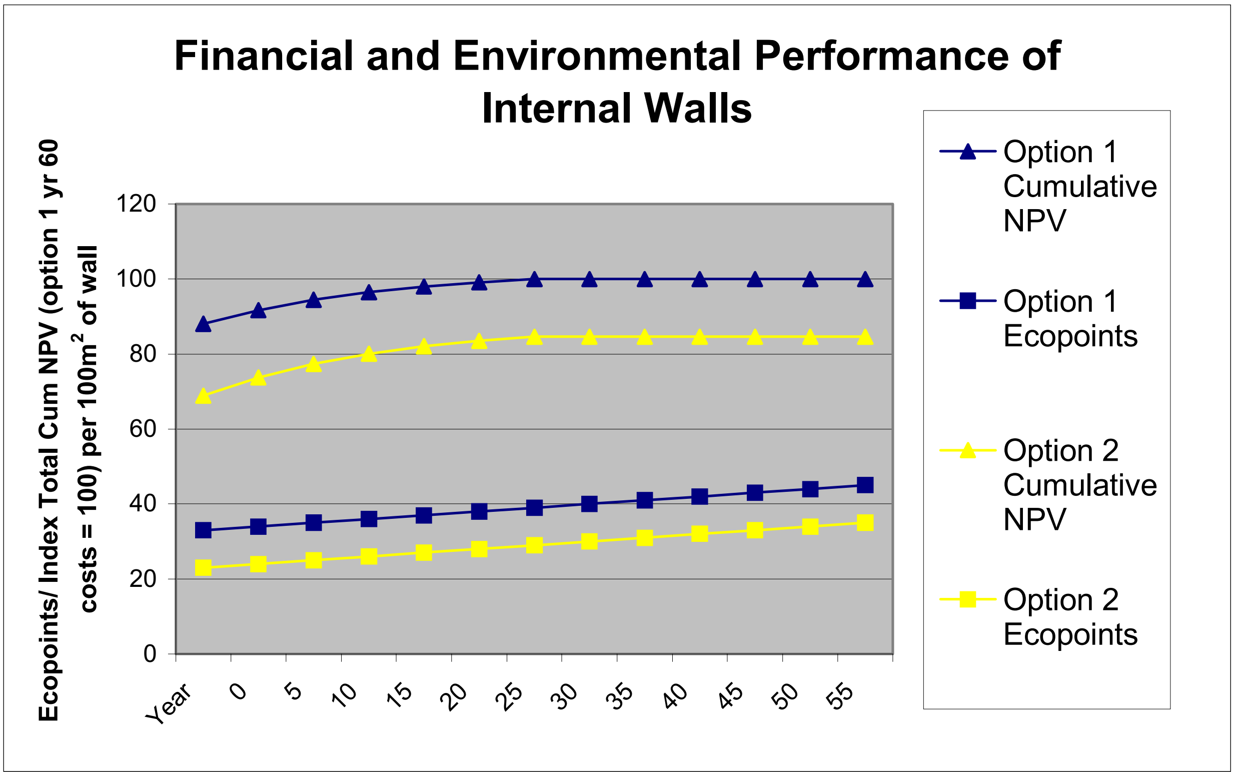
WHOLE LIFE COSTING AND LCA

The integration of WLC and LCA is seen by some as providing a potentially powerful route to improving the 'sustainability' of the construction industry. Economic assessment methods such as Net Present Value (NPV) are well established, and can be applied to buildings. Ecopoints provide a useful solution to including environmental assessment in decision making. By combining WLC and LCA data, environmental information can be used along side financial information to evaluate generic options in the building at the early stage of building design.

For example, WLC and LCA were used by a construction consultant to demonstrate their ability to evaluate the sustainability of the options within a building element. This study presented WLC and LCA data on the same graph, as shown for internal walls in figure 2 below.

The benefits to the contractor were that they could demonstrate to their client a reasoned method for assessing the sustainability of different building options. The benefits to the clients were that they were presented with a clear technique with which the choices based on financial and environmental criteria had been made.

Fig 2 Use of WLC (NPV) and LCA (Ecopoints) in a combined assessment process



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The Green Building Advisor: Evolution of an Ideas Tool

Nadav Malin, *Environmental Building News*, Brattleboro, Vermont, USA

Introduction

The Green Building Advisor is a software tool that fills a gap between modeling-based design tools and general, written information. Computer modeling tools are invaluable for getting good data on a building during the design phase, but they can only provide feedback on quantifiable variables, and they often require detailed and time-consuming inputs to get useful results. At the other extreme, there is a great of published material on design strategies and approaches to making green buildings, but these are generic in nature so the reader must sort out what applies to her project. Green Building Advisor offers a middle ground—ideas-level information that is customized to the user's situation without requiring detailed data-entry or modeling skills.

Figure 1: Green Building Advisor main menu.

Green Building Advisor is an educational and professional software tool for architects and designers who want to create environmentally friendly and healthy buildings. The program solicits information about the user's project and searches a database of environmental knowledge and case studies and presents the user with a prioritized list of relevant design strategies. The user can then view detailed information on each strategy and case study.

The Green Building Advisor version 1.0 was released during February, 1999. Version 1.0 is limited in its application to the United States. Over 1,200 copies are in circulation as of June, 2000. Version 1.1, with enhanced features, is due out by June of 2001.

How it works

The core of the Green Building Advisor is a collection of strategies for making greener buildings. Rather than presenting these strategies in the form of a huge list, however, Green Building Advisor provides guidance that is specific to a particular project. Green Building Advisor creates a customized collection of strategies based on information the user enters about her project. Examples of information the user might provide include building function, location, size, size of building lot, whether it is new construction or renovation, and whether the design is for a whole building or just a tenant fit-out. (Based on the location, Green Building Advisor accesses extensive climatic data for the project.) The program then compares this information with a specific algorithm for each strategy, and returns a list of "strongly recommended" and "moderately recommended" strategies, based on the estimated degree of environmental benefit for the particular project.

For example, the strategy "Use skylights for daylighting" is strongly recommended when the project scope includes the whole building, the building has one or two stories, and the location receives low or medium-low amounts of sunshine. If the climate includes more sunshine, or the building has more than two stories, the strategy is designated as "moderately recommended."

To make the lists of strategies manageable for the user, they are organized under five topic areas, based on the area of their environmental impact: Indoor Environment, Energy, Water, Resources & Materials, and Other Ecosystem Impacts. Each to these is further subdivided into subtopics. By selecting a topic and subtopic, the user can view a set of strategies relating to a common subject. Clicking on any strategy in the list reveals additional detail about that strategy: an explanation of what it means and how it might be implemented, its benefits, and potential drawbacks. For the motivated student, there is also a list of additional reference materials relating to the strategy.

To emphasize that each strategy doesn't exist in isolation, but rather is an integral part of an overall design approach, the details also include lists of related strategies that may represent either integration opportunities or potential conflicts. Each strategy is also appraised as its likely impact on initial cost, life cycle cost, and difficulty of design. While browsing through the list of strategies, the user can at any time choose to restrict the list to those strategies that do not increase first cost, or those that reduce life cycle cost. In addition, one or more building phases are assigned to each strategy, denoting whether it must be addressed during pre-design, design, construction, or post-occupancy. The user can also restrict the current list to strategies that are relevant to a particular building phase. Finally, the strategies are linked to green building case studies, providing examples of how the strategies have been implemented.

Case Studies

A selection of case studies from across North America, and a few from overseas, is included in version 2.0 of the Green Building Advisor. The program includes basic project specifications, descriptions, photographs, and construction details. The case studies have been selected to represent a broad range in terms of building type, size, and climate region. Like the strategies, these are identified with specific data so that the ones most relevant to the user's project are presented first.

Just as the strategies are linked to the case studies, the case studies are linked back to the strategies. In this way the user can learn more about a particular design aspect of a case study by reading the details and reference materials for the linked strategies.

Libraries

While the program is intended to present information relevant to a user's project, it is also designed to accommodate those who just wish to browse through the entire library of case studies, strategies, or reference materials. These lists are organized just as they would be for a specific project, except that no strategies are designated "strongly" or "moderately" recommended.

Having users browse the strategies independently of any reference to a current project poses a potential problem, because some of the strategies are appropriate only for certain climates or building types. The software includes guidance mechanisms to help clarify this point so users don't read the list of strategies as a checklist that might be applicable to any project.

Reference materials, which are linked to the individual strategies, are also accessible from a master library. These include supplementary documents available within the software itself, materials available on the Internet (which are accessible directly from the software if the user has a live Internet connection), and bibliographic references to documents and software available elsewhere. There is also a directory of green building products so the user can find specific products associated with the strategies and case studies.

Ongoing Evolution

With version 2.0, Green Building Advisor takes the first steps toward international relevance. The location map allows users to select a site in any country, and climate data are available for sites all over the globe. While still limited to an English-language version, metric units are included for non-American users.

In a more general enhancement, the utility of the Green Building Advisor as an educational tool will be advanced by adding explanatory details at each heading level, in addition to the details provided on each specific strategy. Thus, for example, there will be explanations about the general advantages and issues with lighting in general, and daylighting in particular, before getting into more specific explanations about strategies such as the use of open-plan office or interior transoms to enhance daylight penetration.

Also in future versions the amount of detail available on many of the case studies will be enhanced. More detailed energy performance information and cost information will be provided where available, and the results of any rating systems that may have assessed the building will also be included. Finally, strategies that suggest the use of specific products will be linked directly to those products.

Acknowledgments

The author wishes to thank the agencies that have funded the development of the Green Building Advisor, including the U.S. Army Corps of Engineers Construction Engineering Research Lab; the U.S. Department of Energy, and the U.S. Environmental Protection Agency. This paper is based on the work of the many people who created the Green Building Advisor: Stottler-Henke Associates, Inc., the developers of the Environmental Knowledge Base, on which the Green Building Advisor is based; the staff at CREST, including Michael Totten, Christopher Gronbeck, Eric Woods, and Melissa Garland; E Build's partner in content development, Gail Lindsey of Design Harmony, Inc., and the author's partner at BuildingGreen, Inc., Alex Wilson. Among the many technical experts who contributed their knowledge to the software are: Bob Berkebile; David Johnston; Gail Lindsey; Marc Rosenbaum; Joel Ann Todd; Ian Campbell; Muscoe Martin; Larry Strain; Bill Reed; Anne Sprunt Crawley; Dru Crawley; Mark Rylander; Dan Nall; Bill Thompson; Andy Shapiro; Terry Brennan; Joseph Lstiburek, Betsy Pettit, Richard Pinkham, Kim Sorvig, Peter Yost, William Bobenhausen, Catherine Coombs, Harvey Bryan, Terry Emmons, Anish Kumar, and James Patchett.

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Current details on the The Green Building Advisor can be found on the Internet at:

http://www.GreenBuildingAdvisor.com.

The software may be purchased from:

BuildingGreen, Inc.
122 Birge Street, Suite 30
Brattleboro, VT 05301
802/257-7300, 802/257-7304 (fax);
http://www.BuildingGreen.com

ENVIRONMENTAL INDICATORS FOR REAL ESTATE SECTOR

Work in progress

L.R, M.Sc., Researcher, Liisa Raunemaa
R.L, M.Sc., Researcher, Riitta Lahtinen
KTI, The Institute for Real Estate Economics
Iso Roobertinkatu 1 A 5, FIN-00120 Helsinki, Finland
Tel +358 9 6840 330, fax +358 9 6840 3310
e-mail: liisa.raunemaa@kti.fi, riitta.lahtinen@kti.fi, www.kti.fi

INTRODUCTION

Nowadays companies in all sectors are facing more rigorous environmental regulations. In addition, to the increased governmental obligations the customers have challenged the companies. Because of this, environmental excellence is regarded as a potential competitive advantage.

In Finland, the significance of environmental impacts of the real estate sector has been recognised only recently. Some efforts are made to promote ecologically beneficial operations, but the concrete measures taken and the results obtained are still few. In the real estate sector, the environmental issues are often dealt only in separate projects which results are not transferred or taken into account in company's day-to-day operations. The connection between the management of environmental issues and the economic performance has to be clarified.

In order to create business-oriented environmental indicators that support the company's operations and integrates the environmental factors into the company's management and accountancy systems the research project called "Environmental key figures of the real estate and construction sector" was launched on 1st of May 1999. The research project will be completed in August 2000.

KTI, The Institute for Real Estate Economics is responsible for the research project. The project is carried out in co-operation with KPMG, Rakli (The Finnish Association of Building Owners and Construction Clients) and the participating organisations. The five selected pilot companies are property investment company Aleksia Plc., Helsinki City Real Estate Department, State Real Property Agency and Finland's major retail companies called SOK and Kesko Oyj. In addition, there is a monitoring group consisting of ten companies operating in the sector. The project is linked with a Nordic project in order to enable international comparison in the future.

THE RESEARCH PROJECT

Objectives

The objectives of the research project are:

1. to develop a set of environmental indicators that support company operations
   - ➔ by integrating the environmental factors into the company's management and accounting systems
   - ➔ by transforming the environmental aspects into factors that are taken into account in decision-making.
2. to create a basis for both environmental benchmarking and environmental reporting systems for the real estate and construction industry.

The developed indicators are a tool to concretise the company's environmental aspects. To be more exact, they make it possible to set objectives to environmental aspects, to control them and to monitor the output effects. The indicators will be connected to existing control and measurement systems of the companies' business activities.

Implementation

The first one of the objectives is carried out by following the process of a strategic management system, the Balance Scorecard. According to the Balanced Scorecard process the implementation of the project is divided into four phases:

1. clarifying the vision and strategy,
2. defining the critical elements of success,
3. defining the indicators and
4. implementing them

During the research project there have been several workshops with the pilot companies and with the monitoring group. The results from the pilot companies have been the base for development of the environmental indicators and for common environmental reporting to real estate sector in Finland. Jointly organised workshops have ensured that the results obtained in the research project are widely distributed and made use of in the real estate sector. The developed environmental benchmarking system is tested during the summer 2000 in the participating companies.

The results and benefits of the research project

As a result of this project a set of environmental indicators and an environmental benchmarking system called "The Environmental Benchmarking for Real Estate Business 2000" have been defined. The benchmarking consists of four sets of indicators:

1. Environmental management
2. Leasing and customer interaction
3. Real Estate usage and maintenance
4. Investment process

Set of indicators includes questions concerning critical environmental factors to promote the possibility to take advantage of environmental business opportunities. Section one evaluates and monitors the standard of company's management and information systems, which show, for example, the company's capabilities to respond to environmental challenges set by stakeholders. Section two explores the company's ability to take environmental aspects into consideration in their own leasing processes. In addition, it evaluates how well company is able to support customers' environmentally oriented activities. Section three measures the environmental impacts of the real estate property and also the company's actions to minimise negative impacts. The last section concentrates in evaluating the company's commitment to take environmental factors into account in their investment process.

The indicators will enable systematic monitoring of environmental issues in each company as well as comparison between the companies. The information obtained from both the benchmarking and the company specified environmental indicator systems can be used in company's decision-making, in communication and in comparing the company to the competitors. With the indicators companies are able to increase the efficiency of their core business processes, to cut down the environmental costs and to demonstrate the environmentally friendly quality of their activities. There is also benefit of an increase in the competitiveness of real estate sector and improvement of the public image of the real estate industry in Finland. In the future, benchmarking system will enable comparison with the other companies and even with the international markets.

CONCLUSIONS

In spite of the common enthusiasm and increased amount of environmental objectives the standard of environmental performance differs between the companies. Nowadays, the information systems are not sufficient to produce information for environmental monitoring. The companies are not able to provide detailed information about their environmental performance. This fact was a challenge for this research project.

At the moment, there are few pioneers in the real estate sector who are ahead of others. However, in the future the situation will almost certainly change. This is due to increased awareness of environmental issues. The ability to take environmental aspects into decision-making will become easier as common indicators are created for the real estate sector. This set of indicators enables also the developing of information systems.

The indicators developed for the pilot companies differ clearly from those of the business. This is quite understandable because the indicators developed for the pilot companies are based on their strategy. In contrast, indicators for the whole real estate sector must be generally accepted among the participating companies. Because of this generalisation, the role of environmental management section is weighted in the common indicators.

As a conclusion, this developed set of environmental indicators is a tool to promote companies' environmental performance measurement. Still, one must remember that the realisation of this fine objective requires change of attitudes, commitment, contributions and sacrifices.

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ACADEMIC AND GOVERNMENTAL APPROACHES ON LCA OF BUILDINGS IN JAPAN

Toshiharu IKAGA[1], Akira ISHIFUKU[2] and Yutaka TONOOKA[3]

1) General Manager, Dr, Nikken Sekkei Ltd., 2-1-3 Koraku, Bunkyo-ku, Tokyo 112-8565, Japan
2) Visiting Professor, Dr, Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo 169-0072, Japan
3) Professor, Dr, Saitama University, 225 Shimo-Okubo, Urawa-City, Saitama 338-0825, Japan

Introduction

Building have various impacts upon the local and global environment through their life cycle as illustrated in Figure 1. In Japan, one-third of total CO_2 emissions are related to the construction and operation of buildings including the production of building materials as shown in Figure 2. Therefore it will be one of the most effective measures to create sustainable society that architects and engineers themselves can easily use the life cycle assessment (LCA) software in the basic or schematic design phase of each building.

LCA Software proposed by AIJ

An academic approach to develop LCA software has been done since 1990 by the subcommittee on LCA guidelines of the Architectural Institute of Japan (AIJ) to address various kinds of buildings, such as offices, stores, hotels, schools and hospitals. Authors developed and published the LCA software to assess the following environmental and economical impacts through life cycle of buildings in November 1999 as shown in Figure 3. LCA database on primary energy consumption, CO_2, NO_x and SO_x emissions associated with production of building materials and equipments were shown 4 kinds of boundaries (i.e. domestic and / or foreign consumption expenditures, with / without fixed capital formation) using the 1990 Input-Output Tables of Japan.

LCA Software for Government Buildings

The Design Guideline for the Planning of Green Government Buildings was enacted in March 1998, by the Government Buildings Department, Ministry of Construction. This guideline contains the three design tools as shown below.

(1) Assessment Tool to Select Major Green Technologies

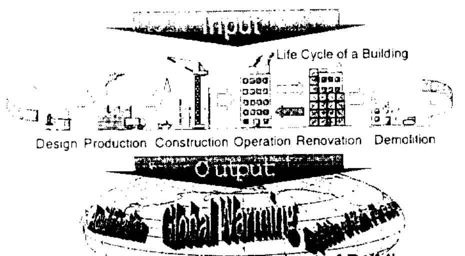

Figure 1: Life Cycle Assessment of Buildings

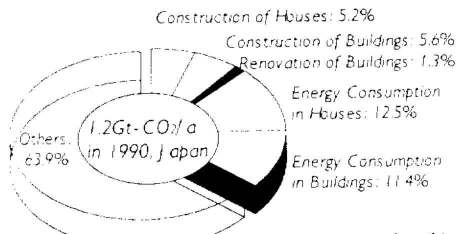

Figure 2. One-third of total CO_2 emissions are related to the construction and operation of buildings

(e.g., 30% reduction of $LCCO_2$), it is important to ensure the appropriate adoption of the green technologies prior to setting up the basic design stage as shown in Figure 4.

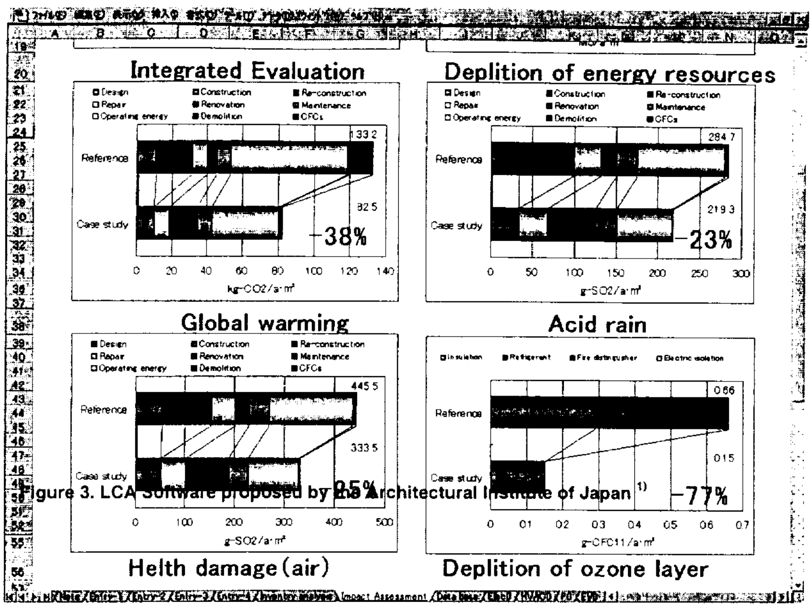

Figure 3. LCA Software proposed by the Architectural Institute of Japan [1]

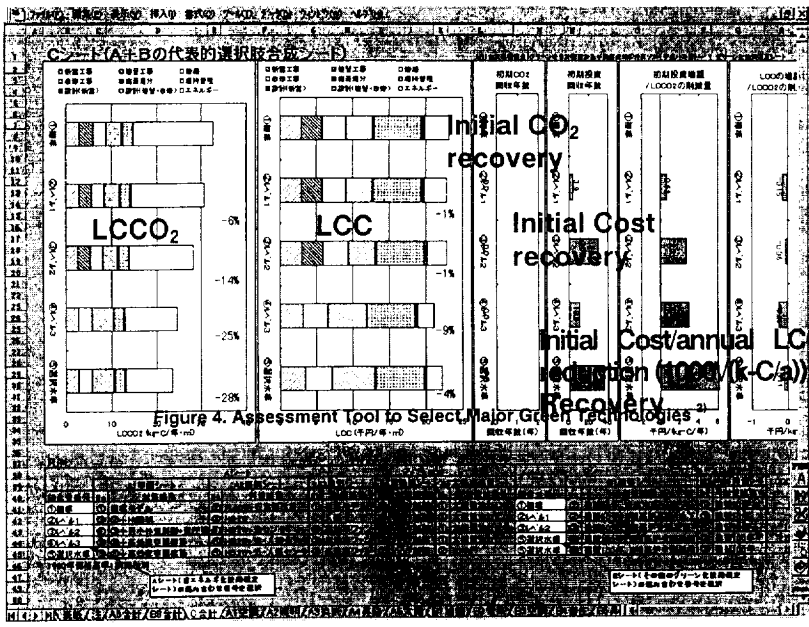

Figure 4. Assessment Tool to Select Major Green Technologies [2]

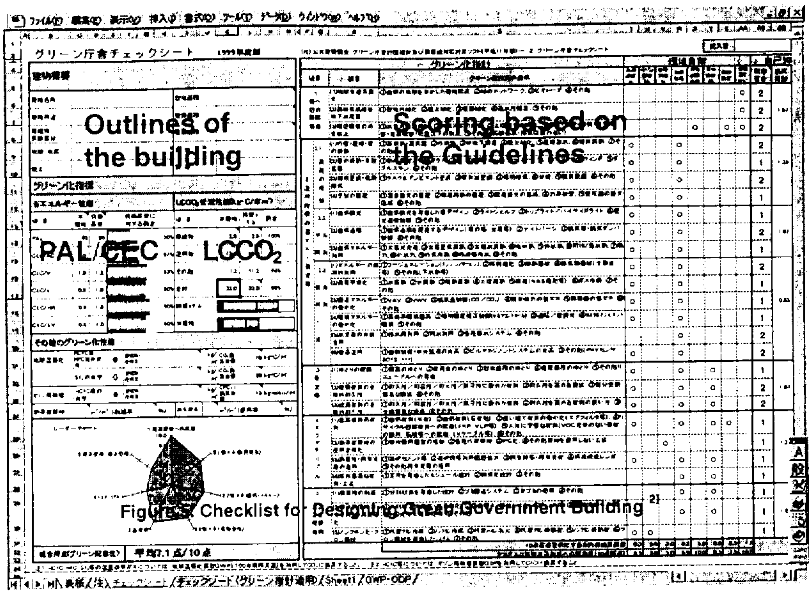

Figure 5 Checklist for Designing Green Government Building

(2) Checklist to Design Green Government Buildings

"The Checklist to Design Green Government Buildings" is for the designer to check himself the criteria for an environment-conscious building. This checklist may be an appropriate tool for the environmental management system (ISO-14001) due to its use at each phase of the design. The assessment result is displayed in a radar chart and can be checked for green as shown in Figure 5.

(3) $LCCO_2$ and LCC Assessment Tool

"$LCCO_2$ and LCC Assessment Tool" is used for the designer to check $LCCO_2$ in the basic design phase. CO_2 database and calculation method are based on the proposal by the Architectural Institute of Japan.

Conclusions and Recommendations

It will be one of the most effective measures to create sustainable society that architects and engineers themselves can easily use the life cycle assessment (LCA) software in the basic or schematic design phase of each building. Then, academic and governmental approaches to the LCA of buildings are expected to contribute to a sustainable future.

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ASSESSING METHODOLOGIES FOR ENVIRONMENTAL PERFORMANCE OF OFFICE BUILDINGS IN BUENOS AIRES

Maria Jose Leveratto, Maria Leandra Gonzalez Matterson and Silvia de Schiller.
Centro de Investigación Hábitat y Energía, FADU-UBA
Pabellon 3, piso 4, Ciudad Universitaria (1428) Capital Federal. Argentina.
ferpont@lvd.com.ar lgh@cvtci.com.ar schiller@fadu.uba.ar

INTRODUCTION

Due to economic growth, the privatisation of public companies, and the needs of new international groups, many new office buildings are being built in Buenos Aires, Argentina. Although this typology implies higher energy demands for construction, operation and maintenance, with high impact in the surrounding environment, sustainable approaches to the design and operation of these buildings are not yet considered in their brief.

In this context, assessment methods to evaluate environmental impact of buildings could provide an important tool for change. This can highlight and qualify the benefits of practices complying with higher environmental standards compared with the minimun levels required by regulations.

Focusing on the potential application of some of the existing environmental assessment methods to the context of Buenos Aires, this study compares the British BREEAM for offices (Building Research Establishment Assessment Method); LEED (Leading in Energy and Environmental Design) from the United States; and GBC (Green Building Challenge). The final goal is to identify variables and tools appropiate for Argentina, with special emphasis on rating office buildings in Buenos Aires. As part of this study, an existing office building is assessed using the methodology proposed in the most complex and regionally oriented of the three methods studied, the Green Building Challenge.

PRESENTATION

Environmental assessment methods and the Argentinian context

The analysis includes a review of the variables considered by each method, taking into account the relative importance given to them. Energy was the most relevant variable, representing around 20% of the total final score. BREEAM addresses the importance of monitoring and of company's green policies. Its main limitation is that it takes into account the amount of CO2 released to the atmosphere as the only means to rate the environmental impact of the energy source. In Argentina electricity is produced by hydro, gas or nuclear plants. Not considering other environmental problems derived from these sources produces a bias and limits results. LEED is simple to use, mainly because most data required to comply with it are accessible and understandable by architects and constructors. LEED includes heat island mitigation considerations, but it weights variables, specially urban issues such as density or public transport with a very local, national perspective. In a city like Buenos Aires, with high built densities and a wide net of public transport, the importance and characteristics taken into account to rate these variables should be reviewed. GBC is proposed by a team of international experts and has a regional approach to the rate of variables. It highlights the importance of urban context, and requires good monitoring.

The main potentialities and limitations of the three methods are summarised in the Table 1, below.

Table 1. Potentialities and limitations of the studied methods

Method	Potentialities	Limitations
BREEAM	· Designed for offices · Many buildings assessed · Comprehensive and clear	· Controversial environmental indicator chosen to measure energy use
LEED	· Easy to use · Rating system well business oriented	· Very local perspective · Relies on existing US standards and regulations.
Green Building Challenge	· Respects local diversity and regional reality · Validated by International team	· Complex to use · Requires deep monitoring · Could be manipulated to modify final results

After reviewing the three methods, the assessment of an existing office building was carried out to further test the application in the local context. Although it is complex and requires more data, GBC - Building Performance Rating System - version0.9g2000 was chosen, mainly because local approaches for rating and the regionalization of variables are proposed.

CASE STUDY WITH GBTOOL

An office building for Telecom built in 1997 was chosen as a case study. The building was designed by an U.S. team and local partners as part of a recent major urban intervention in the port area. It was constructed using modern technology and better materials than those commonly used for building in the region. Even though the design is not specifically intended to be green or sustainable, it might have good potential for improvements. Extensive information was available and managers agreed to provide the data needed.

An important challenge was to define a correct benchmark building, representative of common practice and appropiate for comparison to any other office building in the region.

Even though the main objective of the case study was to test the method rather than a building as such, results with GBC showed the building rated slightly better than the common practice. It qualified lowest in resource and energy consumption. It could be concluded that expensive technology did not imply “greener” decisions neither in design nor in management.

Limitations using the GBC method in Buenos Aires.

To adapt GBC, or any other method, to local conditions, a national team of experts has to define local benchmarks. This is especially important to evaluate aspects related to urban characteristics. Buenos Aires is a densely built and highly populated city where transport and commercial facilities are accessible. One problem in this context is how to improve conditions in a noisy and polluted environment.

Another issue, difficult to assess in the example, was energy consumption and management during the construction process due to the lack of reliable records.

If complex variables such as embodied energy of building materials are included in the analysis, accurate simplification should be proposed to allow the assessment of the variable avoiding different interpretation and conceptual mistakes.

CONCLUSIONS

It is clear that building assessment methods have to be sensitive to local priorities and conditions to obtain reliable and useful results. For Buenos Aires these priorities should include adapting and reviewing the follnwing issues:

1. Contributions to greenhouse and ozone layer depletion gases. A global perspective should be included taking into account total national contributions and political and social implications of decisions adopted in the country.
2. Issues related to public transportation, should consider aspects such as air and noise pollution produced by the system and the quality of services provided. Pondering only the presence of public transport would not be enough in Buenos Aires where, due to lack of controls and technical upgrading, buses are the worst polluters in the city.
3. Accessibility to green open spaces has to be considered as a priority.
4. Monitoring requirements should be reviewed and adapted to local possibilities to allow simplified data collection.

Finally, it should be pointed out that a reliable building performance assessment method is important not only for rating and recongnising better practices, but as an agent for change. Many big international companies are aiming to show the public they are doing business in a "green way", trying to pollute less, recycling or supporting programmes of nature conservation. It is time to include these concepts in the design of buildings representing them. This new approach could encourage public control and should produce improvement in the urban environment.

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CARBON DIOXIDE INTENSITY RATIOS:
A Method of Evaluating the Upstream Global Warming Impact of Long-Life Building Materials

Richard MacMath
Pliny Fisk III
Center for Maximum Potential Building Systems, Inc.
8604 FM 969
Austin, Texas 78724

ABSTRACT
A carbon dioxide intensity ratio (CDIR) is defined here as the ratio between the net upstream CO2 impact (emissions minus storage) of a material and the weight of the material. A material with a positive CDIR is a net CO2 source and one with a negative CDIR is a net CO2 sink. The CDIRs indicate that metal, synthetic organic, and ceramic building materials are net sources of CO2 emissions and that some natural organic or biomass materials are net CO2 sinks. This is due to the capacity of biomass materials to absorb CO2 and transform it to carbon in the mass of the material. The relative impacts of one material compared with another in terms of CO2 released or absorbed is information that is relevant to assessing the upstream global warming impact of building materials and products.

INTRODUCTION
Industrial processes release CO2 in two ways; by the combustion of fossil fuels and by the physical or chemical transformation of materials. In the U.S., a vast majority (98%) of CO2 emissions resu'ting from the production of building ma' :rials is caused by fossil fuel combustion oc‹ ırring during the upstream (i.e., pre-use) life cyc ,e stages – raw material acquisition, transport, material or product manufacture, and distribution. Only a small fraction of the building industry's total (2%) results from upstream physical and chemical material transformation processes (e.g., the chemical reactions of cement production). Some building materials (and.wastes), both synthetic and natural, can function as sinks for CO2. For example, biomass materials, such as wood, may contain as much as 53% carbon (by weight) in their material content. If significant amounts of carbon from atmospheric CO2 can be stored semi-permanently in certain building materials, then perhaps some of these materials can be considered to be net CO2 sinks. A net CO2 sink is a material which contains an amount of carbon in its mass greater than the equivalent amount of CO2 released during the upstream stages of the material's life cycle.

UPSTREAM CO2 INTENSITY RATIO
The CDIR of a material or product can be described by the following equation:

$$CDIR = (CO2_e - CO2_s)/\text{material weight}$$

where $CO2_e$ = the weight of upstream CO2 emissions, and
$CO2_s$ = the equivalent weight of CO2 stored as carbon in the mass of the material.

A material with a positive CDIR is a net CO2 source and one with a negative CDIR is a net CO2 sink.

The CDIRs for twenty-four common long-life building materials are shown in Figure 1 (at end of paper). Metals are net sources of CO2. In the case of iron and steel, for every pound used in buildings, roughly two pounds of CO2 are emitted upstream. Therefore, CO2 emissions are 2 times greater than the end use weight of steel in buildings and the CDIR is 2. By weight, synthetic organic materials such as polystyrene have a similar impact. Ceramic materials, on the other hand, emit much less CO2 per unit weight. For every pound of concrete used in buildings, for example, slightly less than 1/50 (0.02) pounds of CO2 are emitted upstream. Therefore, CO2 emissions are 1/50 the end use weight of concrete in building and the CDIR is 0.2. By weight, the upstream impact of portland cement is much greater, having a 1.2 CDIR.

Most natural organic building materials and products, such as sawn timber and plywood, are net sinks of CO2. For example, for every pound of sawn timber, lumber, plywood, or particle board used in a building, the net storage of CO2 is 1/4–1/2 pound for the life of the building or product. Therefore, these materials have a CDIR of –0.25 to –0.5. This is a very rough approximation, for the actual CO2 emissions that can be allocated to timber and fiber production vary greatly from region to region and depend on the source (e.g., tropical), management practices, and type of wood (e.g., softwood or hardwood).

CONCLUSION

It appears that most metal, synthetic organic, and ceramic building materials are net sources of CO2 emissions. Only natural organic or biomass building materials appear to be net CO2 sinks. This seems obvious due to the capacity of biomass materials to absorb carbon dioxide and transform it to carbon in the mass of the material.

Two factors can improve the balance of CO2 source materials; substitution of low CO2 impact materials for high CO2 impact materials and the selection of high recycled content materials. The first factor is demonstrated by the use of portland cement substitutes such as fly ash. Portland cement substitutes can significantly reduce the largest component of CO2 emissions in the life cycle of concrete production. The manufacture of portland cement accounts for about 95% of all CO2 emissions resulting from the production of concrete. The second factor is demonstrated by the manufacture of recycled content steel. The use of recycled steel can reduce CO2 emissions if it can be manufactured into structural steel shapes at a lower energetic cost than steel made from virgin raw materials.

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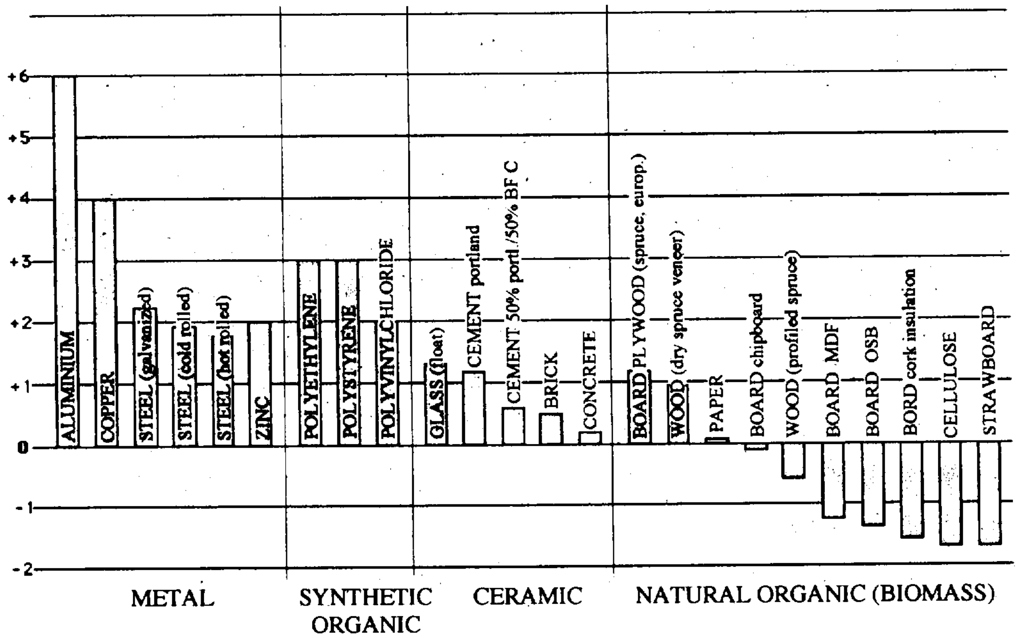
Figure. 1: Carbon Dioxide Intensity Ratios By Weight for Twenty-Four Common Building Materials.



A positive CDIR indicates a net upstream CO2 source and a negative CDIR indicates a net upstream CO2 sink. Metals, synthetic organic, and ceramic building materials are net upstream CO2 sources. For example, aluminum manufacturing emits 6 pounds of CO2 for every pound of material produced. Some natural organic or biomass materials are net upstream CO2 sinks. In general, the denser the biomass material the greater the carbon content and the greater the CO2 accumulation. For example, medium density fiberboard (MDF) is a net CO2 sink sequestering CO2 (and converting it to carbon content) at a ratio of about 1.2 pounds of CO2 for every pound of product produced.

WEB-BASED TOOLS FOR ECOLOGICAL ENGINEERING - A SURVEY

Mr. Nicola Maiellaro
Housing and Social Infrastructures Institute, National Research Council
70124 Bari, strada Crocifisso 2/B, Italy

INTRODUCTION

Construction and use of buildings causes environmental damage at many levels. Thus, for example, carbon dioxide emissions from the consumption of fossil fuels contribute to the global greenhouse effect; tall buildings can cause dangerous winds in the neighbourhood; and many buildings suffer from the sick building syndrome.

Thus, many building design professionals, now involved in "green building design" or "sustainable design", initiate "environmentally-responsible" projects based on their own recognition of the need to reduce human impact on the local and global environment; the efforts to implement green design practices have largely consisted of adoption or eclectic adaptation of various technologies and solutions to perceived environmental problems. Nevertheless, the bio-climatic principles, known and tested in architectural design, are hardly ever or never put into practice. Sustainable building principles, after all, are almost unknown.

Some studies have examined the impediments to the development of these technologies and the motivations of the actors especially involved in bio-climatic building projects. A range of obstacles in the fields of communications, dissemination and awareness of know-how, as well as tools, financing, funding and investment versus operating budgets have been described.

Based on the conclusions of these studies, a number of people are working to put into practice and implement the proposed actions, in particular within the scope of communications, information, training and dissemination of know-how.

SHARING INFORMATION

The success of sustainability in general and sustainability in the built environment in particular is very much dependent on both overcoming professional barriers and sharing information. New technologies and new patterns of communication and interaction create unimagined opportunities for access to information and knowledge and new ways for individuals, communities and nations to learn and to work together. The compilation and dissemination of documents concerned with sustainable building in electronic format provide substantial benefits for those who are able to access Internet. Government Agencies, Research Institutes, professional Associations and even individuals now have their own web page devoted to sustainable building, so news and information concerning sustainable building, extensively reported in the Internet, represent a rich mine of information and starting points for designers and developers, as well as for the public.

Sometimes the sites are like showcases for books, products and services, but a wide range of sites with effective tools are also present - more information is available in our web-site "Sustainable Building Resource" (http://www.iris.ba.cnr.it/sustain).

The ultimate problem is not where to identify concrete possibilities and patterns of intervention or how to make them feasible, but rather how to speed up their implementation and widen their extent. Basically, what constitutes an obstacle in this direction is not the lack of knowledge, but rather the inadequate availability of information organized and structured so as to be easily accessible by their potential users.

TARGETING INFORMATION

A lot of effort must to be made to define a user-profile and provide it with targeted and free information: building owners and clients, for example, are often ignored, even if they play a very important role in disseminating

sustainable building since they represent the demand of the building sector.
Examples towards this address are "Top Ten's - Information for Consumers" (http://nahbrc.org/builders/green/index.html) and "Urban Options" (http://urbanoptions.org/index.htm), where a user can take a house tour to learn about saving (energy, water, materials, and ...money), reducing waste and pollution, and making a healthier home. A floor plan drawing provides a guide to jump room by room and see how to manage homes in more sustainable ways using not only text, photos and sketches for how the demonstration house works, but also a spreadsheet.
This spreadsheet can help to determine how much water, energy, and money can be saved by improving the efficiency of various water-using fixtures in a home (http://crest.org/environment/gotwh/general/indoor-water/index.html).

WEB-BASED APPROACH
This feature introduces another question regarding the approach to the Internet. While many applications amount to little more than reformatting static text into Web pages, the Internet shows its true potential when it enables users interactively to obtain customized information.
A Web-based approach has several distinct advantages over the traditional software production and distribution process. First, given the sophistication of Web development tools, the user interface can be designed (and subsequently modified) with considerably less effort (and thus lower cost) than with traditional methods. Second, the cost to distribute the product is minimal. Furthermore, future refinements or additions to the program do not require physical redistribution or reinstallation of the software or documentation. Changes need only be made to the master version (located on the home server) for all users to have the benefit of these changes. Any user with a forms-enabled Web browser sees a seamless interface free of most hardware and software compatibility and installation problems. Regardless of the computing resources they have locally available, users have access to powerful computational engines residing on the host server. Another advantage is that users of any Web browser can access the tool regardless of platform, and the Web provides immediate access to all the other relevant information that is constantly evolving on the Internet.

WEB-BASED TOOLS
Web-based tools are mainly dedicated to energy, but other topics related to sustainable building are also present, as follows (in alphabetical order).

- "ENERGYsmart" is designed for utilities which may help their customers make smart energy choices, from how they use energy in their home, to what equipment they purchase, to the way they purchase energy. It combines energy education with a powerful energy analysis function and takes advantage of the capabilities of a PC and the Internet to deliver interactive, entertaining experience. The system interacts with users and provides detailed, practical and customized recommendations for saving energy and reducing energy costs. It is designed to use present billing data and, based upon the home profile, directs users towards utility products and services that are less expensive for them (http://www.nexusenergy.com/001.htm).
- "Home Energy Checkup", a guide - designed for educational purposes only - to saving money and increasing comfort in houses while reducing energy use and pollution at the same time. To use this program, the user needs to enter information about climate, energy prices, heating and cooling equipment, and appliances; the program will then allow the user to evaluate retrofit options. The purpose is to provide a quick economic analysis of potential energy efficiency retrofits in a single family house for typical climates; it runs directly in the web browser without downloading any software (http://www.ase.org/checkup/home/main.html).

- "ICLEI Personal CO_2 Calculation" aims to calculate yearly direct personal carbon dioxide (CO_2) emissions using data filled in a form by the user. This calculation only applies to direct personal emissions which typically represent about 25% of the total per capita CO_2 emissions in industrialized countries. This calculation does not include emissions from other sectors of the economy related to personal consumption such as emissions associated with the manufacture of goods or food. The calculation is compared to world averages and suggestions for reducing this amount will be given (http://www.iclei.org/iclei/co2calc.htm).
- "On-Line Home Energy Audit" is an on-line audit started in 1996 by ICLEI, still in progress, currently looking for funding to complete the web-site (http://www.iclei.org/audit/index.htm).
- "Radon Project" at Columbia University assists homeowners in deciding whether they have a serious radon problem (http://www.stat.columbia.edu/radon).
- "The Building Thermal Envelope Systems & Materials Program" at Oak Ridge National Laboratory (ORNL) implemented interactive calculators aimed to determine energy efficiency of a new or existing building using values specific to a particular construction type and location (http://www.ornl.gov/roofs+walls/calculators/index.html).
- "The Home Energy Saver" calculates residential building's energy use based on default values or detailed assumptions specified by the user. Within the tool's interface, links to lists of energy-efficient appliances and vendors of energy-efficient software and products make the tool's interface unlike any traditional disk-based product. This tool computes a house's energy use on-line based on methods developed at Lawrence Berkeley National Laboratory. By changing one or more features of the modelled home, users can estimate how much energy and money can be saved and how much pollution prevented by implementing energy-efficiency improvements. All end uses (heating, cooling, major appliances, lighting, and miscellaneous uses) are included (http://hes.lbl.gov).

A voluntary program to rating the environmental home performance based on BREAAM is at present being studied also in Italy, funded by the E.U. SAVE II program. The research "Application and follow up model for building energy and environmental certification schemes" intends to activate its web-based tool on the server of the Piemonte Region.

CONCLUSIONS

The success of sustainability in general and sustainability in the built environment in particular, is very much dependent on overcoming professional barriers and educating people. For students and researchers, the Web, especially, is becoming a virtual place for one-to-one as well as group communication and also collecting data from remote sites and sharing information by offering access to text-based information, searchable databases, photographs, recordings, and video images.
Elementary rules, guides, guidelines, handbooks, database and software are now widely available on the Internet. The challenge is to diversify these tools for different actors, stakeholders and system boundaries, and adopt on-line interactive calculators; the web-based approach is really the most promising; it has several distinct advantages over the traditional software production and distribution process as has been reported in this paper.
Up-to-dated information is available in our web-site "Sustainable Building Resource" (http://www.iris.ba.cnr.it/sustain), member of the 'Sustainability Web Ring'.

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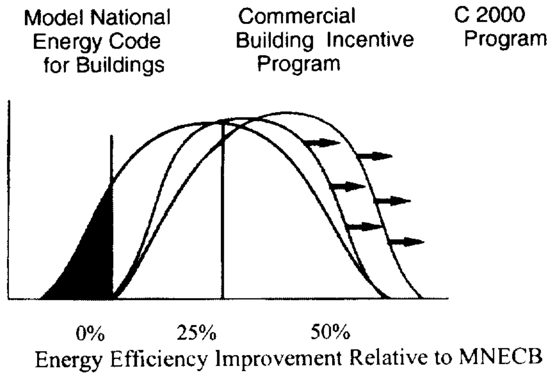
Commercial Building Incentive Program: a Canadian Initiative Providing a Base for Sustainable Building

Louis Marmen
Director,
Housing, Buildings and Regulations Division
lmarmen@nrcan.gc.ca
Office of Energy Efficiency
Natural Resources Canada
580 Booth Street, Ottawa, Ontario
Canada KIA OE4

Jim Clark
Manager,
Commercial Building Incentive Program
jclark@nrcan.gc.ca

a. Introduction Integrating broad environmental concerns for building performance with more specific policy objectives such as reducing energy use and associated emissions is a continuing program design challenge. An energy code, the Model National Energy Code for Buildings (MNECB), has been published in Canada in 1997, that would effectively impact on all new building construction in the areas of energy use and green house gas reduction. Building on the MNECB, an energy use reduction program, the Commercial Building Incentive Program, was developed starting in 1995 and launched in early 1998. Starting in 1993, a stringent advanced building design program, C2000, was developed and deployed. Figure 1 places the 3 programs on a program continuum based on energy efficiency.

Figure 1



b. Presentation

The Model National Energy Code for Buildings Natural Resources Canada (NRCan) and others have devoted significant effort and resources to the development of the Model National Energy Code for Buildings. Six years of research and consensus code development through the National Research Council culminated in its publication in September of 1997. The MNECB provides energy use requirements that are life cycle cost justified on a regional basis in prescriptive, trade-off and performance version. It is intended to provide a base level for Canadian construction practice in the commercial/institutional sector.

The Commercial Buildings Incentive Program (CBIP) CBIP is a national program aiming to familiarize the industry and move design practices towards higher energy efficiency levels thus facilitating the adoption of MNECB. Accordingly, an incentive program was devised utilizing the MNECB as a baseline for incentive calculation. In addition, common software (EE4.CBIP and EE4

Code), based on the well proven DOE 2.1e engine, is used for larger (4950 M^2 and greater) building simulation. EE4 is a user interface that compares the design with MNECB reference and calculates the savings and incentive. EE4 Code is the MNECB compliance checker.

Based on the lessons learned in C-2000, it was decided to focus the financial incentives of new CBIP program on adsorbing incremental costs for the design process rather than subsidize capital improvements. However, several changes in approach were necessary for a program that was intended to have a large impact and transform commercial building design. CBIP objectives were narrowed to energy only and the performance threshold set at 25% improvement over the MNECB. The philosophy of placing emphasis on supporting the design process was retained[1].

The C-2000 Program The C-2000 Program was designed in 1993 as a small demonstration of very high levels of performance. C-2000 technical requirements covered energy performance[2], environmental impacts, indoor environment, functionality and a range of other related parameters[3]. Initially contributions were provided according to a sliding scale ranging from 7% of capital costs in large projects to 12% in small projects. This has been changed so that financial and technical assistance is provided for the design process, such as the provision of a design facilitator and subject experts, energy simulations, and extra design time for the core design team.

Table 1: Overview of Characteristics of C-2000 and CBIP Programs

	C-2000 Program	CBIP Program
Projects to 06/ 2000	7 built, 14 designed	53 built, 350 applications
Annual Budget	Approx. $200,000	Approx. $10 million
Building Performance Factors Considered	Energy consumption Environmental Loadings Indoor environment Functionality	Energy consumption CO_2 emissions
Energy target	50% better than MNECB	25% better than MNECB
Incentive/support	Varies from $5k to $25 k	Three times annual savings, up to $80 k

Current Practice, MNECB, CBIP and C2000 Energy Intensity Values in Canada
Current design practice in the commercial sector varies from region to region across Canada and between building segments. Table 2 indicates a 34% difference between the highest and lowest energy intensity for new small offices (i.e. between Montreal and Vancouver, respectively). Moreover, there are some segments of the commercial sector, such as high rise office and retail buildings, in which the current practice is reported to be 10% more efficient that MNECB. In the high rise office segment this would be energy use of about 25kWh/M^2 per year. The first two columns of Table 2 are survey[4] generated, while the rest of the columns represent modelled results[5] of real designs using NRCan's EE4 software. The data set is, at this time, too limited for in depth analysis.

Table 2 Energy Intensities - Small Office

			CBIP				
	Planning	Model	Designs		Refer ence		C2000
Current	Practice	MNECB	Range	Average	Range	Median	
	(MJ/M2)	(MJ/M2)	(MJ/M2)	(MJ/M2)	(MJ/M2)	(MJ/M2)	(MJ/M2)
Halifax	930	775	NA	NA	NA	NA	NA
Montreal	1007	775	529	529	860	860	NA
Toronto	891	852	649 - 852	751	892 -1287	1090	295
Prairies	1007	969	506 - 857	682	905 - 1295	1100	NA
Vancouver	736	698	580 - 904	620	827 - 1294	852	331 - 446

Monitored Energy Results for C2000 and CBIP Buildings Three C2000/CBIP buildings have had monitoring reports completed. The performance of the two earliest C2000 designs did not match well with the modelling results, however the metered consumption for the most recent C2000/CBIP building is within 2.2% of the modelled results[6]. This likely reflects the modelling experience gained in dealing with advanced building features and the introduction of EE4.

Industry interest in Designer Tools CBIP supports EE4 and the related On- Line Screening Tool with five staff, whose tasks range from user support to writing new code to correct DOE2.1e engine shortcomings. EE4 also serves C2000, which employs an additional tool, the GB Tool, to assess the wide range of environmental criteria for that program. These tools have proven popular in Canada and internationally as shown in Table 3. Most of the international visitors are from the US, where the DOE 2.1e software is well known.

Table 3 CBIP Internet site statistics[7] for May 2000

Sessions		Visitors		Average session length	1:08:31
Visits = 1	578	International	50%	EE4 downloads*	350
Visits > 1	233	Canadian	32%	Case study downloads*	3500+
Visitor sessions 811		Unknown	18%	Technical Guideline downloads*	2500+

* Statistics for 1999/04/01 to 2000/03/31

c. Conclusion and Recommendations A survey of programs participants has shown only one of 24 respondents would not participate again[8]. Based on this and the information presented earlier, it appears that both programs are successful from both a subscription and technology transfer basis. The next steps are likely to elaborate the training, labeling and technology commercialization components to deliver a fully developed new building program for the commercial sector.

d. References

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2. At the time, the energy requirement was 50% better than the ASHRAE 90.1 standard (the benchmark is now the Model National Energy Code for Buildings, MNECB). Both are North American standards for good practice.
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5. CBIP internal program database, NRCan, June 2000.
6. CBIP internal Web Trends document, NRCan June 2000.
7. DOE2.1e Simulation Reconciliation Alice Turner Branch Library Saskatoon, SK, Gf Shymko; Natural Resources Canada, 2000.
8. Incremental costs within the design process for energy efficient buildings, Nils Larsson and Jim Clark, Building Research and Information, 2000.

Commonwealth of Pennsylvania Growing Greener Initiative and The *Commonwealth of Pennsylvania Guidelines for Creating High Performance Green Buildings*

Wendy S. Powers
Conservation Consultants, Inc. 64 South 14th Street, Pittsburgh, PA, 15203, USA

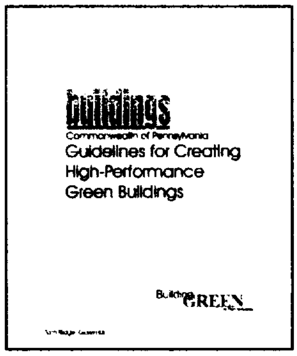
This session will present a discussion of the politics and policies leading to the current Grower Greener Initiative in the Commonwealth of Pennsylvania, USA, and the development of *The Commonwealth of Pennsylvania Guidelines for Creating High Performance Green Buildings,* which is now being used as a tool to change the way state buildings are designed, built and operated.

PRESENTATION

Political Environment

The *Commonwealth of Pennsylvania Guidelines for Creating High Performance Green Buildings* are part of a statewide initiative to green the Commonwealth of Pennsylvania. The Governor's Green Government Council (GGGC) was formed with the mission of assisting Commonwealth agencies to implement strategic environmental management practices which support sustainable development and move towards the Commonwealth's goal of zero emissions.

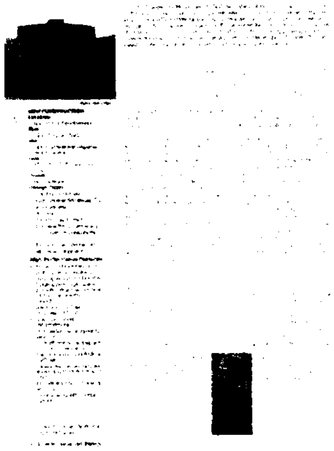
The first two steps toward that mission were to produce the *Guidelines for Creating High Performance Green Buildings* and to create Model Green Leasing Specifications, requiring even facilities that the Commonwealth leases to meet high-performance green standards. The Pennsylvania Department of Environmental Protection's South Central Office Building and Ebensburg Office were both designed and constructed following the guidelines. Other projects of the GGGC include certification of Pennsylvania's public forestlands as being managed with sustainable forestry practices, a paper reduction project undertaken by the Department of Revenue which allowed taxpayers to submit forms electronically, and concentrated recycling programs in the Department of Corrections, the Capitol Complex, and the State System of Higher Education.



In a letter at the beginning of the document, Pennsylvania's Governor Tom Ridge states, *"Our Green Buildings Initiative provides a sound philosophical, pragmatic approach to the design and construction of our state facilities. Pennsylvania has positioned itself as the first state to officially declare integrated design, energy efficiency and sustainable technology as the bedrock for all future building programs."* Green buildings are seen as a foundation for greening the practices of state agencies, from recycling to procurement, and even policy.

Audience

The *Guidelines for Creating High Performance Green Buildings* was written for decision makers. It introduces the concept of green building and the steps necessary to create them. It describes the green design process from the decision-makers point of view, outlining what should be expected from the design team and what performance levels should be expected from all systems. It also explains the need for integrated systems thinking from design concept, optimization, documentation, and construction, through commissioning, operation and maintenance.



The guidelines could also have been written for design professional, giving specific information about green strategies, construction details and materials. However, it was decided that the first step toward greening state buildings would require educating the decision-makers, and thereby driving the market. State design professionals, working for the Department of General Services, will be educated through interactive training sessions led by professionals with experience in green design.

Other places and organizations have dealt with this differently, producing guidelines that address the concerns of decision-makers and design professionals in one document. These models are also valuable. The bottom line when developing educational materials on green building is to identify a target audience and write to their concerns and areas of interest.

The Document

The *Guidelines for Creating High Performance Green Buildings* is separated into four sections including *Green Design Systems, Green Design Process, Case Studies and References*. The Design section discusses the various systems of the building and what kind of performance should be expected from each. The Process section describes the steps of the design process and what should be expected from the design team. The Case Studies provide a wide range of green buildings described to raise awareness of all the potential and variety available in high-performance green buildings. The References offer sources of further information on many of the sustainability issues raised in the document.

Each of the first three sections provide lists of key information for easy absorption of the material. A busy manager could skim the document for key information before reading it for detail. In the Design and Process sections the lists are actual checklists of performance features to include in the design or things to do during the design process. In the Case Studies section the list provides the key facts about each case study.

CONSLUSIONS

There are a variety of ways to educate both the market and design professionals about green building. In this case the process has started with a concentration on state agencies, decision-makers and design professionals. Although green building has begun to catch on in the private sector in the Commonwealth of Pennsylvania, the government has committed to being a leader in the field, to strengthen and lend credibility to the movement.

ESTABLISHING BENCHMARKS FOR LIFE CYCLE ENERGY ANALYSIS

Stephen Pullen
University of South Australia, North Terrace, Adelaide, Australia

INTRODUCTION

The design and construction of buildings with a reduced impact on the environment is likely to involve the identification of key environmental indicators followed by the setting and monitoring of performance benchmarks. A number of schemes have been developed which have adopted this approach although the actual key indicators vary depending on the scheme in question (Reijnders & Van Roekel, 1999). However, a common element to the reduction of environmental impact is the minimisation of greenhouse gas emissions arising from energy consumption based on fossil fuels. Comprehensive analyses consider the life cycle energy consumption of buildings of which the major contributors are the 'running' or operational energy and the embodied energy of the construction materials.

The purpose of this paper is to outline some of the issues arising when setting and implementing benchmarks for life cycle energy analysis with particular emphasis on embodied energy. To highlight the methodological difficulties that must be dealt with, reference is made to the energy consumption of existing housing and new residential development in South Australia.

SETTING OF BENCHMARKS

The setting of benchmarks for the energy consumption of houses can be based on proportional improvements over existing levels, eg reductions of 10%, 20%, 50% etc. The first step in this process is to establish the existing energy consumption levels. In the Australian context, there have been various surveys of the operational energy consumption of houses (Williamson *et al*, 1993). The findings of a more recent study of 25 houses in the Adelaide area of South Australia (Pullen, 2000) were broadly similar to these earlier surveys. In addition to surveying operational energy, the more recent study estimated the embodied energy of the houses so that an approximate life cycle energy benchmark could be established. Since that time, a further 15 houses have been studied and the results for all 40 case studies are summarised in Table 1.

Table 1. Average operational energy and embodied energy for 40 houses

	Age (years)	Floor area (m^2)	Annual operational energy		Embodied energy (as built)	
			(GJ)	(MJ/m^2)	(GJ)	(MJ/m^2)
Average	28.0	169.0	133.5	790.0	975.4	5920
St. dev.	23.7	56.4	41.8	275.0	294.1	1295

Both the operational energy and embodied energy of the houses were evaluated in primary energy terms (Dept. of Mines & Energy, 1992). The operational energy included the normal reticulated supplies of gas and electricity as well as any other fuels such as heating oil, bottled gas or wood. The embodied energy of each house was determined using a spreadsheet technique which uses the principal dimensions of the building to evaluate quantities of materials and the total embodied energy. Embodied energy values for individual materials had previously been evaluated from input output analysis using tables of the economic transactions between the various sectors of the Australian economy (ABS, 1997). The 40 case studies comprised of houses of varying size, age, materials, construction technique and numbers of occupants. The data described represents the beginning of a database which is relevant to local conditions and which can be used for the preliminary setting of benchmarks.

IMPLEMENTATION OF BENCHMARKS

Attention must be given to the method of implementation to ensure that the overall objective of reducing environmental impact is achieved. There have been a number of residential developments in Australia which have been designed to have a lower environmental impact. One example is the Newington Olympic Village housing development where a limited range of house designs have been produced by the builder/developer consortium which have been eco-rated (Atkinson, 1999). However, in the Australian private housing sector, it is more usual that a new residential development would have at least a dozen different building companies on-site, each with a substantial range of their own designs. The marketing aspects of large variety, customised designs and freedom of choice are important factors in the commercial success of such developments. Hence, a mechanism must be used which encourages the reduction of environmental impact but, at the same time, does not severely constrain a potential house buyer in their choices of builder, house design and construction materials.

One such mechanism is being used in the Mawson Lakes residential development in Adelaide, South Australia which is a joint venture between the South Australian Land Management Corporation and Delfin Lend Lease. This uses legal encumbrances on the sale of individual building lots to encourage energy efficiency. Encumbrances have normally been concerned with appearance factors such as roof cladding materials, fencing type and boundary setbacks. However, in the case of the Mawson Lakes development, benchmarks have been included in the encumbrances which relate to both operational and embodied energy of the houses to be constructed on the available land. The benchmark targets have been ultimately set at 50% of existing Adelaide housing energy levels with a gradually increasing target for the embodied energy starting at 10% (Delfin Lend Lease, 1998). Tools are being developed which assist the purchasers of land at Mawson Lakes to influence the energy consumption of their future houses and an *operational energy* scorecard has already been developed (Saman *et al*, 1998).

The implementation of the benchmark target for *embodied energy* may be through a similar scorecard system. Initial research has indicated that scorecards for generic types of house (eg two storey, villa style, courtyard design, etc) would be convenient for people with little or no knowledge of embodied energy to achieve the benchmark targets. The selection of alternative materials for their generic house design would enable buyers to comply with the encumbrance. The success of the scorecard would depend on there being a similar intrinsic embodied energy for each generic type of house regardless of different external features and different building companies involved.

To test this hypothesis, six two-storey houses constructed at Mawson Lakes were selected and their embodied energy evaluated. The houses were constructed by different builders and there was a range of external appearances. The level of detail of the analyses included all fixtures, finishes, outdoor structures, paving, fencing and services. The results are shown in Figure 1 and indicate an average embodied energy intensity of $4400MJ/m^2 \pm 520MJ/m^2$ which is approximately ±12%. This level of variation suggests that a scorecard tool based on generic types of houses would not be sufficiently accurate to determine whether the initial benchmark target of 10% reduction was being achieved. The use of a scorecard based on each individual house design rather than generic house type may be the solution.

DISCUSSION

The comments on the embodied energy of existing housing and new residential development highlight some methodological issues which are common to the broader agenda of establishing benchmarks for life cycle energy analysis. With regard to setting benchmarks, the information for embodied energy shows that existing levels must be clearly defined. The 40 existing houses studied were of varying age and included many older houses built during periods when heavier construction was more commonplace. This tends to establish a higher benchmark making reductions on this easier to achieve by new environmentally conscious developments.

Hence, a more realistic target would be based on a representative sample of houses of, perhaps, less than ten years of age with a correspondingly lower benchmark.

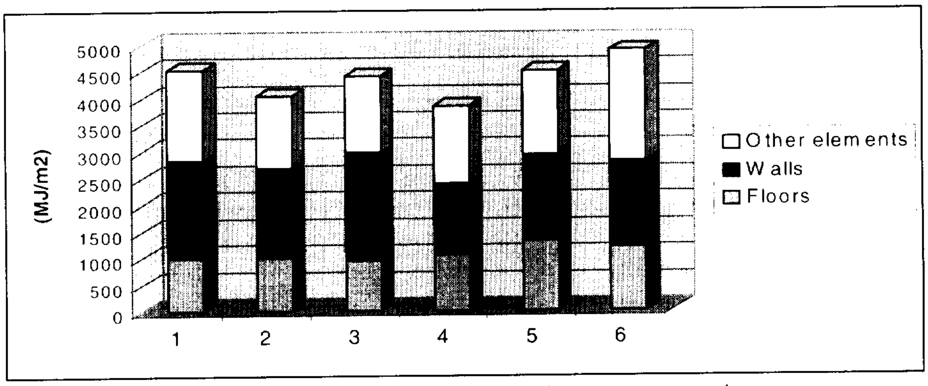


Figure 1. Embodied energy intensities of six new two-storey houses

When implementing benchmarks, it is important that the full range of buildings in a development are considered and that any sample used is representative. As an example, the average embodied energy of the small sample of six two-storey houses at Mawson Lakes was 4400MJ/m², suggesting a reasonably low level compared with other Adelaide housing. However, in a South Australian context, single-storey housing is more typical and this is likely to have a higher embodied energy due to the larger building 'footprint' requiring a larger footing and roof. In addition, the tools used to implement benchmarks must be sufficiently accurate. Clearly, it is not reasonable to expect high levels of discrimination from tools that are based on methodologies or data that have unacceptably large potential errors.

CONCLUSIONS

The establishment of benchmarks for life cycle energy analysis should be based on representative data for previous and existing energy consumption levels. The methods and tools by which the benchmarks are implemented must have sufficient accuracy to ensure that their capability is not exceeded. The study of data from existing and new housing can assist in highlighting issues that must be successfully dealt with when establishing benchmarks so that the resulting tools are credible and effective.

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ENERGY CHECKING PROCEDURE FOR SINGLE FAMILY HOUSES

V. Richalet and N. Adra, F. Neirac, L. Zarzalejo, U. Groes, H. Despretz

1. DGCB/LASH, URA CNRS 1652, Ecole Nationale des Travaux Publics de l'Etat, Rue M. Audin, 69518 Vaulx en Velin, France
2. Ecole des Mines de Paris, CENERG, Rue C. Daunesse, 06565 Valbonne Cedex, France
3. Centro de Investigaciones Energeticas Medio Ambientales y Technologicas, Avenidad Complutense 22, 28040 Madrid, Spain
4. SEBRA Arkitekt/energi/byfornyelses A/S, Fibigerved 1, 4792 ASKEBY, Denmark
5. Agence de l'Environnement et de la Maitrise de l'Energie, 500 Route des Lucioles, 06565 VALBONNE Cedex, France

INTRODUCTION

EC-PRO (Energy Checking Procedure) aims to provide dwellers with a energy certificate where he could find information about:

- his home energy performance in comparison with target figures
- his energy bill break into the various uses of energy
- the possible energy conservation measures with calculated savings and costs.

This project was partially supported by the EEC DGXVII. The paper comments the mains issues of the project and an application case.

PRESENTATION OF EC-PRO

Overview

To fulfil previous objectives, the developed procedure includes the 3 following steps:

- ❑ Visit and monitoring: to collect data about energy bill, fabric (fig.2), geometry and systems for Space Heating (SH) and Domestic Hot Water (DHW). An **electronic questionnaire** helps to define household pattern. Low cost measuring instruments can be used to record rooms air temperatures, appliances energy consumption, lighting duration (fig.1).
- ❑ Analysis of the collected data in 3 calculation steps thanks to a **computer tool** EC-PRO
  - standard consumption defined for a standard indoor and outdoor climate, standard casual gains and a minimum ventilation rate.
  - actual consumption defined for the recorded set-point temperature, a local climate and real casual gains as calculated from the occupants behaviour.
  - Selection of energy conservation opportunities (ECOs) and calculation of the actual energy consumption savings when ECOs are applied together with cost and payback time.

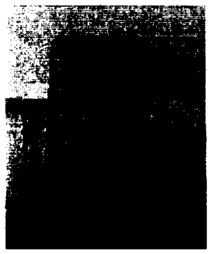

fig.1: Meter to record consumed electricity

Fig. 2: Visual inspection of walls inside.

- ❑ Certificate delivering
  The house tenant receives an **Energy certificate** (fig.3) presenting the energy indicator of the house on a performance scale (range A t oG), a breakdown of energy expense into the various uses,and an Energy plan giving the possible ECOs with cost and calculated savings.

Calculations

Space heating needs, referred to as "net consumption" are calculated according to PrEN832 standard [1]. Outside temperature and solar radiation are given from TRY data or other statistical climate data set for various locations per country. Indoor temperature is fixed by the user, constant or intermittent. The length of the heating season is a calculated parameter depending on the building.

DHW heating needs are calculated as a ratio per square meter for the standard calculation or according to the real hot water flow and the real hot water temperature at the producing plant.

SH and DHW consumption calculation takes into account the various sources of losses through the heating plant: emission, control or tank efficiency, pipes losses, and boiler losses. Actual consumption for appliances and lighting is calculated from appliances manufactured individual consumption or metered one and from information about the occupants' behaviour for each equipment.

ECOs are first proposed in regards to the typology of existing houses and some chosen targets in terms of thickness of insulation, U value, set point temperature, burner efficiency, etc. Energy savings can be calculated by iterating the same routines as the previous step. For more details about the algorithms, the reader can report to the project final report [2].

Results and discussion

15 houses were monitored during one week minimum using the chosen monitoring protocol during winter 1999. One example is presented as an illustration (fig.4).

Fig.4 : House PL is located near Lyon (FR), built in the 1975 before Thermal regulation.

First, the used measuring devices gave full satisfactory in what we expected. But required time to visit rooms, install sensors, and unload data was deemed to long in regards to the affordable cost of the procedure. Indeed, the market survey done prior to the development of the procedure on a set of 200 people in France and Spain, locates this cost below 100 Euros. This needs to be refined in the future but, to our opinion, does not question the interest of having such measurements.

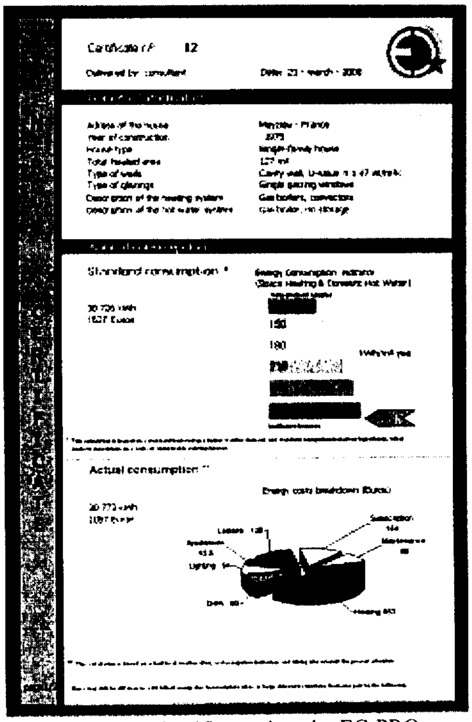

Fig.3 : Energy Certificate given by EC-PRO

Energy use	Energy bill	Standard consumpt.	Actual consumpt.
SH	26093 kWh	31496 kWh	23153 kWh
DHW		4940 kWh	4156 kWh
Other	2644 kWh	2290k Wh	3464 kWh

Table 1: Validity of energy consumption prediction for test house PL

The obtained figures (table 1) show interest of deriving an actual consumption in addition to the standard one because there are large discrepancies between true occupancy and a standard one (19°C, standard climate, casual gains 5 W/m², DHW needs 21 kWh/m²/year). The recorded indoor temperature measurement, the recorded lighting duration, the efficiency of the burner were very important data to increase confidence into the calculated consumption for SH, DHW and household.

Also, the procedure allows to calculate a breakdown of the energy expenses (fig.5) and to propose valuable ECOs as illustrated for the selected example case (table 2).

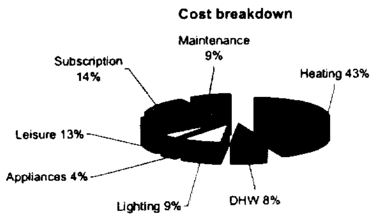

Fig. 5: Breakdown of energy cost for house PL

Suggested ECOs	Savings per year	€
Fill air gap within outside walls with blown insulation	6752 kWh	135
Add insulation layer in attic	2421 kWh	48
Insulate walls to garage	531 kWh	10
Set point 19°C (instead 20°C)	806 kWh	16
Insulate pipes	308 kWh	6
Replace refrigerator for low energy one	182 kWh	14
Suppress stand-by mode on TV and Minitel	257 kWh	21
Low energy dishwasher	228 kWh	18

Table 2: Calculated ECOs for house PL

A typology of existing houses for the 3 countries of interest, with calculated figures for standard consumption and ECOs has shown that a very large potential of energy conservation is expected in the domestic sector. The market survey has shown that the dwellers are waiting for such an information although they are not ready to pay much for that.

CONCLUSIONS

The paper presents briefly the main outputs of the EC-PRO project which shows that:

- It is possible to derive actual performance of houses in addition to standard one to provide more reliable information to the user.
- The potential for energy conservation can be derived on the basis of such an information, including measures as lowering set point or applying set back, insulating heating pipes.
- A measurement of the necessary data input is quite expensive at the moment but could be lowered using a dedicated equipment.

Several products have been developed for this purpose: a calculation tool, an electronic questionnaire, a monitoring protocol. In addition a typology of single family houses in the 3 countries of interest has given interesting figures of energy consumption through the different ages of housing, together with calculated ECOs. People interested could find more information on the Web site: http://www.cma.fr/ecpro

Next step of such a project should be dissemination and partnership to demonstrate full application. This will be our goal in the coming year.

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A SYSTEMATIC APPROACH TO WEIGHTING ENVIRONMENTAL EFFECTS OF BUILDINGS

Arch, D. Eng. Ulla Westerberg,
(ulla.westerberg@hig.se)
Centre for Built Environment
University of Gävle
SE – 801 76 Gävle

EcoEffect – a method for environmental assessment of buildings

EcoEffect is a method for environmental assessment of buildings including the outdoor environment, (Glaumann 1999). It is developed for existing multi-residential buildings. The structure is general and the method is being adapted to the assessment of planned buildings. The results of the assessments are presented in four environmental profiles; *energy use* and *materials use representing external effects, indoor* and *outdoor environment* representing *internal effects*.

LCA (Life Cycle Analysis) is used for the calculation of the external environmental effects in terms of emissions, waste and consumption of natural resources. *Internal effects*, risk for different forms of ill-health and discomfort and lack of biodiversity, are assessed by criteria.

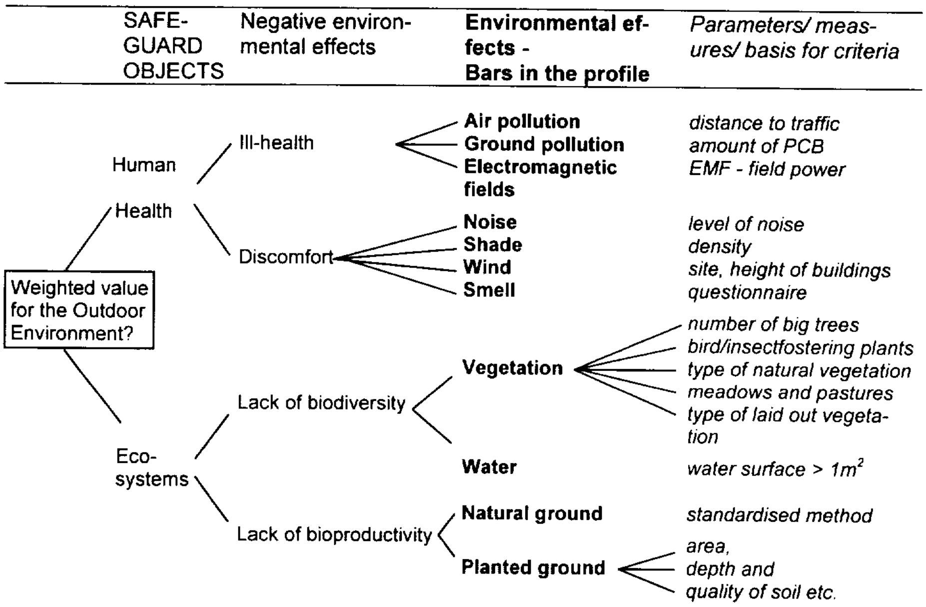
The choices of methodology, environmental effects, criteria, etc. represent more or less conscious choices and values, which influence the result. The individual bars in the profiles are more or less comprehensive, like "consumption of natural resources" in the profiles for energy and materials use. Aggregation to single bars or numbers, substituting the profiles, is often necessary e.g. to facilitate comparisons between properties or conditions in and around a building. But this also means integrating another layer of values that drastically reduces information and intelligibility. Problems as well as qualities to a certain extent will be hidden. Therefore the weighting process has to be easy to follow and the weights easy to choose and change. Summarised assessments, however, should be accompanied by the detailed environmental profiles so that inferior conditions can be singled out and possibly cured.

A systematic weighting process based on facts and shared values is a prerequisite for transparency and legitimacy. The environmental profiles in EcoEffect are the basic levels of the hierarchic problem structures that will be used in the weighting process, exemplified below. The Analytic Hierarchy Process is used as a model for the multi-criteria weighting strategy with systematic comparisons from well-defined and quantifiable aspects (Saaty 1993).

Weighting aspects

The weighting of environmental effects is made with respect to their detrimental consequences for human health, ecosystems and natural resources in a global and long-term perspective. The consequences of the *external* environmental effects, which are presented in the profiles, are diffuse, diverse and to a large extent not yet known. The *internal* environmental effects on health and biodiversity, however, are specific and limited to the lifetime of the building (or an individual) and therefore easier to compare. In an existing building the effects can even be measured or observed. In spite of these differences in scale and scope the weighting structure for internal and external effects is basically the same. The following is a very brief discussion on the choice of weighting aspects.

We have chosen the *extent, intensity* and *reversibility* as general labels for the weighting aspects. The more extensive, the more intensive and the less reversible the environmental effect is the worse it is and the more weight it should be given in the valuation.



This is an example of a *weighting hierarchy*, in this case for the outdoor environment. The relative weights within a group of effects, those connected in a node, are the result of systematic comparisons based on well-defined and preferably quantifiable attributes, weighting aspects. Each line in the weighting hierarchy corresponds to a weight.

The *extent* of an environmental effect or consequence can be interpreted as the amount of an emitted pollutant, the accumulated exploitation of a natural resource or the number of individuals affected by an environmental effect. To be intelligible the amount or the number has to be related to an earlier time, such as before industrialism or the time when measuring or counting started. The extent in this way tells something about the change that has taken place. The depletion of natural resources is measured as supply horizon, i.e. time until a resource will be exhausted at the present rate of exploitation. This is disputable due to problems of definition, lack of reliable data, metals and minerals do not disappear, etc.

The *intensity* corresponds to toxicity or harmfulness for the individual or ecosystem. The concept of DALY, Disability Adjusted Life Years, developed by WHO, includes an attribute – the disability adjustment which is explicitly given for a number of diseases - with a meaning similar to that of *intensity* and *reversibility* in combination. The disability adjustment weights will be employed in the weighting of different forms of ill-health with complementary additions. *Intensity* as an aspect of consumption of a natural resource corresponds to dependence and accessibility. Market value of the yearly exploitation reflects the societal dependence. Change in embodied energy reflects the change in accessibility.

Reversibility refers to the inherent possibilities to recover and to possible counter-measures. Natural resources can be finite or renewable. Damages to ecosystems and individuals can be reversible and they can recover after exposure or when the environmental effect ceases. Then time for recovery can be used to measure the reversibility. Recycling is a form of recovery that requires energy input. Energy or costs are used as a measure of the efforts or counter-measures demanded.

Preliminary weights have been processed in the group of researchers. We are still investigating methods and scales; expert panel discussions or questionnaires? AHP pair-wise comparisons, simple rating or ranking?

Comparing different forms of discomfort caused by the outdoor environment of the building – a simplified example

The risk of discomfort due to noise, shade, wind and smell respectively is assessed by criteria. The criteria constitute the reference in the comparison of the different forms of discomfort, i.e. when comparing shade with wind the reference is "unacceptable" corresponding to a load value of 3. The criteria for wind and shade are based on results from surveys of outdoor activities and outdoor climate in housing estates, (Westerberg 1989). Noise is either measured or calculated with respect to distance from traffic or number of vehicles. 55 dB is the limit for load value 3, i.e. unacceptable conditions, which is unacceptable also according to planning guidelines for traffic noise in housing areas. The risk of unacceptable smell around existing buildings is assessed by means of a questionnaire.

The *current state* and *change* in the *extent* or *frequency* of a certain form of discomfort is a societal concern. The more frequent the problem is and the faster it is growing, the more attention and weight it deserves. The *tendency of change*, we assume, deserves more weight than the *current state*. *Intensity* refers to the degree of *harmfulness* or discomfort that is experienced by the individual. This deserves much more weight than the frequency. The discomfort on the individual level is *reversible*, i.e. you are assumed to be cured instantly when the exposure is over. *Reversibility* in the case of discomfort refers to the possibility to remove the problem – for an existing building it means sheltering from noise or strong winds or removal of shading obstacles or the source of noise or smell. We have assumed that reversibility is more important than frequency and that harmfulness is somewhat more important than reversibility.

There is little quantitative information on the frequency of unacceptably noisy, smelly, windy or shady environments nor of costs to improve the situation, so "qualitative" weighting is the only way out. Noise might be the fastest growing source of outdoor discomfort. *Harmfulness* can be experienced by anyone, but people's references differ very much in this respect. This was clearly demonstrated in a recent pilot study. 20 colleagues, mostly researchers within the field of indoor climate, were asked to rate the harmfulness of different sources of discomfort on three different scales. Three types of rating methods were used; pair-wise questions as in AHP, a 5-grade semantic scale from no importance to great importance, and finally simple ranking. The individual results differed depending on the scale used, and as a whole there was little accordance in the answers. AHP has been criticised for its linear scale, which does not correspond to most people's mental scale, which is supposed to be logarithmic. Comments supporting this critique were made spontaneously. Moreover, the pair-wise questions were reported to create an uncomfortable feeling of answering inconsistently. In fact almost 50 % of the answers turned out to be unacceptably inconsistent according to the AHP inconsistency test. Just rating on a semantic scale gave the least distinct but probably most reliable result. Smell was considered most and wind least "discomfortable".

It is quite difficult to justify any weights for discomfort because of the lack of hard facts and its contextual nature. A qualitative but systematic argumentation accompanying the weighted assessments, however, helps to interpret the result and to change the weights according to another rationale or context.

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ENERGY NEUTRALITY FOR EXISTING COMMERCIAL BUILDINGS: FICTION OR FACT?

Ir. Daniël van Rijn, Ir. Cuno van Geet, Ir. Ruud Trines, Novem BV Utrecht/Sittard, the Netherlands.

In order of Novem and the Dutch Government Building Agency (GBA) a study into the possibilities for far-reaching energy saving in existing office buildings was carried out by Blesgraaf bureau voor bouwen & milieu in corporation with Deerns Raadgevende ingenieurs [3]. In this paper we will present the results.

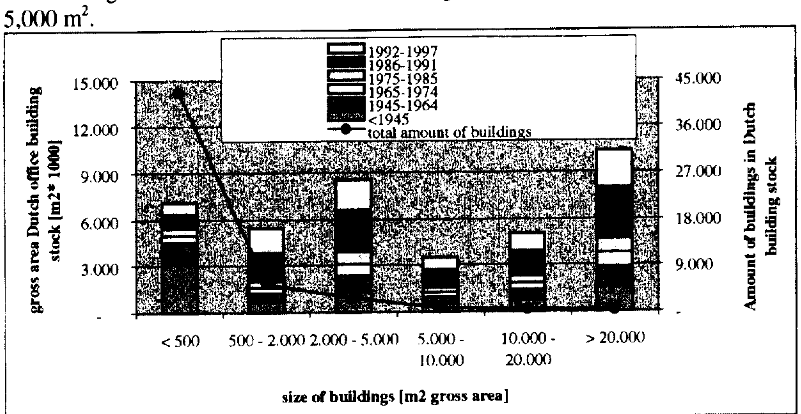
THE LTGO PROGRAM

The Dutch national programme Long Term Built Environment (LTGO) aims at achieving substantial energy savings in buildings. Main goal for new buildings is energy neutrality on annual base for (groups of) new buildings and minimal 70% energy reduction for existing buildings all with maximum costs of 30%. LTGO identifies and solves technical, legal, financial and organisational aspects in close co-operation with market parties. Main challenge is the existing building stock, residential as well as non-residential buildings. Within this last group office buildings, schools and buildings for medical care have priority. In 1999 the office building sector was investigated. Studies about the sectors schools and medical care will be completed this year.

THE DUTCH OFFICE BUILDING STOCK

Size and age

The Dutch office building stock contains about 50,000 buildings with an area of about about 40 million m^2 gross area.It seams that the main segment of office buildings exists of buildings larger than 5,000 m^2.



* The subdivision of buildings > 5.000 m^2 is based on extrapolation of the GBA building stock.

Figure 1: Subdivision of the Dutch office building stock in m^2 gross area and amount of buildings.

Subdivision in classes and reference buildings

Based on energy related technical features it was possible to categorise the building stock in 14 classes. For adequate analyses, reference-buildings were made using these features[1].

Autonomous developments

The office building sector will increase. Market conformity (efficiency of working space and changes in primary processes) will dominate the process of retrofitting of buildings. This process influences the possibilities for energy efficiency. Particular threats for energy are flexible working-hours and amount of working places per m^2, use of ICT equipment and increasing use of air conditioning because of changing need for comfort.

A 9 % 3,200*10³ m²	**B**	6 % 2,400*10³ m²	**C** 6 % 2,400*10³ m²
D 4 % 1,800*10³ m²	**E**	9 % 3,600*10³ m²	**F** 8 % 3,200*10³ m²
G 1 % 500*10³ m²	**H** 1 % 400*10³ m²	**I** 3 % 1,200*10³ m²	**J** 3 % 1,200*10³ m²
K 4 % 850*10³ m²	**L** 9 % 3,600*10³ m²	**M** 16 % 6,400*10³ m²	**N** 21 % 8,400*10³ m²

Figure 2: Building classes and their proportion in m² gross area in the Dutch building stock.

LTGO PREREQUISITES FOR ENERGY SAVING CONCEPTS

Using optimal combinations of state of the art techniques

LTGO concepts consist of state of the art techniques. Although available, quite a few of these techniques are not widely applied. For the time being, non-technical problems, such as costs, are not taken into account.

Linking up with maintenance and transformations cycles

Introducing state of the art energy saving techniques in an office building is rather expensive and disturbs the primary processes. Therefore, in most cases autonomous introduction is not possible. Introduction is only possible within normal maintenance and transformation cycles. In that case, concepts in buildings are not introduced in one action but are built up in time. The maximum energy saving can only be reached at the end of the last relevant maintenance or transformation cycle.

Maintaining and improvement of quality

At all times, the quality of the building as a whole and especially the indoor air quality must be guaranteed. This holds true for the final situation as well as moments in the cycles mentioned above, when just a part of the concept is implemented.

ENERGY SAVING CONCEPTS WITH STATE OF THE ART TECHNIQUES

Based on the technical features of the building classes and the LTGO prerequisites mentioned above, eight general saving concepts are developed. Concerning differences in use, within each concept three types are distinguished: non intensive, normal intensive, high intensive. The impact of the concepts on energy use can be enormous. On building level, saving percentages of 50% and more are often reached. Even in the newer buildings, percentages of 40% and higher are met.

TECHNICAL POTENTIAL USING STATE OF THE ART CONCEPTS

In principal, with the developed state of the art concepts an enormous amount of energy can be saved. The technical potential, this is the potential by 100 % implementation in the building stock, is about 40 - 60%. For this potential, the classes E, F, M and especially N (built after 1985!) are important. Small buildings, even though there are quite a few of them, are not interesting.

TOWARD THE LTGO AMBITION

Even after complete implementation of the state of the art concepts - and for sure that is not going to happen - a gap of 10 - 30% energy saving remains. Only with new, expensive techniques or techniques not related to buildings the LTGO ambition can be reached.

The most important techniques are: very efficient artificial illumination systems, systems for optimising the use of daylight, improved electricity supply as part of the building (for instance PV on roof and facades), improved electricity supply not related to the building and intelligent dynamic facades combined with methods to reduce the internal heat load (concepts 1,2, 3 and 6).

Besides, in order to make implementation of concepts and techniques successful, knowledge of building and maintenance processes, institutional features and decision making processes is indispensable.

CONCLUSIONS

1. Within the existing Dutch office building stock a large potential for energy saving is available using state of the art technology. Technically savings of about 40 - 60% can be made.
2. In practice, the potential will be much lower because of non-technical barriers. The different types of non-technical barriers and the influences should be investigated.
3. The main part of the technical potential can be found in the classes E, F, M and especially N. Small older buildings are not interesting, although the savings per m2 gross area in that type of building can be quite high.
4. Large scale introduction of state of the art concepts is only possible within normal maintenance and transformation cycles. The concepts in buildings are not introduced in one action but are built up in time. The maximum energy saving can only be reached at the end of the last relevant maintenance or transformation cycle.
5. Although the technical potential with state of the art techniques is rather high, it is not enough for the LTGO ambition for existing buildings. Therefore it is necessary to develop and use other techniques and methods, as well as to enlarge the scope of the energy system. The developments must focus on: very efficient artificial illumination systems, systems for optimising daylight, improved electricity supply, both as part of the building (for instance PV on roof and facades), and not related to the building and finally intelligent dynamic facades combined with methods to reduce the internal heat load.

ACTIONS

These conclusions have already led to the following Novem-LTGO actions:

1. The presented study will be continued. In this follow-up non-technical aspects will be investigated. If necessary the concepts will be readjusted.
2. The concepts will be tested in the marked. Financial support is possible. Especially testing in the classes E, F, M and N is interesting.
3. LTGO will support developments for techniques and methods mentioned under conclusion 5.
4. Studies into the possibilities for far-reaching energy saving in existing schools and buildings for medical care are carried out at present. These studies consider technical and non-technical aspects, such as building and maintenance processes, institutional features and decision making processes.

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[1] These features are presented in [3].

ENVIRONMENTAL IMPACTS DUE TO STORMWATER, EXPLORATORY STUDY

Therese Malm, MSc and Annika Malm, MSc

1. KTH, Royal Institute of Technology, Infrastructure and planning, Built Environment Analysis, A-building, S-100 44 Stockholm, and J&W Energy and Environment malm@arch.kth.se
2. Göteborg Water and Sewage Works, Box 123, 414 41 Angered annika.malm@vaverket.goteborg.se

INTRODUCTION

EcoEffect (1,2) is a method for environmental assessment of real estates that is being developed at the division of Built Environment Analysis at KTH and Centre of Built Environment at HiG. It includes five areas; Materials use and Energy use based on life cycle analysis, Indoor environment and Outdoor environment based on criteria and Life cycle costs. Stormwater has, so far, been assessed according to criteria based on the calculated amount of drained water per person and year from polluted surface areas (3). This exploratory study intends to show the potential environmental impacts of stormwater derived from its measured content.

PRESENTATION

Precipitation on a real estate form surface runoff, stormwater. The stormwater is transported via pipes or ditches to a recipient or a treatment plant with or without previous local treatment. Reasons for local treatment of stormwater can be to retain the groundwater level, to decrease the hydraulic load to a treatment plant, economical or esthetical (4).

The amount of contaminants in the stormwater reaching a recipient depends on the amount of contaminants in the rainwater, types and size of surfaces, and if or how stormwater is treated (4).

The model used for calculating the environmental effects of stormwater is described in figure 1. Measured pollution concentrations in the stormwater from different types of areas include wet and dry deposition and corrosion from metal surfaces is used. An additional measured corrosion concentration is added for metal surfaces. A total load is calculated for each pollutant in g/year derived from these measured pollution concentrations.

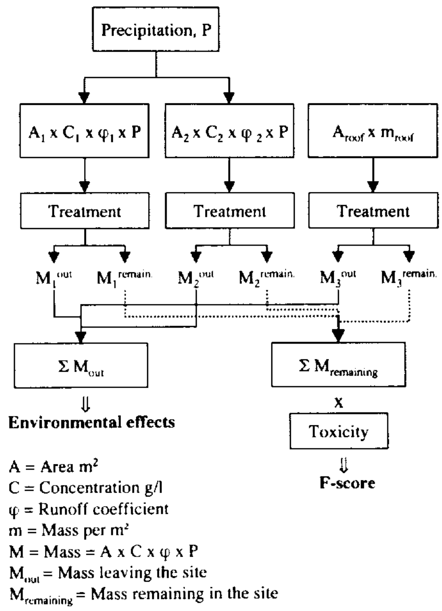

Figure 1: The structure of the model for one substance.

The land use classified and values for phosphorous, nitrogen, lead, copper and zinc are shown in table 1. The values derive from a number of measurements in urban areas during the 90'ies (5,6,7,8).

Table 1: Mean values in mg/l

	Traf-ficked areas	Parking lots	De-tached houses 2)	Block of flats	Parks	Culti-vation lots	Water 3)
P-tot	0,3 1)	0,1	0,3	0,4	0,1	0,15	0,002
N-tot	2,0	1,1	1,8	2	8	8,5	2,5
Pb	0,28	0,1	0,1	0,17	-	-	0,1
Cu	0,07	0,04	0,05	0,1	-	-	0,05
Zn	0,3	0,13	0,2	0,3	-	-	0,2

1) Median value, (mean value not representative)
2) Incl. semidetached houses
3) Atmospheric wet and dry deposit

The table below show the additional values for roof materials, facade and details as drain-pipes etc of copper, zinc or lead.

Table 2: Values from Stockholm (9,10)

Copper	1,35 g/m^2 .year
Zinc	3 g/m^2, year

Concentrations of pollutants are based on measured values in stormwater and the amount of precipitation must therefore be reduced for type of area. This is done with the Runoff coefficient (φ). Impervious areas have a high coefficient and pervious a low.

There is a number of treatment methods for stormwater, e.g. ponds, wetlands, infiltration trenches and oil separators. The appropriate treatment depends on the composition of the stormwater i.e. heavy metal concentration, nutrient content, the amount of suspended solids etc. A combination of treatment facilities is often a good way to reach an effective treatment. Treatment efficiency is difficult to measure which means that values used are uncertain (4).

To attract attention to the building owner about toxic substances in the building and outside, both in materials and in ground, a F-score has been developed in EcoEffect. The F-score is the amount of a toxic substance multiplied with a toxicity score. The toxicity score is determined according to the relative toxicity of the substances. The F-score can only be used in comparisons with other F-scores (1).

Copper, zinc and lead gives potential ecotoxicity and human toxicity. The toxicity values are separated in emissions to land and emissions to water. Phosphorous and nitrogen compounds gives potential eutrophication but no toxicity (11).

The results for environmental effect (impact) is expressed per user in percentage of total impact (1). Total impact is the environmental impact one person do per year (11).

According to EcoEffect environmental effects arises at the boarder of the real estate. Within the real estate a F-score is calculated. As a complement to the F-score, environmental effects are calculated.

The model structure shown in figure 1 can be implemented in the EcoEffect database. The model is depended on appropriate data for pollutant concentration and treatment efficiency. Another way is to use other programmes to calculate the load of pollutants and EcoEffect to calculate the F-score and environmental effects.

EXAMPLE

Example site: 19 500 m^2 from which 13 700 m^2 is living area (block of flats, roof area 2000 m^2), 500 m^2 parking lots, 100 m^2 roads, 4 500 m^2 park and 700 m^2 cultivation lots.

Environmental Effects and F-score due to stormwater for following alternatives of the site are calculated and discussed. (12).

1. Ordinary roof materials without occurrence of copper, zinc or lead. Stormwater is discharged in the recipient outside the real estate without previous treatment.
2. Ordinary roof materials occurrence of copper, zinc or lead. Stormwater is treated in a pond at the site before discharging.
3. Roof material copper. Stormwater is discharged in the recipient without previous treatment.
4. Roof material copper. Stormwater is treated in a pond at the site before discharging in the recipient.

The results is expressed in Figure 2, 3 and 4.

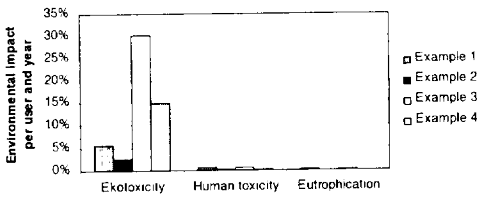

Figure 2: Environmental effects outside the site caused by stormwater at the site

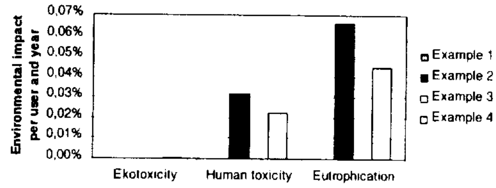

Figure 3: Environmental effects at the site caused by stormwater at the site

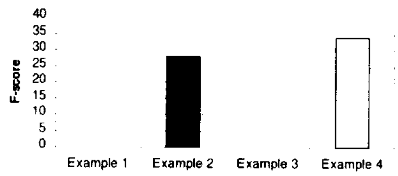

Figure 4: F-score caused by stormwater at the site

The result of the four examples shows that copper roofs lead to higher ecotoxicity with or without previous treatment. The F-score is fairly equal for example 2 and 4 which show that the high toxicity of lead compared to copper (10:1 in ground (11)) contributes more to the F-score than the increased amount of copper in example 4.

CONCLUSIONS AND RECOMMENDATIONS

- It is important to consider emissions from stormwater, either the building is new or old. Stormwater should be appropriate managed and, if necessary, treatment facilities should be built.
- Materials of copper, lead or zinc that corrode have a determining impact. Especially copper has a high toxicity to water and a copper roof has a significant part of the total environmental effect.
- A more advanced model should be considered if stormwater is shown to have an important impact in EcoEffect.
- The aim is to decrease the environmental effect to a point when the effects outside the site is insignificant. To control the source of pollution is a possible way.

FURTHER WORK

- The model used for calculating the environmental effect of stormwater can be further developed.
- Other components (e.g. PAH, pesticides, cadmium) can be included in the model.
- Local treatment of sewerage can be included and environmental valued in the model.

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LIFE CYCLE ASSESSMENT OF VENTILATION UNITS

Mikko Nyman, Tarja Häkkinen, Kai Tattari
1. VTT Building Technology, P.O.Box 1804, FIN-02044 VTT, Finland
2. VTT Building Technology, P.O.Box 1808, FIN-02044 VTT, Finland
3. VTT Building Technology, P.O.Box 1805, FIN-02044 VTT, Finland

INTRODUCTION

Interest in ecological aspects of buildings has arisen among building owners and clients in recent years. The Finnish Development Centre for Building Services has collected up a number of companies and major clients (the cities of Helsinki, Espoo and Vantaa) to prepare a common approach to life cycle assessment (LCA) of building services systems and components.

A major goal is to be able to present environmental product declarations to customers and clients.

A subtask of the project was life cycle assessment of ventilation units (Figure 1). VTT Building Technology (an institute of the Technical Research Centre of Finland) has carried out the research in close co-operation with the participating companies.

GOAL AND SCOPE

It is important that the designer of the building services system is aware of the consequences of his choices during all design phases.

Designing and dimensioning of ventilation units affect greatly the use of energy in the building and thus both the costs and the environmental impacts.

The research project dealt with the effects of dimensioning and the effects of the heat recovery on environmental impacts of ventilation units. A comparison was carried out between different sizes of air handling units equipped with different types of heat recovery heat exchangers and with one without heat recovery.

The life cycle assessment (LCA) methodology was used in the study.

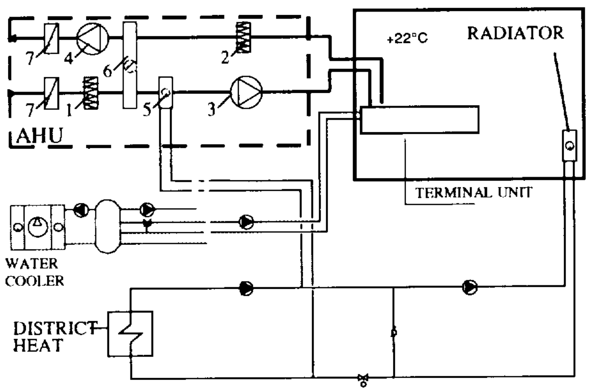

Figure 1. Ventilation unit (air handling unit, AHU) is part of a building services system. It comprises of supply air filter (1), exhaust air filter (2), supply air fan (3), exhaust air fan (4), heating coil (5), heat recovery device (6), dampers (7).

FUNCTIONAL UNIT

According to the standard ISO 14040 the functional unit is generally defined as a quantified performance of a product system.

The air flow of ventilation (2 m^3/s) was defined as the functional unit in this comparative research.

The size of the ventilation unit is irrelevant in respect of the occupant or of the building. The ventilation rate (air flow of ventilation) is the main thing that matters.

It is also irrelevant in respect of the occupant or of the building whether the air handling unit is equipped with some sort of heat recovery or not.

The same ventilation function can be performed with different sizes of air handling units which may be equipped with some sort of heat recovery.

Other functional requirements of the air handling units such as total pressure of the unit p_{tU} (250 Pa), filter class and noise level were same for the compared alternatives.

SYSTEM BOUNDARIES

The products studied were air handling (ventilation) units, which include exhaust and supply air fans, exhaust and supply air filters, a heating coil for supply air, exhaust and supply air dampers, and a heat recovery heat exchanger. The study included production of the materials and the use of the air handling unit (2500 h/a, 20 a). Climatic data of Helsinki, Finland was used.

INVENTORY ANALYSIS

Results of the inventory analysis include masses of main materials of the air handling units, electrical energy consumption of the air handling units, thermal energy recovered in the heat recovery unit and the environmental burdens respectively.

The environmental burdens during the use stage were assessed on the basis of electricity needed for producing the required air flow. The reduction of burdens caused by heat recovery from the exhaust air was assessed on the basis of district heating (CHP) needed for heating the required air flow to a supply air temperature of 17 °C.

Example of the results is given in table 1.

Table1. Environmental burdens of two alternative ventilation units (lifetime 20 years) for 2 m^3/s equipped with plate heat recovery. Nominal face velocity of AHU1 is 3 m/s and of AHU2 it is 4 m/s.

	Environmental impact from					
	Production process of materials		Production of electricity		Savings due to heat recovery	
Environmental burden	AHU 1	AHU 2	AHU 1	AHU 2	AHU 1	AHU 2
Energy						
Non-renewable energy, GJ	41	34	1340	1960	-4860	-4690
Renewable energy, GJ	3.2	2.8	324	474	-270	-260
Energy content, GJ	0.19	0.16	-	-	-	-
Emissions to air						
CO_2, t	2.4	2	50	73	-375	-362
CO, kg	12.3	10.5	74	108	-154	-149
Nox, kg	7.2	5.9	117	171	-785	-757
SO_2, kg	4.6	4	84	123	-787	-760
HC and VOC tot, kg	8.5	6.8	143	210	-1065	-1027
CH_4, kg	7.2	5.7	140	206	-1065	-1027
Particles, kg	3.3	2.8	123	179	-643	-620
Heavy metals, g	34	28	(*)	(*)	(*)	(*)

(*) data not available

IMPACT ASSESSMENT

The environmental impacts considered were climate change, acidification ja photochemical oxidant formation. The data was characterized according to references 3 and 4. Example of the results is given in table 2.

Table 2. Environmental impacts of two alternative ventilation units (lifetime 20 years) for 2 m^3/s equipped with plate heat recovery. Nominal face velocity of AHU1 is 3 m/s and of AHU2 it is 4 m/s.

Environmental impact category	Environmental impact from					
	Production process of materials		Production of electricity		Savings due to heat recovery	
	AHU 1	AHU 2	AHU 1	AHU 2	AHU 1	AHU 2
Climate change, t-CO_2	2.5	2.1	53	78	-401	-387
Acidification, kg-SO_2	9.6	8.1	166	242	-1337	-1290
Photochemical oxidant formation, g-ethene	585	511	2600	3668	-10648	-10275

CONCLUSIONS AND RECOMMENDATIONS

According to the results of the study heat recovery from the exhaust air is incontrovertibly an environmentally friendly solution for reducing the heat losses of ventilation.

Heat recovery compensates totally the harmful environmental impacts of the ventilation unit and in addition it reduces the harmful environmental impacts caused by heating of ventilation air.

The same ventilation can be produced using different sizes of air handling units. A bigger unit has more mass and material, but it requires less electrical energy due to a smaller flow resistance than a smaller unit during the use stage.

In addition to a lower specific power input (SFP, kW/(m^3/s)) of the bigger air handling unit also the temperature efficiency of heat recovery will be higher than that of a smaller unit.

A bigger unit causes less environmental impacts than a smaller unit.

The nominal face velocity of an air handling unit should be rather 2 m/s than 4 m/s.

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ROOF- AND FACADE INTEGRATION OF PV SYSTEMS IN A LABORATORY BUILDING, RENOVATION OF THE ECN BUILDING 31 WITH PV, THERMIE SE/115/97/NL/DK

ir. Tjerk Reijenga, dr.ir. Henk Kaan
1. BEAR Architecten, P.O. Box 349, NL-2800 AH Gouda, The Netherlands, tel.: +31 182 529899, fax: +31 128 582599, e-mail: tjerk@bear.nl, internet: www.bear.nl
2. ECN, Renewable Energy in the Built Environment, P.O. Box 1, 1755 ZG Petten, The Netherlands, tel: +31 224 56 4689, fax: +31 224 56 3214, e-mail: kaan@ecn.nl, internet: www.ecn.nl

Photovoltaics (PV), though not yet competitive in the economic sense, is a promising technology for future energy supply. In order to make PV more economical, PV integration in buildings is an option that may save money. The International Energy Agency has defined a task "PV in the Built Environment" (IEA Task VII). Within the subtask casestudies the buildings concerned are "followed" in order to learn from the processes and to disseminate experiences. One of these cases is a laboratory building, which is located in the Netherlands. The building was built in 1963 and will be renovated. Energy savings, compared to the present situation, will go up to 75%. The building will be equipped with a PV integrated sun shading system for the south facade and roof, while transparant PV modules will be used for the staircases facade. The centre can be visited on the Internet: www.bear.nl. A webcam can be found at www.ecn.nl/unit_de/dego/object31/index.html

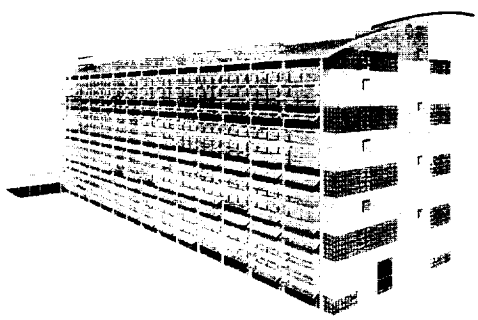

Fig. 1: The design of the PV system.

INTRODUCTION

Purpose

Since the energy crises of the seventies, and, with more emphasize, since CO_2 reduction has become a worldwide political issue, it is generally understood that in the shorter or longer term fossil fuel generated energy has to be replaced by forms of renewable energy. From this point of view photovoltaics (PV), though not yet competitive in the economic sense, is a promising technology for future energy supply. In order to make PV more economical, PV integration in buildings is an option that may save money by easier mounting systems, savings in roofing materials, and savings in floor space. Within the Implementing Agreement on Photovoltaic Power Systems, the International Energy Agency IEA has assigned a number of tasks to be carried out, one of these being Task VII, "PV in the Built Environment". One of the buildings involved is a laboratory building that is located at the site of the Netherlands Energy Research Foundation ECN in Petten, The Netherlands. For this building a PV-integrated sunshading system, a PV cladding system and PV roofing system have been developed.

Approach

The project is elaborated by a team of engineers. The PV facade is integrated in the total design for renewing the building. The project is a collaboration between the Dutch Task VII participants ECN, BEAR Architects, the local utility ENW and Shell Solar Energy, and the Italian representative in Task VII, architect Cinzia Abbate of Rome. A Danish manufacturer of sun shading systems (Dasolas/Alco) is involved in manufacturing the combined PV support / sunshading system. The PV project is supported by the European Commission.

THE BUILDING

The building concerned is the so-called General Laboratory of ECN; a building built in 1963, total floor surface 3530 m^2. A survey showed that the building has several major technical and thermal shortcomings, which will be taken away in the renovation process. The total yearly electricity consumption of the existing building is 286,000 kWh, being 80 kWh/m^2. This is high, compared to other buildings of the same period. The large number of computers causes this, as do the inefficient lighting system and the inefficient heating and ventilation system. At present, the total yearly heat demand is 1750 GJ, which is about 140 kWh/m^2, a normal energy consumption for a Dutch building of the sixties. However, the heat gains from the computers are not included in this number, so in fact heat demand is higher. The comfort in the building is far from ideal. Partially this is caused by failings in the facade (cold in winter), partially by overheating in summer.

TARGETS FOR ENERGY SAVINGS

Energy use of the building

When defining the energy targets for the laboratory building after renovation, it was decided not to exceed the level of heat demand of 50kWh/m^2/year. Electricity demand should not exceed 40 kWh/m^2/year. These targets are quite ambitious. However, they do not include the process related energy demand. Simulations with the TRNSYS program showed that the goal of reducing primary energy demand to 80 kWh/m^2 could be obtained. In this case, co-generation and application of photovoltaics can substantially contribute to this goal. Energy savings, compared to the present situation, will go up to 75%. Overheating is quite an important problem. In order to avoid airconditioners –the building should be cooled by natural ventilation and summer night cooling- heat load should be as low as possible. Apart from efficient office machines and well-used automatic switch-off appliances, outside sunshading devices should be applied as much as possible. This requirement is one of the points of departure for the PV system design. Thus, exceed of temperature during summer months is far below the standard. In addition PV generates a considerable amount of electricity.

Integration of the PV system in the building

All together about 700 m^2 of PV will be installed, saving more than 90 % of the building related electricity consumption (lighting, ventilation, elevators) and more than 30% of the total electricity consumption in the building. The building will be equipped with a PV integrated sun shading system for the south facade, in this shading device 340 m^2 PV is integrated. Another 330 m^2 is integrated as a sunshading roof construction. Finally 30 m^2 of PV is mounted as a cladding system on the staircase outer wall. All together the PV system produces 56,440 kWh per year. From the THERMIE program, the EC supports 40% of the costs of the PV system, whereas the Dutch government pays an additional 9 %.

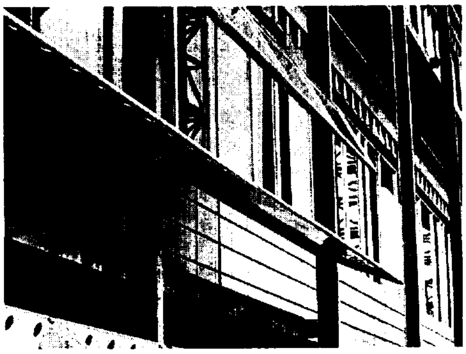

Fig. 2: The sunshading PV system.

THE DESIGN OF THE PV-SYSTEM

What requirements were defined for the PV system? As said before, the system consists of three parts: the sunshading integrated system, the roofing system and the PV cladding. The latter has no special requirements; it is just for electricity generation and for architectural expression.

The sunshading integrated system

The south facade has a problem of overheating in summer. It was clear that the PV modules should be integrated in the outside sunshading system. Such a solution may:

- optimize solar gain;
- give good shading of the building in summer;
- make daylight diffuse;
- ease maintenance of the building and cleaning 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 width of the rooms behind. In order to make a choice for the width of the lamellas various solutions for an integrated system were examined. The study showed, that the best results for solar gain, shading and daylighting were obtained with a model using 4 fixed lamellas per floor. Considering the solar ratio between a fixed system and a moveable 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 room 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 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. 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, much energy consuming air-conditioning system will not be necessary.

Fig. 3: The view through the window.

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 devices such as ventilators and air ducts. So it was decided to construct the parasol as a watertight part of the building.

RESULTS

Innovative Parts of the Project are:
- The integration of standard PV modules in custom-made lamellas;
- The regulation of daylight by the lamellas.
- The way to avoid air-conditioning in relation with the lamellas.

One of the purposes of the demonstration project is to have a case study for IEA Task VII where experts can discuss questions regarding design, production problems, wiring, interconnection of PV and lamellas, and non-technical aspects like involvement and role of utility, local government, and owner/user. The above project certainly contributes to that goal.

CONCLUSION

Good results are expected by this building integration. The scientific innovation and relevance of the project are high. The PV system is architecturally integrated in the building. By integrating the PV system in the building, a better quality/cost ratio will be reached. Thus the project may encourage the application of PV systems as an energy-conscious retrofit.
This integrated PV facade will give good results. To optimise the facade on daylighting, sun shading and heat load, research is done on the shading of the PV lamellas. This research is elaborated in the design. No additional cooling is necessary because of the shading system.
The building is now (2000) under construction and will still be finished in 2000. A webcam is available at www.ecn.nl and www.bear.nl.

PARTICIPANTS

- Netherlands Energy Research Foundation ECN, Petten (NL)
- Dasolas International production, Lystrup (DK)
- ENW / NUON utility, Alkmaar (NL)
- BEAR Architecten, Gouda (NL)
- Studio di Architectura di Cinzia Abbate Rome (IT)

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METHODICAL LCA-DESIGN

Ir. W. Zeiler
Kropman B.V. Mechanical & Electrical Contracting
Verrijn Stuartlaan 36
2288 EL RIJSWIJK
Tel. : 070-3401401
Fax. : 070-3999351
E-mail: w.zeiler@ry.kropman.nl

Decision support is needed within design processes in order to take into account all the aspects of life cycle assessments. During the whole design route the environmental LCA aspects should be used side by side with other design criteria. With environmental aspects involved the uncertainties become overwhelming.
The environmental impact of the product, which still has to be designed, has to be taken into consideration without knowing quantified or qualified specifications. In order to develop appropriate tools for decision support in design processes, it is necessary to found them on an understanding of design.

Design and introduction

Design, as a solution-evolving process, involves activities of searching information, analyzing, manipulating and structuring information about the problem to be solved. Generating new information, and evaluating and communicating information is a major activity within the process. Design has normally a very dynamic nature, with a tendency to ad hoc actions, which should be supported by design aid systems. To develop the required model of design support an existing model has been extended: Methodical Design [Van den Kroonenberg, 1986]. The methodical design process can be described on the conceptual level as a chain of activities which starts with an abstract problem and which results in a solution. Four main phases are distinguished, in which eight levels of functional hierarchical abstraction, stages, can be distinguished. A feature of Methodical Design is the occurrence of a four-step pattern of activities in each stage. In system theory the same activities are proposed for decision processes as can be found for the design process.

System Theory	Activity	Methodical Design
Definition Demands	Generate	Problem definition phase
Synthesize Analyze	Synthesize	Working principle phase
Evaluation Decision	Select	Decision phase
Implementation Application	Shape	Shape giving phase

The four phases, with their specific level of aspect abstraction, have their own requirements for the descriptive model of decision making. Each defining its own associated inference: to the aspects of life cycle assessments.

Hierarchical abstraction means the decomposition of information into levels of increasing detail, where each level is used to define the entities in the level above. In this sense each level forms the abstract primitives of the level above. These terms in the upper level, form condensed expressions of a given relational and/or operational combination of primitives from the level below.
The sets of generic primitives are located at distinct levels of abstraction, ranging from the system level to the physical level. The contents of the layers is based on the technical vocabularies in use, therefore we will speak of technology based layers or levels. Each layer represents an abstraction of the levels below. For a more extensive description of the models that formed the basis for the notion of technology-based layers. It is important to realise that the actual contents of the layers as well as the number of layers will be domain-specific. Generic components represent behaviours that are known to be physically realisable. They are generic in the sense that each component stands for a range of alternative realisations. This also implies that the generic components still have to be given their actual shape. Relevant technical or physical limitations manifest themselves in the values of a specific set of parameters belonging to the generic components. These parameters are used to get a rough impression of the consequences of certain design choices at the current level of abstraction for the final result. In most practical situations, purely hierarchical design is an illusion due to the interrelations between the elements of a decomposition. Discarding the dependencies among subparts will often result in conflicting mutualrequirements between the parts during recombination. The separation is made between;

- Information level, knowledge orientated, representing the "conceptual world".
- Process level, process orientated, representing the "symbolic world".
- Component level, device orientation, representing the "real world".
- Part level, parametric orientation, representing the "specification world".

The distinguishing is made in four levels of aspect abstraction in the descriptive model of design. Each defining its own ontology and associated inferences.

A concept of Lego, Logic Evolved Generic Objects, building blocks is developed for representing HVAC (Heating Ventilation And Air Conditioning) processes. The Lego-blocks are fundamental representations of basic physical processes.

This new approach to conceptual design which combines technical systems theory and design methodology with bond graphs representations as Lego-blocks is developed. The benefits of this approach strongly depend on the availability of generic models, Lego-blocks stored in structured libraries. In the EBIB-project an Electronic Library of Installations Blocks is developed by Kropman, The University of Twente and The Netherlands Energy Research Foundation ECN. The University of Twente and the Netherlands Energy Research Foundation ECN developed re-usable and sharable model components in the thermodynamic domain for the OLMECO design library. The OLMECO project is an Esprit project for building an Open Library for Models of in mEchatronic Components. [Zeiler, 2000].

Design level	Main topic of abstraction	Output	Focus from LCA point on
Problem definition	Information "conceptual world"	Need Design problem	Environment
Working principle	Process "symbolic world"	Functional specification Physical solution process	Energy Exergy
Detail design	Component "real world"	Module structure Prototype structure	Re-useability
Realisation	Part "specification world"	Material properties	Resources

The four phases, with their specific level of aspect abstraction, have their own requirements for the descriptive model of decision making within the design process. The model libraries structure helps to focus on the LCA aspects.

The usability and reusability of the model library has been demonstrated by a large-scale evaluation experiment, modelling and simulating the heating installation of a hospital in The Netherlands. [Top et.al. 1994].

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EXTERIOR WALL - R.C. SLAB COUPLING DETAIL DESIGN WITH OPTIMUM THERMAL AND MOISTURE PERFORMANCE

M. Cem ALTUN
Istanbul Technical University, Faculty of Architecture, Taskisla, 80191, Taksim, Istanbul, Turkey

INTRODUCTION

In Turkey nearly all residential buildings do have a reinforced concrete (r.c.) skeleton structural system with infill walls. Components of the structural system like, beams, columns or cantilevered slabs in the exterior envelope mostly interrupt the thermal insulation layer or the self-insulated infill wall providing thermal resistance, which causes "thermal bridges". Heat transfer in such areas is larger than in "clear wall" areas, which are free of such thermal anomalies. Thermal bridges not only increase heat transfer but also are potential cold surfaces for moisture accumulation. With proper architectural detail design thermal bridges in the exterior envelope should be avoided as far as possible for energy savings and achieving acceptable inner surface temperatures. Energy savings will result in reducing air pollution and CO_2 emission and surface temperatures should be at a level to achieve indoor thermal comfort and eliminating risks of mould growth and aesthetic problems caused by moisture.

A research project was set to analyse the hygrothermal performance of intersection areas of building components in the exterior envelope of residential buildings with r.c. structural system.

In this study the coupling area of "exterior wall / floor slab" is examined from creating thermal bridges point of view. Different architectural details with different construction types are hygrothermally analysed. Wall constructions with and without thermal insulation are taken into consideration. Wall construction material, placement of the thermal insulation and its thickness are utilised as variables. The indoor and outdoor climatic conditions are considered to be constant.

With the results of those analysis recommendations for the design of architectural details with optimum thermal and moisture performance for this coupling area, using common construction types and typical building materials for residential buildings in Turkey, are presented.

METHODOLGY

For the assessment of the hygrothermal performance of different constructions; heat flow through exterior surfaces, condensation risk at inner surfaces and upper surface temperature of floor slabs are the selected criteria.

Construction Type

In the study a corner partion of a five storey high residential building' envelope with a r.c. skeleton structural system is taken into consideration. The partion includes, the column, beams, floor slab and the infill wall. The column is square shaped (40/40 cm) and the beam has a rectangular shape (25/50 cm). The thickness of the r.c. slab is 12 cm. Taking the r.c. components geometry as constants, different infill wall constructions are examined. Those constructions are; wall without thermal insulation (C1), wall with thermal insulation only on the outer surface of r.c. components (C2), wall with thermal insulation placed on the outer (C5) or inner (C3) surface and on the centre plane (C4). For the insulated constructions the thermal insulation thickness is taken as 5 and 8 cm alternatively. The floor slab is finished with a screed (3cm, λ= 0.87 W/m°K) for each alternative. The U-value for the clear wall area of the infill constructions C1-0, C2-5 and C2-8 is 0.59 W/m²K , on the other hand for the constructions C3-5, C3-8, C4-5, C4-8, C5-5 and C5-8; 0.55 W/m²K, 0.39 W/m²K, 0.54 W/m²K, 0.38 W/m²K, 0.56 W/m²K and 0.40 W/m²K respectively. Detail sections of the wall configurations are given in Figure1. The material properties are given in Table1.

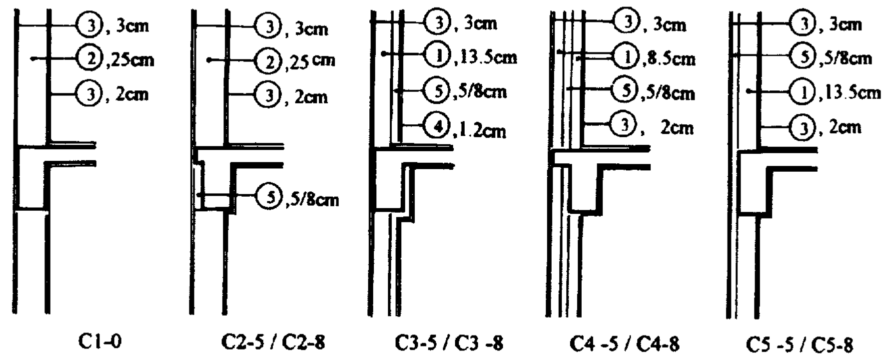

Figure 1. Section detail of wall constructions.

Table 1. The material properties of wall layers (Density, γ and Thermal Conductivity, λ).

Nr.	Material	γ, kg/m^3	λ, W/m°K
1	Hollow Brick	900	0.45
2	Aerated Conc. Block	500	0.17
3	Rendering(Cem.-Lim.)	1800	0.87
4	Gyp. Plaster Board	900	0.21
5	Polystyrene (XPS)	25	0.04
6	Reinforced Conc.	2400	2.09

Calculation Method

The thermal performance is determined with the PC-program "Heat 3" which is using a transient, three dimensional, finite difference model for heat transfer [1]. Heat flows and surface temperatures for both wall and slab are calculated for steady-state conditions. Cut off planes for the corner 3-D model are located 1 m in distance from the column and beams in two directions as recommended in [2].

Condensation at the inner surface is set as the moisture performance criterion. Interior relative humidities that might cause condensation on the inner surfaces are determined according to the calculated lowest inner surface temperature values and psychrometric charts [3].

Climatic Conditions

In the simulations, both the indoor and outdoor temperatures are considered to be constant; 21°C and 0°C respectively. Film coefficients are taken as 0.13 W/m^{2}K for the inner and 0.04 W/m^{2}K for the outer surface.

RESULTS

Heat flow per square meter of the corner constructions, insulated at the centre plane (C4-5), insulated internally (C3-5), with only insulated r.c. components (C2-5) and without any insulation (C1-0) are higher than the externally insulated (C5-5) construction by, 21%, 26%, 30% and 105% respectively for a insulation thickness of 5 cm. Heat flow per square meter of the corner constructions, insulated at the centre plane (C4-8), insulated internally (C3-8) and with only externally insulated r.c. components (C2-8) are higher than the externally insulated (C5-8) construction by, 38%, 41% and 71% respectively for an insulation thickness of 8 cm. In increasing the insulation thickness from 5 to 8 cm, the heat flow decreases for the construction C5 by 32%, for C4 by 22%, for C3 by 24% and for C2 by 11% (Table 2).

The lowest inner surface temperatures are determined at the corner of wall, column and slab upper surface intersection point, for the constructions C2, C3, C4, C5. The lowest inner surface temperature for the construction C1, is determined at the corner of beam, column and slab lower surface intersection point. The construction with the highest inner surface condensation risk is C3-5. If the interior RH exceeds 45% condensation will occur. Where as for construction C5-8, the interior R.H. has to be higher than 87% to cause condensation at the point with the lowest temperature (Table 2).

The temperature field of the upper surface of the slab varies for each construction with increasing values towards the interior space. 20°C is taken as a reference surface temperature. The distance from the exterior wall surface of the point with this temperature, is calculated. There is little difference between the same configuration with 5 or 8 cm thick insulation. The largest distance is calculated for construction C3 with 71 cm and the smallest distance for C5 with 52 cm (Table 2)
.

Table 2. Heat flow rates (HF), minimum inner surface temperatures (T_{min}), indoor relative humidity value (RH) with condensation risk at (T_{min}), distance of nearest point with 20°C on floor slab to the external surface (L).

	HF, W/m2	T_{min}, °C	R.H., %	$L_{20°C}$, m
C1-0	23.4	11.1	>53	0.67
C2-5	14.8	16.0	>74	0.62
C3-5	14.4	8.6	>45	0.71
C4-5	13.8	15	>70	0.67
C5-5	11.4	17.8	>82	0.52
C2-8	13.3	16.8	>77	0.61
C3-8	11.0	9.6	>48	0.71
C4-8	10.8	15.7	>73	0.67
C5-8	7.8	18.8	>87	0.52

CONCLUSION

Different exterior wall / r.c. slab coupling areas are hygrothermally analysed. The following conclusions might be useful in the design of exterior wall systems.

- The construction without thermal insulation has excessive heat losses through the r.c. components, though its acceptable U-value of the infill wall. For this configuration there is also the risk of surface condensation at certain points, even at indoor R.H. in the range of 50%.
- The internally insulated (5/8cm) construction has, despite of its acceptable heat flow rate, the risk of surface condensation at certain points, at an indoor R.H. >45%. Also large portions of the floor slab adjacent to the exterior envelope do have surface temperature less than 20°C.
- Constructions with thermal insulation only on the outer surface of r.c. components and with thermal insulation placed on the whole outer surface or on the centre plane do have a acceptable performance in terms of heat flow, surface condensation risk and slab surface temperature.
- The r.c. components of the exterior envelope have a crucial effect on the hygrothermal performance of buildings. In designing for a sustainable environment this should also be taken into consideration beside the properties of construction in the clear wall area.

ACKNOWLEDGMENT

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ENERGY PERFORMANCES OF DOUBLE-ENVELOPE FACADES IN MEDITERRANEAN CLIMATES

M. Beccali, G. Scudo
DITEC, Politecnico di Milano, Via Bonardi 3, MILANO 20133, ITALY
tel +39-02-23995106, fax tel +39-02-23995118, e.mail: beccali@mail.polimi.it

ABSTRACT

In the last years double-envelope facade technology has been adopted in many project for large new building in Central and North Europe. The purpose of this work is to investigate advantages and drawbacks of their use in warmer climates such as the ones in Mediterranean Area.
Energy calculations have been performed with DOE 2.1E for the sites of Milan, Rome and Athens in order to test the overall performance of a set of different configurations obtained through an optimisation process dealing with some design variables. Winter and summer loads have been calculated, together with primary energy demand and CO_2 emissions, and compared to the ones of a set of reference buildings. Also economic performances indicators have been assessed.

INTRODUCTION

It is well know that one of the most important problems related to the use of sunspaces (even if they appears as a glazed double building envelope) is the risk of overheating in summer seasons. At the same time, for different climate conditions, the warmer are the winter the smaller are the energy, and economic, advantages coming from the "free-heating" provided by well oriented glazed spaces. In addition, it must be noted that in Southern regions the effectiveness of vertical surfaces as solar radiation collectors is lower than in Northern areas.
Starting from these considerations, the first task of this work was to assess, through the energy and economic point of views, the relative and the absolute importance of a set of design variables affecting the double envelope performances and to assess three "optimised" system configurations for three different Mediterranean locations.

REFERENCE BULDINGS AND DOUBLE ENVELOPE ENERGY PERFORMANCES

A reference building has been defined for two purposes. The first one was to have a sort of Business as Usual case for the performances comparison. The building has been imagined for commercial (office) utilisation. All the internal loads (occupancies, lighting, equipment, etc.) have been defined accordingly. The second reason deals with the choice of considering the double envelope as an add-in to a "conventional" building (except for the changes required in the interested facades).

The design variables and the optimised configurations

In order to test different double envelope configurations, eight design variables have been considered:

1) the orientation of the facade: it can vary from East to West (through the South);
2) the height of the sunspace: it can have the same height of the building or can be interrupted at each stage floor;
3) the width of the sunspace: it can range from 20 to 120 cm;
4) and 5) the glasses typology and their displacement on the two curtains: 16 different glasses (from Window 4 – DOE-2 library) have been considered (clear, low-e selective and tinted) for both internal and external panes;
6) the dimensions of internal glazed surfaces: three different glazed/opaque ratios (23, 56 and 89%) have been considered in order to define the internal wall of the double envelope;

building with a 35% glazed/opaque ratio and a building with a glazed curtain wall (CW).
All the buildings are considered to be heated through natural-gas (with overall efficiencies complying with national standards) and electric water chillers both connected to air/hydronic systems. Thus, for these four case buildings, natural gas and electricity consumption have been calculated together with primary energy demand (fig. 1 and 2).

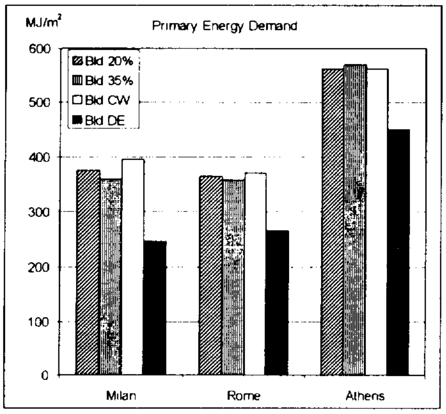

Figure 1. Primary energy demand

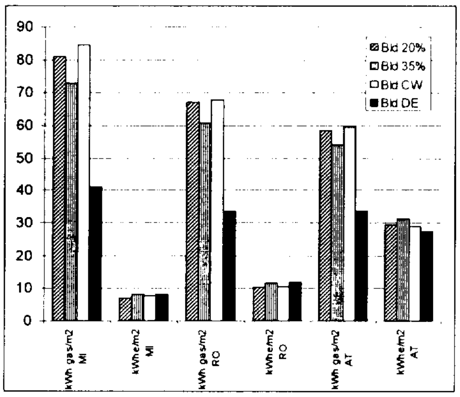

Figure 2. Gas and electricity consumption

From the economic point of view, the Simple Payback Time (SPT), related to the extra-costs of the double envelope with the respect to the other technologies, has been calculated. Obviously, SPT takes into account either the investment costs, either the energy cost during the life time of the building (fig. 3).

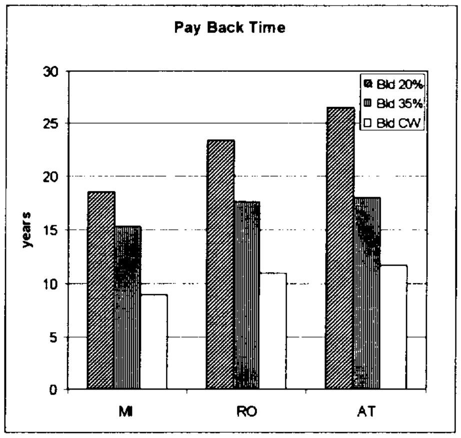

Figure 3. Pay back times

It's interesting to note that with respect to a building with curtain wall, the Payback Times of the Double Envelope are of about 10 years and not strongly affected by the climate. This fact should be considered by the designers that more often prefer the first technology to the second one.

FINAL REMARS

The work has highlighted two important issues. The first is related to the assessment of the importance of the effects, on the energy side, of some design variables of a double building envelope. The second deals with the assumption that, if such system is well designed, interesting energy saving results are suitable also in Southern Europe where cooling issue has a wider importance.
Last but not least, it must be stressed that any assessment of energy required for lighting purposes has been made. Thus, it is quite evident that, provided the large glazed areas related to the Double Envelope, higher natural lighting contribution are expected than in the other building cases, thus higher energy savings could be foreseen.

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7) the typology of the structural frame: three technological solutions have been considered;
8) the typology of sunshades: overhangs, internal and external venetian blinds.

Energy calculations have been performed with DOE 2.1E for the sites of Milan, Rome and Athens. Winter and summer loads have been calculated together with a conventional primary energy demand and the related CO_2 emission. Also economic performances indicators have been assessed.
For each one of three location, the work has highlighted the importance of each one of the above listed design variables, allowing to describe some "optimal" sunspace configuration.
The following table shows the maximum ranges of variation of primary energy demand related to each design variables choices.

	Max ranges of variation (%)		
Design Variable	**Milan**	**Rome**	**Athens**
Position of glasses	24	25	34
Glasses typologies	22	14	42
Frame typology	0.9	2.8	1.4
Dimensions of Internal Windows	19	17	17
Sunspace typology	1.2	7.9	7.3
Sunspace orientation	49	44	27
Sunspace width	19	11	6
Shading devices typology	7	16	8

Table 1. Design parameters sensitivity analysis

Its worth noting that both glass position and typology play a very important rules in the performance of the building, especially in Athens. Orientation is also relevant in the latitude of Rome and Milan. Also the internal window dimension represents a key parameter in the design stage.
Table 2 shows the optimal configuration resulted by the above mentioned sensitivity analysis.

	Optimal Arrangement		
Design Variable	**Milan**	**Rome**	**Athens**
Position of glasses	Double external- single internal		
Glasses typologies (external panes)	Low-e U= 1.96, T_{sol}= 0.53, T_{vis}= 0.72, r_{sol}= 0.13	Selective U= 2.38, T_{sol}= 0.47, T_{vis}= 0.75, r_{sol}= 0.2	Selective tinted U= 1.78, T_{sol}= 0.28, T_{vis}= 0.44, r_{sol}= 0.1
Frame typology	Glazing bars and posts on the external side		
Dimensions of Internal Windows	30% glazed		
Sunspace typology	Full-height		
Sunspace orientation	South		
Sunspace width (cm)	120	120	100
Shading devices typology	Internal venetian blinds		

Table 2. Optimal design configuration for the three locations (U-values are in W/m^2K)

It must be noted that in the optimisation process, only two parameters have shown a strong correlation to the climatic context: the glass typology and the sunspace width.
In the southern location a selective glass, able to cut-off about the 70% of solar radiation, is required in order to prevent the sunspace overheating. On the other hand in Milan, a low-e glass could improve the winter free-heating provided by the sunspace to the internal spaces. For the same reasons, a lower volume of the sunspace is to be preferred in Athens than in Milan and Rome.

Energy and economic performances related to conventional buildings

In addition to the reference building two other cases have been defined in order to make a more wide comparison: a conventional

Long Term Energy Storage in acquifers for small capacities.

Ir. Broekhuizen MBA	Installect Rozenstraat 11 7223 KA Baak The Netherlands
Ing. G.W. Kamphuis	Installect
Ing. A.J.W.M. van den Boomen	GeoComfort, Schotse Hooglanderstraat 49, 5165 AC Waalwijk, The Netherlands
Ing. T. Timmermans	Westerloo Boringen, Europaweg 146 5707 CL Helmond, The Netherlands

Summary

Cold storage is common in the Netherlands in capacities higher then 500 kW.
This paper deals with the development of a system for lower storage capacities on basis of monowell technics. The system (GeoThermic) can provide cooling capacities from 100 till 350 kW with electricity input up to 3 kWe; so with COP > 100. The storaged heat of the system is used for preheating the air while the water has been cooled down. The heatexchanger with groundwater is placed in the well more then ten meters under groundwater level. The system is quick to install and has no problems with groundwater pressure, unliked gas and long procedure time.

Situation and context.

In the Netherlands, systems with cold storage in acquifers had become normal practice. However there are almost no systems for small cooling capacities < 500 kW (1).
For this there are several reasons:

1. the systems are to expensive
2. the time to get permission from local authorities is too long and expensive.
3. The technics are to complex for smaller systems, especially because of the dedicated controll systems for keeping control of the pressure of injection.

Most systems are based on doublets; one well for extraction of water and the other for injection (By change of the season the wells change of function.
A way to reduce costs is to use a monowell (See figure 1). In a monowell the storage of cold and warm are not next to each other but the cold storage is under the warm storage in the same borehole. Cold and warm are separated by layers of clay. With more simplification the recirculation variant can be used with onely one pump. This system is not realy a storage system but can also be used for cooling and preheating air.
By use of a monowell you should be sure of a good separation between warm and cold. In practice it is possible with special technics to find also smaller clay and disturbing layers which can be a good barrier between warm and cold.

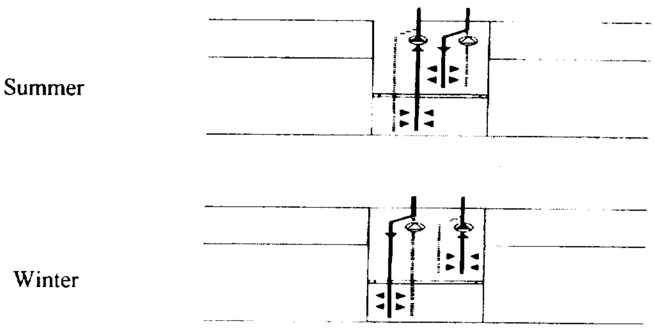

Figure 1: Monowell: warm water in upper part, cold water under.

An other constraint is the long procedure time to get permission from the authorities. Extraction of groundwater is bound to regulations with procedure times of more then half a year. Especialy for smaller capacities this is in most cases a to long period. Besides the cost of the permissionprocedure is high is relation to the scope of these projects.

The last before mentioned constraint was the complexity of the required control system for this kind of technics. This control system is especialy necessary to keep groundwater under presssure and prevent unliked gases and a bad functioning well.

GeoThermic

Installect developed with the boreholemaking company Westerlo a new system the so called GeoThermic(GT) (See figure 2). This system can cope with the above mentioned limitations for small systems(3).

A monowell with an underwater heatexchange system has been developed. In this configuration the water of the cooling systems goes down in earth to a heatexchanger. Groundwater is not brought up above the natural groundwater level. Problems with control of injection pressure are history.
In this way there is technical (and and conform the regulation) no displacement of groundwater above groundwaterlevel, which means there is no need for a permission procedure for extraction of groundwater.
With the system it is possible to warm up and cool down the air with energy of the storaged water in the acquifer. Air can be prheated up to 10 degrees C (that is on the level of a good heatrecovery system).
For cooling purposes the system can be used as an alternative for cooling machines.
The COP of the system is >100. Systems with COP's of 150 are possibe.
This is possible because of the underwater heatexchange. Because of this there is no need for overpressure for groundwater. The systems are designed for capacities up to 350 kW cooling capacity.

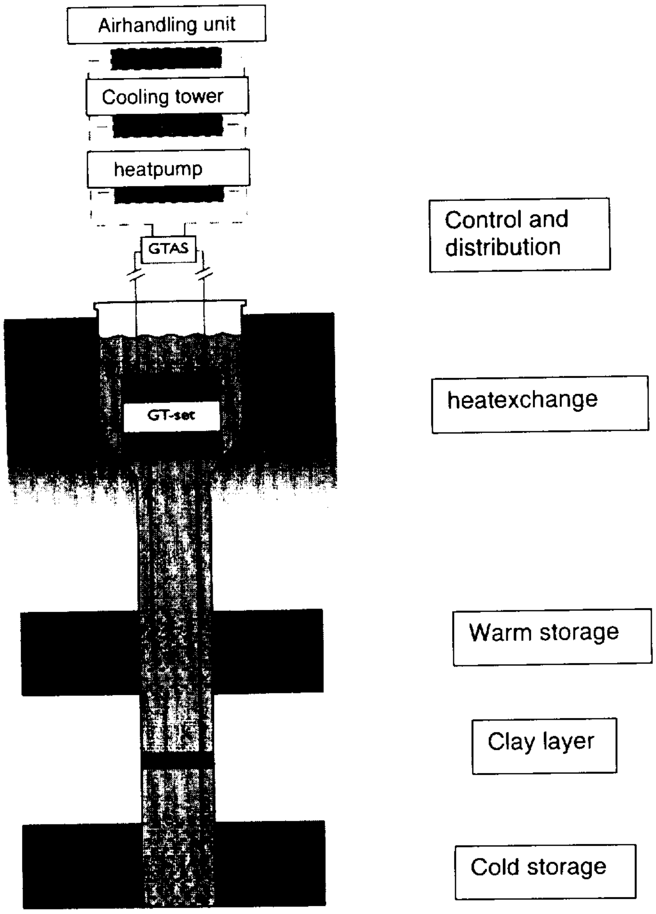

Figure 5: Configuration of the GeoThermic.

The benefits for the environment are:
- low use of energy for heating and cooling
- almost no space for technical installation (underground systems)
- no noise
- far less primary materials for heating/cooling installation
- In combination with a heatrecovery (twincoil), air handling systems without a separate heatcoil are possible. (Use of fossiles for heating air is zero!)

The system is tested with a pilot version on location of Installect in Baak (See figure 3). NOVEM has given financial support for the testfacility.
The first GeoThermic in reallife environment is installed by Energyresearch Centre Netherlands in Petten. In this project the GeoThermic is installed in combination with a heatpump. The distibution systems had been change in low temperature for heating and high temperature for cooling purposes. Cold can be loaded by airhandling units, a free cooler and with the heat pump.
Several other systems are realised and are in preparation.

Several other systems are realised and are in preparation.

Figure 3: Pilot of GeoThermic testfacility by Installect Baak.

Conclusions and recommendations

- With the GeoThermic energystorage is also possible for smaller capacities. The units can be installed quickly because of reduction of time and money for procedures.
- The configuration is more robust than the conventional storage systems because of the underwater heatexchange. The system can be offered as a turnkey system. This qualifies GeoThermics for use in industrial environment.
- In a service economy there is a trend to small offices. With this new technic energy saving on basis of energy storage are now also possible for this market.
- The GeoThermic fits in the trend to high temperature cooling, lowtemperature heating and zero energy buildings (4).
- There is need for further research on the case of thermal losses caused by unliked groundwaterflow. For bigger systems the losses are low (5). For smaller systems the infuence of groundwaterflow will be more.
- The systems are limitated by the possiblity of building small heatexchangers in the narrow borehole. A round heatexchanger with characteristics of a plateheatexchanger should open new perspectives.
- The control of the unit needs further development. The aim is a control on basis of fuzzy logic and LON-technology without vulnerable measurements under groundwaterlevel.

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TOWARDS GREEN ENERGETIC SOLUTIONS FOR HOTELS

N. Chatagnon*, L. Tabary*, K. Launay⁺, A. Bornarel⁺, E. Akiki⁺
* EDF Pôle Industrie / R&D Division / Electricity Applications in Building Branch
Les Renardières 77818 MORET SUR LOING Cedex France

⁺ TRIBU - 19, rue Frédérick Lemaître
75020 PARIS, FRANCE

ABSTRACT

In order to assess energetic solutions for hotels according to environmental criteria, Electricité De France (EDF) conducted a study with the technical consultant TRIBU in 1999. The main objective of this study was to propose an environmental assessment grid for hotels. This study was structured in two parts :

- First, we tried to establish precise requirements emphasising especially on energy (insulation level, heating system design and management...) and on environmental impacts related to the energy. Two cases was studied : a typical 3* hotel located in Paris and a typical 3* hotel located in Nice (south-east of France).
- Secondly, from the learning of the previous step, we derived an environmental technical specification for 3* hotels which use electricity. Threshold values or recommendations were given for environmental criteria not related to the energy. This technical specification should help people confronted with a similar project in another context.

INTRODUCTION

The legitimate positioning of Electricité De France is the energy and associated services : our mission consists in offering efficient energetic solutions. Today, efforts are given to propose solutions in agreement with environmental criteria.

In 1999, EDF and the technical consultant TRIBU initiated a study in order to define an environmental technical specification for 3* HQE (High Environmental Quality) hotels which use electric energy.

The main objective was to have an assessment grid for evaluating electric solutions for 3* hotels according to environmental criteria. These prescriptions are based on the 14 « targets » defined by the French HQE Association [1]. The environmental quality targets involve both the indoor and outdoor environment. They break down into 4 families: eco-construction, eco-management, comfort and health.

PRESENTATION OF WORK

Methodology

In the context of our study, the energy management target takes a particular importance. So, in a first step, we have been working on this target and on the environmental impacts related to the energy.

It was necessary to define indicators and references to evaluate and compare solutions. Owing to the diversity of environmental criteria, we have considered several indicators that can be either quantitative or qualitative. In order to get a summary and legible environmental profile, without reducing the information, we have determined one indicator for each target, except for the « energy management » target to which are associated several indicators. The environmental output is a multcriteria profile.

The reference building corresponds to the typical 3* hotel defined by EDF-R&D Division.

Two different climates have been studied: a moderate climate in an active urban environment (Paris) and a sunny climate in a countryside environment (Nice). With the experience of TRIBU, we have defined a mean reference energetic system for 3* hotels : gas heating system with fan coil units, electrical cooling system and electrical storage domestic hot water.

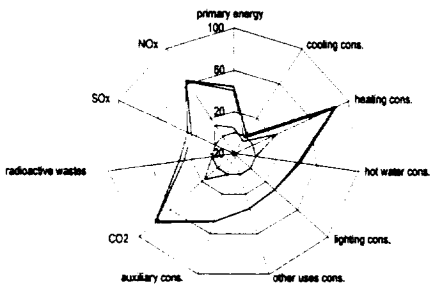
The specificities of the hotel sector, related to the occupation and the use, have been inventoried in order to assess the adaptability of a system to the sector. These characteristics have direct consequences on technical and management choices. For example, a business hotel is mainly occupied the night. Therefore, windows of rooms needn't be very large, that it isn't the case for a tourism hotel. Small windows have the advantage of limiting solar heat gains in summer.

The following step has consisted in realising a preliminary energetic assessment.
The selection of electric solutions for simulations has been done through the double criterion of their interest in the hotel sector and of their environmental quality. Among these, we have selected standard solutions that have been used as references. At this stage, we have a qualitative assessment of solutions.
Simulations of the selected solutions have been made with the environmental assessment tool PAPOOSE [2] and with the energetic tool PAPTER [3].
An analysis of results let us accomplish complementary sensibilities analysis in order to study the influence of some parameters and to propose improvements according to the energetic criterion.

In the last stage of the study, the technical specification of a HQE 3* hotel using the electric energy has been defined. Prescriptions are based on the 14 targets given by the HQE French Association. The elements of the technical specification have been determined with the results of energetic simulations for targets related to the energy, and with expert valuation for the other targets.

Energetic assessment results

After selection, we have retained six energetic solutions for simulations, criteria chosen for the assessments were energetic consumptions, atmospheric emissions (CO_2, NO_x, SO_x) and radioactive wastes. Figures 1 presents the environmental relative improvements of 3 solutions with the reference for Paris location.



—	reference	—	air-to-water heat pump with heat floor and convectors
—	upgraded insulation	—	water-to-water heat pump with heat floor and convectors

Fig. 1 : Comparison with reference -3 hotel Paris-*

These simulations show that, with a good insulation, we can improve the performances according to all criteria, apart from cooling consumptions. The latter increase lightly because upgrade the insulation of walls has the effect of storing the internal heat gains. Also, we can see that choose an efficient HVAC system allows to reduce more than 80% the heating consumptions and more than 40 % the hot water consumptions. Overall, on the whole of solutions studied, CO_2 emissions are divided about by 3 compared with the reference and radioactive wastes by 2.
The results analysis has permitted to draw several conclusions and to emerge some sensibility parameters such as isolation, control of solar protections, consign temperature, internal heat gain and auxiliary consumption.

Environmental specifications for hotels

The environmental specification for hotels has been structured according to the 14 targets. For each target, several actions to improve the environmental quality of hotels have been identified.
We have attributed to each action a performance level (*, ** or ***). These levels represent the relative performance of actions related to the target considered. An example of the environmental specification is shown on the figure 3.

	Actions related to the sub-target "insulation, thermal mass and solar gain" of the target "management energy"	**Performance**
1	Choice of an interior thermal insulation with ***treatment of all cold bridges***	☆
2	***Knu of windows*** (joineries + glazing) less than 2 W/m².K	☆
3	Control of ***solar protections*** and ***shutters*** according to the occupation of room and to sunny periods.	☆☆
4	Choice of an interior thermal insulation with breakers of cold bridges.	☆☆
5	Choice of a ***distributed thermal insulation*** in the thickness of exterior non-bearing walls.	☆☆
6	Choice of an exterior ***insulation***.	☆☆
7	***Knu of windows*** (joineries + glazing) less than1,8 W/m².K	☆☆
8	More than 70% of rooms are ***oriented between SSO - SSE***.	☆☆
9	***Knu of windows*** (joineries + glazing) less than 1,5 W/m².K.	☆☆☆

Fig.3 : Example of the environmental specification

The assessment of an energetic solution is made target by target. The performance of the solution according to a target is the sum of stars obtained. Scores achieved for each target aren't aggregated together.

The actions defined for a target can have positive or negative interactions with others targets. It is therefore necessary for actors to make a choice and to structure their environmental points of view before assessment.

CONCLUSIONS AND PERSPECTIVES

As environmental actions can have contradictory interactions, define universal solutions which respond on all criteria seems to be utopia. Before assessment, actors must structure their environmental priorities.

At this stage of the study, the assessment of electric solutions has been mainly realised according to environmental criteria related to the energy. At short term, it is envisaged to evaluate them through the overall environmental technical specification defined. At the end of this work, ways of improvements will able to emerge. Results will be presented during the conference.

After that, we should study the acceptability of green efficient solutions in terms of clients, investment and operating costs. Then, these solutions should be validated on site.

Similar reflections are in progress [4] using other assessment methods in other sectors, such as residential (individual and collective residential) and teaching buildings.

In further ways of research, it should be interesting to develop a descendant approach. This approach should consist in defining new solutions (eco-design) from environmental requirements. We can notice that such methods have been already elaborated for products.

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AIRTIGHTNESS PERFORMANCE AND SYSTEMS IN ENEA LABORATORY BUILDING "LA CASA INTELLIGENTE"

G.Fasano, G.Giorgiantoni, G.Giuli
ENEA The Italian Committee for the New Technologies, Energy and the Environment
Department of Energy, Rational Energy Uses Div.

INTRODUCTION

Buiding activity will more and more focus in the future its action in an integrated way including as a whole well being and health of the occupants, external and internal environment, energy, final use destination. We have now a dissemination of studies which focus the attention of the specialists to important items such life cycle cost of the materials, the possibility for recycling the demolition products, the analysis of the processes to manufacture the building components in a more friendly way for the environment, less polluting materials for furnishing and an increased attention for comfort and ventilation, with more emphasis to the exploitation of the natural characteristics of the external environment to achieve the mild insertion of the building in the urban network.

It can be easily recognized at the end, that what we commonly define as ***sustainable building*** is a multidisciplinary approach. Many aspects and sciences are involved. Many studies should be undertaken to finally implement techniques and products and disseminate further results in the scientific community.

Since these needings are widely understood in our country too, it was decided to propose in the framework of MICA - ENEA agreement (MICA is the Italian Ministry of Industry Commerce and Craftsmanship), the building of a permanent structure where research and studies on the field could take place with the necessary permanent support of structures and experience. The steering committee of the agreement finally approved on March 1996 the operative plan in which the activity 2.9.1 had as final goal the construction of a house for civil purposes having low energy consumption, using automated system for energy, indoor air quality and safety management. It was decided to build the facility in the ENEA research centre of Casaccia located at 35 km from Rome. All the procedures for the necessary authorizations were finalized and in the mid of June '98 the excavation works started. At the moment minor finishing works only are still pending for this facility.

PRESENTATION

This presentation deals with the studies which we can undertake and some peculiar characteristics of the systems we installed in this facility.

Airtightness Performance. Data regarding the envelope behaviour of detatched houses are not that common for the Italian situation in the literature. Other situations were investigated in the north of the country for safety studies, but we are aware that the climate is varying widely from north to south, and then readings of the Italian reality would enrich our experience.

The instrumentation to be used includes a blower door [1] which temporarily will be fitted on the entrance opening, data logger and computer with the dedicated software to perform depressurization and pressurization tests up to 50 Pa, to obtain ACH (Air Changes per Hour) and ELA (Equivalent Leakage Area) and in general all the parameters which might be of interest to foresee the behaviour of the house during natural ventilation under the influence of the external environmental agents (wind, wind bluffs etc).

The blower door consists of four components :

- Blower Door Fan
- Door Frame (aluminium model)

- DAB (Data Acquisition Box) 8 channels data logger plus portable computer in which APT (Automated Performance Testing System) ver 1.0 software was installed.
- Accessory case.

Blower Door Fan
The Blower Door Fan consists of a precision molded fan housing with a 550 W AC motor capable of moving up to 10 900 m^3/h of air. Air flow through the fan is determined by measuring the slight vacuum created by the air flowing over the fan inlet when the fan is operating. It is used to blow air into or out of a house. When air is blown out of the house, it causes a slight negative pressure or vacuum in the house relative to outside. This negative pressure induces outside air to enter the house (infiltration) through cracks or holes found in any exterior house surface.The Blower door fan meets the flow calibration specifications of both CGSB Standard 149.10-M86 and ASTM Standard E779-87. To accurately measure fan flows less than 4 100 m^3/h of air, calibrated low flow rings are provided and are attached to the fan inlet. The standard Minneapolis Blower Door system comes with 2 low-flow rings capable of measuring as low as 510 m^3/h. The blower door can be also used to pressurize the house by blowing air into the house and creating a slight positive house pressure relative to outside (exfiltration).
Our section gained significant experience in the implementation of this device and other works were presented in the past [2]. The knoweledge of the infiltrations and the exfiltrations of the building will put us in position to foresee and calculate energy losses, dispersal of the internal pollutants, performance of the ventilation apparatus.
Door Frame
The door frame (and nylon panel) is used to seal the fan into an exterior doorway. It is adjustable to fit any size opening. Final adjustment and sealing are achieved by means of cam levers on the side of the assembler. Significant readings of the instrumentation assembly are shown in the poster.

Home automation. A protocol of EIBA system was installed. This protocol will make the transmission and data management. Since energy management, anti intrusion, alarms, shutter controls, heating, air conditioning and ventilation are the main functions which have to be covered by the electrical system, the need to minimize wiring works, hazards and complication deriving from a conventional distribution of power raised. To find a more effective solution a decentralized system structure which is called *instabus EIB European Installation Bus* developed by a primary European firm was adopted. This system is usually designed as a management system in the electrical installation field, and may be suitable for buildings such business premises, schools, hospitals, factories and domestic residences. For instance the system allows the programming of the intensity of lighting, the visualization with a TV monitor or a PC monitor. Incoming info-messages and/or the status of the system can be seen on the screen. The control of situations occurring simultaneously is hard when relying to conventional systems. The system has a decentralized structure based on a one line system, on which all bus services can communicate without the help of a control center. This is possible through the use of microelectronics, which is the intelligent part of each device. The *instabus EIB* enables managing of all functions and sequences through a single common bus line (two-core cable), also suitable for medium and small electrical installations. Up to 64 bus devices may be connected to each of the lines. For each line a line coupler controlling the address of the telegrams and filtering out the messages determined for another line or area (for instance LC2) exists. In one area 12 lines can be installed and furthermore up to 15 areas can be federated using the bus itself.

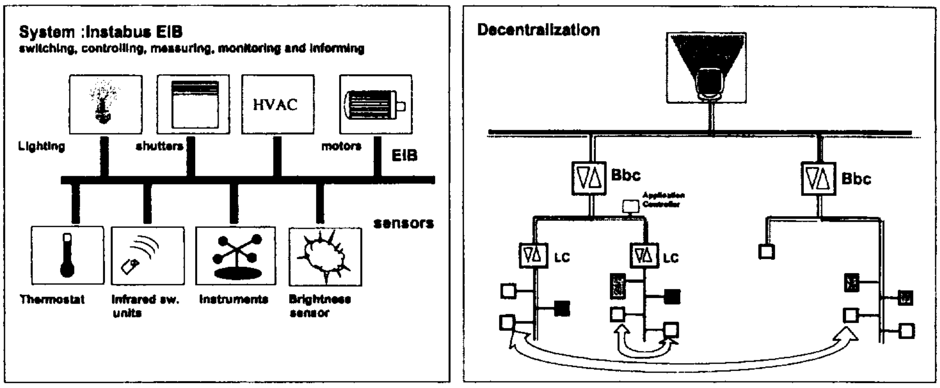

fig. 1

Heating systems : radiant panels performances and results. This system is not diffused in our region. It behaves to the cathegory of "*mild heat systems*" which operating temperature is 25 °C of the heat carrier.

Ventilation system. Performances of new systems such direct expansion split systems or natural ventilation systems will be investigated. In particular experiments on mechanical ventilation and passive stack ventilation will be undertaken. Attention will be given to airtigtness of the building itself, resulting this phenomena in great losses of energy, [2] since we understand from the statistics that one third of primary energy is consumed in non industrial buildings in the OECD countries, such as dwellings, offices, hospitals and schools. Ventilation in dwellings will in the future represent up to 10% of the total energy use. A test matrix was already studied and it is ready for final revision.
In the framework of the participation to the Working Group for the updating of the Italian standard UNI 10339, field tests on ventilation efficiency are in program. As far as indoor air quality is concerned, programs to study the emissions from furnishing materials are foreseen. Agreements with private Italian firms have been undertaken and are under finalization.

CONCLUSION AND RECOMMENDATIONS

This facility which now is near to completion, shows many promising branches of investigation which might be of real benefit for the country. We are understanding that starting from the first ideas of the function of this laboratory, the same increases its possibilities. We are thinking about experiments on controls, disabled people, safety, systems performances and also field tests which fallout might be foreseen for the Italian standards on ventilation and climatization. It is the task of our section to improve and finalize this promising possibilities.

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THE PV INTEGRATED ROOFING PRODUCT.

Michiel Ham
Eindhoven University of Technology
Faculty of Architecture, Building and Planning
Group Building Technology H.G. 11.18
P.O. Box 513
5600 MB Eindhoven
The Netherlands

Summary

A very important aspect of Sustainable Building is the production and use of energy. According to the Dutch building code, a building has to be designed in such a way that the energy use of this building is as low as possible and will not exceed a certain level. Yet energy will be needed to make the building perform its duty's. Consequently the next step in sustainability is to focus on the generation of the energy needed. Wind Energy has proved to be very successful, however application in heavily populated areas is not likely. Photo Voltaic generated electricity (PV) can be a very good alternative especially for housing projects as there are no moving parts and no noise is being produced. PV only needs a well oriented surface preferably facing south. One important condition must be fulfilled : the surface must be free from shadows of trees or other buildings. Surfaces like this exist on many houses and consequently many experiments and projects using PV on roofs have been realized. This paper deals with the development of a integrated roofing product capable of generating PV and performing the roofing functions as well. In this development proven existing techniques are combined in order to create a new product. The new roofing product is designed for both new and existing roofs. Contrary to so many PV projects this product is developed to be mounted on the roof by inexperienced individuals, preferably without subsidies.

Introduction

Many PV projects have been realized in order to show the enormous possibilities of PV and to gain experience with the combination building element and electricity generating. Unfortunately most of these projects could only be realized by many specialists in several fields and consequently there was the need for strong financial support from government organizations.

The enormous potential for PV electricity production is best illustrated simply by looking at the size of the Sahara desert area needed to generate the *entire* world energy needs using PV. It can be calculated that a size of only 800 x 800 km2 is sufficient to generate the entire worlds energy need using PV. [1]

PV must be considered to be the answer to our energy need because of several reasons : the source, the sun will always be there and produces predictable amounts of energy every day. The PV energy is generated without any pollution, noiseless, no moving parts, in short in the most ideal way we can imagine. The problem for today unfortunately is the high cost of PV panels.

Lowering the cost of PV panels will hopefully be boosted by technical development on the one hand and the Global need to produce sustainable energy on the other hand. The task for the building technology researchers is to develop today the building systems in which PV can be integrated. Enough experience is to be generated in order to have the PV concepts ready by the time PV is economically competitive and becomes the real alternative for electricity production.

Many projects have been realized by professionals, almost all of these projects were entirely dependent on subsidies. As more and more individuals are becoming concerned about their personal contribution to the sustainable society, a growing need for the development a ready to fit PV system was observed.
This paper deals with the development of a PV roofing product for the do it your self individual and its consequences.

Analyses.

In the Netherlands most roofs of dwellings are covered using ceramic or concrete tiles. The PV roofing product must be fit in these tiles.
In order to make a PV system function at least three and preferably four items are to be considered. Necessary is a PV panel that is able to catch incoming solar irradiation and convert this solar energy into electrical energy. The PV panel must be placed on the roof in such a way that typical building technology requirements such as wind- and water tightness are respected. Also a device is necessary that converts the DC electricity into domestic usable AC 220 or 127 Volts, the so called "Inverter". In order to have at least some idea how the PV system is actually performing it is desirable to add a meter showing the electrical power being produced. These basic requirements are to be combined with the idea that no professional skills should be needed for mounting the product. This basic assumption brings up the concept of an integrated roofing product with only a wire and a plug to be connected into the domestic electricity system.

Thus the concept is reduced to a box and a wire.

The realization of this idea basically had to be focussed on the building technology items such as wind and water tight and being able to offer this performance for a long period with very limited maintenance.
The problem of a good connection between roofing tiles and a flat element can be considered to be solved in roofing products such as skylights. In these existing and technically proved roofing products the need for inexpensive materials en complex form is answered by using the vacuum forming technique using HDPE, (High Density Poly Ethylene) skylights. This technique offers the possibility to use recycled plastics on the one hand and enables to create spatial forms on the other hand. Using this technique both a form can be made that gives an excellent joint with ceramic or concrete roofing tiles and allows an inverter to be built in thus reaching the goal of a "box with a wire". Adopting a technique known in a specific roofing sector proves ideal to create a product for the developing Sustainable Building sector.

Conclusion

The development of the PV integrated roofing product could be realized on short notice due to use of a combination of existing techniques. In the same way an improved product was developed featuring two PV panels instead of one.
Basically the entire product development consisted more about formulating the right question than creating the answer.
The idea of the development of a do it yourself type product proved to be very successful introducing it into the professional roofing market. As the product was entirely new for this market. The real do it yourself market is probably yet still to be developed and will take some years.

The main problem for the integrated PV roofing product today is the factor money. For the individual there is no economical benefit investing in PV and thus generating Sustainable Energy. A simple calculation learns that installing 100 Wp will cost approximately \$ 350,- to \$ 450,-
Electricity production of this installed 100 Wp in the Netherlands will be an estimated 80 kWh/year.
This represents \$ 7,- to \$ 8,- yield per year and even without interest it would take more than 50 years to have a return on investment. Knowing that the expected life span will only be an estimated 20 years there will be no economical benefit.
In this way PV will need subsidies forever and will never become accepted by the general public on their own roof.

In order to reach the Government declared goal of having 10 % sustainable energy in 2020 other mechanisms must be considered in order to make it attractive to invest in sustainable energy.

In Germany since January 2000 the Yield for sustainable produced electricity is approx. \$ 0.50 kWh, in some areas even a higher yield is given.
In this case a production of 80 kWh is rewarded with some \$ 40,- thus creating the possibility for a return on investment of only 10 years.

Together with a service life of 20 years for the PV system this could stimulate the use of Sustainable energy production by individuals.

In Netherlands some 6 million dwellings exist. If each would be equipped with 4 PV integrated roofing products the production would reach 10 % of the household electricity consumption, using today's techniques.

Discussion.

The developed product is designed as a do it yourself product. Considering the developing PV market it is possible that do it PV yourself will take some more years yet. However an easy to handle product is always an advantage also for the professional sector.

The factor money is still the main problem, if we want 10 % sustainable energy in 2020, are we willing to pay for it based on today's cost ?

[1] http://emsolar.ee.tu-berlin.de/iscb/teaching/od_welt1.jpg

ADVANCED ENERGY EFFICIENCY DESIGN STRATEGIES IN RETAIL BUILDINGS

Sheila J. Hayter, P.E., Paul A. Torcellini, Ph.D., P.E.
National Renewable Energy Laboratory, 1617 Cole Boulevard, Golden, Colorado 80401, U.S.A.

INTRODUCTION

This paper presents two U.S. retail building projects that were designed and constructed using the energy design process. These buildings, the BigHorn Center in Silverthorne, Colorado, and the Zion National Park Visitor Center in Springdale, Utah, were both completed and occupied during the spring of 2000.

To successfully realize any low-energy building, the design team must make cost-effective energy minimization a high-priority design goal. The building's energy use and energy cost depend on the complex interaction of many parameters and variables. This interaction is most effectively evaluated with hourly building energy simulation tools that have passed IEA BESTEST process [Judkoff, 1995]. The team followed a nine-step energy design process was followed throughout the design, construction, and commissioning of these low-energy buildings [Torcellini, 1999]. The design teams consisted of the owner, architect, and engineer, who fully executed each step to ensure the successful design. It was essential for at least one team member to act as the energy consultant and evaluate all design decisions.

Daylighting substantially reduces the electric lighting loads and minimizes the cooling loads in both buildings. Optimized envelope features include improved insulation, engineered glazing selection, and overhangs designed to optimize daylighting and building thermal requirements. The HVAC system includes radiant heating sources (e.g., slab heating, Trombe wall, and electric radiant panels), natural ventilation cooling through automatic window control and downdraft cooltowers (no mechanical cooling), and a transpired solar collector to preheat ventilation air. Photovoltaic (PV) systems incorporated into the design of both buildings significantly offset building electrical demands and loads. Both projects have a net metering agreement with the local utilities to receive full credit for power that the PV system exports back to the grid. The energy management systems (EMS) optimize operation of the electrical lighting systems and other electrical and mechanical systems in the building.

BIGHORN CENTER

BigHorn Center consists of a 1579-m^2 hardware store and a 2044-m^2 building materials warehouse.

BigHorn Center Daylighting Design

Project architects incorporated aesthetic strategies that maximized the building's daylighting potential. The total glazing area was engineered to minimize the sum of heating, cooling, lighting, and ventilation costs while maximizing daylighting availability and avoiding glare in the retail space. Daylighting enters the retail space through south- and north-facing clerestory windows, north-facing dormer windows, and windows on the east and west ends of the buildings. Overhangs over the south-facing windows block summer solar gains and help reduce cooling loads.

Daylight enters the warehouse primarily through an east-facing dormer and translucent insulated ridgeline skylights. Providing daylight to the center of the warehouse was a more important design requirement than avoiding summer direct solar gain. In this particular case, the best design solution was to use skylights; however, it should be noted that this might not be the best solution in all climates and for all building types.

The daylighting distribution in both spaces is improved by reflecting light off the bright white interior ceilings and walls. The hardware store floor tile is also white. Efficient compact fluorescent fixtures (controlled by a photo sensor centrally located in the retail space and a second sensor in the warehouse) provide auxiliary lighting when there is insufficient daylighting.

Computer simulations show that the combined effect of the daylighting system and the energy-efficient lighting fixtures is expected to reduce building lighting loads 79% compared to the base-case building (Fig. 1).

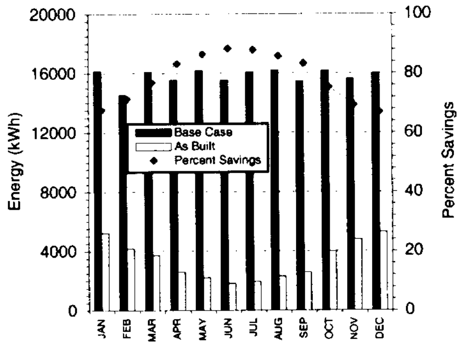

Fig. 1 Monthly lighting energy estimates for the base-case and as-built buildings showing percent savings.

BigHorn Center Mechanical Systems

The building cooling loads were significantly reduced because daylighting minimized the lighting loads and overhangs minimized summer solar gains. The low cooling loads combined with the cool, dry summers (25°C DB/7°C WB) made it possible to use natural ventilation cooling to maintain occupant comfort during the summer.

The natural stack effect induces air movement through the building when the clerestory windows are open. The building's EMS automatically opens these windows when cooling is needed. Ventilation air enters the building though open doors in both the front and the back of the building and through manually operated windows located on the west façade. These open doors neither interfere with normal building activity, nor add security concerns for the owner.

A hydronic radiant slab is used to maintain comfort in the store during the winter without conditioning the large volume of air in the space. Temperature sensors located in the slab relay information to the EMS that governs the hot water produced by the boilers. The slab temperature is adjusted based on the occupancy schedule to provide more heat during occupied hours. Gas-fired, long-tube, overhead, reflective radiant heaters provide heat in the warehouse.

A Transpired Solar Collector (TSC) was installed on the entire available area of the warehouse south wall. The BigHorn Center TSC is 209 m^2 and is constructed of dark brown, corrugated metal with flat slits cut into the material, through which ventilation air is drawn. When the fan is operating, solar energy absorbed by the dark façade is transferred into the warehouse.

PV modules laminated onto standing-seam metal roof panels were installed on the south-facing roof of the hardware store clerestory and the warehouse dormer. The amorphous-silicon PV modules were wired into three arrays, each serving one phase of the three-phase power system. The design capacity of the PV system is 8 kW, and the array covers all the available south-facing roof area.

The EMS optimizes operation of the mechanical and lighting systems in the retail store. The system controls setback of the heating system, operates the automatic window actuators, operates the ceiling fans, and balances daylighting and electric lighting to maintain constant lighting levels.

Building Envelope

The building envelope was optimized to minimize heat loss/gain and infiltration. Extruded polystyrene insulation was installed on the outside of the steel stud walls to minimize thermal bridging. Batt insulation is located between the studs. Insulation was installed under the entire slab in the hardware store. All glazing is double pane with a low-e coating.

Expected Building Performance

Computer simulations show that the energy-efficient building design saves about 21 kW in demand, making it possible to meet a significant portion of the annual building electrical load with an 8-kW PV system.

Figure 2 shows simulation results indicating that the BigHorn Center energy costs are expected to be 62% less than the code-compliant base-case building [Hayter, 2000].

The business plan for the project encompassed the ability to sell "green" products in the retail environment. To that end, the building became a statement to the sustainable mission, and the energy features were an integral part of the building. PV modules integrated into the roofing were an additional cost; however, the marketing value of this investment, coupled with the other features, created a total cost-effective business plan. Even before construction of the BigHorn Center was completed, the owner saw increased sales in his existing facility, which he attributed to the publicity he received for installing the PV system and other sustainable design features.

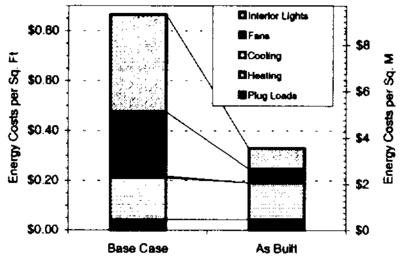

Fig. 2. Energy cost performance of the code-compliant base-case building compared with the as-built building.

The BigHorn Center is one of the first examples in the United States of integrated daylighting and natural ventilation cooling systems in a retail space.

ZION NATIONAL PARK VISITOR CENTER

The Zion National Park Visitor Center and Comfort Station used the same integrated design process. The design team optimized the performance of the aggressive low-energy design strategies into the 808-m^2 Visitor Center complex. Design features include daylighting, unvented Trombe walls, downdraft cooltowers for natural ventilation cooling, energy-efficient lighting, and advanced building controls. Computer simulations show that these features save about 10 kW in electrical demand.

The optimized Visitor Center is smaller than the initial building design. Designers saved space by moving permanent exhibits outdoors and eliminating building mechanical systems. The estimated construction cost of the optimized building is 40% less than the initial design [NREL, 2000].

Zion National Park is located in a remote area of southern Utah, where power reliability is an issue. For this reason, an uninterrupted power system (UPS) was required. The only additional cost to convert the UPS to a PV-for-buildings system was the PV array because the battery storage and balance-of-system components were already a part of the design.

A 7.5-kW roof-mounted PV system was installed on the south-facing roof of the Visitor Center. Because the daylighting and natural ventilation cooling systems minimize electrical loads, designers anticipate that the building's PV system will export power to the utility grid during the summer. During power outages, the building control system will shut down nonessential electrical loads so that the PV/UPS system will be capable of supporting enough building operations to continue business.

SUMMARY

Using a whole building energy design process, two buildings were designed and constructed for similar costs as conventional construction. These buildings are currently being monitored to verify their anticipated energy performance. Initial data indicate that both buildings are operating according to their designs. The key to successful completion of these buildings was a committed owner and a design team willing to achieve established energy goals.

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TRNSYS 15 – A SIMULATION TOOL FOR INNOVATIVE CONCEPTS

M. Hiller, S. Holst, A.Knirsch, M. Schuler
TRANSSOLAR Energietechnik GmbH, Curiestr.. 2 , 70563 Stuttgart, Germany,
fon: +49 711 / 67976-0, fax: +49 711 / 67976-11,http://www.transsolar.com, hiller@transsolar.com

1. INTRODUCTION

In the planing process the application of building simulation for developing and evaluating energy concepts is increasing. The growing commercial usage make new demands on the software. The new version of TRNSYS, TRNSYS 15, considers these demands by improving both, user interfaces and modeling capacity. For the building simulation, the main novelties concern the simulation of thermo-activated building components and solar buffer zones. These new models provide not only a higher accuracy but allow a simple user-friendly input and therewith reduce the error-prone.

2. NEW: SIMULATION OF THERMO-ACTIVE BUILDING COMPONENTS

Thermo-active building components (slabs or walls of a building) are used to condition buildings by integrating a fluid system into massive parts of the building itself. Examples are radiant floor heating or cooling systems, radiant ceilings or wall heating or cooling systems.

Due to the fluid pipes a multi-dimensional heat transfer problem has to be solved for calculating thermo-active construction elements. Usually, a Finite Element Method (FEM) or Finite Difference Method (FD) is applied for such problems e.g. TRNSYS component TYPE 160 [1]. Therefore, the building component to be examined needs to be transformed into small three-dimensional grid cells. In order to achieve a sufficiently high level of precision, the grid must be sufficiently dense. In general, this leads to complex calculations and long calculation time. In addition, a certain level of experience is required for creating the geometric input and an effective grid design.

For this reason, a more powerful alternative method for modeling thermo-active construction element systems was developed by EMPA [2] and integrated in the multi-zone building model TYPE 56 of TRNSYS 15. The integrated model is based on solving the stationary differential equation for heat conduction.

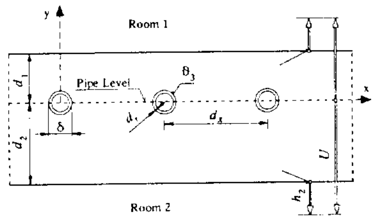

Figure 1: Typical structure of a thermo-active construction element

The heat conduction through the element is reduced to a one dimensional form by applying resistance models. Thereby, the existing transfer function method of the building model TYPE 56 for walls can be used for solving the one dimensional heat conduction problem. The developed theory can be applied for dynamic simulation by a smart approximation. Due to the large thermal mass of thermo-active components a dynamic (time-dependent) simulation of its behavior is important.

The model is defined easily within the building description as a "wall" with an so-called active layer. As input data for the active layer geometric data e.g. pipe spacing and property data e.g. pipe wall conductivity and fluid data e.g. inlet temperature are required only.

In the following, a comparison of both models, the new integrated model and the finite difference model TYPE 160, has been performed for a continuously operating concrete core cooling system. The simulated room is a typical south facing office (21 m^2) with an unsuspended concrete ceiling. The simulation is performed for 8 hot summer days according to VDI 2078. For TYPE 160, the ceiling with the concrete core cooling is modeled by 500 temperature nodes. The ambient temperature, the air temperature, ceiling temperature and supply and return temperature are shown for the last 4 days in figure 2.

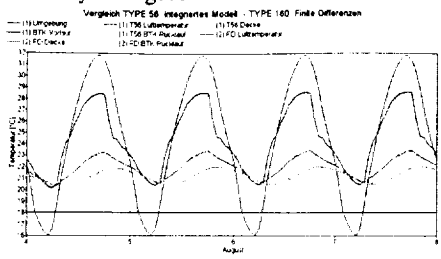

Figure 2: Resulting temperatures of comparison

The resulting temperatures of both model indicate a good agreement. The simulation time of the integrated model of TYPE 56 is only 1/5 compared to the simulation time of the finite difference model TYPE 160. Therefore, TRNSYS 15 includes now a building model offering an easy-to-use and efficient way of modeling thermo-active building components.

3. IMRPOVED: SIMULATION OF SOLAR BUFFER ZONES

For the simulation of solar buffer zones the modeling of solar short wave radiation is important. Therefore, significant improvements have been integrated in TRNSYS 15 which reduce the input effort and the error-proneness drastically including a higher accuracy.

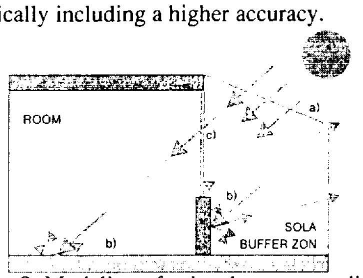

Figure 3: Modeling of solar shortwave radiation

a) Incoming solar radiation (external windows)

Since version 14.2, an extendable standard library of typical window and glazing systems is included. This library contains detailed data like angular dependent transmission, reflection and absorption of single window panes based on WINDOW 4.1. In addition, various external and internal shading devices can be defined.

b) Solar distribution with a room

The new distribution model enables a separate treatment of beam and diffuse radiation within a room. The diffuse radiation is distributed by area absorptance weighted ratios to all surfaces of a room. For beam radiation distribution factors are introduced. The distribution factor of a surface represents the percentage of incoming beam radiation that strikes this surface. The movement of the sunlit parts within a room, from an east oriented wall in the morning, over the floor at noon to the west oriented wall in the evening hours can be modeled by time-dependent distribution factors.

c) Forwarding solar radiation (internal windows)

In general, solar buffer zones are placed in front of a "real" room whereas the separating wall is mainly transparent. Therefore, a large amount of the incoming solar radiation is forwarded from the buffer zone to the room behind it. In TRNSYS 15, the user simply defines an adjacent window between the buffer zone and the room. The same detailed window model is applied as for external windows taking into account the angular dependencies. In addition, shading devices can be defined.

5. FURTHER IMPROVEMENTS

For consulting work the evaluation of thermal comfort in buildings is a common task. Temperatures only are insufficient as an indicator of thermal comfort. Due to these facts a comfort evaluation according to EN ISO 7730 [4] is integrated in the multi-zone building model TYPE 56 of TRNSYS 15.

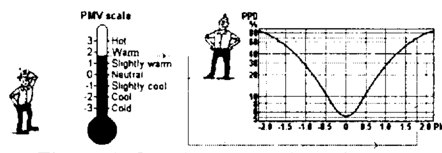

Figure 4: Comfort evaluation with PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied)

Besides the multi-zone building model other models have been improved and new components have been added. (A complete list is available on our web page http://www.transsolar.com). An interesting new feature of TRNSYS 15 is possibility to call external DLL's (Dynamic Link Libraries). This feature provides a comfortable integration of new components which are not written in FORTRAN or not directly for TRNSYS.

IISIBat – graphical input interface

For users especially in commercial application the program interfaces play an important role. The graphical input interface **IISiBat** has been completely rewritten in C++ and offers now all the comfortable features of modern window programs. In addition, suggestions of users such as layer techniques, improved project and component management and exchange are realised. A new feature is the so called "DCK reader". Therewith, IISiBat is not only able to create a TRNSYS Input file (in ASCII) but also to read in a TRNSYS input file and to recreate a graphical display of the defined system.

SIMCAD for TRNSYS

SIMCAD is a new object oriented CAD tool designed specially for generating building description data for the simulation with TRNSYS. Besides the reduced effort for creating the building geometry data the possibility of visualization the entered data is a major advantage. Since SIMCAD is a standalone programm it does not require any licenses of other CAD packages

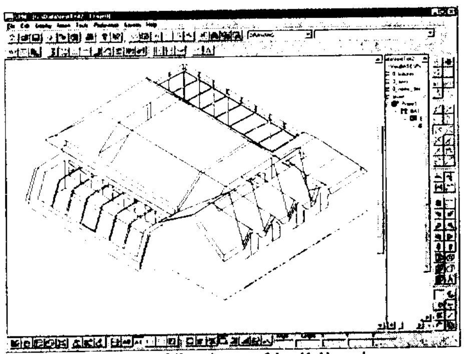

Figure 5: 3D view of building input

6. CONCLUSIONS

Responding to a growing commercial application new developments of both user-friendly interfaces and mathematical models have been implemented into TRNSYS 15. For the building simulation, the main novelties concern the simulation of thermo-activated building components and solar buffer zones. These new models provide not only a higher accuracy but allow a simple user-friendly input and therewith reduce the error-prone significantly. Also, interfaces like the new IISiBat and SIMCAD for TRNSYS add to the reduction of input errors. For the advanced users features for calling external programs or DLL's increase the flexibility of the program. Due to these new features TRNSYS is an even more powerful tool for the thermal simulation of buildings and energy systems that satisfies new demands of innovative and forward-looking energy concepts.

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IMPROVING THE SIMBAD TOOLBOX FOR THE DEVELOPMENT AND ASSESSMENT OF INTEGRATED CONTROL STRATEGIES

Authors: Ahmad HUSAUNNDEE, Augustine BOLHER, Mireille JANDON, Jean-Robert MILLET, and Jean-Christophe VISIER

CSTB
BP 02, F77 421 Marne la Vallée Cedex 02, France
Phone: +33 1 64 68 83 18
Fax: +33 1 64 68 83 50

ABSTRACT

Smart control systems can improve the overall performance of the energy management in buildings as well as indoor comfort. Thus, improving the control system is one of the most cost-effective approaches to saving energy while abiding to comfort constraints. Currently, the different building applications (HVAC system, Lighting system, solar protections, etc.) are mainly controlled separately. Recent projects focused on simultaneous management lighting and solar protections for energy saving by optimal use of natural lighting to provide visual comfort to occupants. The following step is to link the management of lighting & solar protection equipment with HVAC systems with the same target of reduction of energy consumption. The present work makes use of a building equipment toolbox (SIMBAD) of a general-purpose simulation tool to set up simulators for the design of integrated control strategies.

KEY WORDS

Lighting systems modelling, natural lighting, HVAC models, integrated control, system simulation

INTRODUCTION

With increasing environmental awareness, improving energy management systems is still a concern in the building sector for a reduction of energy consumption. This is coupled with an increasing demand for better indoor comfort following tighter regulations and user demands. The use of intelligent integrated control systems seems to be an efficient way to achieve such aims by enhancing communication among different applications.

The development of such control strategies implies the use of simulation techniques for the study of their impact on the controlled building zone. SIMBAD (SIMulator for Building And Devices), developed by the CSTB, is used for such studies.

This paper presents the progress in SIMBAD toolbox which was initially dedicated to HVAC equipment to include models of lighting and solar protection equipment. The models are used to build simulators adapted for the modelling of integrated control strategies.

SIMBAD BUILDING AND HVAC TOOLBOX

SIMBAD [1], is developed in a general-purpose simulation tool (MATLAB/Simulink [2], [3]). The toolbox consists of a building zone model, models of heating ventilating and air conditioning components, controllers of such equipment and various utilities (weather data files, occupancy profiles...) that are necessary to build up virtual systems to study the behaviour of HVAC plants.

The toolbox benefits from the user friendliness of the Simulink graphical environment and uses the "drag and drop" method of the graphical environment to select the components required. The latter are linked together to build the systems.

One characteristic of the toolbox is the definition of connection vectors to transfer data from one block to another: air vector carrying air vector, water vector, information network, weather vector... These connection vectors enable the user to build the systems following the actual layout of the plant either on the air-circuit or water circuit.

Another important aspect of the models within the toolbox is that they use parameters that can be obtained from manufacturer's catalogues, data from certification bodies, norms...

To facilitate the use of the toolbox, the building zone model is provided with a list of predefined buildings. In fact, for control studies, the user need to verify that the control strategies or individual controllers are suitable to a class of buildings instead of one particular building.

THE BUILDING ZONE MODEL

The first main modification is brought onto the building zone model. The existing model represents the thermal behaviour of the building by second order differential equation following a thermal-electrical analogy [4]. The model gives a resultant air temperature and a mean wall surface temperature. The influence of solar radiation is taken as a heat flux on one node.

To integrate illuminance phenomena and in parallel a better model of solar radiation, the model requires a specific modelling of the window and also of solar protection equipment.

The level of modelling of natural and artificial lighting is restricted to its use for control studies. The model does not give a close representation of the actual illuminance distribution in the zone but an average value taken to be on the working plane at the centre of the zone. This assumption is related to the fact that the illuminance sensor used in the control loop gives only an average value over a restricted area of the zone.

Window and solar protection models

Natural lighting

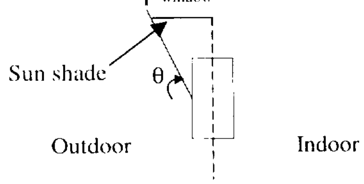
The model is based on the simplified model of COMET [5]. Natural light in the zone depends on:

- The vertical illuminance on the window
- The characteristics of the window
- The characteristics of the zone (size, reflection factors...)

The vertical daylight factor used here is defined as the ratio of natural lighting to outdoor vertical illuminance is given as:

$$DF_v = \frac{2.t_d \cdot A_b \cdot \theta}{A_t \cdot (1 - R^2)}$$

t_d Transmission factor for diffuse light
A_b (m²) Surface area of window
A_t (m²) Total surface area of internal walls
R Mean reflection coefficient for internal walls of the zone
θ (°) Angle of vision of the sky from the centre of the window in a vertical plan perpendicular to the window



To include a screen blind, the window is divided into two parts following the position of the blind and two different transmission factors are used.

We note that the model takes into consideration direct sunlight that is transmitted directly and also in "diffuse form" They appear as different coefficients in the calculation of the transmission factor.

Solar heat gain

In a similar way, the solar heat gain into the zone is calculated using a transmission coefficient for the shaded and unshaded part of the window following the position of the screen blinds. Typical values of the transmission factor are used [6].

Artificial lighting

Modelling of luminaires

The model gives the artificial light flux following the command of the controller using the following equation:

$$Flux = C \times \frac{ELI \cdot P_{Lamps} \cdot \eta}{MF}$$

C (0-100%) Command from controller
ELI (lm/W) Luminous efficiency
P_{lamps} (W) Power of lamps
η (-) Efficiency of luminaires
MF (-) Maintenance factor of luminaire

Artificial illuminance on working plane

The impact of artificial lighting in the zone is given by:

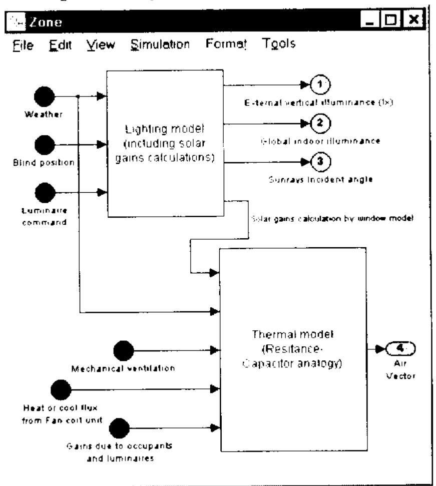
$$E_{art} = \frac{Flux \cdot U \cdot Ce}{S_{floor}}$$

U the Utilance factor
Ce the space overcrowding factor,
S_{floor} (m²) the floor surface area
Flux (lumen) the effective illuminance flux emitted by the lamps.

The average illumination on the working plane is the sum of the artificial and natural light.

Implementation in Simulink graphical environment

The new models appear as separate blocks in the graphical environment. The building zone model thus consists of a thermal model and a lighting model. The latter includes the calculation of solar gains via the window & solar protection. The thermal model now receives an appropriate calculation of solar gains following the blind position.



The building zone model for thermal and lighting phenomena

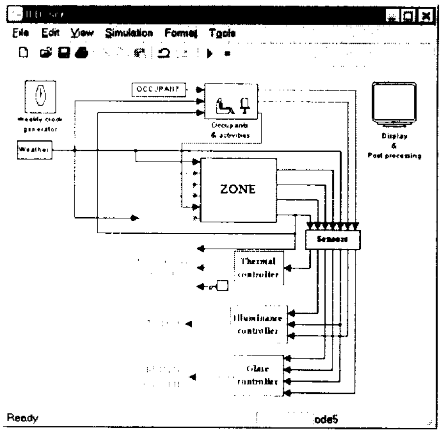
MODELLING AN INSTALLATION FOR INTEGRATED CONTROL

Prior to modelling the installation it is important to consider the appropriate "environment" of the system. In this case it refers to the weather data and the occupant's behaviour. The control studies require short time step weather data files since it is important to monitor sharp changes in outdoor illuminance due to "clouds" on the behaviour of the control loop. As regards the behaviour of occupant, the occupation of the offices is considered either full day from 8.00am to 6.00pm or with 2-hour interruption at lunchtime. Besides the action of the occupant on the lighting equipment is also simulated as: switching on at 9.00am, 2.00pm, and 4.00pm or switching off at 10.00am. These scenarios are used to determine the robustness of the control strategies.

The installation, set up for the definition of the control strategies, represents a zone with a fan-coil system for heating and cooling, a single row of light with electronic ballast and a screen blind.

The installation is built using the generic scheme developed in [7] using the general system theory. In the control system the following rules are applied:

- The blind controller has a priority to limit glare using a step by step control of the blind position following the position of the sun.
- The light controller adjusts the illuminance level to have the minimum level on the working plane. It can be a PID controller for lights with electronic ballast or on/off control with a hysteresis.
- The HVAC controller adjusts thermal comfort. In this case, the fan coil unit has a PI control.



The complete zone model for assessment of integrated strategies

The system shows fully independent control of the applications. It can be considered that for communication between controllers:

- The blind can answer to a request of the light or HVAC.
- The light controller can request blind for more natural light
- The HVAC controller can request the blind to reduce solar gains or ask the light to switch on to bring more internal gains.

The definition of integrated control strategies requires prior definition of the information exchange among controllers at the zone level but also with the plant control and energy management system. The integrated control strategies are being studied within a European project INTECOM involving 3 research centres, 1 university and 3 manufacturers.

The system modelled can be further converted into an emulator to test real prototypes of the integrated controllers developed by the manufacturers.

CONCLUSION

The SIMBAD toolbox now contains the appropriate models to test integrated control strategies. The user-friendliness of the graphical environment enables different models of the controllers to be plugged in with different information flow and tested on the same installation. This enables comparison of integrated and non-integrated strategies but also the influence of the types of data exchange between applications.

Once real prototypes of the intelligent controllers are available the block representing the controllers on the installation can be replaced by communication blocks to the real prototypes. The simulator then functions as an emulator in real time.

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THERMAL STORAGE FOR SUSTAINABLE DWELLINGS

Kenneth Ip PhD MSc MCIBSE CEng, Jonathan Gates BSc
University of Brighton, School of the Environment, Cockroft Building, Lewes Road, Brighton, United Kingdom BN2 4GJ

INTRODUCTION

In the UK residential buildings account for 27% of the final energy consumption (Department of Trade and Industry, 1999). It can therefore be argued that the use of solar energy in this sector has great potential for reducing energy consumption and CO_2 emissions. The main problem with utilising solar energy is that its availability is often intermittent, variable and unpredictable. These problems can be addressed by an active solar combisystem using phase change material for thermal storage. This paper focuses on the potential that such a system presents in reducing winter space heating demand.

THERMAL STORAGE

Thermal storage can either take the form of sensible heat storage (SHS) or latent heat storage (LHS). Latent heat storage is accomplished by changing a material's physical state whereas SHS is accomplished by increasing a material's temperature. To store the same amount of energy smaller quantities of material are required for LHS than for SHS. This can be illustrated by using a common building material such as concrete, which has a sensible heat capacity of approximately 1.0 kJ/kg (CIBSE, 1986b) whereas a phase change material (PCM) such as calcium chloride hexahydrate can store/release 193 kJ/kg of heat on phase transition (Lane, 1983). A further advantage of LHS is that heat storage and delivery occurs at a constant temperature, which makes it ideal for reducing temperature fluctuation in space heating applications.

PHASE CHANGE MATERIALS

An ideal PCM should fulfil a number of criteria such as high heat of fusion, high heat capacity, high thermal conductivity, small volume change at phase transition, be non corrosive, non toxic, non flammable and exhibit little or no decomposition or supercooling (Ghoneim et al., 1991). Organic and inorganic compounds are the two most common groups of PCMs. Inorganic compounds have a high latent heat per unit mass and volume, are low in cost in comparison to organic compounds and are non-flammable. However they can suffer from decomposition and supercooling which can affect their phase change properties. Most organic PCMs are non-corrosive, chemically stable, compatible with most building materials and have a high latent heat per unit weight. Based on the selection criteria established two PCMs namely calcium chloride hexahydrate and sodium sulphate decahydrate are being considered for use in the current research.

STORAGE SYSTEMS

Phase change materials need some form of containerisation in order for them to be used for thermal storage in buildings. This presents a challenge to the choice of PCM and the method of containerisation. A number of proposed systems encapsulate the PCMs in building materials such as plasterboard (Feustel, 1995) (Salyer and Sircar, 1997), building blocks and concrete (Chahroudi, 1978) (Salyer et al., 1995). Other systems rely on bulk storage, where large amounts of PCM are stored in tanks or cylinders, in these systems a secondary medium is required to 'transport' the heat. In 1998 Ip proposed a system for solar energy storage and space heating. It comprised of an array of solar collectors and lengths of double walled metal tubing in which the PCM (calcium chloride) was encapsulated between the pipe walls. Computer modelling showed that this system had the potential to reduce energy savings between 18–34% (Ip, 1998).

However the sustainability of the above systems can be questioned in that some of them store heat that is generated from electricity and the system components and the PCMs are not recyclable. Some other disadvantages of these systems are that they can take up a considerable amount of space and building layout can restrict their use. The proposed system in the current research attempts to address these issues which include: sustainability, service life, ability of the components to be recycled, ability to be installed in both new build and retrofit applications and the ability to maintain internal design temperature.

SYSTEM CONFIGURATION

The proposed system is a combisystem that will be able to contribute to both space heating and hot water demand. The system consists of evacuated tube collectors with heated water being stored in a highly insulated tank. A number of panels that are filled with PCM are interconnected as illustrated in Fig. 1. The panels are made from recycled plastic with small-bore recycled plastic pipework running through them. Once filled with PCM the panels will be sealed but provision is made to allow the PCM to be emptied from the panel. A series of PCM panels can be joined through pipe connections at either end. These panels can be installed either between or on top of floor joists or on a concrete slab. The panels are 1 – 1.5 m long to ease handling and 400 – 600 mm wide to facilitate fitment between floor joists. Water heated by the solar panel will be used to charge the panels and during the summer when space-heating demand is low, this water will only be used to meet hot water demands. Back up heating will be provided by a combination gas boiler or a wood stove. Electricity generated by photovoltaic cells (PVs) will be used to drive the circulation pump in the solar collector's closed water circuit.

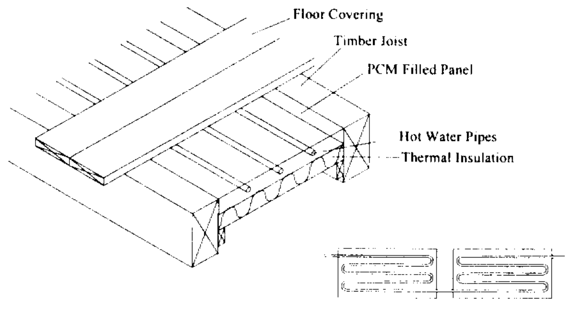

Fig. 1. Proposed System Diagram

ENERGY SAVING POTENTIAL

The energy saving potential of the system is dependent on solar availability and the efficiency of the thermal storage system. Solar availability in the SE England is amongst the highest in the UK. A south-facing surface inclined at 30° to the horizontal in SE England would receive an annual mean daily solar irradiation of approximately 9.8 MJ/m^2 (CIBSE, 1986a). An initial estimation of the solar energy captured, using a collector efficiency of 70% and system efficiency between 25% - 50%, shows the system has the potential to capture between 1.7 MJ/m^2 – 3.4 MJ/m^2 of solar energy.

Applying this in conjunction with previous work (Ip, 1998), for a two storey 3 bedroom house with a total floor area of 100 m^2 and a heating load of 1.6 MJ/ m^2, using a collector area of 6 m^2, would produce energy savings in the range of 6% - 12.5%. This figure excludes additional energy savings attributed to the ability of the system to meet domestic hot water demand. It must also be noted that further reductions can be expected if the system is used in a low energy building incorporating passive solar architecture. The use of a PV powered water pump not only saves energy but also maintains the system efficiency, by automatically adjusting the water flow rate in response to the solar availability.

EXPERIMENTAL DESIGN

The next phase of the research involves setting up an experimental model of the proposed system to evaluate its thermal performance and compare it with the computer simulation predictions. This experimental work aims to establish relationships between the solar energy, phase change heat storage and heat contribution to space heating. It is anticipated that the results can be used for practical design purposes.

CONCLUSION

The use of an active solar combisystem incorporating PCM has tremendous potential for reducing the impact of residential buildings on the environment and can help in the long overdue move to dwellings that are more sustainable. A combisystem offers the possibility of providing all year round reductions in energy use and CO_2 emissions. The proposed system uses solar energy, which is renewable, and the components are either from recycled materials or designed to be recyclable. This paper has identified the potential of the proposed system to reduce space heating requirements and the need to establish design data for practical and wider applications.

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APPLICATIONS OF ELECTRICITY AND SUSTAINABLE BUILDINGS EXAMPLE OF A DETACHED HOUSE

M.H. Laurent, L. Tabary, N. Chatagnon
EDF Pôle Industrie / R&D Division / Les Renardières 77818 MORET SUR LOING Cedex France

GENERAL LAY-OUT

There is no doubt that protection of the environment is an increasing concern. Nevertheless, it does not cover the same concepts in all developed countries. In Latin countries, the environment forms part of our immediate lifestyle, and includes the district that we can see from our window, the air that we breathe. In the English-speaking world, concern for protection of the environment applies more to conservation of large untouched areas (Amazonia, Antarctica), preservation of the planet.

In France, public authorities talk about the concern to protect the planet on the world scale. This is also resulting in increasingly severe national energy saving and generation regulations. Incentives to energy savings were justified in the past by the need for energy independence of France and economic constraints, and will continue in the future due to new impulse defined in environmental regulations.

In France, building, public works and development companies agree on the concept of the " EHQ " (Environmental High Quality) building. The EHQ nature of a building depends on two aspects :

- respect of the environment throughout the entire building life cycle (construction, operation,...),
- respect of the health of occupants and the quality of its indoor ambiance.

SIMILARITIES IN ELECTRIC AND ENVIRONMENTAL APPROACHES

In general, it is worth noting that the first "climate system" with Direct Electric Heating, was invented by electrical industry (to improve indoor comfort), and the concept of systems is essential for energy optimisation of buildings. Moreover, the relatively high cost of electrical energy naturally oriented R&D efforts made by manufacturers in this industry towards reducing consumption of electrical uses and a global analysis (system + building structure). Since the only way to reduce a customer's electricity bill was often to consider all his electrical uses and their interactions with each other (as for an EHQ building), the electrical industry has developed extensive know how that is useful for reducing consumption of electricity applications, which has beneficial effects on uses related to other energies (sizing, control, efficiencies, thermal insulation).

Less generally, it is worth mentioning a few examples of electricity uses that could directly participate in improving the design of EHQ buildings :

- energy efficiency :
  - ◊ cooking : microwave oven (better energy efficiency since there is no need to heat the cavity) and induction hobs (better energy efficiency since the saucepan is not heated, no thermal inertia),
  - ◊ washing by ultra-sounds,
  - ◊ climatic use: reversible thermodynamics (EER equal to at least 2) with a sufficiently wide power range to enable a variety of uses (preliminary heating of new air),
- air quality improvement : electric cooking appliances and heaters do not generate local pollution as CO, NO, NO_2, SO_2 [1],
- air treatment : UV, pyrolysis,
- water treatment : membrane techniques for treatment of water and liquid waste, use of UV to prolong storage or use rain water.

AN ENVIRONMENTALLY FRIENDLY ELECTRIC HOME

In 1998, EDF organised an architecture and engineering competition for a detached house (the dream home of most French families) [2]. The purpose was to design a modern house equipped with equipment available on the market and not requiring any special developments.

The specification

- a house for "living in" offering a pleasant lifestyle to a family of 4 persons within a living area of 150 m².
- a flexible house, in other words offering an upgradable internal area capable of matching new lifestyles (e.g. work at home) and the change in the family structure,
- a comfortable house in many respects :
  - ◊ indoor temperatures in summer and in winter ("four seasons" comfort),
  - ◊ acoustic, with respect to outdoor noise equipment noise, and also indoor noise,
  - ◊ visual (view outdoors, natural lighting),
  - ◊ ambiance and Indoors Air Quality.
- an environmentally friendly house through:
  - ◊ a reduction of its impacts of the environment, from its construction to its demolition. In particular during its life - low energy and water consumption,
  - ◊ its integration into its immediate environment.
- low energy operating costs. (see table 1)

	Total euro/year	euro inc. VAT/year.m²
heating + cooling	572	3.8
Dom. Hot Water	229	1.52
lighting	114	0.76

Table 1 : targeted operating costs for 1998 competition

The results

The winning pair (Pierre Lombard, Architect and Olivier Sidler, Consulting Engineer) adopted a global approach to optimise the selected solutions and offer a very coherent project in which each technical and architectural choice is important.

Globally, energy consumption is reduced of more than 50% when compared with current references.

The construction cost (including annexes), is 216 478 euros (inc. VAT) for an inhabitable area of 125 m² (to which another 133 m² of unheated annexes should be added representing a third of the total investment cost).

NB : these annexes could be reduced to reduce the construction cost.

The solutions proposed

Architectural choices

The prize-winning house has a "bio-climatic" architecture :

- house oriented so as to maximise solar inputs in winter.
- large well-oriented vertical windows, construction of a large integrated veranda at the south so as to benefit for solar radiation in winter while providing protection from it in summer (upper part covered and insulated, top and bottom openings enabling free cooling ventilation at night).
- plants used to improve comfort in summer : trellis with deciduous plant cover providing shade over the top of the veranda.
- house oriented to protect it from the dominant cold winds (redirected by the sloping roof),
- construction of buffer rooms at the north (garage, workshops, attic, cellar,..)
- cylindrical main volume (exchange area less than for a cube, for the same volume).

(kWh)	reference Consumption	improv. (%)
heating	10507	57%
Domestic Hot Water	3594	52%
lighting	940	79%
appliances (exc. cooking)	3145	50%
cooking	760	40%
Total	18946	55,4%

Table 2 :energetic results from winning project (reference is constituted by regulatory requirements and/or common practices)

Thermal comfort

Extra insulation : outside thermal insulation triple glazing,

High thermal inertia and good energy management.

This set of choices results in natural cooling of the house. Heating is ensured by:

- electric radiating ceiling (good comfort and high energy efficiency),
- complementary very efficient fireplace,
- regulation.

Ventilation and Indoor Air Quality

Considering the little progress made in existing techniques (as CO_2 sensors, treatment of incoming air) and the higher cost of more efficient techniques (as dual flow), ventilation is controlled by a conventional mechanical ventilation system with regulated humidity. The materials used inside the house do not require any surface treatment (slate or linoleum floors, untreated wood for the veranda,..)

Domestic hot water

- use of economic showers and reductions in the length of the distribution network
- use of solar energy (3.3 m^2 sensors, double tank - solar tank + additional electrical tank, systematic preheating of water by the solar tank).

Limitation of heat losses due to storage and distribution (short, star, insulated network).

Household appliances

- priority has been given to the use of appliances without standby (computers, microwaves) or if not possible with simple or controlled cutoff devices,
- oven and refrigerator not close to each other,
- natural area for drying the washing,
- induction plates on the cooking hob (low energy consumption, no inertia) and extra insulation around the oven.

Lighting and visual comfort

- large amount of natural lighting. For further comfort, remaining lighting needs have been provided by multiple points with a variety of light fittings, but all based on a design compatible with the use of compact fluorescent lamps to reduce consumption by a factor of 3 to 5 (simply replacing conventional incandescent lamps by compact fluorescent lights without changing the light fitting degrades the degree of visual comfort).

Acoustic comfort

- Outdoors noise : fresh air through the veranda (noise buffer area), and windows with triple glazing,
- Noise related to equipment operation : appliances with excellent acoustic attenuation, heating mode chosen without noise.
- Noise inside the home : mobile partitions between rooms made from materials with high sound absorption, use of acoustic bricks with hollow compartments.

Flexibility

The house in this project is organised for use by a family of 4 persons with two children. Frequently used areas can easily be modified : the open kitchen can be concealed by a curtain, the office area can be isolated by a removable mobile partition,... The different use of annexes also opens up future possibilities : independent apartment for children and teenagers, a second home with independent access...

CONCLUSION

The example of the competition launched in 1998 by EDF demonstrates that electricity can serve as main energy into an environmentally friendly home.

However one should not forget that tomorrow's sustainability will rely onto 2 other main characteristics which have to be taken into account in the building sector:

- the ageing of the building stock (80% of the residential buildings that will exist in 2030 are already built today). It is more difficult (technically and economically) to guarantee comfort and high energy performance if the building is not well designed,
- the increasing poverty of a part of the population which should induce the search for affordable solutions.

Electricity companies have made many development efforts to improve the energy efficiency of electrical uses, with the initial purpose of economic competitiveness. Electricity applications can undoubtedly contribute to the design of EHQ buildings, and some can even improve buildings either by their high energy efficiency, or by their ability to improve the Indoor Air Quality and the quality of water.

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AIR HANDLING SYSTEMS WITH LOW ENERGY DEMAND

Mäkinen, Pekka, M.Sc. (Tech) [1], Railio, Jorma, M.Sc. (Tech) [2]

[1] ABB Fläkt Oy, Kalevantie 39, 20520 Turku, Finland
[2] Association of Finnish Manufacturers of Air Handling Equipment, Eteläranta 10, 00130Helsinki, Finland

INTRODUCTION

The aim of this contribution is to discuss the design criteria of air handling units (AHU's) and air distribution systems, to meet the need to reduce the electric power and energy consumption in the air handling systems.

Traditionally, attention has been paid primarily on the demand of thermal energy in buildings, for heating and cooling. However, the electrical energy required in the air distribution systems can become even many times higher than the heating energy demand in modern buildings.

Preliminary studies have revealed that very simple measures, together with attention to life-cycle costs (LCC), can result in significant energy and cost savings. The measures should be realistic: for example, reducing the pressure drop of filters is desirable, but if this requirement prevents high-quality filtering completely, the end result is questionable. Therefore it is necessary to compare different technical solutions as real alternatives only if they can provide exactly the same indoor environment.

Within these conditions it is possible to build decision-making tools for designers and their clients to optimise the energy demand of building services. These tools include measurable target levels for overall electrical energy consumption, to be applied at early design stages. For detailed design, for example selection of air handling units, tools to assess product characteristics are needed in order to fulfil the overall target in a cost-effective way.

Activities to develop a common methodology and design tools are ongoing also among European industry (EUROVENT), and in European standardisation (CEN/TC 156).

SFP UNIT, Specific Fan Power

-Definitions

The unit SFP is defined as the ratio between the power input for the fans and the maximum air volume flow rate, as follows:

$$SFP = \frac{\sum P}{q_{\max}}$$

where

SFP is the specific fan power demand of the building [kW/ (m³/s)]
ΣP is the sum of the electric power supplied to all the fans in the building [kW]
q_{max} is the largest design supply or exhaust air flow in the building [m³/s]

For individual AHUs, another index SFP_v is applied:

$$SFP_v = \frac{P_{SA} + P_{EA}}{q_{\max}}$$

where

SFP_v is the specific fan power of an AHU [kW/ (m³/s)]
P_{SA} is the power supplied to the supply air fan [kW]
P_{EA} is the power supplied to the exhaust air fan [kW]
q_{max} is the largest supply or exhaust air flow in the AHU [m³/s]

-Classifications

Five categories have been defined in prEN 13779 for the SFP index:

category	*maximum SFP.*
SFP 1:	1,0 kW/ (m^3/s)
SFP 2:	1,5 kW/ (m^3/s)
SFP 3:	2,5 kW/ (m^3/s)
SFP 4:	4,0 kW/ (m^3/s)
SFP 5:	not defined

Of course it is not always desirable to aim at the most stringent category. The most important thing is to pay a proper attention to the energy demand of the air distribution systems.

SPECIAL QUESTIONS

-What is behind fan efficiency? The overall efficiency is affected by many factors. The efficiency measured for the standalone fan is only one factor, to be multiplied by efficiency ratios of the motor, the belt drive, the speed control system, and the system effect ratio.

-Component selection in AHU's and ductwork

--the energy-efficient design of components includes consideration of each component, and also attention to the influence of one component to others.

--tables are presented in prEN 13779 to show some guidance values for pressure drops

--pressure drops of individual components are presented not as binding values, but as recommendations for good design

STANDARDS

Attention has already been paid on the energy efficiency of systems in Draft European Standard prEN 13779.

The CEN Public Enquiry on prEN 13779 closed in May 2000, and at the moment of writing this paper the results of this enquiry are not yet available.

Finland paid attention to the fact that Category "SFP1" is not yet a realistic target and therefore the category for "Low" energy consumption should be according to "SFP2", aiming to SFP value 1,5 kW/(m^3s^{-1}). Table 1 presents Finland's opinion how to modify the recommended maximum pressure drops to meet different SFP categories.

The selection of components to match the target level can be based on default maximum pressure drop for each component – if certain component with higher pressure drop is selected (e.g. because of higher filter class), then the overall target can be achieved by lower pressure-drops of other components, respectively. For industrial applications, however, the figures in prEN 13779 are not necessarily valid due to the special demands of the production processes, but still their relevant parts can be taken as design basis. The design process will end up in Specific Fan Power (SFP) categories for each individual air handling unit (SFP_V) – now not only as a target value, but as a measurable design value of even as a guarantee value.

SYSTEM CONSIDERATIONS

There are many system-related aspects to be considered, here just a few to be mentioned:

--in demand-controlled systems the control strategy has much influence in the energy consumption

--fan motor selection and dimensioning: also here the control method has much influence in the overall fan efficiency

Total optimisation is one key issue. For example, to select the filters from a lower class would reduce the pressure losses, but will also affect negatively on the supply air quality and therefore also on the indoor air quality.

It has to be pointed out that looking at the SFP issues from the "AHU" point of view can result in different conclusions that looking at the "system" point of view. Especially the air leakages in the AHU and ductwork may look irrelevant. It is necessary to keep in mind that the target of the system is to supply a certain air flow, not inside the AHU, but into the rooms in the building. So, all leakages will mean waste of energy and money, and may also have a negative influence on system functioning. In the light of this, the best choice will in any case to select both the AHU and the ductwork from the most stringent air leakage category defined in standards, see for example EN 1886.

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Table 1 Recommended maximum pressure drops for specific components in supply air systems (NOTE! the values are somewhat different from prEN 13779. A similar table in prEN 13779 presents recommended pressure drops for extract air systems)

component	**Pressure drop in Pa **)**		
	Low	Normal	High
Ductwork	120	200	300
Heating or cooling coil	40	80	120
Heat recovery unit	100	150	200
Air filter per section *)	100	150	250
Silencer	30	50	80
Terminal device	30	50	100
Air inlet	20	50	70

*) final pressure drop before replacement
**) values for individual components may be exceeded - then the overall target can be achieved by lower pressure-drops of other components, respectively

LIFE CYCLE COSTS FOR AIR HANDLING UNITS, A PILOT STUDY

Sakari Sainio, M.Sc. (Tech) [1]
[1] Espoon- Vantaa Institute of Technology (EVTEK), Vanha Maantie 6, FIN-02600 Espoo, FINLAND

INTRODUCTION

This paper discuss the factors influencing the life cycle costs (LCC) of air handling units (AHU), and gives some feedback about the different methods available for LCC calculations. In pilot study an office building AHU was studied.

MAIN GOALS AND SCOPES

The parameters in LCC calculations were:

- *Dimensioning of the unit.* It is very common in Finland to select one size smaller unit than recommended by the manufacturer. The result is low investment costs but higher pressure drop both in heatig coil and heat recovery unit. This means higher using costs. Because of the higher fan speed, more sound absorbation is needed which rises the pressure drop and power demand of the fan as well.
- *Type of heat recovery.* Two heat recovery type were examined. Rotor type heat exchangers have been slightly more expensive than plate heat exchangers. On the other hand energy efficiency of rotor exchanger is better.
- *Filter type and area.* With larger filter areas the investment costs are rising but the benefit is: service and electricity costs are decreasing.
- *Type of fan.* The centifigural fan with backwards oppositing wings is slightly cheaper than fan with forward oppositing wings.
- *Method of power transmission.* Two different type of belt drives were examined. Conventional V-belt demands more power than flat belt, but again its investment costs are lower.

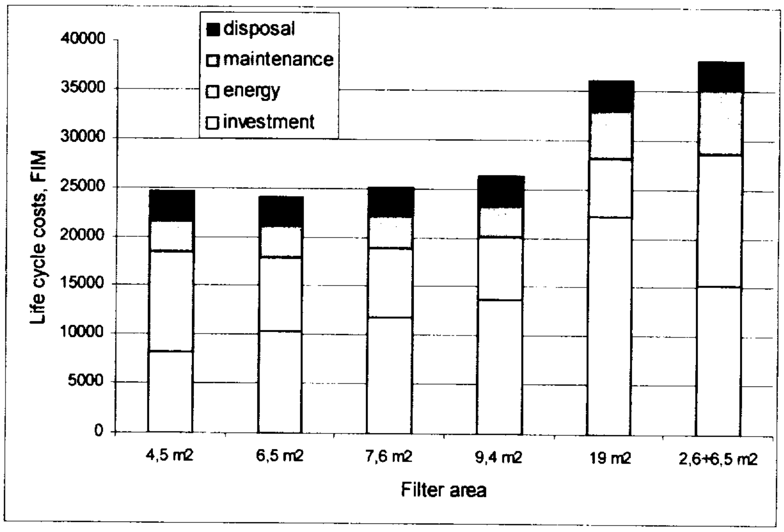

Fig 1. Optimizing the filter area of a ventilation unit. The annual operating time of a ventilation unit is less than 2600 hours. The optimum filter area is inrceasing when increasing the operating time.

Alltogether 15 different combinations were studied on rough level and optimization calculations were made for above mentioned parametres in this pilot case.

SYSTEM BOUNDARIES

The system studied was an AHU, which included exhaust and supply air fans, exhaust and supply air filters, a heating coil for supply air and a heat recovery heat exchanger.The air volume of AHU was 2 m^3/s and operation time 10 hours during working days (5 days a week).

Energy price and investment costs were from the beginning of 1999 in Helsinki area.Units life cycle length was 20 years and rate of interest 4 %. Climatic data of Helsinki, Finland was used.

RESULTS FROM CALCULATIONS

The pilot calculations gave a realistic view about the complexity of LCC calculations in the field of building services.

Accurate energy consumption calculation depends on input values, e.g. climate data and simulation of AHU's thermal behaviour.

Life cycle cost calculations are sensitive to life cycle periods lenght and chosen rate of interest.

The conclusions from the calculations can be summarized as follows.

1. The manufacturers' recommendation in AHU's dimensioning gives optimum result. Slightly higher investment costs compared to the undersized AHU are gained with lower using costs. In this case lower pressure drop in heat recovery exchanger, filters and heating coil cause smaller electicity energy consumption.

2. Rotor type heat exchangers had lower life cycle costs than plate heat exchangers. This conclusion mainly results from better energy effiency of rotor type heat exchanger and therefore leads to smaller heating energy consumption.

3. The smallest available filter area for AHU was not optimum in this pilot study. Optimum filter area is strongly affected by yearly operation time. In general, in this size and operation time category of AHU's, "long type" air filter packages with less pressure drop seem to have better life cycle economy than short ones.

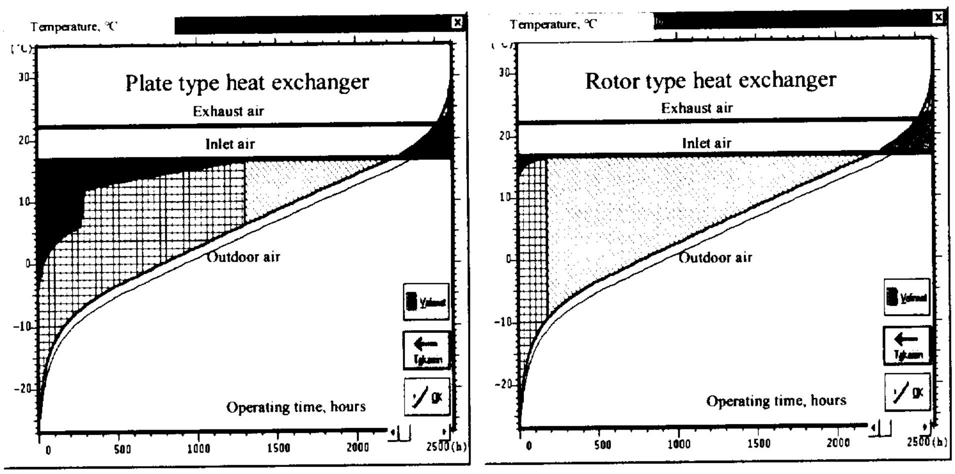

Fig 2. Better energy economy of rotor type heat recovery exchanger (diagram on right) is based on higher coefficient of effiency. Darker areas on the left in diagrams present the needed extra energy (heating coil). Plate type exchanger needs extra heating below + 5 °C, rotor exchanger below - 9°C.

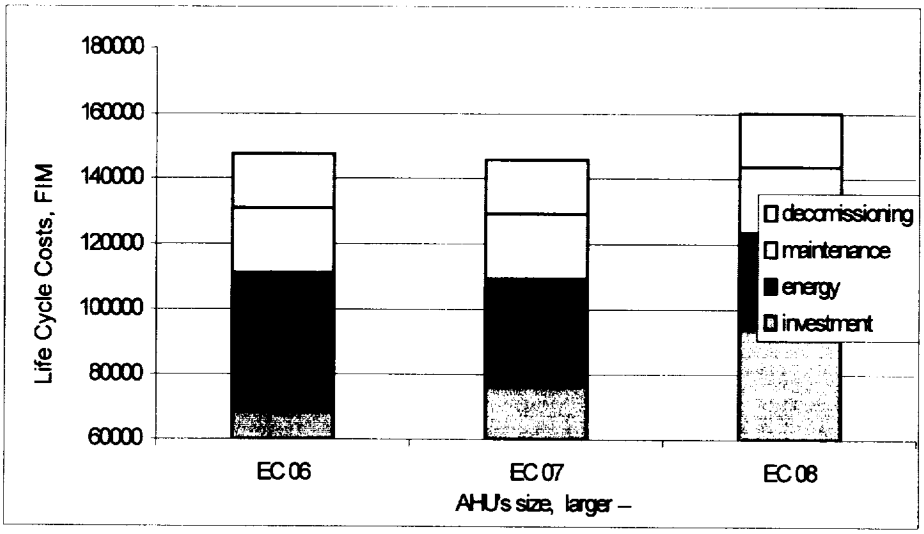

Fig 3. Comparison of three different sizes of AHU. EC07 is result of manufacturers selection and optimum in this case. Both smaller and bigger units gave higher life cycle costs.

4. With the other parameters, type of fan and method of power transmission, the same conclusion was obvious: total life cycle economy is best with slightly higher investment costs, but lower energy costs are gained during the usage period. However, the differencies in these last two parameters are not so significant than in dimensioning the AHU, filter selection or type of heat recovery exchanger.

CONCLUSIONS

In all studied parameters, AHUS's best life cycle economy was achieved with higher investment costs but lower usage costs.

There is obvious need for commonly accepted methods for LCC calculations in building services branch.

ACKNOWLEDGEMENTS

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USE OF GEOTHERMAL HEAT PUMPS TO SAVE ENERGY AND REDUCE "GREENHOUSE" IMPACT OF BUILDING CONDITIONING SYSTEMS

Dr. Lynn Stiles, Ph. D., Geothermal Project Director and Dean of Natural Sciences and Mathematics; Ms. Alice M. Gitchell, M.S., Geothermal Project Administrator. The Richard Stockton College of New Jersey (NAMS), PO Box 195, Pomona, NJ 08240-0195, USA.

INTRODUCTION – The purpose of this project was to quantify carbon dioxide emissions reduction as a function of installed geothermal (ground coupled) heat pump heating and cooling capacity. Energy savings and emissions reductions are highly dependent on building use patterns and climate, and are only indirectly related to installed heat pump capacity. A 50 kW_c installation at an elderly care facility might save more energy and accomplish more carbon dioxide reduction than a 70 kW_c unit at an office building open only 40 hour per week. (Readers from North America are reminded that 1 Ton = 3.5 kW_c cooling capacity.)

DETERMINATION OF CARBON DIOXIDE EMISSIONS BY MATHEMATICAL MODELING – Micro-AXCESS Energy Analysis Program, Version 10.01, was used to determine the energy use of designed buildings. It was applied to eight widely varied buildings for which complete structural design information was available. Climate data for New Jersey, a coastal state in the northeastern United States, was utilized. New Jersey has a temperate climate and roughly equal heating and cooling energy loads. For each building, three different heating/cooling systems were modeled, one a conventional system and the other two involving geothermal heat pumps. The conventional system consisted of a gas-fired boiler for heat and electrical air conditioning. The two heat pump systems (medium efficiency and high efficiency) reflect the range of heat pumps readily available.

ENERGY ANALYSIS AND EMISSIONS COMPARISONS – The AXCESS program generates a monthly energy profile quantifying gas and electrical demand under the specified conditions of climate and building use, as shown below.

Table 1 - Sample output of AXCESS model for classroom building

	Typical System		Geothermal Medium Efficiency	Geothermal High Efficiency
	Gas Therms	Electric kWh	Electric kWh	Electric kWh
Jan	2,730	60,937	78,095	75,815
Feb	1,389	65,765	76,457	75,310
Mar	815	76,615	83,263	82,382
Apr	478	70,855	72,724	71,759
May	202	74,663	66,495	63,893
Jun	0	91,109	78,582	73,283
Jul	0	122,579	107,517	98,906
Aug	0	106,210	91,538	84,147
Sep	165	107,257	95,120	89,540
Oct	331	88,754	85,017	83,025
Nov	740	75,522	80,186	79,321
Dec	2,020	62,408	75,335	73,662
Total	**8,870**	**1,002,674**	**990,329**	**951,043**

A standard emission factor (AP-42) can be used to determine the carbon dioxide emissions associated with natural gas combustion. When heat pumps are substituted for the conventional system, natural gas consumption drops to zero and electrical demand changes.

Carbon dioxide emissions associated with electrical generation are harder to quantify. The electrical generating mix varies and is usually unknown. Sources suggest emission factors ranging from 0.35 to 1.09 kilograms of carbon dioxide emitted per kilowatt-hour of electricity generated (NRDC, 1997). The lowest value reflects a substantial contribution from nuclear generation, and the highest represents coal combustion under unfavorable conditions. For this work, we selected a value based on a United States average and used by the State of New Jersey in its emissions trading program. This value is 0.59 kilograms of carbon dioxide emitted per kilowatt-hour of electricity generated (Climatewise).

The most common seasonal emissions savings pattern (seen in six of the projects studied) showed savings to be most striking in summer, less substantial in winter and lowest in spring and fall. This reflects the high cooling demand characteristic of New Jersey.

RESULTS – The annual carbon dioxide savings associated with use of heat pumps is summarized below.

Table 2 - Comparison of typical systems with medium and high efficiency GHPs

Project type	Size (m^2)	Cooling capacity (kW_c)	CO^2 reduction (percentage)	CO^2 reduction (kg/kW_c)
1 - Commercial office	517	88	19% - 34%	156-255
2 - Commercial office	15630	1755	41% - 46%	177-201
3a - College cluster housing (10 month occupancy)	2286	105	38% - 45%	75-91
3b - College cluster housing (12 month occupancy)	2286	105	43% - 50%	167-198
4 - College classrooms	1791	263	19% - 26%	63-87
5 - College classrooms	7509	1053	18% - 26%	51-73
6 - College classrooms	2326	352	17% - 31%	85-159
7 - Middle school (ages 11-13)	13023	1232	29% - 42%	136-192
8 - Elderly care facility	5390	632	28%-34%	120-144
9 - Single family residence	195	23	48%	186

Ranges reflect modeling medium to high efficiency heat pumps.

CONCLUSIONS AND RECOMMENDATIONS – In all cases studied, annual emissions were found to be lower with geothermal heat pumps than with the conventional system. Emissions avoidance associated with medium efficiency heat pumps ranged from 17% to 43% and for high efficiency heat pumps the range was 26% to 50% compared with a standard system.

If a higher emissions factor for electrical generation was assumed, certain months (usually in winter) would show geothermal systems to have higher emissions than conventional systems for medium efficiency heat pumps (but not for high efficiency heat pumps). If a low emissions factor (hoped for in the future as cleaner electrical generating techniques come into use) is used, both types of heat pumps show an advantage every month of the year.

Project 3 (college cluster housing, which resembles "townhouse apartments") is of particular interest because it shows the value associated with use of geothermal heat pumps for air conditioning. Summer use of the facility roughly doubles the avoided carbon dioxide emissions. The middle school (project 7) likewise shows increased savings in summer. It is to be anticipated that future school construction in New Jersey, USA, will include air conditioning to allow for twelve-month community use of facilities.

The calculated values for avoided emissions per unit of installed cooling capacity provide means for planners to judge the net positive impact of geothermal installations on air quality. Further investigation is needed to extend the applicability of this work.

ACKNOWLEDGEMENT – The Geothermal Project gratefully acknowledges the contribution of Billy J. Hemphill of Vinokur-Pace Engineering Services, Incorporated, who performed the AXCESS computer modeling referenced above. The United States Department of Energy through the New Jersey Board of Public Utilities provided funding.

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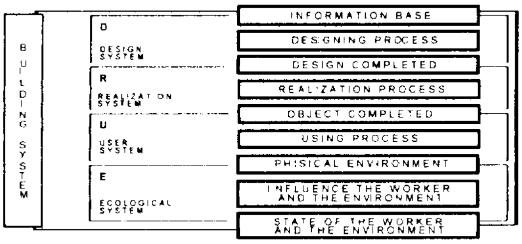
Prof.Ph.D Zygmunt Szparkowski – Warsaw University; ul. Koszykowa 55, Warszawa
Msc. Katarzyna Zielonko, Msc. Janusz Marchwiński, Ph.D Wiesław Rokicki – Warsaw University

ARCHITECTURAL PROBLEMS OF DOUBLE GLAZED FACADES BASED ON THE EXAMPLES OF NEWLY ACCOMPLISHED BUILDINGS IN WARSAW

A double glazed facade, also called a ventilated facade consists of two independent layers separated from each other by dozen up to tens centimeters. The idea for the facade relies on addition of the external layer, like single glazed, lighter wall fitted with vents to the curtain wall with openable windows. A natural air circulation is taken from the outside to an empty space between two layers affected by the so called stuck effect. In this way an accustic and thermal buffer comes into being, which allows the retention of the indirect contact between internal and external environment..

A facade's outlay is very high – from 1500 up to 3000DM, which seriously exceeds the value of a traditional, well isolated and finished curtain wall. The energy saving related to the extra investment outlay amounts only to 2% - 4%[1]. Nevertheless, double glazed fasades have become trendy and commonly used solutions for office and commercial buildings located in city-centres or in areas of adverse atmospheric conditions. The above has occured thanks to the possibility of effective protection agaist noise, pollution, wind pressure, excessive overheating of rooms and the prospect of using natural ventilation to act as air-conditioning support as well. It must be emhasized that besides functional advantages, double glazed facades create new aesthetic effects that may become the crucial criteria of their application.

Considering the model system of architecture[2] the problem of single or double glazed shield's application does not actually concern the design or realization system, but refers to the exploitation system and ecological influence. (tab.1)



tab.1 Model System of Architecture

In recent years in the very centre of Warsaw three new office buildings have been built by applying the ventilated facade. These are:

fig.1

Les Tours BRC – (25-storey ; total area - 56 000 sq.m.) consists of two towers connected with each other – a rectangular- and semicircular one, which act as independent units. In the semicircular section, above the 18th storey,there is an atrium.All elevations above the 1st floor are made as two layer kits. (fig.1)

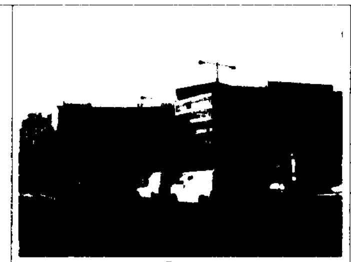


fig.2

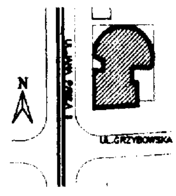
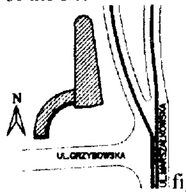
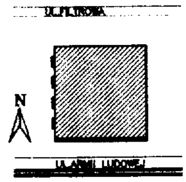
Saski Business Center – (7-storey; total area 18 000 sq.m.); is based on an elongated rectangular plan with semicircular wing, creating a piazza by the nearby crossroads. Double glazed elevation has just been fixed in this wing.(fig.2)

fig.3

Fokus Filtrowa – (16-storey; total area- 50 000 sq.m.) has been formed on the rectangular plan with an atrium in the middle and divided to 4 units. There is a winter garden merged with the atrium in the middle of the building. Double glazed elevation is applied on the southern and partialy western building's shield .(fig.3)

[1] Daniels Klaus(1998)"Low-Tech, Light-Tech, High-Tech Building in the Information Age" wyd. Birkhauser Publishers Basel-Boston-Berlin
[2] Szparkowski Zygmunt(1978)"System ekologiczny architektury zakładu przemysłowego" Wydawnictwa Politechniki Warszawskiej – Warszawa1978

The above mentioned buildings, homogenous in function and localization will serve as the examples for architectural problem studies, presented in five groups. The table below shows their analysis.

	Buildings		
	1. Les Tours BRC (fig.4)	2. Saski Business Center (fig.5)	3. Fokus Filtrowa (fig.6)
URBANISM	• elevation double glazed elevation was applied in the whole building above the 2nd floor; to minimize nothern elevation, semicircular wall was designed  fig.4	• elevation double glazed elevation was applied only in the rounded wing of the building, which favourably turns aside the elevation to the southern direction and by the way rightly forms the exposed edge of the site  fig.5	• elevation double glazed elevation was applied in the southern part of the building; it is simultaneously a front wall situated by a motorway; several floors high windows shaped also as a double glazed kit are fixed on the western, side wall  fig.6
FUNCTION	• natural ventilation's use (integration with BMS, connection with atrium)		
	• protection from noise and pollution (of busy city streets)		
	• application of an effective sun protection (external louvers)		
	• user's comfort improvement by means of openable windows		
	• wind pressure protection		• wind pressure protection – western elevation
	• emphasis on the prestigious building's nature		
	• obtainment of the facade's visual effects as a 3-d element		
AESTHETICS	• it obtained the effect of two transparent shields' superposition • by obtaining two different divisions – horizontal and vertical – a distinction is hardly discernible	• the application of double glazed facade in the rounded wing allowed clear distinction from the rest part of the building • the facade is the multiple of the single modular element	• there was obtained the effect of glass wall over the stone wall's supreposition in the front elevation • double-layered west elevation windows seem to be immersed in the building's volume
STRUCTURE	• it was applied system,3-d glass kits assembled in aggregate (agile assembly) • elevation was made by GARTNER and designed as a result of producers' and designers' cooperation • the void's width between two layers amounts to 29cm	• the internal, curtain wall was made first, the external layer was built afterwards • elevation was made by GARTNER and designed as a result of producers' and designers' cooperation • the void's width between two layers amounts to 20cm	• the internal, curtain wall was made first, the external layer was built afterwards • both layers were built apart by different executors and designed as a result of architect's and consulting engeneers' cooperation • the void's width between two layers amounts to 50cm

E X P L O I T A T I O N	• user's individual window's opening and louver's steering		
	• by the window's opening heating is off (energy savings) • large window's surface (its dimension is a result of facade's articulation design) and the way of window's opening hamper exploitation • lack of full division between following floors causes bad acoustic effects	• window's surface opens in two directions • full division between following floors and glass elements, that divide void further are good acoustic protection	• full division between following floors and glass elements, that divide void further are fairly good acoustic protection

Conclusions:

- it is not always possible to fit a building's orientation with its position according to the urban context– (Les Tours BRC- location on the site suggests setting the rounded volume from the main crossroads' side.
- it is no use applying a double glazed facade to the whole surface in case of each kind of building's shape and its situation on the site.
- ventilated facade functions are used best in case of integration with BMS and by connection with atrium or any other space to act as a thermal buffer.
- in case of high buildings a double glazed facade plays a substantial role to counter wind pressure provide and allows for window to be opened on each storey.
- by use of double glazed elevation one can obtain the 3-d facade impression (Les Tours BRC, SBC) or the effect of superposition of the glass shield over the more massive facade, primal one (Fokus Filtrowa).
- the facade's division is poorly varied and monotonous (Les Tours BRC, BSC).
- the facade's duplication effect (concerning both glass surface and crossing structure elements) may have a negative impact on users (SBC).

Summation

The analysis of above presented examples and other global realizations calls for a profound review of an architectural „occurence" like double glazed facades. First of all the facade's application should follow deep and reliable analysis connected with solution's outlay. It ought to follow substantiation of needs related to the exploitation process and ecology as well.

The architectural problem of double glazed elevation is mainly connected with aesthetic function, that is a testimony of architectural quality. An architect's role relies on fitting and putting in order the interaction between interior, external skin, service and functional quality and aesthetic function. His task is impeded in applying sophisticated, technological solutions because he is made to use only standardized and finished elements. Their location is strictly defined to one and only position according to technical and technological requirements. It affects lack of variety and limits the possibilities of the facade's articulation. There are also limits connected with the right scale, proportions and harmonious composition of the facade. A solution making the standardized, single elements homogeneous and giving them flexibility in the facade's perception is the graghical and pictorial effects' use. In the project of BSC building's facade, graphical element has been applied, which is not a result of outlay's reduction. It was conceived as a declining rhythm of dots in a color of structural components, which fills the strip below the user's sight line. The strip would have created an impression of continuity and element's infiltration. Furthermore the joint's lines would have disappeared and the facade would have earned an individual features.

The 'Fokus Filtrowa' building, which is being built without any participation of sophisticated double glazed facades' producers seems to avoid the mentioned problems , because each layer is made individually. The interial wall is responsible for the composition of the facade due to the windows' arrangement and stone panel divisions that fill the surface between them. The external wall is an added screen, the articulation of which is subordinated to the composition. Although less technologically advanced, such a formation gives greater design posibilities.

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EVALUATION OF THE SOLAR RESIDENTIAL AREA GELSENKIRCHEN

F. WOUTERS[1] (MSC), C. PETERSDORFF[1] (MSC), DR. W. WIESNER[2]

1 - ECOFYS GmbH
Eupener Str. 137
D-50933 Cologne
info@ecofys.de
2 - TÜV Rheinland GmbH
D-51101 Cologne

ABSTRACT

The State Northrhine-Westfalia (NRW) in Germany aims at stimulating innovations in solar and low-energy architecture through the project „50 Solarsiedlungen, NRW" (50 solar residential areas, NRW). The building projects are not only characterised by an innovative energy concept, but also by excellent social, ecological and urban parameters. A holistic planning and building process, in which architects, investors and energy experts work together, leads to an optimised combination of ecological and economic aspects.

In Gelsenkirchen the first 'Solarsiedlung' is presently being built. In this area 77 buildings will be realised in solar low-energy standard (~ 40kWh/m²a). Solar collectors cover 60% of the required heat for hot water consumption and 40% of the electricity demand is covered by photovoltaics.

TÜV Rheinland has been commissioned by the government of Northrhine-Westfalia to co-ordinate the evaluation of the project, Ecofys is responsible for the scientific support. Aim of the evaluation is the analysis of the energy performance of the area, to check whether the standards have been achieved. In a holistic analysis, not only technological aspects but also the user-interaction will be studied.

SPECIFICATIONS FOR THE 50 SOLAR RESIDENTIAL AREAS, NRW

The State Northrhine-Westfalia (NRW) in Germany aims at stimulating innovations in solar and low-energy architecture through the project „50 Solarsiedlungen, NRW" (50 solar residential areas, NRW). The building projects are not only characterised by an innovative energy concept, but also by excellent social, ecological and urban parameters.

The program aims to demonstrate that innovative ideas in the field of energy conservation, renewable energies and low-energy construction are feasible in the building sector. Next to general requirements, specific energy related requirements have been formulated:

A pre-check guarantees that the urban planning enables an optimal use of passive and active solar energy. On the building level, the annual energy demand for space heating has to be at least 25% better than the current German standard (Wärmeschutzverordnung 95). On top of that, at least two of the following three requirements will have to be met:

1. Passive Solar Buildings: The annual demand for space heating shall be at least 60% lower than the current German standard. This can be achieved by passive solar energy and insulation of the building envelope.

2. Solar Heat Supply: at least 60% of the required heat for hot water consumption shall be covered by solar energy.

3. Solar Electricity: at least one third of the annual electricity demand has to be generated using photovoltaics.

THE SOLAR RESIDENTIAL AREA GELSENKIRCHEN

The project in Gelsenkirchen meets the second and third

requirement of the program using PV and solar thermal hot water systems. On a total area of 38.000 m^2 in a central location of Gelsenkirchen a total number of 77 row houses are being built. A direct tram-connection guarantees sufficient mobility for the inhabitants, also without a car. The area will be completed in 2000.

Insulation of the Building Envelope

Half of the buildings are stone houses, the other half are wood-structure houses (see Figure 2). All buildings will be built to low-energy standard (~ $40kWh/m^2a$). The orientation of the buildings is mostly south, so an active and passive solar energy use is safeguarded. An energy optimised positioning of the rooms was an important criteria in the design process. The hygienic air quality is guaranteed by a ventilation system.

Energy Supply

The energy supply concepts of the northern and southern part of the site are different. The 29 single family houses in the northern part each have their own solar assisted gas-fired condensing boiler for space heating and hot water. The solar collectors cover up to 65% of the energy need for the domestic hot water production.

The 48 single family houses in the southern part have a district heating system per row. A feature of these central systems is that they not only supply the heat for space heating and domestic hot water to the houses, but the solar heat and electricity generated on the houses (again 65>% of the domestic hot water need) are first transported to the central units and distributed from there. These central units are managed by the local utility.

Because all houses have hot-fill connections for the washing and dishwashing machines and gas connections for the cookers/stoves, the households exhibit a 35% lower electricity consumption than usual. The rest of the electricity demand can be covered up to 40% by photovoltaics. Figure *3* compares the total primary energy consumption of the buildings in Gelsenkirchen with a building that corresponds to the legal standard in Germany. Energy savings of 46% will be realised.

Figure 1: view out of the solar residential area

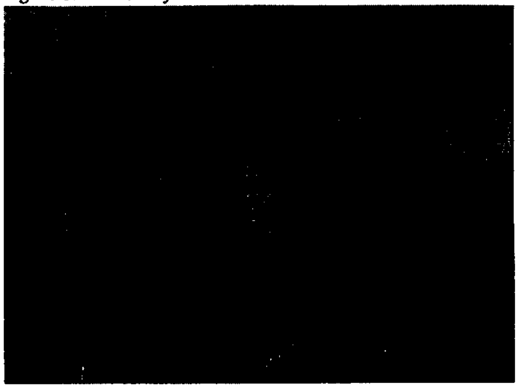


Figure 2: wood-structure houses

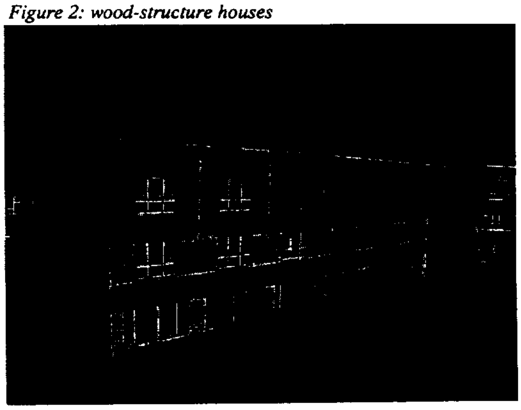
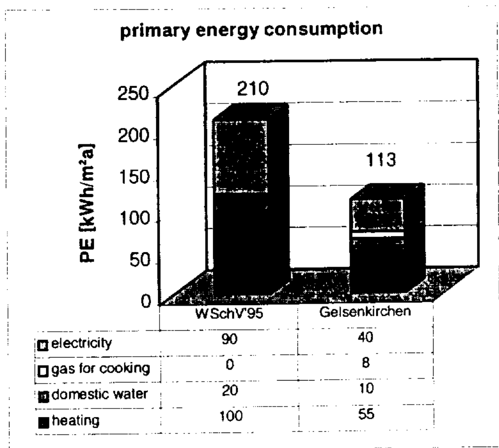


Figure3: primary energy consumption



EVALUATION OF THE SOLAR RESIDENTIAL AREA GELSENKIRCHEN

The project in Gelsenkirchen will be supported and scientifically evaluated by TÜV Rheinland and Ecofys. Aim of the evaluation is the analysis of the energy performance of the area, to check whether the standards have been achieved. The support consists among others of scientific feedback to the building companies, on-site quality control of the building process and instruction and motivation of the inhabitants. The overall evaluation mainly consists of the determination of the energy and ecological standard of the area after commissioning and the comparison of the measured versus the planned energy consumption. In a holistic analysis, not only the technologies but also the user-interaction will be studied.

The evaluation consists of following work-packages:

Advice during building process

It is to be guaranteed that the building construction meets highest quality standards and that the planned energetic and ecological standard is achieved. First step is the examination of the planning, because planning errors that are detected during the building phase can only with difficulty be subsequently corrected. Beyond that the quality of the building process and the agreement with planning is secured by regular visits on the construction site. Blower Door measurements as well as thermographic imaging document the quality of the building process.

Creating awareness among the inhabitants

Apart from the professional realisation of the buildings the inhabitants have crucial influence on the energy consumption. Investigations have shown that also in identically constructed buildings, heating energy consumption can be twice as high but also half as low as the average value, depending on user behaviour.

To influence the user behaviour, information meetings for the inhabitants are offered introducing the topics low energy buildings and energy-saving user behaviour.

Measuring the standard

The centre of attention of the total evaluation is the truly realised energetic and ecological standard of the area as well as the relation to planning. Therefore the energy consumption of the buildings, the user behaviour, the effectiveness of the energy production as well as solar covering will be measured and compared to the planning.

Socio-ecological investigation

In a holistic diagnosis not only the technique, but also the interaction of the inhabitants with the technique will be elaborated. Therefore a socio-ecological investigation will be executed.

Evaluation Of Environmental Loads Due To The Construction Of Buildings In A Thermal Power Plant

Y.K., M. Eng., Yoshida Kimio, O.T., Dr.Eng. : Prof., Oka Tatsuo
1.Electric Power Development co.ltd., 15-1, Ginza 6-Chome,Chuo-ku, Tokyo, 104-8156, Japan
2.Utsunomiya Univ., 2753, Ishii-cho, Utsunomiya, 321-8585, Japan

Introduction

In the construction of buildings in a thermal power plant, we use a huge amount of construction materials, such as scores of thousands tons of concrete, thousands tons of steel etc. These are significantly impacting the environment. In this report we show the basic environmental loads due to the construction of buildings in a coal-fired thermal power plant. Then we show the effect when we use Fly-ash (typical by-product from coal-fired thermal power plants) in concrete to reduce environmental loads.

Presentation

To determine the amount of energy consumption and the quantity of carbon emissions as the basic environmental loads mentioned above, a summation method was adopted as a basis with an "industry-related analysis" method considering the industry-wide ripple effects. In this report we employ those values of environmental-load intensities by industry code based on the i/o table, which we determined in 1999.[1)]

Amount of Energy Consumption and Environmental-Load Intensities due to the Production of Fly-Ash Cement.

Annual consumption of cement in Japan is approximately 80 million tons. Rate of use of blast-furnace cement and fly-ash cement (FAC) is about 20% and 1%, respectively. On the other hand, the amount of fly ash discharged from coal-fired thermal power plants operating

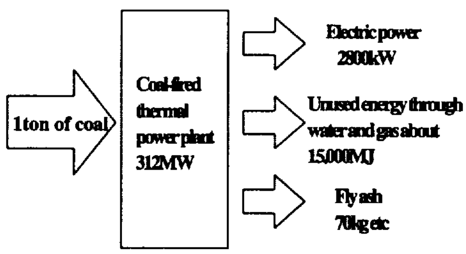


Fig 1 Flow of the consumption of energy and the amounts of power and various by-products at a coal-fired thermal power plant

in Japan reaches approximately 7.3 million tons per year. Approximately one third of the whole amount of fly-ash is dumped for load reclamation without effective utilization, and rate of such disposal of fly-ash is deemed to increase. Figure 1 shows the flow of the consumption of energy and the amounts of power and various by-products at a coal-fired thermal power plant.

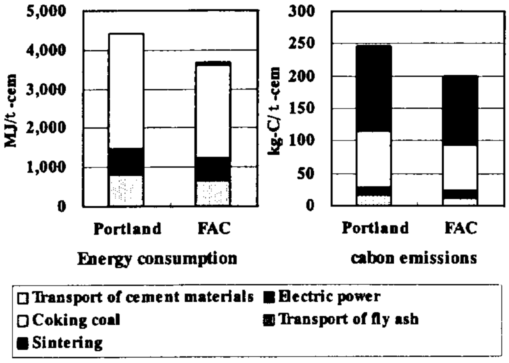


Fig 2 Environmental intensity comparison between portland cement and fly-ash cement (containing 20% fly ash)

Among different grades of FAC, FAC-B (with a fly-ash mixing ratio of 20%) having a relatively long usage track record in the field of building construction was taken up, and the amounts of energy consumption, carbon, NOx and SOx emissions due to the manufacture of FAC-B have been determined in order to obtain their environmental-load intensities for comparison with ordinary portland cement. The results of this comparison are shown in Fig. 2. As for environmental-load intensities, the amounts of energy consumption, carbon, NOx and SOx emissions have come down by 17%, 19%, 11% and 12%, respectively. (NOx and SOx charts are omitted.)

Environmental Loads in the Building Construction of a Coal-Fired Thermal Power Plant and Results of Calculations about the Effects of Their Reductions by using FAC.

Figure 3 and Table 1 show the outlines of a construction project taken up this time to trial calculations and the amounts of major construction materials required for the construction work. For the construction work of the said coal-fired thermal power plant, Fig. 4 shows the results of calculations about energy consumption and carbon emissions throughout the entire plant building construction work (assuming the use of ordinary portland cement), and additionally shows the effects of reducing the energy consumption and carbon

Fig 3 Picture of the coal-fired thermal power plant for calculation

emissions by virtue of the replacement of the ordinary portland cement with FAC. Throughout the entire plant building construction work, when using FAC for the individual structures, the amounts of energy consumption and carbon emissions have come down by approximately 6% and 10%, respectively.

Table 1 Bill of major materials for construction of coal-fired thermal power plant

	Structure type	Total floor area (m^2)	Steel frames (t)	Steel bars (t)	Concrete (m^3)
Main building	Steel	25809	8418	2090	26541
Silos	Reinforced concrete	1134	816	4632	43346
Stack	Reinforced concrete	-	261	939	6546
Appurtenant buildings	Reinforced concrete	17611	1096	1320	11281

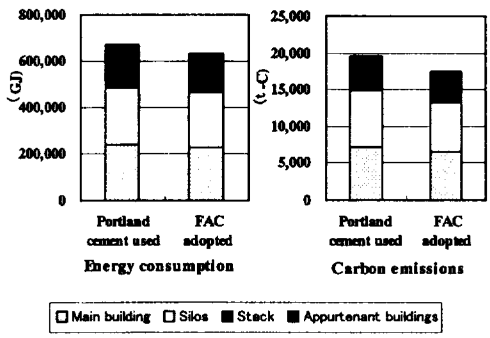


Fig 4 Amounts of energy consumption and environmental loads associated with the construction of coal-fired thermal power-plant buildings, and reduction effects by using FAC

Conclusions and Recommendations

In this report, the amounts of energy consumption and carbon emissions due to the building construction work of a coal-fired thermal power plant have been worked out. In addition, trial calculations of both energy-consumption and carbon-emission reduction effects by using FAC have been made. Major findings acquired there by are as follows:

1) When compared with the manufacture of ordinary portland cement, the manufacture of FAC containing 20% fly ash produces the following reduction effects: 17% fewer energy consumption, 19% fewer carbon emissions, 11% fewer NOx emissions, and 12% fewer SOx emissions.

2) As the effects of using FAC containing 20% fly ash in the plant building construction work, the consumption of energy and the amount of carbon emissions have been cut by 6% and 10%, respectively.

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BEQUEST: TOWARDS SUSTAINABLE URBAN DEVELOPMENT.

Steve Curwell, Department of Construction and Property Management, University of Salford, UK with contributions from the members of the BEQUEST research team.

INTRODUCTION

The Building Environmental Quality Evaluation for Sustainability through Time (BEQUEST) network developed from a conference, "Environmental Impact Evaluation of Buildings and Cities", held in Florence in September 1995 [Brandon et al 1997]. The broad aim of BEQUEST is to create a forum for research, training and practical action in the quality assessment of the urban environment in order to identify the basis for common understanding and implementation of sustainable urban development (SUD).

The network received funding for the period 1998-2001 from the European Union, DGXII, Science, Research and Development, through the 4th Framework Programme (Theme: Human Dimensions of Environmental Change). Discussion between representatives of all actors and a wide number of disciplines representing both the demand and supply sides of the property and infrastructure industries is taking place via a series of interactive workshops and through an electronic network known as the BEQUEST EXTRANET. The network currently consists of 130 members drawn mainly from European countries, but also including a significant proportion from a wide range of other nations across all continents. The project is breaking new ground in I.T. mediated consensus building over (SUD).

This paper presents some of the key findings from the first half of the project drawn from various workshops held in the UK, Amsterdam, Turin, Helsinki and Florence. Fuller details of the interim findings are available through electronic information sheets available via the web site (BEQUEST 1999).

BRIDGING THE ASSESSMENT GAP

BEQUEST workshops have opened a structured discussion of sustainability issues and assessment methodologies with a broader range of actors across a wider range of interests involved in the urban environment than has been seen to date. BEQUEST is beginning to fill the "gap" in understanding between:

- environmental assessment and sustainability assessment of the built environment,
- assessment methods used at the building scale and those at the urban planning scale,
- demand and supply side interests;

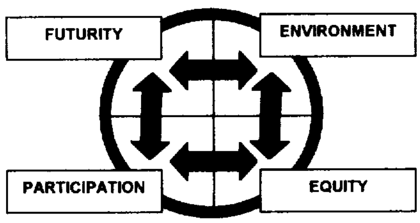
and across three main professional interest groups, i.e., those involved in:

- planning and development,
- provision and management of the infrastructure, and
- design, construction and management of buildings.

COMMON LANGUAGE AND UNDERSTANDING OF SUSTAINABLE URBAN DEVELOPMENT

In the early stages the "PICABUE" definition of sustainable development [MITCHELL et al 1995 & PALMER et al 1997], see Figure 1, was used to measure attitudes and to test understanding of key concepts and terminology.

Figure 1 PICABUE Definition of Sustainable Development.



From this two main conclusions were drawn. On one hand there is a general and positive acceptance of sustainable development as an issue of much wider significance to society than the limited environmental preservation agenda implied by the upper two quadrants of Figure 1. On the other hand, the depth of general professional understanding of the social, economic and equity dimensions is very weak and the relative level of importance that is attached to these criteria when compared with reducing environmental impact is low or unclear. Some of the barriers and constraints to more effective action that result from the relative poverty in understanding is explored below.

LACK OF TARGETS & INDICATORS

In terms of minimising environmental impact there is a lack of clarity and agreement about what sustainability targets should be set and upon the indicators of progress towards a more sustainable built environment. This is compounded by the fact that many professionals actors are uninformed about techniques (i.e., in terms of technological change, good practice and evaluation tools) that will allow them to achieve their objectives. In terms of resource reduction Holland has set a good national example with the objective of Factor 20 by 2050. (The argument for this is based on environmental and international equity grounds). A number of experimental building projects in the E.U. have achieved reductions in energy and/or resource consumption of this level when compared with normal practice, but the mainstream is a long way from such performance levels. Clearly an immediate step change to Factor 20 reductions would bring with it a number of undesirable short-term commercial consequences for the construction industry. The introduction of year on year, aggregated improvements, such as those suggested by the Wuppertal Institute's *Modelling a Socially and Environmentally Sustainable Europe* (WUPPERTAL 1998), appears a more viable route forward. The implications of attempting to achieve such levels of performance improvement for the E.U. construction sector has yet to become an area of serious (research strategy) debate, let alone practical action.

ECONOMIC AND COMMERCIAL CONSTRAINTS

Case studies offering some exemplary characteristics examined by BEQUEST have in general shown an absence of detailed and integrated investigation of sustainable development effects beyond simple economic criteria. Where environmental effects are considered it is usually over a short time frame of less than five years. Thus the intergenerational factor (i.e., Futurity & Equity in Fig.1), although recognized by most actors as a key issue in SUD, is not really part of active decision making at present. From these studies it is clear that economic policy considerations form the key barrier and are central to some potentially serious negative outcomes in terms of SUD. This goes beyond the obvious conclusion that lack of money is, in itself, a serious constraint to making various forms of social and environmental improvements, in all jurisdictions. The negative effects can be traced to two inter-linked factors: the source(s) of funding and the regeneration imperative.

Commercial and political investment decisions are moulded by the availability of E.U., national, regional and local, short-term, re/development financial incentives. The regeneration imperative is created by the short-term socio-political and economic pressure(s) to correct a perceived 'loss of competitiveness' of any particular region, city or district due to a range of factors such as industrial decline, environmental degradation or social malaise. These 'two factors' link together to drive the normal pragmatic approach to setting spatial boundaries and time dimensions in planning of re/development projects. Thus the need for immediate action to improve an area suffering serious decay and/or decline overrides proper consideration of longer-term impacts of the proposed development. Thus the boundaries of political and economic jurisdictions form more important considerations than the potential 'footprint' of various environmental effects (e.g. a river watershed) or social effects (e.g. needs of ethnic of minority groups). In turn this also results in the analysis, and the majority of the tools that are used for the analysis, being restricted to short term consideration of impacts within the specific 'site' or 'planning' boundaries set by the politico-economic drivers. The negative impact of these constraints on the longer term sustainability of urban interventions and development appears to be a seriously un(der)addressed issue in current 'leading edge', 'good practice' in the E.U.

SOCIAL BARRIERS

The resource reductions targets mentioned above and implicit in more SUD are likely to challenge individual citizen's quality of life perceptions and aspirations. Therefore a key social dimension is that of participation in decision making. BEQUEST has, and continues to attempt to, engage with a wider range of actors and has shown that many citizens are highly sceptical of 'official' information, of professional opinions, and in many cases of efforts to engage them in a participatory processes in general. This work has questioned the commonly held assumption that 'better' participation will of itself deliver more sustainable development outcomes. Key elements are likely to be the need to use different forms of participation for different development scales, stages in the process and for different groups of actors. The application of better techniques of conflict resolution or avoidance between various sectorial interests is also important. For example, the public versus private interest and the commercial economic interest versus environmental protection agencies and pressure groups.

Although the vocabulary and the concept of sustainability indicators and targets is recognised by citizens there is little common understanding of intention and outcomes. Therefore citizens do not feel empowered to make a difference and thus are reluctant or unable to consider behavioural changes necessary for more sustainable patterns of living and working, nor to demand better, higher performance buildings and to understand how to operate them efficiently.

CONCLUSIONS - SUSTAINABILITY EVALUATION OF THE BUILT ENVIRONMENT.

The work to date has identified gaps in assessment and evaluation when viewed from a broad SUD perspective:

- Quality of life and environmental quality criteria in relation to a broader context of economic and social issues;
- Integration between meso and maco scales, local regional standards, (eco footprint), planning etc., including the externality costs associated to wider community interests;
- Flexibility index - how building, land use and infrastructure can respond to changing needs, over time;
- Assessment that encompass all the building stock and integrates transport + mobility, mixed use etc;
- Scenario/feasibility testing - is there a real need for change/reconstruction – the options of adaptive reuse related to operational and occupancy needs;
- Transparency for all stakeholders (how are judgements made and who makes them?);
- Bridging between cost and income to ensure relevance to developers and investors.

The main conclusion is that very different techniques are required at the meso and macro scale and to integrate social and economic criteria. Therefore sustainability assessment of the urban environment may form a procedure or process, rather than one integrated method, through which all stakeholders are collectively assisted in selecting (the more sustainable?) option(s) from a range of alternatives. Therefore a key deliverable is the BEQUEST Toolkit, which includes:

- A directory of assessment methods in the built environment.
- A set of protocols for sustainable urban development.
- A decision support information system.
- A directory of advisors in the field.
- A glossary of terms.

The object is to help decision-makers understand the key actions, to identify assessment methods, understand their strengths and weaknesses and when and where they can and should be used.
(The toolkit will be available for demonstration to delegates on the BEQUEST stall at the conference)

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A SUSTAINABLE LANDUSE PLANNING GAME - Balancing Human Consumption with Natural Capital in Sustainable Communities

Pliny Fisk III, Co-Director
Richard MacMath, Project Architect
Center for Maximum Potential Building Systems
8604 F.M. 969
Austin, Texas 78724
USA

SUMMARY
The Center for Maximum Potential Buildings Systems, established in 1975, has operated as an architecture and planning firm using three scalar modes of interrelated performance: 1) the individual building scale as a responsive framework operating on behalf of people's constantly changing needs while internally balancing resource use within the immediate environment; 2) the master planning/site boundary scale to balance resource use relative to ecological footprints of upstream and downstream spatial representations of various life support technologies; and 3) the regional/national economic and environmental scale model incorporating input/output life cycle impact and resource balancing methods material and product specification. This paper briefly covers the second operational design. The procedure has now been incorporated within eco-village planning, restorative master plans and futuristic seventh generation land use scenario building with potential for application at regional and national scales.

BACKGROUND
Approaching sustainability from the perspective of simply reducing resource consumption, even when guided by peer reviewed benchmarking comparison techniques, has little significance relative to the degree of resource balance required in the sustainable world of the future. The need to understand how balance can occur in the total life cycle flow of energy and materials within and without established sets of boundaries is a substantially different approach than conservation planning; these methods and procedures require serious consideration.

The proposed method, Eco-Balance Planning and its accompanying participatory version, Eco-Balance Game, bring together several established procedures that enable a universally accepted basis for measurement between a variety of land use in a participatory manner that is meaningful to the people planning and using these resources.

The game version establishes the necessary understanding of sustainability principles at both the individual and group level. It establishes a basis to visualize the invisible flow of resource use relative to the land and enables decisions to be made across disciplines based on sound data and methodology. The combined use of spatial measurement of human resource use, referred to as eco-capacity footprinting with G.I.S. land planning conventions, provides the basic building block. The unusual interoperability capacity exhibited between play at one level and an international resource planning convention at the other are significant benefits of the approach. Bottom up decision making using spatial representative playing cards with built in pictorial representations of sustainable land use life cycles makes possible an understanding of resource balancing both upstream and downstream at varying depths of specificity.

METHOD

A grid based measurement tool following international protocol of equal area grid cell units becomes the spatial basis representing both input/output within and across boundaries. Being icon (pictorial) based as well as performance based enables the use of object oriented programming between land use spatial areas and their representative life cycle spatially correlated technologies. The fact that a geographically positioned grid cell with a given resource embodiment can possess eco-capacity once an appropriate technology is applied to it is the building block for sustainable planning and interactive gaming.

The incorporation of internationally recognized equal area grid cell projection combined with an infinite "quad" grid system of spatial division enables the recognition of both balance or imbalance of resource use over extended micro and macro-regions while offering unique pattern recognition when desired. The realization that the particular land unit is the metric for dealing with resource issues and that there exists a spatial externality whose burden must be dealt with by the assimilative capacity of the next spatial scale is key in working with the eco-balancing methodology. The forcing of issues such as the necessity, if possible, of balancing the use of air, water, food, energy, materials at every scale or, just as importantly, the recognition of imbalance within each scalar boundary is the basis for evolving balanced land use. The ability to quantitatively balance stems from the material and energy balancing process between upstream and downstream phases of the life cycle. This places the procedure squarely within the next frontier of sustainable development trends by enabling this planning tool to cover a range of geographic scales of performance. Multiple co-related boundaries using the infinite grid provide the playing field whereby balance can be realized.

The procedure requires the use of several conventions. These include but are not limited to the following: 1) the principle of translating resource requirements by a given technology into spatial land units that become the chip cards for life cycle integrated land use planning; 2) the principle of overlaying these spatial chip card representations of technology while continuously linking that technology to actual resource conditions; 3) the incorporation of upstream compared to downstream life cycle phases as the basis for balancing resource use; 4) the strict application of boundary as a demarcation of life cycle performance measurement; 5) the incorporation of orders of balance dependent on levels of integration proceeding from internal balance within the particular human need topic and progressing towards integration between topic areas; 6) the recognition that under highly managed regenerative systems the number of people supported can be increased using few external inputs except the solar constant and regenerative biological knowledge; 7) the understanding that increased optimization of any biological system for the purpose of purely human need is usually at the expense of a healthy natural environment measured in terms of overall diversity.

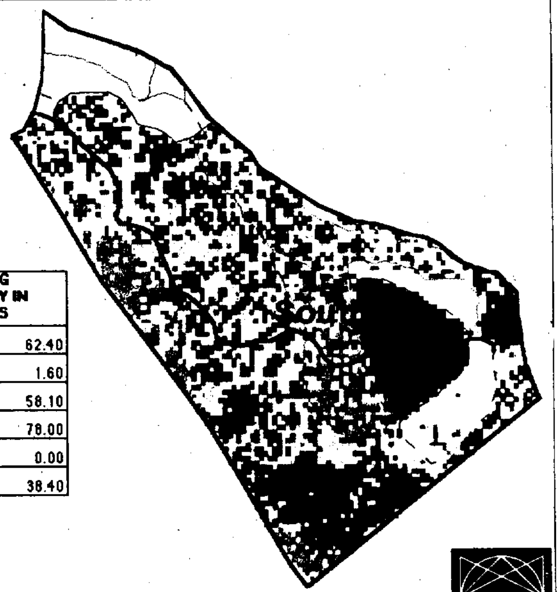
CONCLUSION

According to recently published data, the United States possesses a 20 fold vegetative deficit for balancing its CO_2 contributions through vegetative sequestration. There are numerous other examples of similar imbalances in water sourcing and wastewater treatment for re-sourcing, food production compared with food waste processing to replenish the land, and so on. Misconceptions resulting from how measurement is approached resulting from an inability to assess technology from a broad enough conceptual metrics is one source the sustainable delemna. Balancing the United States' CO2 needs would be virtually impossible to accomplish by convincing the world to assume the burden. Seldom does the land unit itself, starting at the smallest scale, appear as the common denominator to accomplish such measurement and eventual balancing. The probable reason is that our comparative basis for measurement is so thoroughly anthropocentric and urbanized that we are unable to conceive of how any natural balance could exist. Our micro-development examples so far have demonstrated the reality of upstream/ downstream balancing at many scales from the lot level to an extended geographic field where specific externalities can be clearly identified beyond the defined boundary of a project.

REFERENCES

There are over 100 references that were used in developing the EcoBalance™ planning process. Projects, figures, mapping techniques, carrying capacity data are presented. Please Send $10 and a self addressed stamped envelope to Center for Maximum Potential Building Systems, 8604 FM 969, Austin, Texas, USA

LAND USE	SOUTH	CARRYING CAPACITY IN PERSONS
NATURE CONSERVED	12.47	62.40
NATURE MANAGED	11.74	1.60
AGRICULTURE	5.94	58.10
HABITABLE	3.58	78.00
EDGE INTEGRATION	7.76	0.00
WATER	0.49	38.40



PEACEABLE KINGDOM CMPBS

A SOUTH AFRICAN PERSPECTIVE ON DECISION-MAKING FOR URBAN SUSTAINABILITY

Chrisna du Plessis
Programme for Sustainable Human Settlements
CSIR Building and Construction Technology
PO Box 395, Pretoria, 0001
Tel: +27 12 841 3891 Fax: +27 12 841 3400

INTRODUCTION

It is increasingly being realised that sustainable development will require changes in the processes and protocols of decision-making in cities. (Curwell, Hamilton and Cooper, 1998; Du Plessis, 1998). The lack of clear decision-making protocols for urban sustainability is proving to be a serious obstacle to implementing sustainable development.

Sustainable development calls for holistic and therefore complex decision-making. The growing realisation that cities should be treated as systems, and not just agglomerations of functions, is resulting in a worldwide trend towards integrated development planning (IDP). However, IDP does not necessarily lead to sustainable development. The main challenge facing urban sustainability is how to include the ethos and principles of sustainable development in all levels of decision-making in an integrative and iterative process. Recent developments in South Africa legally require all local authorities to address this challenge.

This paper looks at the efforts of three local government structures in South Africa to develop an integrated development planning process that will result in more sustainable cities. It presents the first findings of a study undertaken for *CIB Task Group 38: Urban Sustainability* to identify the understanding of sustainability and key protocols, drivers, and barriers for urban sustainability. The ultimate aim of the study is to identify a decision-making framework for urban sustainability.

THE SOUTH AFRICAN CONTEXT

Section 24 of the South African Bill of Rights states that:

"Everyone has the right...to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that secure ecologically sustainable development and use of natural resources, while promoting justifiable economic and social development."

The SA constitution further places most of the responsibility for promoting social and economic development and a safe and healthy environment on local authorities (Section 153).

Local Government Planning Responsibility

Since 1995, several processes have been put in place to facilitate an urban planning and development process that is participative, integrative and sustainable. The most notable of these are the development of Land Development Objectives (LDO's) regulated by the Development Facilitation Act (67, 1995) and Integrated Development Plans (IDP's) regulated by the Local Government Transition Act (97, 1996, 2nd Amendment) and the Draft Local Government Municipal Systems Bill (1999). All local authorities are required to prepare LDO's and IDP's and regularly review them.

National Sustainable Development Policy

To inform local government as to what the direction and priorities of national government are, three important policy outlines that describe the various aspects of sustainable development were adopted.

The *Reconstruction and Development Programme* (RDP) describes the country's policy regarding human development and provides the main socio-economic framework. It seeks to build a democratic, non-racial and non-sexist future. The *Growth, Employment and Redistribution Strategy* (GEAR) is the country's main macro-economic policy designed to facilitate overall economic recovery. It places emphasis on an export-orientated economy and local economic development. Finally, the *White Paper on Environmental Management* (May 1998) provides the foundation for the country's environmental policy.

Unfortunately, these three guidelines and the policy and legislation resulting from them are often in conflict and there is no coherent strategy for addressing these conflicts.

THE CASE STUDIES

At the time of writing, South Africa has a two-tier local government system consisting of an overarching Metropolitan Council and independent Local Councils. Three case studies representing this hierarchy have been used for the study. All three cities are actively using sustainability principles to drive their strategic decision-making, with various levels of success.

Midrand Metropolitan Local Council (MMLC)

Midrand is situated between Johannesburg and Pretoria. Approximately 85% of its population is living without basic services, housing or access to economic opportunity. It is also one of the fastest growing urban areas in the country. Its major economic growth base is light industry and information technology. The MMLC has declared its intention of turning Midrand into the first South African Eco-City and is actively pursuing this vision.

Durban Metro Council (DMC)

Durban is the second largest industrial hub in the country with a population of 2.3 million and the largest informal settlements in the country. It was the first city in the country to develop and implement a Local Agenda 21(LA21) programme and has used LA21 to guide its IDP process.

Cape Metro Council (CMC) and the City of Cape Town, Tygerberg and South Peninsula Local Councils.

The Cape Metropolitan Area includes 6 Local Councils with a combined population of 2.9 million. Together they administer a World Heritage Site and several very sensitive environmental zones. The CMC officially supports LA21 and has an active Environmental Management Department.

METHODOLOGY

The information for this study was gathered from a set of questionnaires answered by several officials and politicians within each case study, personal interviews with these officials, and the IDP and other policy documentation available for each case study.

PRELIMINARY FINDINGS

Interviewees were required to make a qualitative assessment regarding the levels of policy commitment to certain indicator programmes for economic, environmental and social aspects of sustainable development, as well as the levels of implementation of those policies. A second set of questions attempted to discover what instruments were being used by the local authorities to further sustainable development at strategic level, planning level and operational level, while a third set of questions attempted to identify the key drivers and barriers to decision-making for sustainability.

Policy versus implementation

All three cities scored high on policy for meaningful public participation due to the IDP requirements directed by national government. Procurement criteria that include social preconditions and the support of local economic development also received strong policy support, again because of national policy directives. However, when it came to levels of effective implementation, the scores were considerably less optimistic.

Another high scoring point was policy and implementation for the conservation of natural areas and green spaces. Only Midrand had high scores for measures to reduce resource use and the minimisation of pollution, and although policy called for the support of locally driven "green" initiatives, little is yet being done in practice.

Instruments used to ensure sustainable development

At *strategic level* both Durban and Midrand has a specific policy to address sustainable development. All three cities use the IDP process as a strategic planning tool, with the LA21 principles providing guidance on sustainability. Other guidelines being used are the Natural Step (CMC), the Earth Charter and the Hanover Principles (both Midrand). Tools such as Strategic Environmental Analysis, Community Needs Analysis and State of the Environment reporting are also used to inform strategic decision-making.

At *planning level* spatial development frameworks, based on socio-economic criteria, have traditionally been used to guide infrastructure investment and housing and industrial development. Environmental management plans, environmental impact assessment, community safety plans and local economic development strategies are recent additions to the tools used by these local authorities to guide their planning decisions. The tools used represent a fair balance of environmental, social and economic issues, although in practice the environmental issues outside protected areas are not adequately addressed.

At an *operational level* the questionnaire looked at two aspects: the procurement policies of the local authorities, and the requirements they have for planning approval.

As a result of national policy on affirmative action and local economic development, certain social requirements are included in tender and contract requirements as standard practice. These include employment equity (based on race and gender), the use of local contractors and suppliers, and the creation of opportunities provided for local capacity building and skills transfer.

However, the environment plays a very small role in the decisions made at operational level. Midrand is the only local authority that is currently looking at introducing issues such as life cycle costing in their procurement policies, and at introducing economic instruments that encourage more efficient resource use among its ratepayers.

Apart from general issues such as health and safety, the principles of sustainable development are not reflected in the criteria for project approval. Although there is legislation in place that requires EIAs for certain types of development, this is, in many cases, not satisfactorily implemented and monitored due to the high costs involved and a lack of capacity within the local authority.

Key drivers

In all three case studies, national policy played a definitive role in introducing sustainability to the urban development process. The integrated response required to a series of ecological disasters further prompted the local authorities into action. The vision and dedication from key officials and politicians is a further main driver contributing to the continuous development of decision-making for sustainability.This last driver is both the strongest element in the success or failure of the vision held by these cities, and its ultimate weakness in a transforming and as, yet unstable, political environment.

Barriers to decision-making for sustainability

The main barriers towards decision-making for sustainability were described as:

- A lack of understanding among the different stakeholders of what sustainable development entails and the benefits it can bring to the local authority, the community and business. This also contributes to conflicting policy directives and a lack of clear protocols.
- Low levels of political will to implement sustainable development initiatives.
- Low levels of public willingness to participate in initiatives.
- A lack of capacity within the local authority to effectively plan, implement and manage interventions for sustainability, coupled with ineffective regulatory instruments.
- Little or no co-operation at line department level during the planning stage.

CONCLUSIONS AND RECOMMENDATIONS

It would appear that although there is strong national and local policy support for sustainable development in South Africa, the focus remains on socio-economic sustainability. This lack of emphasis on environmental sustainability can become a serious threat to the country's socio-economic sustainability.

Furthermore, the case studies illustrated that the success or failure of policy implementation relies heavily on the personal commitment of a few local authority officers and councillors and the levels of skills and resources available to the local authorities. Unless clear protocols are established to lessen dependence on individual commitment and skills, the process of introducing decision-making for urban sustainability will in itself not be sustainable.

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Industrial Data on the Material Flows of the Swedish Building Stock

Åsa Jönsson (Ph.D.)

1. **Building Design, Chalmers University of Technology, S-412 96 Gothenburg, Sweden**
2. **Skanska Teknik AB, Lilla Bommen 2, S-405 18 Gothenburg, Sweden, asa.jonsson@teknik.skanska.se**

INTRODUCTION

The large quantities of material flows in society are important contributors to the environmental impacts. The Swedish building stock comprises about 3,1 million buildings, and the amounts of materials already built into the existing stock correspond to around 130 tonnes per capita. Today there is a lack of statistical information and other support for decisions on the material flows generated by the building sector. As a basis for decreasing the environmental impacts from the building stock, reliable systems and routines for gathering and presenting environmental data are needed.

Since the late 1970s, several surveys have been carried out in Sweden for various parts of the building stock. They have generally been based on sample surveys, modelling the existing stock and its characteristics, thus applying *a bottom-up approach*. At Chalmers University of Technology, a dynamic model describing resource deposits and resource flows in the Swedish building stock is now being developed, using a bottom-up approach [1]. The overall flows of resources into and out from the stock may also be described by using general statistical data and data from the building industry and trade associations, i.e., using a *top-down approach*. The existing stock is then considered to be a "black box", in which a certain amount of resources have already been deposited. In the top-down approach, the aim is to describe the *total* flows and eventually distribute them on activities in the building stock. The bottom-up approach is advantageous for the description of built-in materials, whereas the top-down approach is advantageous for the description of changes over time, i.e., of the in- and outflows.

OBJECTIVES, SCOPE AND METHOD

The objective of the project described in this paper was to investigate what industrial data are available in Sweden to quantify the deposits and flows of materials in the building stock using a top-down approach. The results should then serve to check the reliability of the bottom-up model that is being developed at Chalmers (see above), and to compensate for data gaps in that model. The Swedish building stock was chosen as object of the study, including all existing building types. Only mass flows directly related to the physical building were taken into account. Literature studies were first made. Then the presumed data providers were interviewed, mostly by telephone. The full study is to be published in August 2000 [2].

DATA SOURCES

Several data sources may be used to describe the material flows of the building stock. *Swedish official statistics* produce statistical information on a regular basis, such as statistics about the production of commodities, exported and imported quantities of goods, housing, building and construction, and waste. *Statistics Sweden* (SCB), the Swedish office for national statistics, holds databases available in Swedish on the internet, in which private persons may conduct their own searches free of charge (see www.scb.se/databaser/ssd.asp). The official statistics are not further discussed in this paper. Data on the inflows of materials into the building stock may also be obtained directly from the *building industry*, mainly from manufacturers of building products, wholesalers and building contractors. Several *trade associations* compile statistics for their members or for the whole industrial field. Data may also be acquired *using market research institutes* that specialise in gathering this kind of information. Main data sources used in this survey were trade associations related to the building sector, and manufacturers of building products.

RESULTS, DISCUSSION AND CONCLUSIONS

Table 1 summarises industrial data found that describe the annual production/use of some building related materials in Sweden. Partly depending on who produces the statistics, it differs between the data whether they refer to the produced, sold or used quantities, whether they have been adjusted to import/export and how large share of the market is covered. For several products not included in Table 1, statistical data do exist but are not publicly available. For example, data may be kept by trade associations for use by members only.

Table 1. Industrial data on annual production/use of building related materials in Sweden in 1998.

Material/product	Quantities [1998, if not stated otherwise]	Comment
Aggregates [1,2]	75 Mtonnes	delivered quantities
Cement[2,3]	1,15 Mtonnes	delivered by the main Swedish supplier (Cementa)
Ready-mixed concrete[2]	2,1 Mm^3	Production in Sweden; around 98% of the total volume
Concrete in precast concrete products	1 Mm^3	Annual production in Sweden, estimation
Steel used for load-bearing constructions[1,3]	132,4 ktonnes = 2,11 Mm^2	use in buildings; around 70% of the market
Ceramic tiles for floors and walls	6,4 Mm^2	use (including import)
Sawn timber[2]	4,27 Mm^3	use
Wood-based panel[1]	555 000 m^3	use (including import)
Glue-laminated timber[2]	25 000 m^3	Annual use, estimation
Plasterboard [2]	20 Mm^2	Annual use, approximation
Mineral wool[2]	120 ktonnes	Annual use, approximation
Wall covering [1]	44,6 Mm^2	sold quantities; 80-90% of the market (12 suppliers)
Floor covering [1]	19,9 Mm^2	use (including import)
Paints [2]	178 000 m^3	sold quantities
Levelling compounds (flooring)	77,8 ktonnes	data from suppliers, use for ceramics
Fixing & jointing compounds	9,19 ktonnes	data from suppliers, use for ceramics
Doors	1,1 million doors	Annual production in Sweden, approximation
Windows	1,2 million windows	Annual production in Sweden, approximation
Wooden staircases	25 000 m^3	Annual production in Sweden, indoor use, approximation

[1] Data are also available distributed on specific product types and/or use areas.
[2] All applications, including buildings
[3] Data refer to production/use in 1997

Regarding the *output flows* from the building stock, hardly any such industrial data were found on the national level in total or for specific material flows, although there are approximations. One exception was the statistics on white goods at about 250 000 discarded pieces a year.

For some products, use in buildings could not be distinguished from use in other applications. Also, no data sources have been found that distinguish products used for new production from products for renovation. Neither could waste flows from new construction be separated from waste from maintenance and renovation and demolition waste.

For most products, industrial data can be obtained only for a limited time period. Cement is the product for which statistical data have been gathered during the longest time; from 1895 and on. Another example of long data series is for floor coverings: estimates had been made of the sold quantities during 1955-1970, and from then on sales statistics have been compiled. However, for most of the products where industrial data were obtained, systematic compilation of such data has been introduced during the 1990s.

To know better what products are in-built in the existing building stock, knowledge on the time intervals during which specific product types have been marketed may be helpful (see Table 2).

Table 2. Estimated use intervals for some building related materials in Sweden (examples).

Material	Use interval	Comment
Cement	1871-	Manufacture in Sweden on a large scale started by Skånska Cementaktiebolaget
Elevators	before 1900-	Use in Swedish buildings
Glue-laminated timber	1919-	Introduction on the Swedish market
Lightweight concrete	1929-	Industrial production started by Yxhult
Mineral wool	1937-	Swedish manufacturing was started by Rockwool
Plastic products	1950s-	Use in buildings started
Plasterboard	1957-	Swedish manufacturing was started by Gyproc
Plastic floor coverings	1960s-	Introduction on the Swedish market
PVC pipes	1970s-	Introduction on the Swedish market
PVC window frames	1970s-	Introduction on the Swedish market
PCB	1920s-1970s	In 1978, use in all new applications was prohibited
Cadmium in plastics	-1982	Prohibited
Blue asbestos	-1976	Prohibited

It was concluded that top-down data are not in general of good enough quality to quantify what materials are present in the existing building stock. However, for a specific product group or a well defined part of the building stock, data will be good enough to check the reliability of the results of a bottom-up model. Also, for the main part of the material flows, the yearly *changes* in the built-in quantities of materials can be calculated by using industrial data.

ACKNOWLEDGEMENTS

The Swedish Foundation for Strategic Environmental Research, MISTRA, supports environmental research, mainly through broad-based inter- and multidisciplinary programmes. One of these programmes is *Sustainable Building - An Ecocycle System in Buildings and Construction*, with the aim to solve a number of major problems relating to buildings and the external environment. The survey described in this paper is part of - and financed by - this MISTRA programme.

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Professor Jón Kristinsson
Environmental Technical Design
Department of Architecture
Delft University of Technology
Berlageweg 1, 2628 CR Delft
The Netherlands
Phone: +31152786401 fax: +31152784178
E-mail: J.Kristinsson@bk.tudelft.nl
Architecten- en ingenieursbureau Kristinsson BV
Deventer phone: +31570651035
www.Kristinsson.nl

Peter Welleman
Industrial Design Engineer
Technical Illustrator
MarineSafety BV, Rotterdam
Wilhelminakade 701 3007 GG R'dam
The Netherlands
phone: +31104866654 fax: +31104846071
E-mail: pwelleman@marinesafety.nl
Welltech phone: +31-10-2656956
Cleyburchstraat 23 b 3039 DB R'dam
www.marinesafety.nl

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SUSTAINABLE COMMUTER TRANSPORT

Abstract
The second most important aspect of sustainable building is, strangely enough, not the buildings as such, but transport. In commuter traffic two and a half times more energy is generally used than in one's own home.

Commuter transport is based on two main principles:
a. Going by public railway transport from one city centre to another, etc. etc.
b. Travelling by private car from frontdoor to frontdoor during peak hours

The commuter traffic mentioned here is based on 'before and after' transport by private means of transport from one's home to the motorway. Here one leaves behind one's own means of transport - bicycle, electric vehicle, car, private car, roller skates, skeelers, or wheelchair - in a depository and travels collectively by a 24-hour interliner to a step-over station in the town of one's destination. Here one can collect one's bicycle, witkar, wheelchair or skateboard- as one's own means of private transport. If you go a place in the country or to a new destination, you can take your own compact means of transport with you in the carrier.

This simple means of commuter traffic is highly sustainable and interesting from a financial and organisational point of view, if goods are also transported on these interliner carriers in the off-peak hours and during the night. Thus there will be an even stream of traffic on the roads, because of a combined transport system for people and goods. The Icarus carrier ' in status nascendi'.

Keywords:

- individual/collective transport
- a 24-hour interregional transport by road
- commuter transport
- combined transport of people and goods
- semi-public transport
- tailor-made public transport
- reduction in travelling-time
- energy-saving transport
- a better use of highways
- cheap public transport
- new double-deck carriers/trailers/interliners
- information-technology in public transport

- automatic registration of passenger transport
- intelligent commuter transport/traffic
- new means of transportation
- step-over stations along highways
- the motorway a silent artery for towns?
- multifunctionally-built noise-protection walls
- building lots along the highway
- noise abatement zones along highways
- towns will get an economic impulse
- multipurpose transport
- relief of traffic in city centres
- upgrading of ringroads around towns
- STOA is a step-on/off station
- welcome traveller

SUSTAINABLE COMMUTER TRANSPORT

Commuter traffic is highly diverse but based on two main principles in the Netherlands:

Public transport by rail often moves from one city centre to another. A central traffic junction is ususally passed. Another way of travelling to and from work is by private car in peak-hours, all the way from the frontdoor of one's home to the entrance door of the workplace.

Visualized in a scheme, this can be represented in three mobility models:

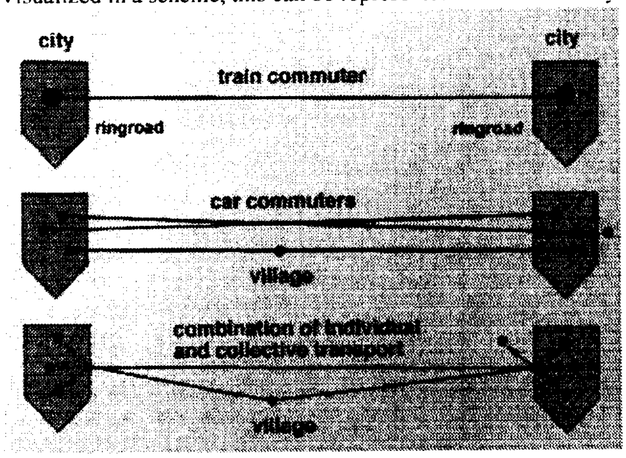

Figure 1

The enormous success of the private car has exceeded all reasonable growth limits. Roads and towns are choked with cars -stationary cars. A parallel may be drawn with wine-yeast, which destroys itself at an alcohol concentration of 12%. Meanwhile public transport is largely deserted, reduced and subsidized.

The train commuter must often travel by bike from a suburb to the railway station. From there he travels to another railway station and then by city bus to his work. This is the correct picture of commuter traffic according to the central government. The motorist sitting in his car and listening to the radio halted in a traffic-jam, reaching his place of work by fits and starts belongs to a fast-growing group of commuters. The policy of having a wide range of places of residence without adequate public transport has encouraged this development up to the saturation point of most roads. The fuel consumption and CO_2 emission of this form of commuter traffic is five to ten times higher than those of public transport. This is not so strange, the energetic output is 2% for a private car with only the driver in it. In the combined individual-collective transport system, called the Icarus carrier, the commuter travels by his own means of transport to the highway: here at the step-over station he will switch and get on the collective interliner. By way of wireless passenger information the driver knows where he has to stop.

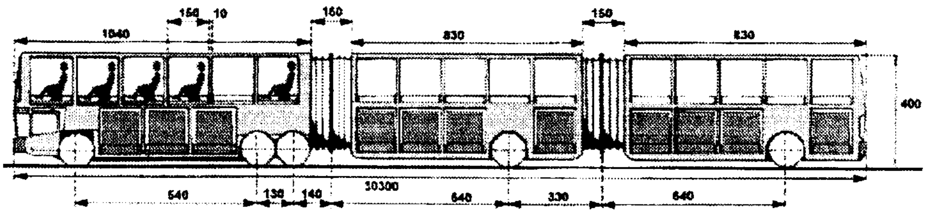

Figure 2. The combined people-goods means of transport is called the Icarus carrier.

The general concept of a carrier is a long, segmented vehicle that can transport people and Icars on two levels. Because of the extended length a high number of small Icars can be all transported at once. Adding segments has a disadvantage, however: the infrastructure of today is not suited to such long vehicles. For safety reasons special highway lanes should be reserved for long carriers and trucks only. These lanes should be equipped with long entrance and exit ramps. Whenever these adjustments to a particular highway are not possible, carriers with fewer segments should be used.

In its most simplified and technologically feasible format, the Icarus is a truck with a carrier/trailer. The carriers may be of various dimensions, including double-deckers with trailer segments. Loading and unloading structures, as well as door dimensions, should be standardized, in order to enable exchange of pneumatically-driven store pallets at high rates of speeds. High-tech telematics should ensure a flawless functioning of the Icarus. The concept of Icarus is based on shipping and road transport systems with flexible working-hours and a possiblity of functioning independently. The Icarus should be a private multi-carrier, able to function both as a small-scale transport system, and as a large-scale international system with connections to rail and air transport and maybe even to modern zeppelins.

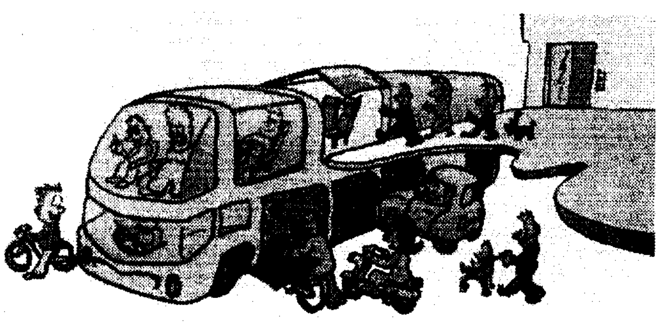

Figure 3.
STOA (the step-on/off station) The step-over device along the highway may look something like this picture.

The traveller

The traveller, in whatever capacity, will be welcomed in a waiting-room which is warm, well-lighted and provided with information, call systems, telephone and telematics. Each traveller, as a registered menber of Icarus, will have arranged beforehand all payments and requests for transport, including times of departure and arrival, so that individual mobility needs can be anticipated.

The first presentation of a 24-hour individual/collective transport was shown on the website of the municipality of Zwolle at the end of 1999. It was visited by 20.000 people all over the world.

All big cities are situated on a highway and sometimes the highway cuts through the town and its extremely poor adjacent development with much noise disturbance and exhaust gases. As mentioned before, the A 28 highway runs right through the centre of Zwolle, a provincial capital in the centre of the Netherlands. This paper is about the fundamental solution to make a virtue of necessity. How can this uninhabited noise-disturbance zone be made into an economic artery next to the medieval city centre?

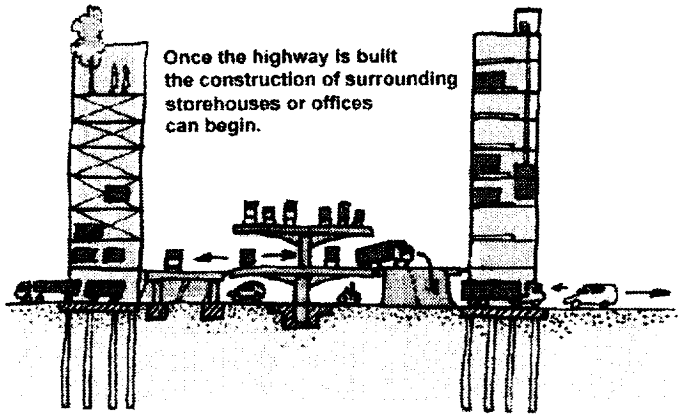

Figure 4

The approach is as follows:

- Resist noise disturbance there where it arises so that valuable land alongside the road is available for building. See figure 4.
- Make the highway narrower by constructing highways in layers, in accordance with the type of traffic and its destination.
- Build multifunctional high noise-protection walls, for example by building warehouses used for storing goods and parking private cars and bicycles.
- Develop a simple, 24-hour people and goods transport by road that, from the highway, reaches
- The multifunctional high noise-protection wall by means of a step-over machine.

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Professor Jón Kristinsson
Environmental Technical Design
Department of Architecture
Delft University of Technology
Berlageweg 1, 2628 CR Delft
The Netherlands
Phone: +31152786401 fax: +31152784178
E-mail: J.Kristinsson@bk.tudelft.nl
Architecten- en ingenieursbureau Kristinsson BV
Deventer phone: +31570651035
www.Kristinsson.nl

Peter Welleman
Industrial Design Engineer
Technical Illustrator
MarineSafety BV, Rotterdam
Wilhelminakade 701 3007 GG R'dam
The Netherlands
phone: +31104866654 fax: +31104846071
E-mail: pwelleman@marinesafety.nl
Welltech phone: +31-10-2656956
Cleyburchstraat 23 b 3039 DB R'dam
www.marinesafety.nl

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A STUDY OF A MULTIFUNCTIONAL TRANSPORTATION SYSTEM FOR THE A28 MOTORWAY

Abstract

This new 'light' transport system presents a fresh outlook on all transport and a more efficient use of the roadways of today. The hart of this system, which operates around the clock, is a new, multifunctional double deck carrier. During the rush hour this carrier is suited for transporting people and for the slow hours it's quickly changed into a cargo-carrier. In addition it is equipped to transport bikes, scooters and even small electric vehicles, so travelers can take care of their own "before -and after transport". This carrier moves rapidly among several terminals, which function not only as gathering places for the public but also as 'high tech' warehouse. These terminals are situated along the highways to block off all the noise and to provide quiet surroundings.
The new transport system is well-matched with the present Western life style, it complies with the Rio-CO2 reduction and it is universally applicable. Although this long-term study - working name "Icarus" - has a broad purpose regarding means of transport, logistics, transshipment, users' wishes and financing, short-term application is the point of departure.

Keywords:

- Building in the nuisance zone
- Multi-layered highway concept
- Connection highway and surrounding buildings
- Reassessing space around highway
- Connectivity among parts of the city
- Separation of local, regional and international transport
- Transferia on tangent nodes
- Individual/collective transport
- Optimum public/private partnership
- No interruption of present traffic
- Full use both in low and peak hours
- Small individual vehicles or "Icarus"
- Rapid implantation
- Highway A28 near Zwolle as case study

The components of the system

The two most important parts of the system are the Icarus carrier and the Terminal. The third component, the small individual means of transportation has enjoyed rapid development the last two decades. All sorts of small bikes and light vehicles are commercially available today, most notably the Smart car and Brompton bike. Prototypes of carriers and corresponding terminals however are not as wide spread yet, although they are easily feaseble with today's technology.

The Icarus-carrier

In its most simplified and technologically feasible format, the Icarus-carrier is a truck with carrier-trailer. The carries may be of very diverse dimensions, although double deckers with trailer segments are considered was well. The unloading and loading structure, and door dimensions should be standardized, in order to be able to change the pneumatically driven store pallets in high-speed rate. The Icarus is functioning flawlessly, thanks to high tech telematics. The idea of Icarus stems from shipping and road transport, with flexible working hours and the ability to cope independently. The Icarus is a private multicarrier, able to function both as a small-scale transport system, and as a large-scale, international system, with connections to rail and air transport. May even to modern zeppelins.

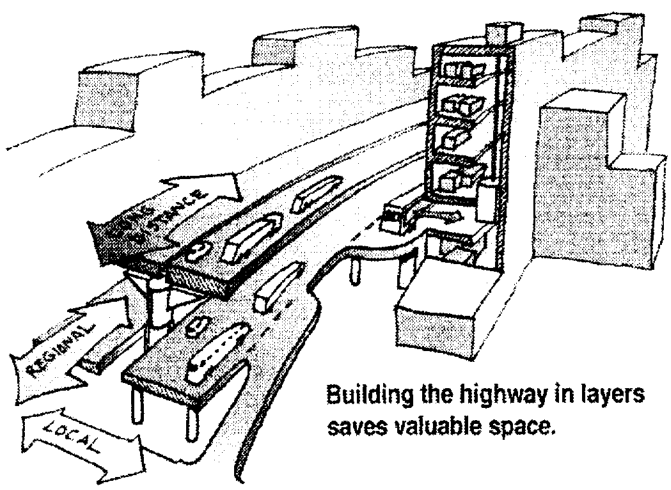


Figure 1

The terminal

The new tangent connection between main road and city has never been tested before. The stations for transhipment and boarding, are diverse of design and capacity, notwithstanding standardization. The terminal is a transfer apparatus between fast traffic and various forms of slow traffic. The terminal connects architecture, store technology and the chip culture.

But how to implement these ideas in the already existing city layout of Zwolle, a community divided in two parts by a large highway. Future planning of the city is impossible without reconsidering the role of the big barrier, which will be increasingly situated near the hart of Zwolle as the city expends. The solution is not only to included the highway in the spatial planning but to heavily integrated it with the future constructions, which will be build over enter- and exit ramps, claiming unused valuable space. Continuous building along and over the highway will eventually block of noise and provided numerous opportunities for commerce and the public, the later demanding more high quality living areas (see figure 2).

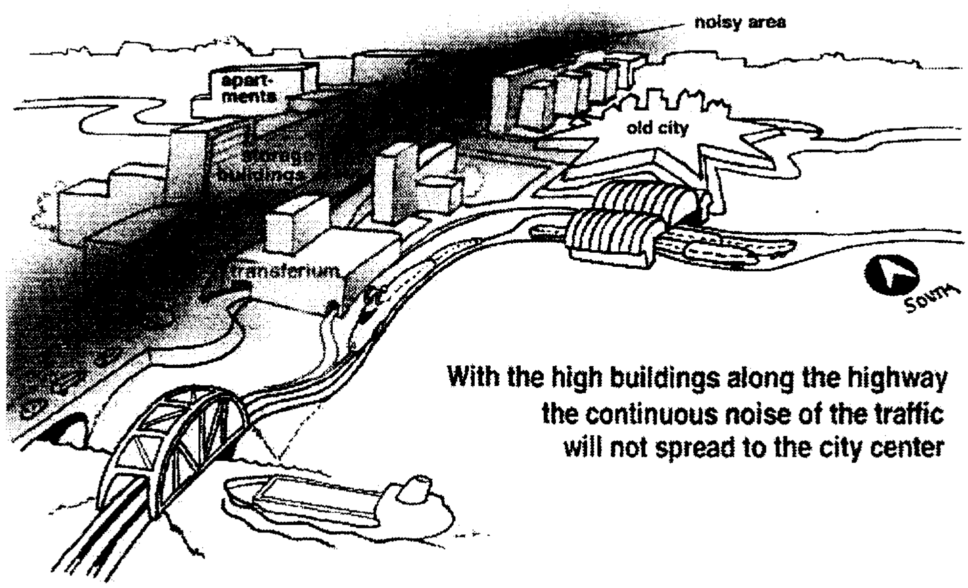
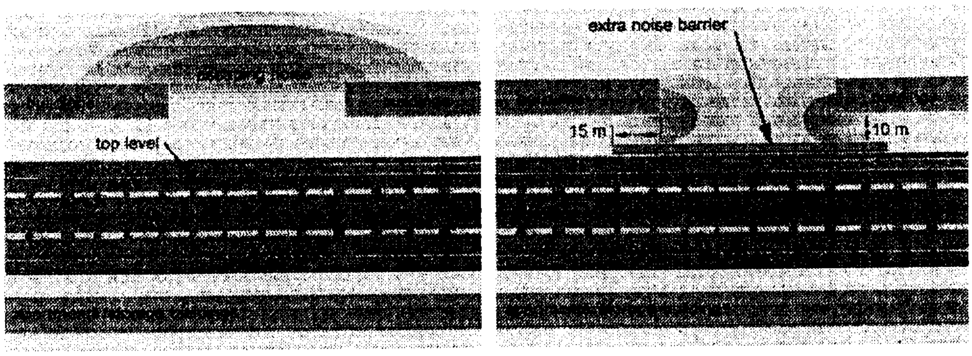


Figure 2

Rapid implementation may be expected through the double usage that boosts expansion by lower running costs. Companies, used to carry out transport of passengers during the off-peak period, may, in the same 'Icarus' system, also transport their personnel, apart from goods. It stands to reason that in some countries legislation will have to be adapted. International standardization of the infrastructure and maintenance of criterions of the carriers of the secondary vehicles and the road stores, are rapidly becoming urgent. Many features of the Icarus system underline an integral transport network concern changes and possibly trend breaking:

-An acceptable replacement for the private car in commuter traffic
-A supplementation to public transport during weekends and night
-Constant use of main roads and means of transport, 365 days a year
-Supplementation to transport of small-scale, unwrapped goods
-The periphery of the city is going to relieve the centrum
-Decentralization of the transhipment and transfer apparatus
-New, personalized approach in collective cooperation
-Decentralization and scaling down in transport goods
-Optimum public/private partnership
-Warehouses may form noise barriers along motorways
-All regions, villages and cities are accessible around the clock, senior citizens and non-car-owners may travel cheaply and safely
- The aim at limitations of the room for environmental use, link the individual transport of the car user and the collective public transport of the more economical and/or environmental-minded traveler.

In order to avoid noise traveling all over the city, as is almost the case now, it is necessary to implement different "blocking" techniques as the pictures below show:



Figures 3 and 4

However in some cases more dramatic constructions need to be considered: covering the highway completely, sealing of the noise source (see figure 5). To secure free movement among different city parts, tunnels underneath the mulilayered highway provided easy access for pedestrians and bikers. However these far reaching plans can only be realized through international cooperation, necessary for development and standardization. With involvement of all stakeholders, highways can become more than just congested obstacles in our way.

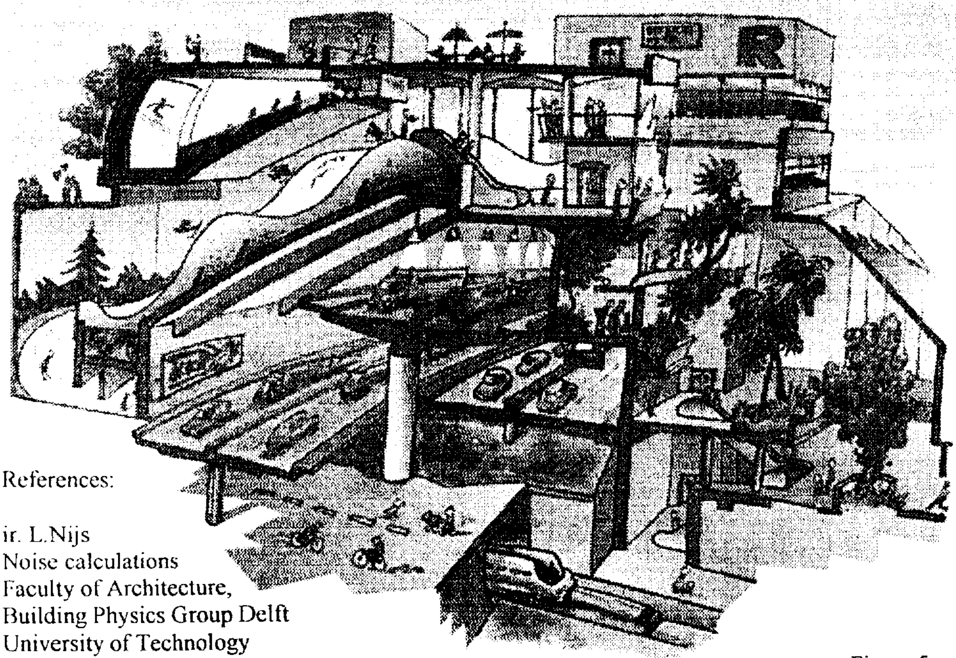


Figure 5

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Noise calculations
Faculty of Architecture,
Building Physics Group Delft
University of Technology
Email: l.nijs@bk.tudelft.nl
ir.de Ruiter - "the ecological city" DIOC, Delft Interfacultaire Research Center
Email: e.deruiter@city.tudelft.nl

THE URBAN ENVIRONMENT IN THE HISTORIC CONTEXT
THE CASE OF THE OLD CITY OF ALEPPO - SYRIA

Dr. Maan CHIBLI
Urban and Environmental Planner / GTZ / SURADEC - PO Box 8844 / Aleppo - SYRIA
e-mail: mnmn@cyberia.net.lb - www.gtz-aleppo.org.

INTRODUCTION

Aleppo's Old City is a unique example of a peaceful harmony between the lifestyle and the need of the people to protect the urban environment. However, the pressure of modern living exposes the fabric of the Old City to great dangers that may damage its very existence. In 1986, Aleppo's Old City was declared an UNESCO World Heritage Site. The City initiated the Project for the Rehabilitation of the Old City in 1992 with the German Government as a partner. GTZ was commissioned by the German Government to administer the German contribution.

PRESENTATION

The Rehabilitation Project in Old Aleppo is not geared towards preserving specific historical monuments. The work is mostly concerned with introducing urban interventions to stop the deterioration of the historic city as a place of habitation, and to keep the inhabitants in place. This has been emphasized by the Old City's Land Use concept, which designates specific areas for residential, commercial, tourist or mixed use to be permitted in certain zones of the Old City. The Old Aleppo is suffering from several environmental problems; some of them need long term planning and others need immediate action measures. An integrative approach is defined to deal with environmental issues in the Old City for the present and the future in the Development Plan (Chibli, D. Plan, 1999), and treated in details in our Action Areas (AA's) where we pointed the priority for interventions (Chibli, AA3 report, 1998). The work comprised fixing objectives and strategies for the following topics:

A- Creation of a legislative framework

Within the absence of legislation in Aleppo, discussions have been carried on with the City Council for the adoption of new laws in favor of the environment. The first one was the control of noise pollution generated by traffic, which have proceeded the "Campaign against noise" and the second was the Environmental Impact Studies for the new projects which is in an experimental phase.

B- Air pollution

Mainly traffic and heating systems cause the increase of air pollution and affect historical monuments. The fleet of cars is obsolete and leaded gasoline and high sulfured diesel-oil are the main fuels. An air pollution assessment was undertaken and revealed that there is a high particulate pollution coming mainly from diesel engines and heating systems and NOx pollution coming form transportation. A program to improve air quality is to be adopted to control emissions exhaust.

C- Noise pollution

Because that the Old City is a commercial and administrative center, noise pollution is becoming an increasing source of discomfort to people living in the area. The "Campaign against Noise" was accompanied by noise level's measurements (Chibli, Abdulwahab, 1999) that revealed that there were high levels of noise especially, close to major traffic axes if we refer to the number of passing vehicles and the European standards.

D- Greening program

Green areas are widely demanded, especially in the Old Çity, to compensate overheating, absorb dust and reduce air pollution. The work in this field is constituted by the creation of a public park in the south of the Old City just outside the Wall, to meet the social and the environmental needs of the population. Another experimentally project (with the University of Berlin) is to green the building's roofs and give thermal comfort for users inside.

E- Water and soil pollution

The main sources of water pollution are the illegally operating slaughterhouses and the leakage between the defective water supply and the old sewer systems. This situation largely affects the sub-soil conditions, which induce heavy damage on structures. The replacement of the dilapidated sewer and water systems of the Old City and the prevention of the illegally operating slaughterhouses will largely improve the situation in this field.

F- Energy use in buildings

The energy use-study we have realized in the Action Areas 3 (AA3) in 1998 was the first study at the level of the Old City (Chibli, AA3 report, 1998). It concerned the residential and commercial activities and showed that in 1998, Jdaideh consumed about 3773.98 toe of final energy. Consumption is essentially constituted of diesel oil, and electricity. The energy use in the Domestic sector amounts to 1325 toe representing 35% of the total energy consumption in the area. Families have access five forms of energies: electricity, diesel oil, gasoline, LPG, and kerosene. Between them, there are three major: diesel oil, electricity, and the Liquefied Petroleum Gas (LPG). Households' diesel-oil consumption amounts to 653.77 toe (49.31%) and constitutes by far the first used energy. Electricity holds a relatively important place and satisfies the following uses: lighting, refrigeration, functioning of appliances, water heating. The electricity, with 371.50 toe it represents 28.02%. The average households consumption was 2805 kWh for a rate of appliances still far from saturation. LPG mainly serves for two principal uses: cooking and water heating. It is conditioned into bottles of 12 kg due to the absence of gas network in Aleppo. The LPG with 203.24 Toe represents 15.33%. Households have an average consumption of 25.9 bottles per year, in terms of frequency it represents the acquisition of a bottle of 12 kg each 14 days. Gasoline serves for Households trips, its consumption amounts to 70.25 toe representing 5.3%. This weak share is due to the low motorization rate 7.5%. Kerosene was used by poor households for cooking and cleaning purposes. Kerosene consumption was 27.03 Toe, which represents 2.04% of energy consumption. Commercial energy use in Jdaideh is 65% of the total local consumption. The commercial energies are predominately diesel oil, electricity, and LPG. In 1998, commercial diesel oil consumption amounts to 859.76 toe, which represents 35.12% and constitutes the first used energy in Jdaideh. It is considered as the heating energy, used for space heating in shops, workshops, restaurants and hotels, water heating and a limited use for generating electricity. Hotels and restaurants are the highest consumers; they have an average consumption of around 222 toe per year, which correspond to 26% of the commercial diesel consumption. Electricity with 837.62 toe holds the second place among the commercial energy use (34.21%). Of electricity used in commerce, 12.5% is consumed in hotels for lighting, cooling, heating, refrigeration and the operation of machines and appliances. Hotels and restaurants rank as the highest consumer in the commercial category, consuming 24% of all commercial energy. LPG with 597.94 Toe represents 24.42%. It is used for cooking and water heating. The hotels and restaurants have an average consumption of 101.4 toe per year, in terms of percentage it represents 17% of the total commercial energy consumption in Jdaideh. Gasoline consumption amounts to 148.20 toe representing 6.05% and used only for transportation purposes. Kerosene is used in shops mainly for cleaning purposes. Its consumption is negligible (0.19%). As long as we consider Jdaideh as a potential terrain for tourist's activities, the development of new hotels and restaurants should be watched carefully. Only two hotels of 14 rooms each and five restaurants consume about 26% of diesel, 24% of electricity and 17% of LPG of the total commercial energy use. Though, the importance of developing alternatives to fossil fuels and on

Table 2: Gross energy consumption by sector in Jdaideh

Source	Residential		Commercial		Total
	toe/year	%	toe/year	%	
Diesel oil	653.77	49.31	859.76	35.12	1513.53
Electricity	371.5	28.02	837.62	34.21	1209.13
LPG	203.24	15.33	597.94	24.42	801.18
Gasoline	70.25	5.3	148.2	6.05	218.45
Kerosene	27.03	2.04	4.69	0.19	31.72
Totals	1325.79	100	24448.19	100	3773.98

reducing the amount of energy produced in the first place through improved energy conservation and efficiency. Solar energy is likely to be introduced in the immediate future.

G- Solid waste

The collection of Wastes is organized by the municipality and carried out daily. The inadequate disposal of wastes in Jdaideh creates a range of environmental problems. Originally, exist the difficulty of surveillance and the absence of penalties, but mainly the total undisciplined and the acquired habits of inhabitants. The "Cleanliness Campaign" was launched in Jdaideh to improve the waste situation (Chibli, Abdulwahab, 1998). The Objective was to raise the awareness of the residents, to secure the enhancement of the waste management and to develop a sustainable mechanism to face such a problem in the future. The campaign can be considered as having been successful and strongly supported by the population.

CONCLUSION AND RECOMMENDATIONS

We resume that planning which does not address environmental issues has little meaning at a time of global warming, declining of natural resources and degrading lifestyle with no doubt. The architect, as well, has a major role to play in determining how well the building will perform in terms of energy use. Increasing energy efficiency in buildings is one of the most significant areas of opportunity for energy conservation. Though, the purpose is to raise awareness among those involved in the planning and architectural process of the relationship between design decisions and environmental issues; and to demonstrate the significance of what planners can contribute to minimize environmental problems. The need to build consideration of environment impact into the design process will be an incentive for innovation and creativity. The environmental consciousness is the most critical element in lying the foundations for a sustainable development into the future.

Opportunities exist for designers to design buildings with high-energy efficiency degree and powered by alternative sources of energy, which will contribute to the reduction of urban air pollution and the protection of the environment. The recommendations amongst others are:

- Setting isolation standards to diminish the energy consumption and the noise level.
- Designing products, which improved energy efficiency.
- Using insulation materials, or solar panels, together with construction. This can dramatically reduce the energy requirements of buildings.
- Encouraging more people to use public transport, through the design of convenient systems which can make people less dependant upon private cars.
- Improving the environmental management in the small and medium sized enterprises.
- Enhancing public awareness, consultation and participation, particularly for problems that manifest themselves at the neighborhood level.

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MATERIAL AND ENERGY METABOLISM IN URBAN AREA

Yoshiyuki Shimoda and Minoru Mizuno

Department of Environmental Engineering, Osaka University
2-1, Yamada-oka, Suita, Osaka 565-0871, Japan

INTRODUCTION

Activities in modern cities are supported by enormous artificial metabolisms of material, energy and water. Enlargement of material flow means the increase in raw material consumption and waste generation simultaneously. In the same way, enlargement of energy flow means the increase in consumption of fossil fuel and emission of CO_2, other air pollutant and waste heat.

The building sector which includes construction and operation of residential and commercial buildings has considerable percentages in both material and energy flows in urban area. Therefore, the relationships between these flows of the building sector and the other sectors must be clarified for objectives as follows :

- To estimate the balance between demand and supply of recycled materials and waste heat.
- To estimate the effect of environmental measures in the building sector on total urban environment.

In this study, the total material and energy flows in Osaka Prefecture, Japan (Population : 8.7million, Area : 1,886km^2) are estimated and the relationship between energy and material flow of building sector and that of the other sector is discussed.

MATERIAL FLOW

The 'material flows' which enters and leaves urban area consists of physical distribution of commodities, solid waste discharge and material stocks as buildings, infra-structure, durable consumer goods and industrial facilities.

Inflow and outflow of commodities and the amount of solid waste discharge are estimated from the census. The amount of stocks as automobiles and home electric appliances (refrigerators, washing machines, televisions and room air conditioners) are estimated from the statistics of sales and lifetime distribution functions and resource intensity.

The amount of accumulated and discarded resources as building materials are calculated from resource intensity per floor area, the statistic data of yearly floor area of started buildings from 1951 and building's lifetime distribution function. The amount of accumulated materials as civil infra-structure is also estimated.

Figure 1 shows the estimated material flow in Osaka Prefecture in 1994. The amount of resources which accumulated in Osaka Prefecture as building material occupies 12.7% of total inflow. The amount of total material input into Osaka Prefecture is 148.8 million ton/year, and 25.4% of total material input is accumulated as stock and 29.1% of them is consumed. Only 13% of consumed material is recycled and the reminder is discharged as solid waste or emitted into the atmosphere. The total material input per capita is 17.1ton/(person year). Since Moriguchi [1] showed that the ground total commodity per capita in Japan is 17t/(person year), total material input in Osaka Prefecture is almost the same as the average value in Japan.

By predicting the change in total floor area from the forecasted population, the number of households and GDP in Osaka Prefecture, the amount of accumulated and discarded building materials until the year of 2030 is estimated. Figure 2 shows the predicted amount of input and discarded resources as building materials. Since the accumulated building materials is larger than the discarded building materials so far, solid waste from demolished buildings will increase. In the year 2030, the amount of solid waste will be 1.8 times as large as the amount in 2000. The important reason for that is the average lifetime of buildings in Japan is shorter

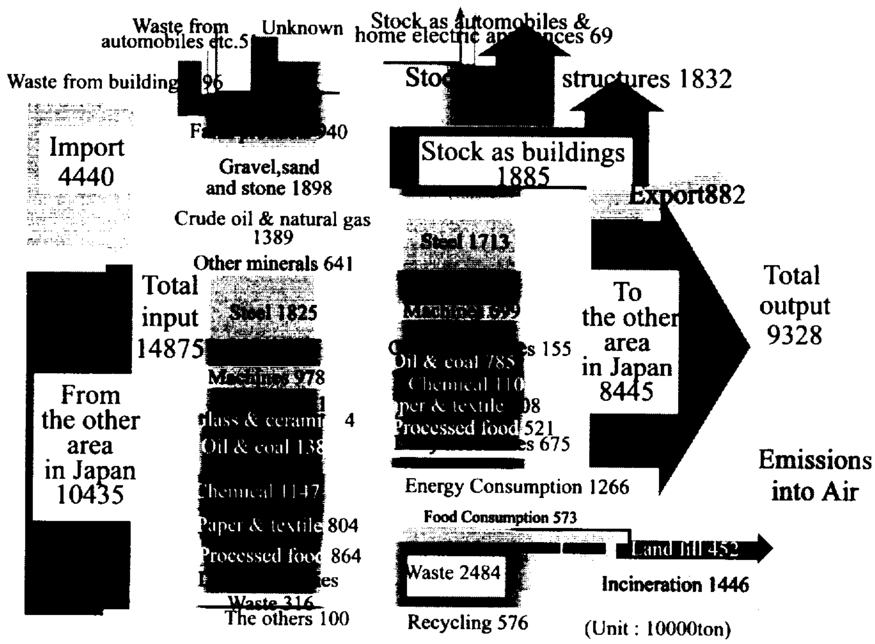

Figure 1 Material flow in Osaka Prefecture

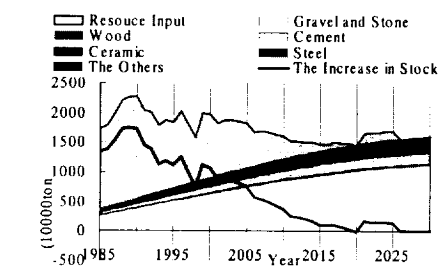

Figure 2 Predicted amount of discarded materials and resource consumption.

than Europe, for example it is 39 years for RC structure office buildings[2]. If the average lifetime of buildings constructed after 1997 is extended to twice as long as the present and total floor area is considered the same as figure 2, the discarded resource becomes a maximum in the year 2016 at the 1.3 times as large as in 2000, and it will be decreased after that. In 2030, the discarded resources will be only 1.2 times as large as that in 2000.

ENERGY FLOW

Different from the material flow, energy flow in urban area forms one-way flow from inflows of energy to energy consumption and waste heat discharge. Energy flow in Osaka Prefecture is estimated for industrial, transportation and residential and commercial sectors respectively. Energy consumption by the industrial sector is evaluated from the survey results for large facilities and estimation for the other facilities. Usable amount of waste heat from large facilities are also estimated.

Energy consumption by automobiles and trains is estimated in the transportation sector,

Energy consumption by the residential and commercial sector is estimated from total floor area of buildings and energy consumption units classified by building use. The energy consumption unit is estimated from the result of our survey on the actual condition of building energy consumption in Osaka.

Since the climate condition in summer in Osaka is severe, energy flow must also be evaluated from the viewpoint of heat island phenomena caused by anthropogenic heat release. Therefore, the amount of waste heat is estimated for sensible heat, latent heat and waste heat to water system respectively.

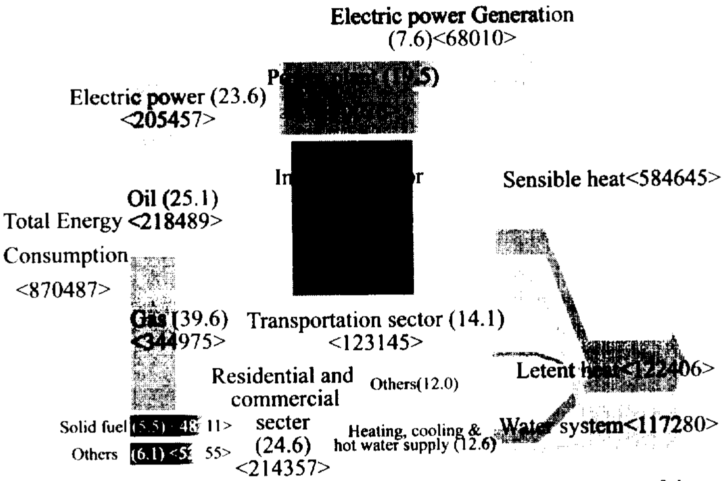

Figure 3 Energy flow in Osaka Prefecture [<TJ/year>, ( )means the percentage of the total consumption]

Figure 3 shows the energy flow in Osaka Prefecture in 1997. Total energy input to this area is 870,487[TJ/year], and it corresponds to 10.1% of total solar radiation in this area. Total energy input per capita is 100.1 GJ/(person year). Building energy use occupies 24.6% of the total energy input and it also corresponds to 30.5% of final energy consumption.
Since about half of energy use in buildings is 'low-level thermal energy' which is used for heating, cooling and hot water supply, it is possible to save this energy by utilizing waste heat from factories, garbage incinerators and power generators. From our estimation, 97,369TJ/year of waste heat from the industrial sector is over 100 [deg C] and it corresponds to 71 % of total low-level thermal energy. At present, only 2,145TJ/year of heat is supposed to be supplied by building cogeneration (CHP) systems and garbage incinerators.
Using the result of total floor area prediction as shown in 'Material Flow' section, it is estimated that the energy consumption of residence will increase by 10% and that of commercial building will increase by 18% from the year 2000 to 2025.

CONCLUSION

In this paper, present status of material and energy metabolism is presented. To apply these chart for sustainable urban planning, following two points must be studied.

Evaluation on sustainability of the energy and material flows

For the sustainable urban planning, it is necessary to define the indicator of sustainability of cities at the beginning. In this paper, 'Total Material/Energy input per capita' is presented. In addition, there are some other indicators such as 'Total Material/energy input per GDP', 'Material/ Energy utilization efficiency' and so on.

Integration of energy and material flows

To improve the sustainability of urban metabolism, integration of these metabolism would be effective. For example, thermal recycle of waste is one of the effective measure to reduce fossil fuel consumption and reduction of physical distribution of commodities also reduces energy for transportation.

Acknowledgement

The authors will thank Mr. Shin-ichi Inoue and Yousuke Takahara for their kind assistance.

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SEATTLE'S NEW DOWNTOWN SUSTAINABLE SUPERBLOCK

LUCIA ATHENS AND FULTON GALE III, AIA
CITY OF SEATTLE, 710 2ND AVE #505, SEATTLE WA 98104 USA

The Emerald City Context

Stretched between the large urban estuary of Puget Sound on the west and a 13,500 year-old glacial lake to the east, Seattle has developed visually more like the hill towns of Asia and Europe than the more traditional urban ports of New York, Los Angeles and San Francisco. **Our city is recognized as a leader in environmental issues**, and is even **called the "Emerald City"** due to its temperate climate and year-round green appearance. Seattle gained fame for being the first city to implement a curbside residential recycling program in 1988. But since that time, Seattle has also come to be known for its (non shade-grown) coffee culture, timber clearcuts, software monopolies, and WTO riots. Recently, the city has struggled with a growth rate of five times the national average with 100 people per day moving into the area. Many of Seattle's residents flock here (54 percent moved here from somewhere else) for the quality of the outdoor environment.

The land and the environment were the top answers when people were asked what makes the Northwest different from the rest of the country. If offered a better-paying job elsewhere, nearly 60 percent said they wouldn't move.[i] Development has tried to keep up with the new population, but at what cost? Since 1972, there has been a 37% decline in natural areas in the Puget Sound region, and an over 50% increase in urban areas. **The City is involved in the largest public building boom since the Seattle fire of 1889**, and private sector development is also booming. On March 26, 2000, King County's Kingdome sports arena, built in 1976, was demolished to make way for a new facility, accompanied by much celebration. The irony is that the county will be paying off the debt on this facility for another 10-20 years, and its destruction represents a loss of resources-in-place such as 443 tons of structural steel and 52,800 cubic yards of concrete. Fortunately most of this demolition waste was recycled. "Buildings are responsible for more external pollution than any other product."[ii] Global warming may also affect the cold water habitat of the region's Chinook salmon, a recent addition to the Federal Endangered Species list. Local wild salmon runs have declined 50-75% since the 1980's.[iii] The salmon is a part of the mythic and cultural history of Seattle, and its impending loss is sending shock waves throughout the citizenry and development community.

Back from the Brink:

On February 22, 2000 the Seattle City Council and Mayor unanimously approved a Sustainable Building Policy, which may in part help to bring our planet **back from the brink of irrevocable global warming**, salmon extinction, and deal with the environmental, social, and economic challenges of the region in a pro-active fashion that captures the imagination. The **Sustainable Building Policy** is part of the City's Environmental Management Program (EMP). The Green Building Team, an interdepartmental committee of technical, policy and program staff was formed to develop the sustainable building policy and to plan for its implementation. Representatives from each department (nine in all) involved in capital development or conservation outreach were included. The policy was widely circulated to various staff for comment in a consensus process. Strong political support from elected officials, including a mayor and council member from the architectural community, played a key role in the quick adoption of the policy.

This unique mix of **people, politics, policies and place** set a stage that has attracted top planning and design professionals from across the country who were willing to give up their more lucrative careers in the private sector to join what is viewed as a creative energy surge not witnessed since the Renaissance. The timing was right. Major projects such as the Civic Center, the Main Library, the Seattle Center Performance Hall and new Pacific NW Aquarium are now being designed and constructed in less than 5 years with capital budgets approaching a billion dollars, and a new commitment to be sustainable within their existing project budgets. Staff thought it was important to show the City's own commitment to sustainable building and develop a track record with projects before promoting these concepts widely to the private sector

The Seattle policy states that the City will finance, plan, design, construct, renovate commission, maintain, operate and decommission its facilities and buildings to be sustainable. The policy pertains to all new and major remodeled facilities of over 5,000 gross square feet of occupied space, and is tied to a green building rating system, known as LEED™ (Leadership in Energy and Environmental Design). LEED™ was developed by the US Green Building Council (USGBC) as a self-certifying system for rating new and existing commercial, institutional, and high-rise residential buildings. Four levels of green building certification are awarded based on the total credits earned in each of several categories: site, energy, material resources, indoor environmental quality and water. The Seattle policy specifies a minimum level of performance at the LEED™ Silver (second tier) level. There are four tier levels, the highest being platinum.

Greening the Sustainable Superblock

In the heart of Seattle's downtown lies a 2.5 block area slated to be redeveloped as a civic center superblock. This new civic heart of the city will include several major building renovations, a city hall, justice center, some private development, and a grand public plaza. The project offers a once in a lifetime opportunity to develop a vast amount of contiguous downtown real estate as an enduring symbol of the city's shared values, including democratic interchange, public celebration, and stewardship. The project Masterplan states "*Sustainability should be clearly visible in the design of the Civic Center and celebrated as a core value to the community... Sustainability should be integrated into all steps of the design process, using a whole systems approach which balances social, economic, and environmental factors.*" As part of this approach, the City's 1% for Arts program is providing for a substantial public art component being integrated into the architecture. The arts and graphic components will provide important interpretive and educational messages about the green design features.

Implementation of the City's new Sustainable Building Policy has taken form in specific integrated design concepts within the Civic Center:

- Raised floors (under-floor plenums) promote "individual controllability" for airflow, temperature and lighting systems in the City Hall
- The Justice Center's west facing, naturally ventilated, "double skin" (glazed thermal buffer) exterior facade (the first in North America on a new building)
- A citywide on-site renewable power generation policy that will lead the way toward a future of cost effective, higher quality, earthquake ready, non polluting on-site power generation

Beyond silver LEED™

Several interdepartmental groups have been working **on increasing the performance level beyond silver LEED™** for the 5 five new and renovated buildings comprising the Civic Center Project. In addition, an economic and environmental baseline analysis by the Center for Maximum Potential Building Systems (CMPBS) has been completed. This study details the upstream environmental and economic impacts of the Justice Center building project on our county, state, and country. This work enables specification decisions to be prioritized to achieve the highest level of environmental (*primarily global warming*) and economic (*primarily employment*) benefit in a way that can be measured using a procedure where peer reviewed national data sets are incorporated in an Input/Output Life Cycle Analysis procedure.

Successful strategies for funding investments within each of the areas listed below will move the projects toward achievement of a "gold" (2nd tier) LEED™ rating. Platinum LEED™ has not been found economically feasible within these urban building types.

Recommendations to move beyond silver LEED™

ELEMENT	LEED POINTS	COST	BENEFIT
	Anticipated	Order of Magnitude	
1. Educational Benefit	1 pt innovation	Minimal initial project cost; minimum O&M	Raise community awareness of sustainable design
2. Environmental & Economic Input Balancing	1 pt innovation	$120K (additional analysis for City Hall, Key Tower, Arctic Bldg. & Park 90/5) Minimal project cost	Addresses 80% of the upstream & downstream environmental issues
3. Distributed On Site Generation of Alternative Renewable Power (DG)	1 pt innovation 3 additional pts. @ 20%	$1.2MM initial project cost $0 O & M	First major step toward pollution free, higher quality, earthquake ready on-site power
4. Personalized Workspaces, Productivity, Commissioning for People	1 pt innovation	$37.4K (additional analysis) $0 Project Cost	1% increase in productivity will pay the electric utility bill in a 100,000SF bldg./ year.
5. Tunnel connection between City Hall & Key Tower	1 pt innovation	$2.0MM (order of magnitude) project cost ~$5.0K/year O & M	Saves ~$200K/year in staff salaries; +3% amortization cost produces under 10 yr. pay back.

Conclusion

The Seattle Civic Center represents a unique opportunity to clarify our shared values and transmit these to future generations. Civic architecture symbolizes these values for many years after its completion through the endurance of its concrete, stone, metal and glass. The Seattle design community is rising to the noble challenge at hand: to take advantage of this unique moment in time to re-invent Seattle's identity and to reexamine our assumptions, attitudes, and expectations about our world, our role in it, and the built environment which expresses our values.

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[i] Susan Gilmore, *Most in Pacific Northwest wouldn't leave if you paid them*, Seattle Times, May 21, 2000.
[ii] D. MacKenzie, Green Design: Design for the Environment, Laurence King Pub., London, 1997, p. 38.
[iii] Sustainable Seattle, *Sustainability Indicators Report*, http://www.scn.org/sustainable/indicat.htm

Sustainable Integration of Infrastructure and Buildings: Opportunities for on-site systems and implications for design practice

Sebastian Moffatt
Sheltair Group Inc, 2-3661 West 4th Ave, Vancouver BC Canada V6R 1P7, www.sheltair.com

INTRODUCTION

This paper examines opportunities for adopting more on-site infrastructure in urban areas, and the implications for design practice. The term 'on-site infrastructure' here refers to small-scale systems located nearby or on building sites, or integrated within larger buildings. On-site systems can be used for any combination of municipal services, including energy and water supply, solid and liquid waste management, surface drainage, communications and access. On-site systems may be clustered so as to serve groups of buildings, and may also be networked for larger scale integration.

Recent technological advances have enhanced on-site performance, particularly for solid and liquid waste management. Project-work by the author on eco-city plans in Canada, USA, Korea and China has revealed potential for distributed clusters of integrated on-site systems, both within dense urban areas, and as part of suburban development[i]. Such on-site systems appear to enhance sustainable urban development in so many ways that it may be argued they are inherently more sustainable than the conventional large and centralised systems.

If indeed on-site infrastructure is significantly more sustainable, it becomes crucial for planners and designers to better understand how to identify and facilitate on-site options when establishing urban land use plans and building designs, and how to determine optimum scale and location.

PRESENTATION – Benefits of On-site Systems, and Obstacles to Adoption

Many of the urban design and development projects undertaken by the Sheltair Group over the last three years have used an Urban Environmental Management System (Urban EMS) as a design and evaluation framework. Urban EMS begins with a clear statement of the basic principles underlying the vision for new buildings and communities, and typically embraces principles within each of the three spheres of sustainability: economic, ecological and social. Figure 1 illustrates this structure, and lists some of the key principles. Understanding these principles of sustainability, and how they are used to create a framework for designers, is essential background for understanding this paper.

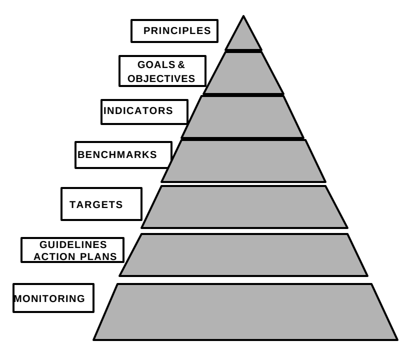

Figure 1 Framework for Urban EMS

Because Urban EMS allows for the development of specific objectives and measurable performance indicators within each sphere of sustainability, it is possible to complete a more comprehensive and rigorous evaluation of development options than is normally possible. It is this EMS evaluation process that has shown on-site infrastructure options to consistently perform better than conventional approaches. Typically significant benefits are realised in all three spheres:

Potential Ecological Benefits: Increased looping and cascading of resources is possible, because on-site systems process resources close to where people work and live. It is also easier to locate industrial parks and complexes close to complimentary urban systems, creating a more efficient 'food web', and integrating the municipal and industrial ecology. Smaller scale infrastructure can be customised to meet local conditions – for example employing cleaner, more expensive technology in those locations where ecological capacity has been exceeded. And as conditions change, a smaller scale system can be more adaptable and replaceable. Because smaller systems can be staged over time, as growth occurs in the population, technology can remain more up-to-date and therefore more efficient. And because the treatment / management processes occur closer to the source, distribution systems use materials and land more efficiently.

Potential Economic Benefits: On-site infrastructure makes it easier to stage the infrastructure investments to match growth in demand. This reduces financing costs and the risk of over estimating capacity requirements. On-site infrastructure can also be more cost-effective to manage, since the fail-safe systems can be much less sophisticated than conventional systems. They can use simple electronics for low-cost monitoring, instead of highly trained operators. They can use a greater proportion of locally produced materials and equipment, and keep infrastructure investments and related job creation within the community. On-site infrastructure frequently involves participation by developers who are required to invest in systems that would otherwise be financed through property taxes or utility rates. This means that infrastructure costs are off-loaded from the municipality and ratepayers, and that users of the new systems have a direct incentive to minimise costs through better design and load management. As systems move on-site, more of the maintenance and operating costs may also be borne by developers and micro-utilities, which can be a relief for both the municipality and the users. Municipalities have traditionally failed to properly maintain urban infrastructure, due to public unwillingness to support the extra tax burden; in the long run it may be preferable to manage infrastructure investments privately, or through public/private partnerships. Moreover on-site systems can mean that developers change the type of business they are in; instead of earning money only from one-time sales of accommodation, a developer can become part of a micro-utility, and earn on-going revenue from the sale of lifetime services. For example, one annual fixed fee to the developer can provide occupants with on-site services ranging from maintenance and security to electricity, gas, water, sewage, waste management, and telecommunications. This expanded role for developers will create competition around accommodation that is affordable from a total cost perspective, and thus provide developers – at long last – with a real market incentive to invest in resource-efficient buildings.

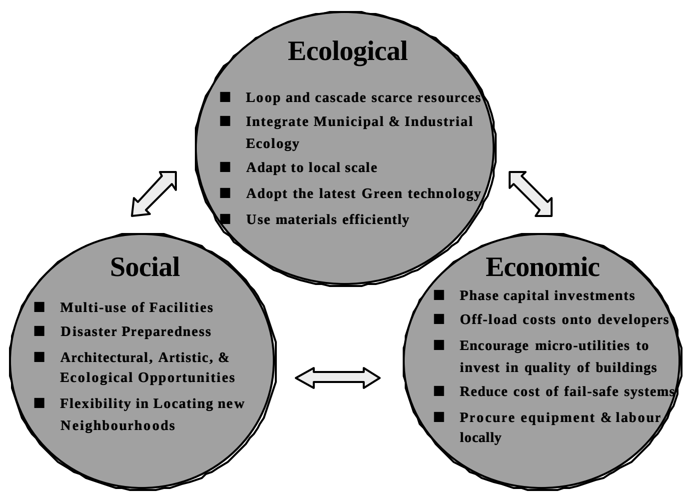

Figure 2 Multiple Benefits of On-Site Infrastructure

Potential Social Benefits: On-site infrastructure creates opportunities for multiple use of infrastructure investments, including buildings, ponds, grounds, towers and so on. Architectural infrastructure can become an important element in neighbourhood design and place-making – using surface drainage for example as public 'water art' and as linear parks, or using renewable energy systems or composted soil as visual landmarks for celebrating ecological processes. On-site infrastructure may be inherently more resistant to disasters like floods, earthquakes, ice storms, and sudden disruptions in energy supplies because the systems are spatially distributed, and less vulnerable to breakdowns in distribution. Another social benefit is the flexibility that is provided by on-site systems, since new neighbourhoods can be located without need to be uphill of the sewage treatment plant, or close to a power corridor or trunk lines.

Obstacles to adoption: Probably the greatest difficulty to adopting more on-site systems is the lack of appropriate institutional structures for ownership and maintenance. If a heat pump is to be shared by a cluster of five buildings, for example, how are rights and liabilities determined, and how is the system managed? Another obstacle is sunk investments in larger systems. Once a community has made major investments in infrastructure capacity it may be reluctant to co-operate with on-site developers, especially if the load forecasts and revenue streams for larger systems have been based on assumptions of universal coverage. Larger utilities also do not welcome a loss of market and control, and they may mount political and economic pressures against on-site proposals. Another major obstacle is the bundled fees and buried subsidies with the taxes and utility rates; owners of on-site systems may find they are also paying for the larger services they don't need. Concern for public liability is commonly a major obstacle. Communities worry about failures in untried technology, and about poor maintenance leading to pollution, environmental exceedences or to unsightly and noisy facilities.

CONCLUSIONS - Next Steps for Design Practitioners

The current planning and design process is biased against on-site infrastructure. Urban planners focus primarily on the designating land uses, and design of transportation systems. Building designers focus on architecture. Both groups lack the skill, mandate and incentive to give proper consideration to on-site infrastructure options, despite the fact that on-site systems can radically alter the nature of both urban land use and architectural design. On-site storm water management, for example, can change the width and construction of streets, the shape, size and layout of development parcels, the functions of city parkland and private landscaping, the types of roofs and surface materials, and so on. When developments combine more than one on-site system, opportunities are created for integrating infrastructure with infrastructure, as well as buildings. Increasingly a different design approach is needed, which includes the following elements:

1. For larger developments, it is crucial to adopt an Urban EMS as a means of evaluating development proposals. If the EMS includes performance targets in the three spheres of sustainability, it can stimulate a more innovative and holistic approach to design. Performance indicators should measure total costs and resource use, including infrastructure costs.
2. Concept engineering cannot be left to the tail end of urban plans and building design. Although engineers typically prefer to provide advice only in narrow areas of competency, the Integrated Design Process (IDP) requires 'big picture' engineers who can participate right from the start, and who are familiar with the basics of on-site systems.
3. On-site infrastructure design needs to explicitly address the liability concerns raised by local engineering departments, neighbours and politicians. The issue needs to be frames in terms of risk management, since conventional infrastructure is also risky. With new, on-site systems, risks can be well managed by following successful precedents from other locations (a 'no guinea pig' policy), by incorporating affordable contingency plans, and by ensuring that new technologies are treated like pilot projects, and used to guide future investment. On-site systems are small scale, and thus especially well suited to experimentation and learning.
4. Some basic rules of thumb are needed to simplify choices for planners and designers, especially when exploring the most appropriate scale and location for infrastructure systems. For starters, it would be useful to let go of outdated ideas like 'best technology' and 'lowest cost option'. The future will be full of environmental surprises, and the best approach is many approaches.

On-site systems require difficult trade-offs. Often the optimum scale from one perspective, like thermodynamics, will be different from the optimum scale for human enjoyment and administration, or for ecology, or for economies of scale. We need practice in examining issues of scale from all such perspectives. Finally it may be worthwhile to remember that our cities are in a state of evolution, and that on-site infrastructure must 'co-evolve' with other types of infrastructure.

Part of the challenge is to create today the foundation required for a truly integrated and sustainable built environment in the decades ahead.

[i] For details on project reports referred to in this paper, access the web site for Sheltair Group at www.sheltair.com

VIIKKI, FINLAND'S FIRST ECOLOGICAL URBAN AREA

Riitta Jalkanen, project leader, architect
Helsinki City Planning Department
Kansakoulukatu 3
00100 Helsinki 10
Finland

The first housing area in Finland to be designed on ecological principles is under construction in Viikki, some 8 km from the centre of Helsinki. There, a new university campus for 6000 students is being built, with housing for 13,000 people and jobs for 6,000. Viikki centre will be located in a science park focusing on biosciences and biotechnology set around university departments. The City of Helsinki has developed the ecological construction model used in Viikki jointly with a special project team, and in association with the Ministry of the Environment, the National Technology Agency of Finland (Tekes) and the Finnish Association of Architects SAFA. The University of Helsinki has set environmental targets for its own building projects and devised a planning and contracting procedure that will raise the eco-efficiency of the buildings.

The goal of Finland's first ecological pilot building area has been to devise ecologically sustainable housing solutions that can be applied more generally in the country. Though ecological building is a broadly approved goal in Finland, rather little financial support has been made available. Even in Viikki, the targets have had to be tailored to the financial resources. It has also proved important to develop a planning and steering method to ensure that the ecological targets are achieved.

First ecological pilot building area

Ideas were generated in two planning competitions. The first was for a town plan that would provide a good foundation for ecological building. Architect Petri Laaksonen's winning entry relied on an interplay of buildings and nature on a finger-shaped pattern. The housing is concentrated around residential precincts with 'fingers' of greenery between the blocks. Each site has a direct link with green areas. On the green 'fingers' it will be possible to cultivate the land, compost waste and make good use of rainwater and water from melting snow. The buildings are both high-rise and low-rise, with some individual houses. Nearly all the buildings face south to make maximum use of solar energy. To achieve a good micro-climate, there will be a wind barrier belt between the housing blocks and the open fields.

Housing will be provided for around 1700 people. A small urban centre with public and commercial services will be constructed round an open space housing a community centre which will itself be a small ecological pilot building. Public transport links to the centre of Helsinki will be good, by bus and in future by light rail. A smooth-running non-vehicular traffic network will link the area with the urban structure, but no requirements for a car-free zone were considered to exist. The parking requirement is half what is normal in Helsinki suburbs, but additional parking can be built if necessary. The aim is to separate the cost of the housing from that of the parking, to ensure that parking costs are paid by car users.

The other competition concerned city block and building design, i.e. actual implementation. It sought both designs and designers for ecological city blocks and buildings, and also developers who would commit themselves to the construction process. Sites were thus allocated to architect/developer groups so that they could implement their ecological ideas.

Ecological building criteria for Viikki

Ecologically sustainable building means showing environmental awareness in every solution. In order to define the basic ecological standard of the buildings, a set of special criteria was worked out. Building projects are thus examined from five viewpoints:

- pollution (CO_2, waste water, construction site waste, wastewater production by residents, eco labels)
- natural resources (fossil fuels/purchased heating energy, fossil fuels/purchased electrical energy, fossil fuels/primary energy, floor plan flexibility, common space use and multi-functionality of spaces)
- health (interior climate, management of moisture risk, noise, exposure of site to wind and sun, alternative floor plans)
- natural biodiversity (plant selections and natural vegetation types, storm water)
- food (planting, topsoil)

The factors that could actually be influenced most in Viikki were given most weighting.

The criteria are at three levels. Compliance with the basic requirements is a precondition for obtaining a building permit. For instance, in the case of purchased heating energy the basic requirement is 105 kWh per square metre per year. This is a 34% saving compared with normal housing designs in Helsinki. In the interests of truly innovative approaches, there is no constraint on the means used to comply with the requirements in each project.

When the criteria were drawn up, their effects on the cost of the housing were calculated. About half of the housing to be built in the area qualifies for government loans. It was agreed with the Housing Fund of Finland that projects could exceed the Fund's maximum price level by around 5% if the architects could show that the additional cost would be compensated by lower costs over the life of the building. The basic requirements were worked out allowing for this additional cost.

About 70% of the area is already under construction. The basic requirement level in the criteria (0 points) has been exceeded by far, and individual buildings average as many as 12 points. The best achieves 17 points, against a theoretical maximum of 30. Saving heating energy during the life-span of a building is a key issue in ecological construction, as it also reduces the amount of harmful emissions to air. Viikki can claim quite good results in terms of energy. For purchased heating energy generated from fossil fuels, an average saving of 47% will be achieved at 85 $kWh/m^2/year$, for primary energy 25 $GJ/m^2/year$, and for carbon dioxide emissions 2700 $kg/m^2/50$ years. The methods used are mainly fairly standard: better insulation of the external envelope, thermal windows, heat recovery from the ventilation system, regulation of heating and ventilation, and use of solar energy.

Pilot building projects

The City of Helsinki has made ecological pilot schemes precondition for every housing project. Themes tested in such pilots include energy and water saving by various methods, use of solar energy, healthy indoor air, housing unit convertibility, more advanced wood construction methods, and resident participation in planning. The pilot building projects have received financial support from the National Technology Agency of Finland (Tekes).

Extensive use of solar energy is still rare in Finland. There are two individual EU-supported solar energy pilots in Viikki, and the area project as a whole is part of the EU Thermie programme. Five developers, Helsinki Energy and an Austrian equipment supplier are taking part. The aim is to make this Finland's biggest solar energy project, with nearly half the household water for 400 housing units being heated by solar energy. This Helsinki City Housing Production Office scheme is part of the EU Sun project, which focuses on energy-saving, use of solar energy and ecological construction.

Six sites in the area have been given over to ecological construction by groups of residents. Experiments will be carried out there with the use of natural materials such as wood, clay and straw in constructing small houses.

The City of Helsinki has its own ecological construction projects in the area, such as a sustainable development daycare centre, an ecological park for children and young people, use of clay in street construction and a new kind of dry water control system. The park will have an urban 'wetland' that will treat the area's surface waters using a combination of retention and vegetation, as well as a garden centre for residents' use.

Conclusions

All the housing projects in the area will be completed in 2000-2001. A monitoring project will judge how well the ecological targets have been achieved in practice and which methods have proved effective in producing an ecologically sustainable result. Residents will be provided with information on the area's ecological goals and how they can help achieve them, make the area a pleasant place to live in and reduce their own housing costs.

In Viikki, the criteria used to define the area's basic ecological level and monitor its realization have proved an important tool in creating an ecologically sustainable housing area. The planning process has also proved a useful training process for developers, builders, planners and officials.

The construction of Viikki will go on into the 2010s. A new set of criteria has been worked out for the next phase, concentrating on the most important issues in terms of eco-construction, which is more focused and easier to use than the present criteria. A related computer program will also calculate the life-cycle of the project based on input data, so it will already be possible at the planning stage to compare the effects that various solutions have on costs.

Aaltonen, Gabrielsson, Inkinen, Majurinen, Pennanen, Wartiainen: Ecological building criteria for Viikki. Helsinki City Planning Department Publications 1998:6

CURRICULUM VITAE

Surname: Jalkanen
First name: Riitta
Date of birth: July 6, 1948
Address: City of Helsinki, City Planning Department
Kansakoulukatu 3
Postal code/city: 00100 Helsinki 10
Country: Finland
Tel.no: +358 9 169 4327
Fax no: +358 9 169 4290
E-mail: riitta.jalkanen@ksv.hel.fi
Civil status: divorced
Nationality: Finnish

Education:
- Candidate in Humanities, University of Helsinki 1973
- graduate architect, Helsinki University of Technology, Otaniemi, 1974

Courses:
- postgraduate course in community planning, Helsinki University of Technology
- postgraduate course in community planning 1980-81 and Nordiska institutet för samhällsplanering, Stockholm, 1987-88
- several courses, international congresses and study trips abroad dealing with urban planning

Working experience:
- Lehtovuori-Tegelman-Väänänen, Architects, 1969-1970
- Helsinki City Planning Department
City centre office, Itäkeskus project, Malmi regional centre project 1971-1990
Kivikko project, project leader, 1987-1992
Viikki project, project leader, 1992-
- Helsinki University of Technology, Department of Architecture: part-time teacher, small-scale planning, community planning and urban space 1983-1987, 1991-

Other:

Lectures and presentations at universities and colleges and at Finnish and foreign congresses and training courses on city planning.

Publications and articles:
- Textbook on residential area planning (*Asuinaluesuunnittelu*: Jalkanen-Kajaste-Kauppinen-Pakkala), Rakentajain kustannus 1990, new edition, Rakennustieto Oy 1997
- Articles in professional journals

Six individual and group grants

Hobbies: city planning and architecture
gardening

Tools for cities on their way to sustainable buildings

Marjo Knapen[1], John Mak[1] & Gert van den Elsen[2]

[1]W/E consultants sustainable building, P.O. Box 733, 2800 AS Gouda, The Netherlands
Tel: +31 182 68 34 34, fax: +31 182 51 12 96, email: knapen@w-e.nl, mak@w-e.nl
[2]Community of Tilburg, Department Building and Environment, P.O. Box 90118, 5000 LA Tilburg, The Netherlands, tel: +31 13 542 92 12, fax: +31 13 542 96 08, email: puelsge@tilburg.nl

To build sustainable, one has to make it a point of discussion. A discussion on sustainability is easier with a tool which sets a standard and quantifies sustainability. That is what the Dutch city Tilburg has done. One of the departments of the local authorities developed the Practical community Guideline - Gemeentelijke Praktijk Richtlijn (GPR) in Dutch -, practical rules for sustainable construction of dwellings for a community or city. It is a tool to quantify the sustainability quality of new dwellings. The municipality can set a minimum level. The tool is developed by W/E consultants sustainable building. It is an easy to use tool, which nevertheless covers the important topics of sustainability. The whole local forum on building was invited to discuss the tool during the development. By doing so the tool is a product of the city. The people who have to work with it believe in it and support it. And that is the strength of the GPR, it stimulates the communication on sustainable building and living.

INTRODUCTION

The first GPR is developed in 1995, at first instance for new dwellings, secondly for new offices. On the basis of experiences with the tool a new version for new dwellings, the GPR-2, is published in 1999. It consists of six modules: energy, materials, waste, water, indoor air quality and overall qualities, like accessibility, flexibility and adaptability. The GPR is a successful tool: surrounding municipalities nearby Tilburg are using it and Rotterdam adopted the version for offices and other industrial buildings.

PRACTICAL GUIDELINE

To make sustainable building quantifiable and practical. That is the purpose of the Municipal Practice Guideline Sustainable Building (Gemeentelijke **P**raktijk**R**ichtlijn Duurzaam Bouwen) of the municipality of Tilburg, in short GPR DuBo. From December 1999, the municipality of Tilburg has been using a second version: the GPR-2 DuBo for newly built houses. Two important features of the GPR are common basis and mutual concern. This paper will discuss the development of this tool, how it has been used, how it is being used and the plans for the future.

In 1995, the municipality of Tilburg designated Sustainable Building as a one of their political ambitions. In order to make Sustainable Building quantifiable and practical, the municipality was looking for a tool. This proved not to exist and that is why they decided to develop a tool themselves: a quantifying method. The municipality wrote the plan, and W/E consultants arranged the soundboard function and developed the system of points. Together, W/E consultants and the Building and Housing Inspection Department of the municipality presented in 1995 the first GPR DuBo: a tool to register the quality in sustainable building of newly built houses. Interest groups in Tilburg, such as architects, developers and housing corporations, were closely involved in the process. From the beginning they were involved in discussions on the elements which they thought should be incorporated in the tool and discussions on the way sustainable building should be quantified. In the discussions held with the interest groups, the first steps were set to create a common basis and mutual concern, two indispensable aspects for the success of this tool.

With the GPR, the municipality has a tool with which she will get an idea of the sustainable building quality and she is able put it on the agenda for discussion. The GPR-2 DuBo for newly built dwellings will also be used for the location 'DE Wijk' (3000 newly built dwellings) together with a deposit arrangement for individual builders: depending on the result of the GPR-2, the principal will get his deposit money back.

GPR: FOR WHOM AND WHEN?

In an early stage of the development of the building plan in Tilburg, sustainable building is being considered. This is necessary, because in this stage major changes can be made which influence the sustainability. The municipality follows the development through a process of support and consultation. Throughout this process there are three moments at which the municipality does a statement about the proportion of sustainable building of the building projects being developed. This takes place together with the interim design, with the final design and with the building specifications. The GPR-2 DuBo is a part of this process and it is the final piece in which all aspects of sustainable building are put together.
The GPR-2 DuBo is an excellent developing aid: when the request for a building licence has been submitted, the GPR-2 DuBo is being used in order to check if the fixed purposes are affected. The GPR is also being used to judge if the indicated measures are really applied.
In this way the GPR-2 DuBo stimulates communication, not only between the builders, but also between the municipality and the builders.The section of Building and Environment of the municipality applies the GPR-2 DuBo. This section not only tests the environmental ambition, but also explicitely presents itself as a consultant in sustainable building.

SIX MODULES

1. *Energy*: Dutch Energy Performance Coefficient is the basis. And: 1. avoid useless consumption, 2. use renewable sources, 3. careful use of non-renewables
2. *Materials*
3. *Waste*: during use and demolition waste
4. *Water*: 1. avoiding consumption of drinking water and 2. using 'other' water
5. *Internal conditions*: 1. Acoustics, 2. gas and dust concentrations 3. Ventilation and 4. thermal comfort
6. *Integral living comfort*: 1. Accessibility, 2. flexibility and future value, 3. social safety

ENVIRONMENTAL SCORE

The GPR helps municipalities to quantify sustainable building and make it practical. In short: the user can get points in 6 modules (see the text block).
The GPR can also be used as an aid for Green Financing (GF), a Dutch tax profit for green built dwellings, and is suitable for the monitoring the appliance of measures of the National Package of Housing (NPW).

The first part of the module Internal Conditions has here been given as an example. Points will be given depending on the contribution of the measure to the sustainable building quality. This results in the environmental score per module: the lowest score is a five and for a number of modules this corresponds to the minimum level of the Dutch Building Code; the highest score is a 10. During the completion, the effect of the measure immediately shows. A general sheet shows an overview of the environmental scores and the project information.

MODULAR LAY-OUT

The GPR consists of modules. This involves flexibility of the tool, because

5.1	Acoustics	(200)		
	1 Reduce noise from outside			
	O Noise <= 55 dB(A)			
	O Level Dutch Building Code: Ga;k < 25 dB(A)	(0)		
	O Level Dutch National Package: Ga;k => 25 dB(A)	(20)		better than Dutch Building Code
	O Noise burden facade > 55 dB(A)			
	O Level Building Code: Ga;k= noise burden - 35 dB(A)	(0)		
	O Level Dutch National Package: Ga;k = noise burden - 35 dB(A)	(20)	S407	better than Dutch Building Code
	2 Reduce noise between residents			
	O Level Dutch Building Code: Ilu;k = 0 dB, Ico = 0 dB	(0)		
	O Level National Package: Ilu;k = +5 dB, Ico = +10 dB	(80)	S407/8	better than Dutch Building Code

modules can easily be adjusted to new opinions, without the whole tool having to be changed. The part of the module Materials that refers to the burdening of the environment by building parts, and the modules Water and Waste can in due time be replaced by a tool like Eco-Quantum (see below). A basic level of sustainable use of materials thus will be laid down in regulations. This requires a revision of the module Materials of the GPR.

EXPERIENCES

The experiences with the GPR DuBo are positive. In Tilburg, developers, architects and principals turn out to use the GPR frequently, although sometimes people have showed some hesitation ('again new rules'). Once the builders got used to the methodology however, they had quickly discovered the advantages of it.

Especially the performance principle (several roads lead to Rome), the flexibility and the modules are attractive. The updated and computerised GPR-2 DuBo only increased those advantages. The tool is very easy to use, you just have to click with the PC-mouse. There are even principals and architects that have linked the guideline to a budget programme. This way they can very easily calculate the financial part of all sorts of environmental alternatives. Also the reactions to the addition of the module 'Overall Living Quality' are positive. People appreciate the fact that now measures in the field of adaptable building and social safety can also be quantified. The score thus made can be used as a marketing tool.

Architects appreciate the GPR-2 DuBo as an aid to design. Because this tool is very complete, things can hardly be overlooked.

To the municipality of Tilburg the results of the GPR-2 DuBo have become very clear: the environmental quality of the houses in Tilburg has increased since the introduction of the GPR DuBo in 1995. Sometimes more, sometimes less, but on the whole it has increased. The municipality expects that this will only continue to an even greater extent.

THE FUTURE

Now that there is a GPR DuBo for newly built houses and for commercial and industrial building, it has become time for a GPR version for existing houses. The existing houses outnumber by far the houses being built in one year. Besides, the environmental quality of those existing houses is not as good as that of the currently newly built houses. So there is a considerable environmental profit to be gained per house. The challenge is to improve the environmental quality of the existing houses. A tool such as GPR DuBo Existing will help to quantify this and make it practical, so communication is easier.

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The Application of the Eco-Efficiency Methodology to the Evaluation of the Urban Scale Structure

-Environmental Assessment for Urban Scale Structure-

KIMATA, Nobuyuki
KAJIMA DESIGN, 6-5-30 Akasaka, Minato-Ku, Tokyo 107-8502, JAPAN

INTRODUCTION

This paper introduces the assessment activity of the urban scale structure, to find out the difference of the performance and the environmental impacts between different types of urban structures, including ultra high-rise structure concept.
The assessment has been proceeded by the project team of the Architectural Institute of Japan from 1999.

BACK GROUND AND PURPOSE

In early 1990th, Japanese construction industry had proposed the concept called "the ultra high-rise structure"(UHRS), which has 1,000 hectare, over 1,000 meter high, around 100 thousand habitants and the life time over 1,000 years. The main purpose of this proposal was to develop new construction market in the super high-rise buildings segment.
By this proposal, a few interdisciplinary project teams include government started to study the feasibility of this concept by different point of view.
Japanese only one academy in the field of architecture, AIJ (Architectural Institute of Japan) has organized project team to study UHRS (Pr. Funakoshi), and A-WG mainly to study the global environmental issue of UHRS.
Most of the Japanese cities had been developed fundamentally without severe restriction, and under the poor urban plan. As a result, the sprawled city area and increasing budgets for the arrangement of their infrastructure suffer many cities.
This A-WG has set the purpose of the study to establish the fair and valid methodology to assess and evaluate the difference of the urban structure to get exact reference data for the sustainable urban development for the future, through the assessment and evaluation of the UHRS concept.

STUDY CONDITIONS

At the beginning of the study, A-WG thought it difficult to evaluate certain structure of city alone. To evaluate and assess the UHRS, A-WG has decided to prepare two reference cities to clarify the effect of ultra high-rise structure or well planned city. One is a city where located in the Tokyo metropolitan area, which has high density of population and large quantity of social stock, called Shinagawa-Ku, has approximately 320,000 populations, and 2,300 ha of city area. And other is a city where located west part of Japan, and very low density of population, the capitol of Tottori prefecture, Tottori City, which has 150,000 populations and 23,700 ha of area.
At the same time, WG decided to prepare well planned city (HD) to compare with the existing city (EX), for each model city. The meaning of well-planned city is the city developed with effective transportation and energy system, realizing high quality of urban life, low environmental impact to the region and globe, and can be called "sustainable city".
In case of UHRS, it is supposed to be composed like HD models, but horizontally developed. By those study condition, it can be compared between EX and HD, HD and UHRS, for Shinagawa and Tottori. Total Model Types prepared can be shown as table-1.

Table-1 Prepared Models

	EX	HD	UHRS
Metropolitan	EXs	HDs	UHRSs
Provincial	EXt	HDt	UHRSt

UTILITY OF EXISTING CITY MODEL

To assess and evaluate the performance of these city models rationally, it is required to define the utility of the cities. There can be many way of measuring utility of the city. However in this study, A-WG has decided to define the utility of the cities by the prepared space for the human activities. Table-2 shows the value for each activity normalized by the number of habitants.

Table-2 Space Allocation for Activities

Space for	Shinagawa		Tottori	
	m^2/p	%	m^2/p	%
Residential	32.8	63.5	37.1	68.2
Cultural Ctr.	0.05	0.1	0.5	1.0
Hall	0.06	0.1	0.5	0.1
School	0.9	1.6	1.4	2.3
Hospital	0.7	1.4	1.4	2.6
Park	3.9	7.6	4.1	7.5
Office	13.0	25.2	7.8	14.4
Shop, Restaurant	0.2	0.4	2.0	3.6
Factory, wholesale	7.2	13.9	8.9	16.4
Power, Water etc.	1.0	1.8	1.7	3.2
Road, Railway	18.5	35.8	106.5	195.8
Total Space	78.3	151.6	171.5	315.3
Building Total	51.6	100.0	54.4	100.0

As it is clear by this table, the difference between Shinagawa and Tottori stays mainly in the space for office and space for traffic fields.

HD MODELS

In case of HD, A-WG decided to prepare model systems for each urban facilities and transportation systems. For the fair and rational comparison of the environmental performance between 3 types of the models, the principle for setting up those hypothetical systems is very important.

In case of urban structure, WG has decided to rearrange mainly buildings, roads for effective traffic system. Office buildings are supposed as large-scale super scrapers and located on or next to the railway stations. Other buildings and multi-flat residential buildings are imaged as integrated mix use buildings, located near and along the railway.

And all those buildings are supposed to be covered by green.

Dwellings are supposed as zero-energy, zero-emission housings and with base isolation system for the earthquake.

Traffic systems are also supposed to be most effective situation. For example, all the existing traffic by cars is supposed to be substituted with the demand bus systems. And total length of road for car traffic is expected to be reduced.

All the life line systems like water supply, sewage, power are supposed installed in the wide trench for future change, and to reduce total energy consumption and improve eco-efficiency.

As explained above, HD models are supposed not to be as a city of high technology, but as a city of high efficiency and low environmental impacts, with least change regarding to the living utility.

As a result, the city area for the buildings and artificial structures are expected to be reduced.

UHRS MODEL

For the evaluation of UHRS, A-WG decided to prepare a simple model for this purpose.

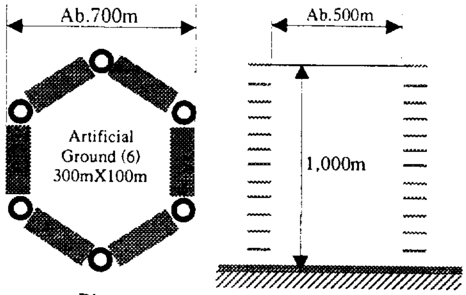

Figure-1 Image of UHRS Model

The basic study model for UHRS can be describe shown as Figure-1, which has a hexagon plan by 6 block of artificial ground (AG), 6 vertical corridor. On the every AG, buildings that have total floor area same as the EX models, are supposed to be built.

Total floor area in existing Shinagawa area can be realized by 2 UHRS towers, and by one UHRS, for Tottori.

In UHRS, the energy consumption for traffic system stays mainly for vertical traffic. And this vertical traffic issue is one of the most delicate and critical one. But most of the existing roads on the ground can be reduced.

The main traffic from this UHRS to another area is expected by railway and the truck transportation to be minimized.

Every type of buildings except factory and facilities for infrastructure is expected to be constructed on these AGs.

The energy system and water supply system is supposed as a system to be integrated and improved in total efficiency.

LIFE CYCLE ASSESSMENT

From the public office of Shinagawa-Ku and Tottori, WG has got the statistic data about the existing population, industrial activities, domestic products, traffics, urban facilities, buildings and etc..

In case of HD and UHRS models, A-WG has supposed the inventory data by the help of other statistics.

As AIJ has developed LCA methodology in 1999, and NIRE (The National Institute for Resources and Environment) also developed NIRE-LCA Ver.3 in 2000, A-WG has proceeded the assessment activity by the help of those methodologies.

EVALUATION OF ECO-EFICIENCY

For the purpose to assess the performance of this USHS concept, A-WG has decided to utilize and apply the concept of eco-efficiency. By the eco-efficiency concept, it is required to define the utility of the object.

In general, urban scale structure has diverse and complex utilities and it is very difficult to define certain value to represent or measure those utilities adequately. In this study, A-WG has to evaluate three types of urban scale structures, and these differences of structures are recognized as the presence of fundamental differences of utilities. Under that recognition, it seems to be impossible to evaluate eco-efficiency of these models rationally.

Then, A-WG decided not to differentiate in life style, total built floor area, neighboring park area, requirements on human traffics for daily activities and transportation of daily goods, criteria for indoor physical environment, total consumption of food, drinking water, quantity of excreta and waste, between EX, HD and UHRS.

These conditions mean the definition of the utilities of urban scale structures, and under those conditions, A-WG recognized that utilities of three models are constant and it is possible to eliminate the value of utilities in comparison of that eco-efficiency.

RESULTS OF THE STUDY

There are several ways to evaluate and show the eco-efficiency, and environmental performance. The table shown below is an abstract of the result of the study. The results are shown compare to the model EX.

Table-3 Performance of Three Models

		EX	HD	UHRS
Energy use for Life	S	1	D	D
	T	1	FD	D
Energy for Traffic	S	1	FD	D
	T	1	FD	FD
Resource Use	S	1	D	D
	T	1	D	D
Impact to the Local Environment	S	1	D	FD
	T	1	D	FD
Impact to the Global Environment	S	1	D	D
	T	1	D	D
Psychological Impact	S	1	D	I
	T	1	FD	I
Risk and Safety	S	1	FD	D
	T	1	FD	D

Where: 'S':Shinagawa case, 'T' :Tottori case, 'D':decrease, 'FD':Fairly decrease, 'I':increase.

CONCLUSION

The UHRS was proposed as one of the future city images, but the results of the study indicates that the HD model is rather superior to the UHRS model totally. At the same time controlled urban development is effective for global environment and required for the future urban development to protect global environment.

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The Use of Benchmarking as a Tool for Implementing Sustainable Urban Development

Ms. Elisa Campbell
The Sheltair Group Inc.
2-3661 West 4th Ave.
Vancouver, B.C.
V6R 1P2 Canada

The aim of this paper is to discuss the role of comparative benchmarking and target-setting in transforming performance indicators into effective tools for measuring and assessing performance, as well as for effecting long-term change towards a more sustainable future. The paper will briefly discuss the concept and roles of benchmarking, and will present case studies where benchmarking and target-setting have been used with indicators to operationalize urban sustainability goals. It will also present an effective tool that has been developed to assist in this endeavour.

INTRODUCTION

While indicators have traditionally been accepted as key tools for measuring and assessing economic performance, it is only recently that they have become associated with social and ecological performance. Even the business world has acknowledged this transformation, where the "shift from treating financial figures as the foundation for performance measurement to treating them as one among a broader set of measures"[1], is considered to be one of the defining features of the change towards a more sustainable paradigm. Indeed, the use of indicators as a strategy for translating concepts of sustainable development into practical results has exploded internationally, with jurisdictions and organizations everywhere measuring resource use, waste generation, human health, and the many other factors that represent the sustainability of our urban environments.

As reassuring as this acceptance of a broader set of measures for assessing performance is, in most cases the application of an indicators approach to sustainability is incomplete and ineffective. With the emphasis on using internal historical trends as performance yardsticks, rarely are indicators measured in relation to an objective ideal or a long-term target. The result is a truncated effort that focuses on past actions rather than on future goals. As such, the utility of indicators for helping to define urban sustainability policies and actions is limited. It is only when indicators are integrated with benchmarking and target-setting that they become a forward-looking and effective tool.

BENCHMARKING

While the simple definition of a 'benchmark' is that it identifies a specific point-of-reference performance value for an indicator, this definition does little to characterize the functional nature of benchmarking. Identifying the key tasks that benchmarking fulfils permits a more complete understanding of its utility.

Benchmarking identifies performance that exemplifies the average and best practices

It is through identifying a range of benchmark values that an indicator develops meaning and substance. Establishing average and best practice performance, based either on real data or on results produced through technical analysis, permits a range to be identified, and an externally oriented performance spectrum created. In so doing, it "makes people aware of improvements that are orders of magnitude beyond what they would have thought possible".[2]

Benchmarking permits comparison with other like buildings, organizations or communities

Using the indicators approach as a framework, benchmarking permits meaningful comparisons with like entities. For example, rather than calculating a generic or universal energy consumption value, benchmarks can be selected for an indicator measuring energy use by residential buildings in cities of less than 5000 people. This increases the comfort level with the data, and promotes acceptance that the performance range is valid and applicable.

Benchmarking permits objective assessment of performance relative to an empirical range rather than to set criteria or weighting systems

Benchmarking permits the identification of where a given building or community fits within a range of empirical performance values. This permits objective assessment that does not rely on a weighting protocol, rating system, or prescriptive criteria. Thus, rather than assessing performance based on a 'good' and 'bad' scale, benchmarks permit a finer grain of measurement to occur. This results in an assessment model that "respects[s] and endeavour[s] to understand and quantify the many shades of grey, replacing the concepts of 'good' and 'bad' with 'better' and 'worse'".[3]

Benchmarking provides a dynamic assessment methodology rather than reliance on a static set of criteria

Benchmarking using pre-established indicators as a framework can result in a continually updated range of performance values. This provides the foundation for a much more dynamic assessment methodology than does a static set of criteria or rating protocol. As such, benchmarking contributes to the continual improvement in performance values, and at a broader scale, to the on-going progress towards a more sustainable future.

Benchmarking generates motivation

Whether at the organizational, community or building level, creating a range of performance values against which individual performance can be compared and evaluated can generate motivation to improve. Known in the business industry as 'competitive benchmarking', the theory that " as soon as one leading company can demonstrate the long-term advantage of its superior performance on quality or innovation or any other non-financial measure, it will change the rules for all its rivals forever"[4] holds true for buildings and communities as well. Although the motivation may be characterized by greater altruism when it comes to environmental performance, motivation still tends to increase when "being the best" is at stake.

Benchmarking is key to setting performance targets

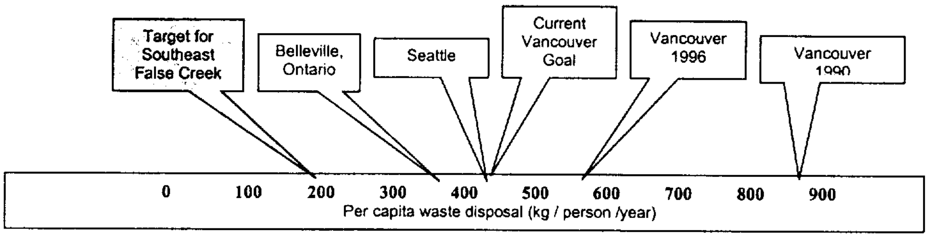
Targets involve the identification of a preferred future performance. One of the most difficult parts of setting performance targets, however, is justifying that the target achieves the right blend of feasibility and challenge. By basing targets in part on a range of existing performance values, it is possible to identify what might be achievable for any given organization, community, or building. It is through this process that desired future performance is identified and can then be translated into policies or actions.

TWO CASE STUDIES

This paper introduces a benchmarking tool that was developed in Canada and that has been used effectively to help organizations, communities, and buildings measure and assess their performance, and translate that information into practical policies and strategies. The benchmarking tool creates a graphic scale generated using any given indicator as a framework. As demonstrated below, specific performance values based on any number of entities are placed along this scale. These performance values can include comparative benchmarks as well as historical performance, current performance, or future targets.

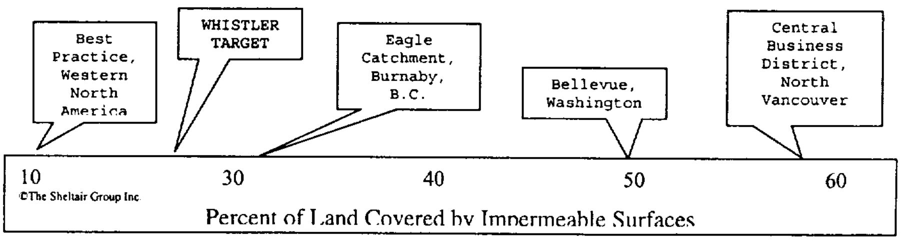
Environmentally Sustainable Development Guidelines for Southeast False Creek

A project was conducted to assist the City of Vancouver in creating policies for the development of a model sustainable community on a downtown brownfield site. As part of the preparation of a complete tool-kit for establishing these policies, performance indicators were selected and targets established. The benchmarking tool was used to assist in establishing the technical and economic feasibility of the proposed targets, while simultaneously promoting the motivation to go beyond standard performance. Benchmarks for like communities in North America were gathered and placed along the scale[5], with background information about these communities used to identify details about best practices used to improve performance.



Whistler Environmental Strategy

As part of its effort to maintain its status as a premier mountain resort community, the *Whistler Environmental Strategy* was prepared. The *WES* is intended to guide the policy and procedures of the town such that they conform to a sustainable mandate, and also to promote motivation to improve performance. As part of this process, a list of 15 core performance indicators were established, for which detailed benchmarking was conducted in order to compare Whistler to other ski resorts. Benchmarking scales were prepared for each indicator, with reference values provided for resorts and similar communities across North America, as well as information about Whistler's past and current performance. This benchmarking has been crucial to setting realistic and yet challenging targets, which, if achieved, will ensure growth in the Resort Municipality of Whistler will respect the environment in which it is located.



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SUSTAINABLE BUILDING PRACTICES AND URBAN RE-QUALIFICATION: A LOCAL PERSPECTIVE

Emilia Conte, Valeria Monno
Dipartimento di Architettura e Urbanistica, Politecnico di Bari, Via Orabona 4, 70125 Bari, Italy
tel. +39.080.5460347, fax +39.080.5460348, E-mail: [conte@poliba.it; vmonno@dau02.poliba.it]

INTRODUCTION

Implementing sustainability in any field of application is a hard task since nobody is able to give an objective definition of the concept, and in fact the term is differently interpreted in relation to the major issues to be dealt with. Despite this, there is a growing, almost inevitable, acceptance of the concept of sustainability, mainly based on the relationships among environmental, economic, and social factors of development. This approach emphasises the physical, material, and external dimension of sustainability, which is very important, but neglects its non-physical, non-material, internal dimension, which is as important [1]. Probably, this is due to the habit of studying problems making a rational description of them, so as to be measurable, in order to suggest possible solutions based on domain-specific and technical knowledge.

This kind of approach also characterises the field of sustainable building, where the quality of the built environment is considered strongly related to sustainability mainly concerning energy-efficient and environmentally-friendly designs. A further step can be found in the Sustainable Building Policy chapter of the Environmental Management Program of the City of Seattle [2], considered one of the most advanced in the world, and in which sustainable building and design are defined on the concepts of the project as a whole and the design as an integrated approach. These concepts highlight how sustainable building practices require an integrated systems approach in which each involved actor must play a role towards sustainability [3].

Following this path, we present a local case study as a field of experimentation of sustainable building practices aiming at urban re-qualification. In particular, we refer to an existing public housing neighbourhood with physical and social decay, where public agencies have never planned management, and for which we suggest an information system, based on geographic information system (GIS) technology, for housing management. Through the case study, we want the complexity of the action scenario and the multi-dimensional approach to emerge as well as the importance of a local perspective, emphasising processes rather than solutions and underlining limits of conventional ways of knowing.

LOCAL SUSTAINABILITY AND HOUSING MANAGEMENT

Sustainability and in particular the promotion of the best practices and local Agenda 21 have oriented housing studies to cope with specific actions aimed at environmental protection and real possibilities of experimentation in sustainable building and its management. In housing policies this approach has led to a necessary reconceptualisation of housing problems and in particular this conceptual reframing has led to rethinking about housing management not only as an exclusively administrative practical action field but as an action field strongly linked to the environmental urban quality [4].

When local sustainability is the focus of policies the differences, the diversity of socio-economic and natural environments and of local cultures becomes a starting point for setting up local action agendas. The involvement of citizens in decision-making represents an inescapable practice to find and give significance to sustainability itself, thus escaping the ambiguities of its definitions. From this point of view environmental protection is more than the protection of natural cycles and networks because it becomes intertwined with the set of information, "energies and materials" constituting the specific features of settlements, their richness and quality [5]. *Local thinking* brings to the foreground relational and spiritual dimensions in making places [6] and stresses the need to think and act starting from problems and processes seen in the complex local/global interplay. These reasons lead to an integrated approach to public housing management required both by urban rehabilitation policies and by the substantive issues posed by local sustainability itself. In this approach different considerations, even though often linked, mainly concerning the possible empowerment of local communities and/or the construction of shared local knowledge as a basis for consensus building, are intertwined with the more consolidated technical approach required by building sustainability. Moreover identifying and facing environmental problems affecting public housing settlements lead to planning and management information needs and requirements, to processes through which information is produced and to the ways in which information systems have been constructed. Local thinking enables the exploration of new paths in using information systems.

DESIGNING THE INFORMATION SYSTEM

Public housing policies have been recently reframed in an integrated direction at a national level, but the opportunities which they have opened up to construct new rehabilitation and management policies have not yet permeated local institutional practices [7]. Looking at local practices this approach is far from being achieved as in our case study concerning the housing management of the public residential Re David neighbourhood, situated in a central urban area in Bari, the main city of the Apulia region in Italy, and in which 2000 people live. In this, as in many other Italian public housing settlements, public agencies did not plan management activity and management actions were aimed at only resolving emergencies.

The lack of specific action in housing management encouraged local residents to build a network of actors concerned in social and physical rehabilitation of the neighbourhood. A group of citizens, promoting different activities based on residents' participation, constructed a shared knowledge base which represents a reference point to set up management policies as a basis for desired negotiations with the public agency. Problems of the health of settlement and social-economic rehabilitation are the main focuses of this bottom-up practice while physical rehabilitation, traditionally left to tenants by local agencies, remains a private field of action.

The complexity characterising management processes – as appears even looking at the small Re David neighbourhood – and the features emerging from local institutional and citizens' practices support the idea of constructing a GIS on housing management which can store not only quantitative but also qualitative information found through local community knowledge. In this sense local knowledge can became a part of the system, thus showing that GISs can provide an arena where policies and conflicts of spatial decision-making are played out [8].

This choice is also made in consideration of the results obtained from knowledge acquisition. The traditional data available about the social-economic and physical environment are too general and not enough to permit the reconstruction of the neighbourhood portrait. The interviews to the local administrators did not give any information about neighbourhood environmental and social decay, while information obtained on the implemented management actions and the physical decay is not precise. Knowledge shown by the local network of actors can be seen as a useful basis also for getting information on the state of the local environment, the buildings and their inhabitants. Thus, all the knowledge acquired confirms that a coherent set of qualitative information analysable from different perspectives challenges statistics based on pre-structured tabular data [9] which do not allow local environmental problems to be recognised and constructed.

For these reasons the GIS should be used in a explorative perspective. In particular two fields of exploration are detected: on the one hand, both the use of the traditional potentials of analysis of GISs and the inclusion of relevant information emerging from questionnaires, interviews and forums could help discover new indicators of sustainability for an integrated housing management; on the other hand, the use of GIS makes it possible to simulate alternative scenarios of urban environments and their implications on urban sustainability. These fields of exploration enable evaluations of management policies considering the specific technological building remedies and also their impacts on the environment at a local level.

CONCLUSIVE REMARKS

With the experimentation on our case study, we have worked with approaches which take into account the social and institutional changes as a requirement for improving sustainability. Physical and technological aspects of sustainable actions are very important indeed, but they could not work without cultural and physiological sustainability which searches for justice and equity of societies: "the poor and the exploited are likely to have some enthusiasm for building a sustainable society if there is something in it for them" [10]. This means considering non-material dimensions of sustainability together with material ones, and extending democratic participation both in communities and agencies, encouraging co-operation in management practices.

In our study we recognise that everyone perceives his/her own reality basing it on his/her own culture, thus affirming that sustainability can be understood and interpreted in different ways, and domain/discipline oriented knowledge often limits and constrains the concept rather than determines it. As a consequence, communicative approaches, culturally derived and context-dependent, can deal better with development and implementation of efficient and effective environmental policies and strategies [11]. Therefore, we question decision-making activity only based on rationality, and solutions only based on quantitative data, since they refer to a pre-defined idea of sustainability searching for objectivity and immobility that sustainability cannot have.

We also consider the role of information as crucial in sustainable development. Information can certainly be seen as the basis of decision-making processes, as much as access to information can be seen as an important means for equity and participation in decision-making. An appropriate information system can be an effective support to decision-making activity, particularly if approaches are used to identify important information required for sustainable policies and actions [12]. Our information system is knowledge-based, including technical as well as common knowledge, considering quantitative as well as qualitative data, and using information technology as an enabling tool rather than an end in itself.

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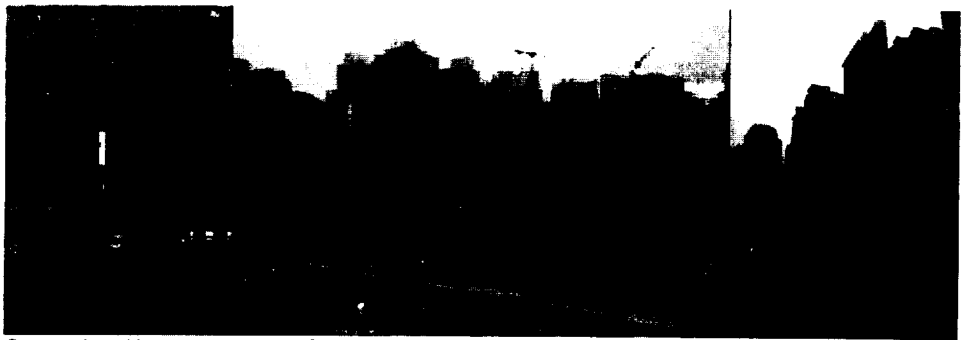
GREEN ARCHITECTURE IN HONG KONG TOWARDS A SUSTAINABLE FUTURE WITH VERBENA HEIGHTS

Sander de Jonge, MSc.
Eindhoven University of Technology
PO Box 513, 5600 MB Eindhoven, The Netherlands



Courtyards and large canopies in building mass — *General overview of building complex and surroundings* — *View from pavement at wind deflector at main roadside*

INTRODUCTION

In Hong Kong there is a serious conflict between the possibilities of consumption and the limits of growth (Planning Department 1994/1998, Citizens 1998, EPD 1999, Study 1998, White Paper 1998). The conflict should stimulate architects to consider sustainable building as an integral aspect of building in Hong Kong. That's why this paper focuses on the following two questions. What is the state of the art of sustainable building in Hong Kong and what are it's future chances?
To answer this question, I will analyse the high-rise blocks of *Verbena Heights* (Anthony Ng Architect for the Hong Kong Housing Society in Tseung Kwan O) as a case of contemporary *best practice* of sustainable building in Hong Kong. The case is considerately chosen after a general overview was given on Hong Kong's best-known sustainable building projects and is put in a broad context of sustainability in Hong Kong. The aim of the research is to create a better understanding of approach, level, category and impact of measures undertaken to reduce environmental loads. Data for the case was collected by means of a literature search, field-research and interviews.[1]
The results indicate that the technical level of measures to reduce environmental pressure is rather high and comparable with Dutch examples of sustainable building. Therefore, sustainable building in Hong Kong doesn't appear to be a technical problem, but rather a socio-economic and cultural problem.
Chances for refined sustainability are to develop a broad integral vision on building and leave pragmatic solutions to specific problems. Other chances are the government's stimulation of sustainable research and building regulations, joining knowledge and experience of sustainable building and the co-operation between those who are involved. Barriers might be the public awareness of necessity of a sustainable approach and a strong confidence in the economy of consumer society.

PRESENTING VERBENA HEIGHTS

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[1] For literature, see list of references. The field-research consisted of two visits at daytime of three hours each, in which district and direct neighbourhood of Tseun Kwan O as well as exterior and interior of the blocks were analysed. Interviews with experts and designers (see list of references) provided more profound and background knowledge.

Introduction

The high rise housing in Tseung Kwan O was developed by the Hong Kong Housing Society, to provide appropriate, high quality and environmental friendly but affordable apartments. At the newly reclaimed land of 21.000 sq. meters, a total gross floor area of 140.000 sq. meters was planned for domestic accommodation and 6.000 sq. meters as (semi-) public space. This means a total number of 3000 flats or approximately 8000 people, resulting in an average of 17.5 sq. meters per capita or 45 sq. meters per flat with averagely 2.6 dwellers. The flats consist of three types: 1-, 2- or 3-bedroom apartments with kitchen and bathroom with a gross floor area of respectively 15, 22 and 30 sq. meters (rental flats) or 40, 55 and 65 sq. meters (saleable flats). The new housing estate should furthermore integrate shops, market stalls, social welfare centres, nursery, kindergarten and communal recreational areas for local self-sufficiency.

Verbena Heights is located in the south east of the New Territories in a dense populated area, which is concentrated in strips between green hills and connected with the rest of the city. This causes a few problems. Busy highways run along the blocks. Because of its specific geographical location, strong winds or (ordinary) typhoons are amplified and can cause serious inconvenience and problems. Due to the sub-tropical climate, with hot and humid summers, heating up of dwellings is another problem. In summer, afternoon day temperatures often exceed 31 °C, whereas night temperature is normally 26°. A last characteristic is that the project is part of a new planned district, starting in 1993 with a population of 127.000, which will reach a total of 400.000 in 2010.

Design principles and characteristics

The design differs from Hong Kong's standard configuration of 'pencil' blocks, in which apartments encircle a central space for vertical transport. Instead, the flats in Verbena Heights have a linear composition of corridors, enclosed with apartments. These apartments are arranged around three central courtyards and above a podium, which contains a variety of communal facilities as social welfare, recreational green areas, a kindergarten, a day nursery, a children & youth centre, a social centre for the elderly and retail. The podium aims to encourage social interaction and community spirit and consists of a few levels. These levels are reached by a multi-level pedestrian system. This system can be reached by a limited number of main entrances to the site. Motor vehicles use the U-shaped roadway at ground level that penetrates the site and ends in a car park below the podium.

Ecological aspects

When reviewing Verbena Heights on environmental aspects, we focus on the themes and method of approach. The case shows different themes on which is focussed: 1) energy, 2) noise, 3) building material, 4) water, 5) wind and 6) waste treatment. With respect to **energy**, the designers strive for a reduction of energy by using 'passive', natural systems on which the building shape and lay out are based.. Natural ventilation and shading are used to reduce energy consumption for cooling. Natural ventilation is optimised through a mounting building height (or 'steps') in the wind direction, strategic apertures in the building mass that increases the permeability of the whole block and finally by a linear building layout instead of a crossed layout so that more facades are exposed to air movement. Shading is achieved by 'interblock' shading, orientation of the blocks in relation to the sun as well as using horizontal shading devices above windows and vertical devices hanging in front of the façade. Alternative sources as solar water heating, wind turbines and photovoltaic cells were found too expensive and space consuming to implement.

With respect to **noise**, the designers focussed on reducing the effect of noise by placing noise barriers at street level and acoustic screens above windows. The screens have a dual purpose: awning and noise mitigation. The second measure is adjusting the building mass to escape from zones where noise levels are inevitably high.

With respect to **building materials**, local or regional products were chosen as much as possible, in order to save transport energy. Examples are the local-made ceramic tiles and Chinese granite surfaces. Besides transport, other criteria have been developed in order to choose building materials. These were: 1) low embodied energy, 2) sustainable sources, 3) recycled contents, 4) durable, 5) recyclable and 6) CFC free. Choices are not made on Life-Cycle Assessments and most recommendations could not be implemented because of high prices. Furthermore, the designers analysed the possibility to reduce the consumption of **potable water** by using sea water for flushing the toilets. It would have reduced total consumption with 30%, but was considered impossible, because some parts of the New Territories are not (yet) provided with seawater infrastructure. The alternative was low-flush (7,5 l) water closets, instead of the normal 9-14 l closets.

With respect to **strong winds**, effects of *channelling, funnelling* and *downwash* are minimised by placing large *canopies* and wind *deflectors* at strategic points. The comfort at pedestrian zones should be improved by these means. According to the designers, comfort and well-being are also increased by vegetation in communal spaces and on surfaces such as the inner court and the façade.

Lastly, the designers concentrated on **waste treatment**. Domestic solid waste and construction waste are Hong Kong's two largest waste streams. A cradle-to-grave approach is proposed to reduce stress on landfills. For the recycling of household solid waste, litter bins are placed at appropriate locations. The inhabitants are supposed to separate their waste in four sections: paper, plastics, aluminium and glass.

CONCLUSIONS

Further steps towards sustainability

The green concepts presented above mean a serious step towards sustainable building. Although, *themes* and *strategies* in green design, related to every *stage* of the building process, could be further developed and *researched* in relation to the typical Hong Kong context of culture, geography, technology, climate and psychology. This research could develop checklists and systems for the environmental assessment of city planning, buildings, systems and products, as a tool for designers of green design.

Other chances to stimulate green design in Hong Kong are to 1) focus on experiments of new practices and ideas resulting in extraordinary examples of best practice in green building, 2) consider specific Hong Kong sustainable aspects and develop specific visions on aspects like the relationship between building in high densities and private personal space, the relation between high-rise building and human scale or built environment and green spaces, 3) generate possibilities to subsidise green architecture, 4) develop ideal, utopian views on sustainability in relation to the far future besides practical green solutions, 5) explore new ways of expressing green architecture.

Lastly it should be emphasised that the main barrier towards green Hong Kong architecture is the absence of a conscious approach to life as a whole. It is not only the partial solution that counts, but also the necessity of a broad and integral approach to the building task, which is beyond pragmatic solutions, considering the whole life cycle of the building, all relevant themes and all possible relations.

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POTENTIALS AND CONSTRAINTS OF CO_2 MITIGATION IN OLD RESIDENTIAL BUILDINGS IN GERMANY

Manfred Kleemann
Research Centre Juelich, Programme Group STE
D-52425 Juelich
Germany

ABSTRACT

The paper focusses on potentials and constraints of CO_2 mitigation in the German residential building sector. A discussion of the saving potentials is outlined, the obstacles to exploit these potentials are addressed as well as the most important policy measures.

INTRODUCTION

The German government declared the national CO_2 reduction goal to be 25 per cent by the year 2005, relative to 1990. The rate of 25 per cent means a physical reduction of about 32 million tonnes in the residential sector. Since market forces alone are unlikely to produce a response of the economy towards the 25 per cent goal, there is a need for government intervention. A variety of policy measures have been applied, but further measures are necessarry.

RESIDENDIAL CONSUMPTION

The most significant factors affecting the growth of energy consumption and CO_2 emissions are summarized in Table 1. In the long-term its expected that the resident population after a small increase will decline and reach again the present level after 2020. But in contrast to this development the number of accommodation units and the floor space area will steadily increase. They will force the energy demand for space heating.

Table 1. Expected development of floor space

		1992	2010	2020
Population	10^6	80.6	83.4	81.2
Floor space	10^9 m^2	2.86	3.33	3.40
Floor space/cap	m^2	35	40	42

Source: PROGNOS 1995

The total final energy consumption in the residential sector amounted to 2389 PJ in Germany in 1992. About 77.4 per cent of this energy has been used for space heating. Only 10.3 per cent are consumed for warm water preparation and 9.6 per cent for electric appliances and lighting. The remaining 2.7 per cent served as cooking energy. The shares of the individual fuels are as follows: district heat 6.7 %, light fuel oil 34.7 %, gas 31.5 %, electricity 8.5 %, coal 7.0 % and biomass 1.5 %. In the long-term its expected that this consumption pattern will change. The share of fuel oil will decline and the contribution of natural gas will increase. Solid fuels will disappear from the market.

DEVELOPMENT OF THERMAL INSULATION STANDARD

Table 2 shows the development of the thermal insulation standard for building envelops in Germany.

Table 2. Development of standards

Standard	Year	Heat demand[1)] kWh/m^2a
DIN 4108	58/69	250 - 340
1. WSchV	1979	180 - 250
2. WSchV	1984	120 - 180
3. WschV	1995	55 - 100
EnEV	2001	40 - 75

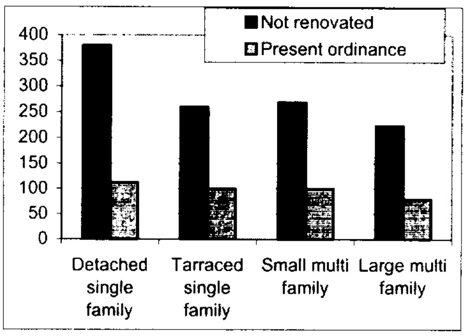
[1)] Related to floor space area

The first column presents the respective German abbreviation. In the next column the year is mentioned in which the regulation came into force. The prescribed specific useful heat demand is shown in the last column. The range of the figures is due to the ratio of building surface to building volume. The higher the ratio, the higher are the thermal losses. This effect of the building geometry is taken into account in the standards. The new "Energy Saving Ordinance" (EnEV) planned for the year 2001 is more strict and will reduce the allowable heat demand by another 30 %. But one should keep in mind that the overall reduction effect in the building stock has a considerable time delay, due to the long lifetime of the existing buildings.

SAVING POTENTIALS

The thermal properties of various building sizes are compared in Figure 1 for the age class 1949-1957. The left columns show the final energy demand in a not renovated condition. Not renovated means that the building is still in the original condition. Detached single family houses have the highest ratio of building surface to building volume and hence they tend to the highest specific heat consumption. Terraced single family houses and compact multi family houses have a low surface to volume ratio and hence a lower heat demand compared to detached single family houses. The right columns present the demand of the fully renovated building according to the present ordinance. The technical saving potential related to final energy is about 70 per cent for detached single family houses and around 60 per cent for the other building types.

Figure 1. Final energy saving potential for various building types of the age class 1949 - 1957 in kWh/m^{2}a (efficiency of heating system 85 %)



The old buildings, constructed before 1957, have a very high demand in the range of 270 to 380 kWh/m^{2}a. When these buildings were constructed no thermal insulation ordinance was in force. Due to the lack of good construction materials the age class of the post war period from 1949 to 1957 has the highest thermal demand. Compared to fully renovated buildings exist technical energy saving potentials from 65 to 75 per cent for the buildings constructed before 1957. After 1957 recommendations and regulations were implemented successively in Germany. Its estimated that 70 to 80 per cent of the older housing stock does not meet the current standard. This means that in the whole residential building sector are average energy saving potentials of at least 50 %.

About 30 per cent of the existing oil fired boilers are between 10 to 20 years old. These units have efficiencies between 78 and 89 per cent. But another 30 per cent of the oil boilers are older than 20 years, with an average efficiency in the range of 71 to 78 per cent. These boilers should be replaced, because with new units about 25 per cent of the final energy could be saved. The share of very old gas boilers is only half the percentage of the very old oil units. If these old regular gas boilers would be replaced by new gas condensing boilers, then about 30 per cent of the final energy demand could be saved.

MEASURES AND OBSTACLES

The practice of building renovation shows, its very difficult to exploit the above specified energy saving potentials because of several obstacles. The two most important are:

- The lack of public awareness, acceptance and information. In practice climate protection activities are not widely accepted by the population as a whole.
- The low price of fuels. The by far most severe obstacle is the missing cost effectiveness of many of the energy saving measures.

With the already implemented CO_2-reduction measures the emissions of the residential sector can be reduced from 128 million tonnes in 1990 to 111 million tonnes in 2005. These implemented reduction measures can be grouped into two main categories:

- Regulatory measures such as "Heat Insulation Ordinance" and "Heating System Ordinance".
- Funding programmes which provide subsidies and low interest loans for modernization of houses.

To reach the 25 per cent reduction goal a considerable amount of additional measures is needed. The most important ones are:

- The Thermal Insulation Ordinance must be improved to the level of the "low-energy" house.
- Official introduction of a building certificate, which identifies the thermal quality of a building.
- A further replacement of old oil boilers by new gas condensing boilers must be forced.
- Extension of funding is necessary to force the additional renovation of existing buildings.
- The extension of the existing information and consulting infrastructure.

CONCLUSIONS

The most important goals of all CO_2 reduction measures are to avoid unnecessary energy consumption by reducing thermal losses of the building envelop, by installing efficient heating systems and by stimulating a responsible heating behaviour. Efficient use of energy is the most safest and environmentally compatible way to contribute to protection of the global climate.

The technologies for high grade thermal insulation of walls and windows and for efficient heat generation are available on the market. However, the specified saving potentials are only exploitable with reasonable economic expenditures. The costs for energy saving measures can be minimized if the measures are coupled to the renovation cycle of the respective building components. But further financial support for thermal insulation measures is indispensable due to low energy prices. Under the present conditions the capital recovery of energy saving investments takes place over a long period, whereas building owners expect a short-term return. Financial support can improve this situation and motivate building owners.

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REHABILITATION OF TENEMENT HOUSING IN EUROPE

Dr.-Ing. Thomas Lützkendorf; Dipl.-Ing. Karsten Tanz; Dipl.-Ing. Martin Menard
Bauhaus-Universität Weimar, Lehrstuhl Bauklimatik, Bauhausstrasse 7b, D- 99421 Weimar
BBS-Ingenieurbüro Gronau + Partner, Thomas-Müntzer-Str. 6, D- 99423 Weimar
Politecnico di Milano, Dipartimento di Energetica , Piazza Leonardo da Vinci 32, I-20133 Milano

1. PROBLEM DESCRIPTION AND GOALS

A large number of tenement housing buildings built in the late 19th and early 20th century exist throughout Europe and are of considerable historic value. However, very often they have not been maintained sufficiently and as a result have suffered considerable degradation, making total renovation a cost-intensive exercise. The advantages and disadvantages of different renovation options need to be evaluated and compared with the cost of demolition and construction of a new building. To inform their decision, planners require sufficient data regarding renovation projects.

This has formed the basis of a SAVE II project aimed at providing relevant information about the financial cost, energy saving potential and environmental impact of the total renovation of old tenement buildings of this period.

Based on a parallel development of suitable methodological instruments and tools, case studies were carried out for selected reference buildings in Milano, Italy and Weimar, Germany. The data collected was used to evaluate the ecological and economic impact of different renovation and retrofit options for typical apartment buildings. The results have proved suitable for supporting the decision-making process in this field.

The aim of this paper is to demonstrate the methodological approach and the main results of the study.

2. METHODOLOGICAL APPROACH

In accordance with the aim of the project, an appropriate method should be developed that enables a comparision of different renovation strategies of existing buildings with the cost of a replacement building. The starting point was to determine a comparable basis for the valuation of the respective quality standards. Quantifiable quality requirements for dwellings were identified and described as well as criteria appropriate for the countries concerned (Germany and Italy):

- Energy-related quality of the building shell
- Energy-related quality of the technical systems
- Sound insulation and fire protection qualities
- Technical standard (electrical and sanitary installation, passenger lifts etc.)

For each criteria a 'normal' and a 'high' standard was determined: 'Normal' represents a medium quality standard sufficient to fulfil the current respective regulatory requirements, whilst 'high' represents a high-quality orientated on future regulatory requirements (such as low-energy standards). The details are contained in the project summary.

Based on these quality standard definitions, the principal alternatives for the comparison of existing buildings versus replacement construction were discussed and formulated as follows:

- Case 1: Renovation to current (normal) standard ⇔ New build to current (normal) standard
- Case 2: Renovation to current (normal) standard ⇔ New build to current (high) standard
- Case 3: Renovation to current (high) standard ⇔ New build to current (high) standard

As the renovation of existing buildings to a high standard typically requires technical and financial investment to such a high degree that it becomes non-viable, this option has been omitted. The comparison is based upon demolition and new build on the same plot, utilising all existing infrastructure. A replacement building at another location results in extra investment (provision of infrastructure) and subsequent costs (travel) as well as necessitating a higher energy and mass flow as well as increased land-use.

The project aims to demonstrate that the renovation and modernisation of existing buildings to current quality standards can be achieved within viable financial and technical parameters and can provide the equivalent comfort level of a new building.

To ensure comparability it has been assumed that the purpose 'dwelling' must be fulfilled over a period of time.

The determination of expenditure for renovation / modernisation of existing buildings includes:

- Energy + mass flow and financial cost for partial demolition including disposal
- Energy + mass flow and financial cost for for renovation / modernisation
- Energy + mass flow and financial cost for upkeep and maintenance
- Energy + mass flow and financial cost for room and water heating

The determination of expenditure for demolition and new build includes:

- Energy + mass flow and financial cost for total demolition of the existing building and disposal
- Energy + mass flow and financial cost for the construction of a new building
- Energy + mass flow and financial cost for upkeep and maintenance
- Energy + mass flow and financial cost for room and water heating

Based upon these methodological considerations, two reference buildings in Milano and two in Weimar were selected and assessed according to the expected renovation and modernisation cost. Further methodological considerations formed the basis of this assessment.
For instance, it was necessary to clarify which simplified 'decision-matrices' (i.e. approaches) are appropriate in planning renovation and modernisation projects in inner-city areas, particularly with regard to the aims of the project. As a result a guide was developed that describes the structure of the process of planning such projects. This formed the framework for the subsequent assessment of the buildings and was adapted and verified during its application. This can be seen as a result of the "Rehabilitation of old tenement housing in Europe" SAVE-II project.
A series of requirements and aims for the buildings to be considered were specified. As preparation for the evaluation, the buildings were analysed (coarse and fine diagnosis) and the building works and expenditure necessary to achieve the specified standard determined according to an object-oriented implementation. This object-oriented 'Element' approach is already proven for the ecological and economical assessment of new buildings.
Elements can be understood as material-constructive solutions (for example 1 m^2 external wall) or as a unit of technical infrastructure (e.g. 1 unit heating system) – each as installed in the finished building.

They represent:

- cost per unit (incl. labour, material, machinery) – expressed in a price
- energy and mass flow for the manufacture and construction (building product and process)
- technical characteristics (for example element section for thermal calculation, U-value)

Within the framework of the project, the element-method was adapted to the field of application. The determination and assessment of energy and mass flow for the renovation and modernisation of buildings including its sustainability over a specified period of time is described according to existing-elements, renovation-elements and finish-elements. The existing-element, renovation-element and finish-element form together the 'renovated building element' and are responsible for its technical characteristics (e.g. thermal performance, noise reduction etc.) Using these elements, the ecological and economical expenditure for the renovation building measures can be determined and evaluated.

The reference buildings in Weimar and Milano were assessed according to the method described. The primary results are summarised in the following points:

3. Primary conclusions

In addition to the aforementioned methodological considerations and developments, the assessments undertaken as part of the project resulted in the following primary conclusions:

- The renovation of existing buildings can achieve a comparable quality standard to new building. The renovation to a 'normal' standard proves to be the most efficient for the majority of the assessed criteria.
- Renovation measures can achieve the energy-related quality of new buildings without problem. However, the achievement of better (lower) values quickly reaches the limits of feasibility.
- The renovation of existing buildings to a normal standard is more economical than a comparable replacement construction. To achieve a higher quality, the cost is estimated to be comparable.
- The expected environmental impact for the renovation of the reference buildings is lower than that for a comparable replacement construction.

Further results, conclusions and references can be seen in the in the final report [1].

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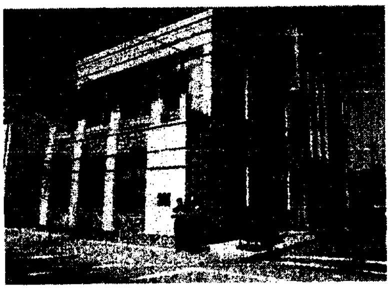
Final report; SAVE II Programme DG XVII, Milan and Weimar, January 1999

CCI Center

Wendy S. Powers
Conservation Consultants, Inc. 64 South 14th Street, Pittsburgh, PA, 15203, USA

This poster presentation will offer a case study of an environmentally excellent building that was constructed and is operated on a modest budget as a green building demonstration by an environmental non-profit in the United States.

PRESENTATION



Introduction

Conservation Consultants, Inc. (CCI) is a non-profit organization working towards and creating new strategies for the built environment to relieve stress on the natural environment and improve human health and quality of life. CCI has built a solid reputation over the past 20 years for high-performance quality work, beginning with energy-efficiency consultation. CCI's programs and services have expanded to include green building consulting, building public/ private partnerships for stronger, healthier schools and neighborhoods, and sustainable energy research and development.

In 1993, CCI purchased an 83-year-old building on Pittsburgh's historic South Side, to be renovated into the CCI Center. The building was developed to be a resource hub for environmentally sound strategies, both by modeling green building techniques, and by concentrating several environmental organizations in one building.

Environmental Impact

By renovating existing structures, CCI recycled two entire buildings, reusing as much of the existing materials as possible. Although part of the structure had to be demolished as it was structurally unsound, a construction waste demolition and salvage program was followed to insure that the waste stream from the building and associated construction activity was minimized.

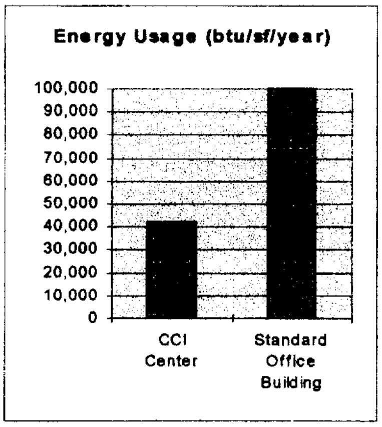
Recycled, salvaged, and non-toxic materials were used throughout the building whenever possible. Salvaged carpet, and kitchen cabinets were used. The office partitions were refinished and reused. AgriBoard, Forbo Marmoleum, recycled plastic lumber, citrus-based non-toxic finish, and VOC-free paints were used throughout the building.

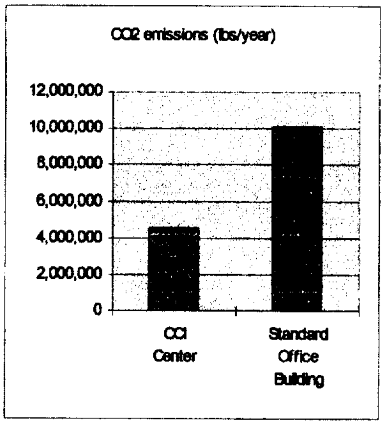
Indoor air quality and occupant health were considered in the use of non-toxic materials, as well as many operable windows for fresh air and daylight. Also, outdoor spaces were created on each level: a garden off the conference room on the first floor, a balcony with planting boxes on the second floor, and a roof top garden accessible from the third floor.

Energy Impact

Many strategies were used throughout the building to maximize energy efficiency. The insulation level in the building was increased to R24 walls, and R38 and R70 ceilings and roofs. Exterior treatments were designed to reduce heating and cooling loads, and thick interior walls provide thermal mass for passive solar heating. Extensive daylighting is provided and electric lighting was designed for efficiency. The building is heated and cooled efficiently by York Triathalon and Robair units that use natural gas. Exposed duct work throughout the building eliminates heating and cooling losses to the plenum. Photovoltaic cells were installed on the south side of the building, providing enough power to run the CCI Center's computer system, and shading southern windows to alleviate heat gain.

The energy usage of the CCI Center is 41,000 BTU's per square foot per year, less than half the 100,000 BTU's of energy consumed by a typical office building. This reduction in energy consumption also represents a reduction of CO_2 emissions to the environment by nearly 6 million pounds.





Economic Impact

As a green building that was constructed on a tight budget, using primarily readily available materials and systems, CCI Center strengthens the green building market by providing an example of an attractive, comfortable, and affordable building that is also environmentally sensitive.

The energy efficiency strategies used throughout the building result in estimated savings of over $12,000 per year. At this rate, CCI will be paid back for the higher initial cost of some materials approximately four years after construction.

Social Impact

CCI management and staff are dedicated to finding creative ways to recycle and reuse all types of waste from the organization. Construction waste management was used throughout construction to ensure that as many materials as possible would have an extended useful life. CCI Center has a recycling program for glass, plastic, office paper, paperboard, and corrugated cardboard. CCI recycles 960 pounds of glass and plastic containers, 1200 pounds of corrugated cardboard, and 3600 pounds of paper annually.

Also, as a demonstration project, the environmentally conscious and energy efficient strategies used in the design and construction of CCI can easily be replicated by architects, builders, and clients interested in green building. The majority of the technologies used, while not common practice, are "off-the-shelf" and accessible to anyone interested in using them with little to no additional effort. This high level of transferability makes it easy for visitors to implement such strategies in their buildings and projects.

CCI Center is intended to be a living laboratory, a showcase of environmentally conscious and energy efficient building strategies. As such, CCI hosts tours of the building for diverse groups of people in order to educate the public on what environmentally sound alternatives to common practice are readily available. Building professionals, community residents, and school children are all made welcome to various tours and educational programs that use the building as a tool, and example of environmentally sound practices.

RECOMMENDATIONS

Green building should not be seen as a high-priced luxury item suitable only for wealthy corporate clients. The value of green building for increasing worker productivity has made it an attractive option for large corporate clients. However, it can be done practically and affordably for clients with more modest building or renovation budgets. Non-profits, small businesses, residential and low-income building owners can benefit greatly from the use of practical green building techniques.

INDUSTRIAL CULTURE AND PRESERVATION OF RESOURCES IN THE INDUSTRIAL BUILDING STOCK

Authors
Bärbel Schwaiger, Niklaus Kohler *)
Uta Hassler, Alexander Kierdorf **)
*) Institut für Industrielle Bauproduktion (ifib), Universität Karlsruhe, Germany
**) Lehrstuhl für Denkmalpflege und Bauforschung , Universität Dortmund, Germany

Introduction

Previous studies on the development of energy, mass and monetary flows of national building stocks have shown a future predominance of refurbishment and maintenance and the probable decline of the share of new construction [EQK99]. This result opens a new field of highly relevant interdisciplinary research. The approach presented here combines historical research, both on written sources and buildings themselves (Bauforschung), with Life Cycle Assessment (LCA) and Building Product Modelling. The basic issues of this study are how to describe buildings in a comparable manner, how to combine different forms of knowledge and how to define common resource values (cultural, economic, and ecological). The main problems encountered are: the difficulty to define scaleable descriptions of buildings and building stocks, the consistent handling of relevant time factors and the complexity of the definition of resources.

The building stock as a research object

In the past, the building stock as a whole has not been analysed in a systematic way. Because of the particular political interest, many statistics exist on the housing sector only. Non-housing and especially industrially used buildings have only been documented as isolated objects for either technical or cultural reasons (e.g. industrial monuments). In regional and city planning the building stock has been considered mainly from the point of view of new communication structures and work forms. The traditional historical inventories, in theory made reference to the whole building stock, however, without an overall analysis or paying any respect to its detailed dynamic. The main interest was devoted to single outstanding buildings perceived as works of art. The research on sustainable management showed the necessity of enlarged system limits and long term predictions of the evolution of mass and energy flows. The first comprehensive approaches describing the building stock and its dynamic were therefore related to the issue of sustainable management [DFG98]. The Committee for the Protection of Man and Environment of the German parliament initiated a study about mass, energy and monetary flows of the building sector [SCH97]. Its objectives were to collect the available information, to quantify the present flows and to predict the evolution until 2030 in order to identify the needs for more detailed research. The industrial stock before world war 2 was identified as a particular field for research.

The industrial building stock - Integration of the approaches

A research project about the industrially used building stock has been conducted in order to increase the knowledge about this important part of the stock. In Europe, changes in the industrial sector resulted in the desertion of industrial buildings. As a consequence, many areas with existing infrastructure are now available for other uses. This stock constitutes an enormous potential.
The industrial buildings, which are today partially or totally unoccupied, are not only economic resources; they also constitute historical cultural and material ecological resources. The monument conservation of individual buildings as cultural industrial heritage will generally lead to conserve a few outstanding objects and to demolish the other buildings. The rest, i.e. large parts of cultural as

well as ecological resources are destroyed mostly by ignorance or by a lack of alternatives. There is a pressing need for new comprehensive conservation strategies. The elaboration of these strategies on a large scale requires a better knowledge of the industrial building stocks in general [HAS00]. Often, the surviving individual buildings are badly documented and even less information exists on the total historic industrial building stock (including the buildings which have disappeared). There is a double need for better knowledge about the industrial heritage:

- The surviving objects are witnesses of the whole stock (knowledge is central)
- The long term transformation process reflects successful maintenance and conservation strategies (methods are central)

The research combines the historical building research with Life Cycle Analysis and with building product and building stock modelling methods. Partial objectives are :

- Knowledge of the structure of the stock (age, use, size, construction types, etc.)
- Knowledge of the dynamic of changes (how and how often are buildings rebuilt, what are the reasons for demolition, etc.)
- Identification of methodological synergies
- Definition sustainability indicators and evaluation processes
- Development of planning and management heuristics to deal with industrial estate portfolios

Some preliminary results :

The are still insufficient data on the size of the non-housing stocks, in particular the pre World War 2 industrial stock. The estimation in [EQK99] attribute approximately 17 % of the surface of the whole stock to this type of buildings. Even if the degree of use of the buildings is not know, first Swiss studies [WUE95] show that the amount of empty or low intensity use of buildings could cover needs for new construction for at least 10 years. Of course these figures do not take into account the morphology of the buildings and their situation.

Percentage of surfaces of the German building stock in 1992

Use classes		before 1870	1870-1918	1919-1948	1949-1965	1966-1978	1979-1990	Total	Subt.
Housing	individual	2,0	3,1	2,9	5,1	4,7	3,6	21.4	
	row	0,2	0,4	0,9	1,6	2,0	1,0	6.2	
	small coll.	1,4	2,2	2,3	4,8	3,6	2,1	16.5	
	large coll.	0,3	0,5	0,2	0,9	1,7	0,8	4.5	
	high rise	0,0	0,0	0,0	0,2	0,7	0,1	1.0	50
Non-housing	office	0,4	1,0	0,6	0,8	0,7	0,7	4.0	
	institutions	0,5	1,2	0,7	1,0	0,5	0,2	4.1	
	commerce	**0,1**	**0,2**	**0,1**	0,2	0,1	0,1	0.8	
	warehouse	**1,1**	**2,8**	1,7	2,4	1,9	1,6	11.6	
	industry	**1,0**	**2,5**	**1,5**	2,1	1,6	1,4	10.2	
	agriculture	1,0	2,4	1,5	2,1	1,0	0,8	8.8	
	different	**1,2**	**3,0**	**1,8**	2,6	1,6	0,7	10.9	50
	Total	9.2	19.4	14.3	23.8	20.0	13.3	100	
	Subtotal			43			57		

The analysis of the historical development of particular building stocks belonging to o firm or constituting an urban fragment show that the re are almost always production or administrative reasons which lead to transformations and demolition of buildings and not at all their constructive state or their age. It seems also that large buildings survive longer than small buildings. Buildings which allow multiple uses tend to survive longer, this is particularly true for warehouses.

There is need for rapid and comprehensive evaluation methods to appreciate the resource value of buildings . First calculations show that from a resource conservation point of view the conservation and /or transformation strategies induce 4 to 10 times smaller flows than new construction (over average life times)

The relatively hesitant use of existing industrial buildings is often due to a lack of their rapid availability and of the fear of complications (building codes, risks of pollution etc.). Small industrial, service and R&D firms generally need rapidly available space with good information technology connections, the possibility to leave or increase surface in short intervals , the possibility to rent or lease instead of building or buying. These demands are more and more taken into account by firms specialised in rapid a la carte refurbishment and transformation of existing, often empty buildings. As new owners or as representatives of owners, these firms have a specific interest in managing the buildings in a flexible medium to long term perspective. They develop their own adapted and efficient management tools independent of the actual user. These tools could be enlarged to include sustainability indicators (resource conservation etc.)

Conclusions

It has proved that short term adaptations of buildings to rapidly changing technical and social needs are inefficient in a long term perspective. There is a clear strategic difference between the short time management of buildings (use) and the long term (intergeneration) management of building stocks and urban contexts. The knowledge of the historical industrial building stock and of it's transformation and the underlying long term management strategies and maintenance techniques should be integrated in the know-how of firms which manage and transform these buildings. The architectural efforts should therefore be concentrated on the imagination of a new social and cultural spatial environment which would accompany and improve new forms of work and communication instead of trying to adapt objects with life times of decades to IT techniques which change every three years.

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A MODEL FOR DESCRIBING THE SWEDISH BUILDING STOCK – THE SWEDISH BUILDING REGISTER AS A DATA SOURCE

Liane Stendel
Department of Built Environment & Sustainable Development, School of Architecture, Chalmers University of Technology, Göteborg, Sweden, stendel@arch.chalmers.se

INTRODUCTION

There is a need for detailed information on the building stock when deciding on suitable measures in planning and management situations in order to obtain a more sustainable development of the stock.

In Sweden, sample survey is an established method for the description of building stocks and sample surveys have been carried out on various parts of the stock and on different aspects since the 1970s [1]. Apart from the high costs, one draw-back connected with sample surveys is that they give one on-the-spot picture of the stock and do not allow for follow-up on continuous changes. In one study, based on sample surveys, it was attempted to describe the stock and its changes over time but only material flows were studied and some of the data used were not up to date [2].

A concept for a model describing the Swedish building stock, concerning resource deposits and resource flows, has now been developed based on a German building stock model [3]. The model itself is still to be finalised. Different national conditions, such as available data and existing structures describing buildings, made an adaptation to Swedish conditions necessary. The concept of the model is presented briefly in this paper but the main object is to elucidate two data sources for the description of the building stock: the Swedish building register (BR) and the property taxation register (FTR).

THE CONCEPT AND THE DATA SOURCES

In the proposed model, the description of the stock will primarily be quantitative and various physical properties will be addressed. Beside general descriptions (use of the buildings, geometry, etc), material, waste material, energy, and water will be described (deposits and flows) and these will present the characteristics of the stock. The model will be an integrated model and it will be developed in steps. It may be used on a national and regional level, and it may also support resource management and decision-making in the building sector. The Swedish National Board of Housing and Planning and the Ecocycle Council for the Swedish Building Sector are addressed hosts/users of the model and its data. Other potential users may be found among government authorities, public authorities, trade organisations, planners, property managers, and researchers.

A systems analytic approach, where the system-in-focus is changeable, has been chosen. Both a holistic (top-down) and a reductionistic (bottom-up) approach are used. In the top-down approach the stock is considered as a "black box" and is described as a whole by for example general statistics and data from trade organisations, producers, building industry, etc [4]. Total amounts of resources, such as material, energy, and water, used will hereby be investigated. In the bottom-up approach individual buildings, building parts, elements and materials can be aggregated to represent the stock or a fraction of the stock. A number of buildings will be investigated in this detailed way. The individual buildings then be scaled to fit and represent the whole building stock. For structuring data existing structures, like the Swedish Construction Industry Classification System (BSAB), will be used as far as possible. All data will be stored in a database. Data emerging from the two approaches will be compiled in an age-use matrix to check the reliability of the results [5].

The frame of the age-use matrix is mainly based on similar frames used in earlier Swedish building stock studies; this is advantageous for reason of comparison. Comparisons with official statistics, foremost statistics regarding the domestic building stock, will be possible to some degree.

In a first rough division, the stock is divided into a domestic and a non-domestic stock. The domestic stock is further divided into single-family houses, blocks of flats, and cottages, whereas the non-domestic stock is divided into five categories: shops and offices, hospitals and buildings for education, industrial buildings, farms, and others. Buildings containing both dwellings and commercial use are allocated to blocks of flats if the dwellings comprise more than 75 % of the area; otherwise they are allocated to commercial buildings (shops and offices). The division of the stock into use classes, is supplemented with a division into age classes (year of construction). In earlier building stock studies, the stock has mostly been divided into periods of 20 years (starting from before 1920 or 1940) up to the actual year of the investigation. In investigations considering only the domestic stock, the periods are instead 15 years (starting from before 1930 to 1975), as these breakpoints approximately coincide with changes in the building codes. Industrial buildings were only divided into before and after 1960. In the proposed model, a more flexible frame with 5-year periods is aimed at. Hereby, the matrix will be adaptable to most of the earlier studies. The number of existing buildings together with the total gross floor building area will be inserted in every age-use class of the matrix.

In the earlier Swedish investigations, mainly the FTR has been used as data source. In the model to be developed, the newly established BR, managed and updated by the National Land Survey of Sweden, will be used to fill the matrix in combination with the FTR.

In the FTR, gross floor areas for properties and year of construction, among other variables, are registered. A property may consist of one or more taxation units and may contain from zero to any number of buildings; single buildings can not be identified. Taxation units are taxable or not taxable. Each unit is given a type code according to certain characteristics of the unit. The type codes are sorted in different categories, such as agriculture, single-family houses, rental properties, etc. FTR data is published annually by Swedish Statistics in a very aggregated form; county-wise and for the whole country and by type of property, owner, area, and age classes. Special processing of the FTR data is necessary to use it for the model matrix. For taxable properties, several variables such as area, age, standard, and building value are available. For not taxable buildings, fewer variables are available.

In the BR, all buildings in Sweden are registered, roughly 3,1 billion buildings. Every building is one unit and has a unique identity. In the BR, a building is defined as a building when used for housing, as a weekend cottage, by industry, trade, for social or cultural purpose, or for common use. Not included in the basic BR are farm buildings on agricultural properties, complementary buildings to other buildings such as storages, out-houses, parking houses, and garages. In general, not insulated buildings are not included. A geographic connection is given by co-ordinates (reference to a map) and a code for location of the buildings, for example, in densely built-up areas or sparsely populated areas. Buildings are not registered with a type code for use but they are related to the FTR by a 'property key'.

The appropriateness of using the BR-data as a source for the matrix in the building stock model and the possibility of combining BR-data and FTR-data for the same purpose have been investigated in more detail, as well as the reliability of the BR-data. A file (tables) from BR with data for one Swedish community (Mölndal-Fässberg) has been tested. The test-file comprises about 4000 buildings with different use and of different type (domestic and non-domestic buildings, single-family houses and blocks of flats, industrial buildings, commercial buildings, offices etc). The tables have been treated in Word-Access in two kinds of studies. In the first study, a number of buildings chosen at random in each use class have been used as a basis for a field study. The correctness of the registered data concerning the use of the buildings was examined by ocular investigation of the 40 selected buildings. In a second study, the tables of the test-file have been related to each other and compiled in different ways. For example, building keys have been related to type codes from FTR tables in order to investigate the possibility of using the BR (and FTR) in the proposed building stock model.

RESULTS AND DISCUSSION

The field study showed a good agreement between the registered use of the buildings and the real use, especially for single-family houses. For buildings registered within the use class 'shops and offices' some discrepancies were found; sometimes they actually belonged to 'domestic buildings – blocks of flats'.

In the BR, buildings can easily be sorted by year of construction and allocated to different age classes. In general, the figures for the domestic building stock are of good quality. Regarding the non-domestic building stock it is sometimes difficult to assign the buildings to the correct age-use class.

The errors in the registers have different causes. For example, taxation units with a value below 50.000 SEK (about 6000 €) are not taxed and therefore not registered in the BR, although such properties are often inhabited (coarsely estimated to 50.000-60.000 buildings). Another problem concerns the type codes. For example, the codes for cottages are not as good as for single-family houses or blocks of flats; cottages are sometimes converted into permanent houses but the code is not changed to the appropriate one. When combining type codes from FTR with buildings registered in the BR, double counting can occur because a property can have several taxation units and it is not possible to allocate the buildings appropriately. Also, in some cases it is difficult to define a single building (a row house with different owners will be registered as several buildings despite it is only one physical building). Furthermore, owners of single-family houses have a tendency to underestimate the floor area, as found by Swedish Statistics.

The BR is a valuable source, in particular as single buildings can be identified. The geographic data makes Geographical Information Systems (GIS) applications possible. However, some disadvantages have to be pointed out. From a material flow perspective even non-insulated buildings such as parking houses are of interest, but these buildings are not included in the BR. Another point is that no unequivocal use of the buildings can be identified.

The sum of the gross floor building areas is the same in the BR and the FTR, but in the BR single buildings can be identified and a geographic location is given. Therefore the BR will be used for the general description of the Swedish building stock and the matrix. In earlier studies only the FTR was available as data source.

CONCLUSION

Data from the BR is found to be relevant and a valuable source to build up the age-use class matrix in the proposed building stock model. The matrix will give a first overview of the building stock composition and it will also be the starting point for future scenarios of the development of the stock.

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THE INFLUENCE OF LIVING CONDITIONS ON HUMAN MENTAL HEALTH

Ph.D. Stjepan Takač[1], M.D. Ahmed Delagić[2], Boris Takač[2]
1. Faculty of Civil Engineering, University of J.J. Strossmayer, Drinska 16a, Osijek, Croatia
2. Clinical Hospital Osijek, Huttlerova 4, Osijek, Croatia

INTRODUCTION

Human beings are observed in their three basic dimensions: biological, psychological and social. To what extent human physical and mental health depends on the influence of urban environment has not been scientifically thoroughly explained.

In order to contribute in this field The Civil Engineering Faculty of Josip Juraj Strossmayer University in Osijek in cooperation with Osijek Clinical Hospital have started an internal scientific project on "The influence of urban environment and building structures on human mental health".

General goal of this study is to find functional connections between mental health of the people in Slavonija and Baranja and the environment they live in.

RESEARCH RESULTS SURVEY

From the very beginning of human race on earth, man has been improving his living conditions. From his life in caves, sod-houses, log cabins to modern life in concrete, steel, wooden houses and objects made of artificial material.

In our study we have tried to find answers to the question to what extent is human mental health a function of urban environment, building structures and materials they are made of. What does the living in dense town environment compared to the more natural way of living in villages bring to a man?

In what way the created living conditions influence the change of human psycho? Do all achievements in this field influence his mental health?

The great German builder-constructor Fritz Leonhard made an extraordinary statement which could be taken as an answer to the above questions: " Basic problem of the society represents the lost sense of beauty and above all the fact that nobody has clearly managed to reach the meaning of surroundings beauty and quality to human psychic and ethical behaviour."

The last census in the Osijek-Baranja county was published in 1991 and the chart 1 gives a review of the county population structure according to their age and the place of living (town, village).

Sex	Age						Total
	< 10	11 - 20	21 - 30	31 - 40	41 - 50	> 51	
	Population						
County	42724	45631	48299	52395	41585	96980	331979
Town	23206	25956	26537	30268	24902	51825	185000
Village	19518	19675	21762	22127	16683	45155	146979

Chart 1. Population structure of the county according to the census of 1991

The researched mental illnesses make two groups, a group of mental disorders and mental disorders in the family. In the group of mental disorders there are psychosis, neurosis, disorders of personality, toxicomania (alcoholism, drug addiction, smoking), tentament suicide, suicide, post traumatic stress disorder.

Psychosis is the most frequent illness with a share of 32,47% of all mental illnesses, followed by a group of posttraumatic stress disorders at 21,10%. Significant share in the structure of ill people takes tentament suicide at 5,33% and suicide at 4,39% of the total.

The results show the higher inclination of town inhabitants to mental illnesses. Figure 1 shows the structure of the ill according to their place of living 1,54% ill people in towns and 0,81 % of ill people in villages i.e. 70,40% to 29,60% of the total number of the ill. The town surroundings obviously brings the inhabitants, besides significant civilisational advantages, factors, which endanger their mental health more than in villages.

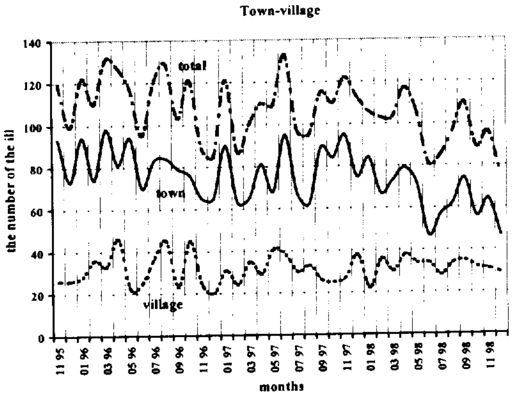

Figure 1. Graph of the sick people structure in towns and villages

It is determined that there is higher percentage of the sick people living collectively (63,86%) and individual (36,14%) way of living compared to the total number of the sick people (fig. 2). There are no data on structure of the population according to the way of living therefore this will not be analysed.

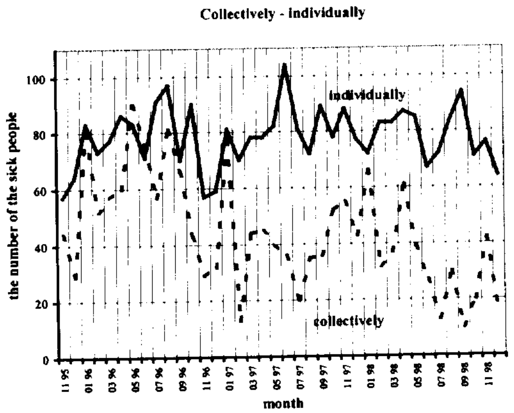

Figure 2. Diagram of the structure of the sick people living collectively or individually

Figure 3 shows the number of the sick people according to the floor they live in. This information deserves further detailed research since it points at the fact that the greater hight of the flat has greater negative influence on human mental health. The information about the structure of the population according to individual levels of living is still not known. Statistic data are not available. The value of this is the notion of the sick people number of those who asked for medical treatment.

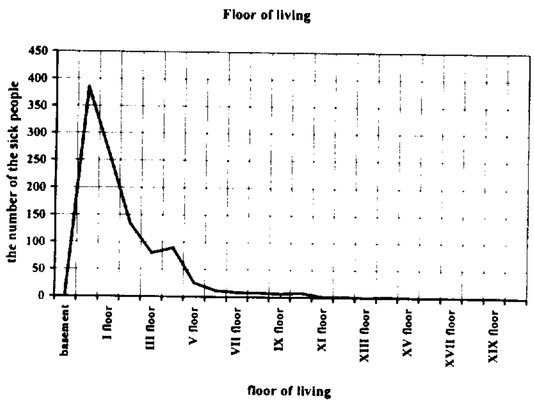

Figure 3. The sick people number according to the floor of living

To bring some interesting results of the research of mentally ill population of the county according to their sex the shown research results are only for a year and it is obvious that male population of mentally ill population at 63,06% prevails, whereas the female population is at 36,94%. The reasons for this fact should be looked for in global variety of the personality structure. The answer to this is ambiguous and not simple but the situation is indicative.

Furthermore, the movement of the sick people within a year oscillates. Christmas and New Year's time notes the least personality destructions wheras it significantly increases during February with male and female population.

CONCLUSIONS

The knowledge of mental disorders causes should be a prerequisite to any organized prevention measures or at least to the part, which aims at controlling and preventing particular mental disorders.

By diagnosing the influence of the human surrounding on mental health of the people would enable organized state action in eliminating negative causes. By the destimulation mechanism of the human environmental elements, which have negative effect on mental health of the people a state could encourage such town-planning solutions, building structures and materials, which benefit people. Science has already suggested that there are some materials with negative influence on human health even directly causing the worst illnesses. This research has proved that village environment has less mentally ill population. There are indications that living in high buildings endangers human health as well as increases the number of attempted and committed suicide.

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THE OPTIMUM SCALE FOR SELF-SUFFICIENCY; FROM FLOWS TO CYCLES

ir. Arjan van Timmeren (1) and ir. Marco Heijligers (2)
Delft University of Technology, Delft, The Netherlands
(1) Faculty of Architecture, MTO-BT / DOSIS, PO Box 5043, 2600 GA Delft; The Netherlands
(2) DIOC-DGO The Ecological City, Rotterdamseweg 139a, 2628 AL Delft; The Netherlands

INTRODUCTION

The search for self-sufficiency of buildings and surroundings has led to several more or less known concepts in which (a form of) autarky is being claimed. Most of the times these different concepts and systems concern different aspects of autarky (energy, water or waste). Besides of that, few times they are compared or combined. A problem in this context is how to unify the input and output of these different aspects of autarky. Moreover the concepts for autarky often obtain a different scale. On one hand there's a tendency to ongoing centralization (and sometimes to globalization), on the other hand concepts that claim autarky concern individual building projects. To find the real sustainable form of autarky, it must be fit in on a socially acceptable way and at the same time be cost-effective. It's important to realize that in the usual practice of urban planning space for water clearance, energy gaining and waste-treatment is found outside the city, while the enlarging of the bio-diversity and food production are sometimes even found outside countries. The consequence is a need to transport energy, water and waste to centralized treatment places outside cities and therefore an enormous amount of technical infrastructure. Especially this technical infrastructure for the transportation of energy, water, and waste is a relative expensive feature in urban planning. Besides of that the fact that this technical infrastructure often is situated under the ground lowers the involvement of 'users' towards the quantities of the 'flows' (water, energy, waste /materials) and therefore negatively influences their behavior. Moreover this need to increase the visibility of the different flows the costs for the needed infrastructure should be calculated directly linked to the amount of use. Finding the optimum scale per flow and meanwhile reducing the costs of unnecessary technical infrastructure might generate money to invest in ecological qualities and sustainable technologies. The optimum would be self-sufficiency, or autarky. Autarky however is not to be found just on one fixed scale. The optimum scales for autarky won't be on a highly centralized level or just on the scale of one single building. It probably will be somewhere in between, and besides of that it will be different for each flow. Therefore the way in which these different optimum scales are combined will be directive for the real sustainability of urban planning.

CONTEXT

A solution in making it possible to compare the environmental impact of the different concepts can be found in a translation to the ground surface that would be necessary to generate the needed energy, clear water, materials and etceteras (Rees, Wackernagel; 1994). This so called 'Ecological Footprint' might be an adequate method, as most of the earlier stated 'consumption needs' depend on (natural) light and therefore need their own surface with direct natural light. With the continuing process of urbanization there is also an unprecedented human ecological transformation. This shift in the spatial and material relationship of human-kind to the rest of the ecosphere underscores the urgency, the 'new necessity' of greening the (built) society. Only, if space can be found to absorb the pressure on the environment due to the production of the goods needed by the world population, the existence of the earth is guaranteed. Urban designers need to think different: they need to realize a 'trend break'. One of the possibilities is to find more space in the city for (ecological) production such as water-clearance and energy gaining to enlarge (artificially) the bearing capacity of the environment. Another is finding the optimum scales for self-sufficiency.

FLOWS, AREAS AND ACTORS

The Ecopolis strategy (Tjallingii;1996) is a new way of urban planning that might help to lower the environmental pressure. It tries to take the flows (water, energy, waste and transport) as a leading factor in ecological sound planning. Besides of that the participants play an important role in the process of (sustainable) urban planning.
The Ecopolis strategy is focussed on three points of view for urban planning: flows, areas and participants. Separating these different points of view is the first step to be taken to approach the problem of finding the optima for self-sufficiency.
Each country, city, neighborhood 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 possibility to quantify them. The effects of a considered solution can therefore be visualized.
Areas have ecological qualities. The livability of areas depends for a great deal on this ecological quality. The sort of use, the spatial qualities and the radiation of solutions to livability and the quality of life are directive for ecological sound urban planning. These spatial qualities can be enlarged through combining the cultural and natural use of areas. Moreover one could try to optimize its use by varying higher- and lower densities related to the necessary optimum scale for self-sufficiency per density. Finally the creation of mixed use will contribute to create ecological conditions.
Finally the actors, consisting of the users, the legislators and the suppliers of the different flows on which autarky is being claimed, have great impact on the environmental pressure of urban space. Their involvement with the surrounding environment is of great influence on their behavior and thus on the sustainability of flows and areas Therefore increasing their awareness has to be the first objective. The personal involvement of users can be improved by making the (existing) flows more visible. Another possibility is bringing sustainable solutions nearer to users via decentralization. A reduction on infrastructure can be achieved.

FROM FLOWS TO CYCLES

To measure the environmental impact of a society the effects and needs will have to be translated to the same units. The earlier stated method of translating all these 'consumption needs' of a country in surface is called the Ecological Footprint. (Wackernagel, Rees; 1994). To make beneficial measures it would be more usefull to consider the ecological footprint of a region, city and its surroundings or a new or existing neighborhood. Then it will be easier to take measures and to relate them to its sources.

An important goal in the sustainable planning has to be to create a balance between the pressure on the environment and the bearing capacity of the available space in the area that's considered. This might underscore the necessity of piling up functions or solutions in the given area and/or the need to find the optimum scale of autarky per flow. The integration of solutions for the different flows, combined with the attempt to reduce the needed ground surface and thus the production of extra 'environmental area', is the subject of this study. Emphasis will be put on the solution and integration of water treatment, energy gaining and re-use of waste. In the latter situation one can imagine that there is a physical end for this kind of enlarging of environmental productiveness. Water treatment, sustainable energy production and food production are based on processes that depend on natural light. Key factor in finding the optimum in this case therefore is the optimum use of sunlight per square meter.

A lot of strategies that aim to achieve environmental improve of the existing flows first of all begin with the attempt to optimize the request of energy, water and materials. On the average they try to do so just by making, or forcing, the users more behave more conscious (via advertising or price increases). One could say however that these strategies that try to realize a more economical behavior try to 'swim against the tide'. Problematic is that a lot of people have a natural habit to compare (in time and place) and therefore long for more and more. They desire to have more space, more comfort and more luxury. Therefore they will consume more in all its factors. This growth of consumption can be restricted only with great difficulty, with expensive and often repressive campaigns from the (central) government.
The central question in sustainable planning therefore has to be in which way it will be possible to create sufficient space in cities in order to fulfil the demand for consumption, without enlarging the pressure on the environment. This need for space for water clearance, energy gaining and waste treatment will lead to more directive input in the program of demands.

DEMATERIALISATION

In made comparisons of environmental impact the factor transport often is left out, or reduced to the necessary energy for transport. The actual use of 'goods' (water, fuel, raw materials, and etceteras) lies much higher. Besides of that, when we realize that fuel, water and raw materials will increase enormously in prize within the next decades it emphasizes the need to find solutions as near as possible to the spring of the environmental 'problems'. Therefore it is self-evident that solutions to achieve the reduction of the former mentioned flows must be found in reducing (technical) infrastructure and the need to transport.
Apart from that it will be necessary to try to connect the different flows and their solutions in a more integral way. The ongoing specialization has led to several autarkic concepts that are based on technologies that try to find solutions for each of the different flows. Biological water treatment for example isn't a problem any more. It's use of energy or the needed ground-surface on the contrary (still) is a problem. Therefore a it will be necessary to make connection of solutions for these different.

Current levels of energy and material-use in high-income cities and countries are biophysical unsustainable. Accumulating empirical evidence of ecological degradation calls for a radical transformation of urban industrial society, including prevailing thinking about form and function. Various material flows and waste assimilation studies have shown that for sustainability, the post-modern world will have to reduce energy and material intensity of consumption by 50%. The needed dematerialization increases to 80%-90% in the high-income countries (Rees, 2000).
New urban construction and infrastructure, to even basic standards, will require enormous quantities of energy and material resources. Buildings account for 40% of global material and about a third of world energy consumption The modern industrial world is a product of petroleum and no suitable substitutes are yet available for many of its myriad uses. The decline of oil may mean widespread price increases and shortages of other resources, particularly if the economy is not successful in 'dematerializing' and shortening or greening the ways of transportation.
As told before the optimizing of the consumption will always help to make the world

more sustainable, in fact it always will have to be the first step. Possibilities for a breakthrough however should be found in new techniques that might lead to increasing capacities of the environment. Under the device: not less but differently. Sustainable urbanism is at the threshold of big changes.
Urban planning has to be based on the principle that space has to be found within the area of the city or the neighborhood. On city-level this means: Put the right functions on the right spots. High densities near centers and excellent public transport (fast and high frequent). Low densities outside the city, absence or very light infrastructure and no facilities (self-sufficiency)

SUSTAINABLE IMPLANT

Combined with eco-city design principles, green building technologies have the potential to make a major contribution to the conservation efforts. For autarkical concepts it will be useful to concentrate on finding an optimum in between the existing centralized concepts and decentralized techniques. With the gained money through reduced (techn.) infrastructure and the gained possibilities because of the inter-connection of different flows on a scale superior to that of one building a real paradigm shift might be realized. On neighborhood-level this it might be a solution to design a sustainable main structure of transport and treatment of water, energy, materials (and waste), and to make it more visible. This structure should be enabled to be flexible to cope with changes for sudden developments (increasing and decreasing flows, improving techniques). It should incorporate closed systems for water, energy and waste and habitants should participate with the different processes. Their support can be used for the maintenance of the qualities. A tool, called Sustainable Implant (S.I.), is being developed. It tries to combine different technologies concerning the three main flows on which self-sufficient concepts mostly are based on a different scale than the nowadays usual central scale or scale of one building. The instrument will be developed and implemented in three different case studies in the Netherlands. This paper will mention one.

RUIGOORD, THE NETHERLANDS

The Ruigoord case has been chosen because of the extraordinary spatial, social and ecological qualities of this settlement. The research was carried out in cooperation with the residents of Ruigoord. The study is a response to the threats facing both the village of Ruigoord and the surrounding natural environment and develops the idea of creating a new Ruigoord. The research is based on a vision of environmental design that emphasizes the relations between the built environment, the social environment (people-oriented) *and* the natural environment (plant- and animal-oriented). The analysis of the existing Ruigoord reveals its various special qualities. The new Ruigoord will be based on these qualities. The concept of the sustainable Implant will be tested in this situation.

CONCLUSIONS

Efforts to make the built society more ecological should be based on the combination or integration of solutions. The scale of these solutions is of major importance to the long-term effects.
To achieve a paradigm shift in sustainable urban planning or even to achieve a self-sufficient society a more decentral way in closing the flows to cycles will help to make users more conscious of their behavior: the solution near to it's source.

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TOWARDS SUSTAINABLE BUILDING DEVELOPMENT IN HONG KONG

Anthony Wilson,
Architectural Services Department, Queensway Government Offices,
41/F., Queensway, Hong Kong

The paper provides a brief historical background of Hong Kong development to inform how well planned, high density living can be an efficient asset for future sustainability.

Hong Kong is estimated to have an ecological footprint 236 times greater than its land area [1], which raises the question, can it ever be sustainable? The answer may be no, but we can certainly make improvements.

Hong Kong has wonderful geographical properties of steep hillsides sheltering a deep harbour. Village remains indicate habitation existed around 6000 years ago but it was the arrival of ships in the harbour in 1841 which was the catalyst for development.

The narrow shoreline was quickly developed for transport routes, military and storage buildings. To overcome the shortage of land, the tops of smaller hills were removed and used for fill to provide new land and improve the harbour front. The created platforms on the hills were also used for new buildings as a double benefit.

Early buildings were designed to suit the environment within the limits of the technology at the time. Common features were; two to three stories high, balcony access on the upper level with archway facades to shade the thick solid external walls, high ceilings and natural through air flow, double tile roof for better insulation and the use of lighter external colours to reflect heat.

Fig 1. Early Buildings

Population demands resulted in the need for a large public housing programme. Land shortage continued but the introduction of concrete technology provided temporary relief with older buildings pulled down and higher ones built. The environment was not properly considered and private development was built to maximise short term profits with many buildings being replaced after only 15 years.

Land on Hong Kong Island and Kowloon became impossibly short. Commencing in the late 1970's, new towns were constructed in the New Territories with proper infrastructure links to the city. As in the past, reclamation combined with high rise building were the techniques used. The complex problem of accommodating a high density population with mixed use neighbourhoods and suitable public transport systems did not fully consider the long term impacts on the environment

Fig. 2. Tai Po New Town

Since 1997 there has been a major change in public awareness about the environment and accepting ownership of Hong Kong. Support to improving the environment was given by the Chief Executive in 1999 and now innovative approaches, a change of thinking, and support from everyone is needed to produce a better quality of life for the future.

Innovative urban planning design to provide a more sustainable city form is required. Because site utilisation must be maximised, demands on ground level space increase and it is common to find markets, cooked food centres, shops, libraries, recreational facilities and games halls all in one multi-storey complex. Podium developments in private housing estates is common.

It is necessary to preserve more of the existing urban fabric. Buildings, precincts and features of architectural and historical significance can be restored and retained. The lost development potential can be transferred to adjacent sites.

The long escalator from Central to Mid Levels has had double benefits by reducing vehicular traffic and also reversing urban decay in the surrounding area by the introduction of pedestrians which has generated the growth of restaurants, café's and shops.

New comprehensive planning areas now consider more preservation and pedestrian accessibility with main roads and the preferred transport solution, cleaner railways, located under ground with mixed and residential accommodation of up to 45 floors above.

The Architectural Services Department is leading the industry by being ISO 14001 certified. We are improving the design of building envelopes and using energy efficient systems for building services plant. Life cycle concepts for planning and materials are under investigation. We use salt water from Government mains for waste flushing to reduce fresh water usage, and the major sewerage systems are being improved by the Government. A review of building regulations by the Building's Department is taking place which will improve future designs and help to reduce material usage through less recesses for lighting and ventilation in external walls.

Almost all building materials are imported and due to the climatic conditions and hard usage, our selections have to be based on long life, minimum maintenance and avoiding being in the least environmentally acceptable category. For example, bark from trees cannot be used as footpath material in parks due to steep slopes, heavy rain, humidity and heavy traffic usage.

Household waste collection is taken to landfill which will cease to be available after 2010. A central incinerator is now under detail planning. Demolished materials urgently require the establishment of more recycling industries. Designing out waste at the start through more prefabrication and better detailing is necessary.

Hong Kong, as an example, illustrates that through economy of scale, high rise gives great benefits and may be in some cases a viable alternative to urban sprawl, especially if all environmental aspects can be taken into consideration at the commencement of planning. Hong Kong is now thinking and acting more positively in moving towards finding and implementing more sustainable solutions to accommodate an increasing population whilst complimenting and preserving the original, physical setting of this exciting and vibrant city.

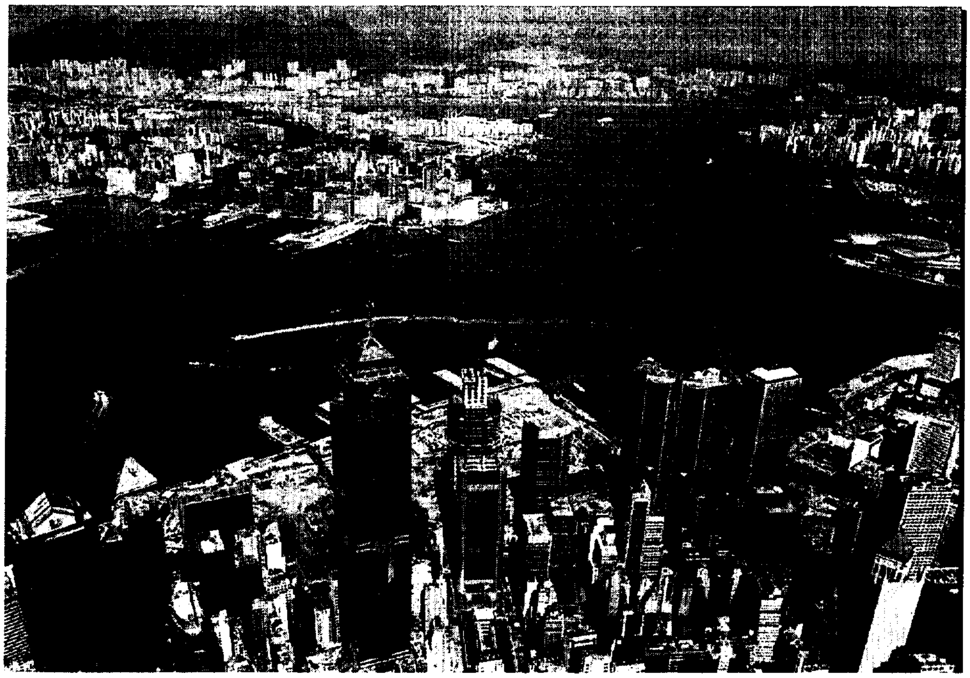

Fig. 3. Hong Kong Harbour looking towards Kowloon

1. "Heading towards sustainability?" Practical Indicators of Environmental Sustainability for H.K. 1999 pg 169 Centre for Urban Planning and Environmental Management. University of Hong Kong

INTEGRATING INDOOR AIR QUALITY AND LIFE CYCLE ASSESSMENT IN SUSTAINABLE BUILDING DESIGN

Hal Levin
Building Ecology Research Group, 2548 Empire Grade, Santa Cruz, California 95060 USA
hlevin@cruzio.com

INTRODUCTION

Many interests and issues compete for professional building designers' attention and priorities. Indoor air quality and "sustainable design" have been increasingly among these interests in recent years [1]. While neither has yet gained widespread acceptance or general use in the building design professions, both are now being used more frequently in the United States and certain parts of Europe. The tools available to designers include several directly using or derived from life cycle assessment (LCA) software and concept approaches.

LCAs that have been done on building materials have either ignored indoor air quality (IAQ) or have actually stated that integration of IAQ into LCA practice is either impractical or infeasible [2]. Their assertion hinges around their perception of the relative availability of data and the complexity of its analysis for general environmental impacts and for IAQ impacts [2]. Generally LCA practitioners lack awareness of the methods and practices available to evaluate or compare products' IAQ performance.

Design of a "healthy" building requires consideration of the impacts on humans from both material production and installation in buildings as well as the impacts on building occupants through indoor air quality effects. Therefore, indoor air quality must be assessed and the results must be integrated in LCAs on building materials.

IAQ is neither more complex nor are relevant data any less available than data on materials' impacts on the general environment. Labelling and classification schemes for material emissions have been developed and applied in Denmark, Finland, Germany, and the USA.

METHODS

Various methods for developing IAQ evaluations of candidate products can be integrated into life cycle assessments. Data needs, accuracy, availability and quality are important criteria for selection of methods. Each method was developed by the author and has been applied in various building design projects to assist architects in product selection. All three methods should include determination or estimation of IAQ profiles from installation through the end of the product service life.

Surface Protection, Maintenance and Cleaning Products

Many materials require periodic surface treatments and cleaning in order to perform well. For example, many non-textile flooring products require lacquer and wax applications to protect their material surface and improve their appearance. The total life cycle emissions from such products can easily exceed those from the material to which they are applied. Therefore, emissions from products routinely used with a given material should be included in analysis of Life Cycle IAQ. They should also be used in building material selection processes based solely on IAQ. So-called "green" paints that are not easily cleanable result in more frequent painting and, therefore, potentially larger emissions over the life cycle.

The following criteria have been used to evaluate the alternative methods:

- Accuracy; Are the results accurate and reliable?
- Health-Based Results; Are the results directly related to health impacts?
- Data Availability; Are the necessary data readily available and reliable?

- Time Required to Perform Analysis: How much effort and time is required by the designer to perform this type of analysis?
- Communication of Results: Can the results be easily communicated to and understood by the users?

RESULTS

The results include description of the three methods used in various projects and the comparison using the criteria described above.

Method A: IAQ Concentration Calculation and Assessment

The first method is the most theoretically complete and comprehensive IAQ assessment, designated here as Method "A." It requires acquisition of data on emissions from a product or material as the it will be used in a projected building. Product specific data are obtained from manufacturers or suppliers who have tested their products or from other tests. Calculations are made of indoor air concentrations of chemicals of concern attributable to the candidate product over the life of the building [3-4]. These concentrations can be compared to a reference value, for example, 1/40 the TLV or MAK value, as suggested by Nielsen et al [5]. Method A involves high data intensity, low data reliability, and the difficulty or impossibility of acquiring all necessary data. Generic product emissions data may be available, for example, for other products of the same class or type, but data for the specific products being evaluated may be lacking. The ratio of the calculated concentrations to the reference value can then be plotted alongside the typical LCA plots of other inventory items (e.g., greenhouse gas emissions, energy consumption, toxic chemical emissions, etc.). Since designers actually choose from among different brands of similar products, product-specific data unavailability could be a major barrier to use of this method.

Mthd B: Potential Emissions "Indicators"

Method B involves calculations based on simple, reasonably accessible and reliable data on product contents. Just as for emission

are not available. For wet products or thin films, these data include the total mass of the chemical compounds of concern in the product and the vapor pressures for these chemicals. For dry products with thickness >1 mm, the diffusion coefficient should also be determined for the chemicals of concern and for the specific product being evaluated. A simple calculation produces a dimensionless number that can be used to compare alternative products.

Since designers are generally choosing from available products for a particular application, the relative potential emissions can be used for a first order estimate of IAQ impacts. If differences are not large in the emissions of chemicals being compared (e.g., <2x), then the IAQ impacts can be considered similar. The actual values can be plotted and displayed as relative potential life cycle emissions, concentrations, or exposures.

Method C: TVOC Concentration Calculation

Method C involves obtaining emissions data for TVOC values only and using them to develop estimated concentrations and life cycle exposures. These estimates are then compared. The projected or estimated TVOC concentrations can be compared for each alternative product. A ratio of each product's calculated result to the lowest calculated result can produce a simple reduction of the data to a value that can be easily understood by non-indoor air quality specialists. Alternatively, the life cycle concentration and human exposure values can be used directly in the comparison.

DISCUSSION

Table 1 summarizes a comparison of the methods showing the advantages and disadvantages of the three methods. None is free of problems, but all can be used as screening or selection tools.

Method A is the most accurate for developing an IAQ profile. It compares calculated concentrations to a health-based reference concentration, thus enabling decision-makers

Method A include the high data intensity, the low data reliability, and the difficulty or impossibility of acquiring all necessary data.

Table 1. Advantages and Disadvantages of the Three Methods

	Method A: IAQ Concentration Calculation and Assessment	Method B: Potential Emissions "Indicators"	Method C: TVOC Concentration Calculation
Accuracy	Moderate to High	Moderate	Low to Moderate
Health-Based Results	Yes	No	Imprecise, potentially inaccurate
Data Availability	Low	High	Moderate
Time Required to Perform Analysis	Large	Small	Moderate
Communication of Results	Difficult	Difficult	Moderate

Data are generally far more readily available for Method B except when manufacturers refuse to divulge their products' chemical contents. There is a general trend toward more disclosure as companies compete to be regarded as "environmentally-friendly." The disadvantage of Method B is that the potential impacts of the chemical emissions reported as "TVOC" cannot be related directly to health-based standards. Bornehag *et al* concluded that there is no scientific basis for stating whether TVOC can be used as indicator of VOC health effects [6]. However, TVOC emission values can be compared as semi-quantitative estimates of potential emissions.

Method C has the advantage that TVOC data are more readily available than individual VOC data. However, since TVOC values cannot be used as an indicator of health effects, therefore, Method C does not provide results that can be related directly to impacts.

CONCLUSION

Based on the comparison of the three methods, it is clear that one will not always be more practical, useful, and reliable than the others. In general, Method B is more frequently feasible and provides results that have an order of accuracy as good as or better than many indicators used for LCAs. These three methods can be used for product IAQ assessments whether or not LCA is being conducted. The total building life cycle material emissions' impacts on indoor air quality. Further work needs to be done to develop data to make IAQ assessments more practical and reliable. This is also the case for most factors in typical LCAs and should not be considered a barrier to inclusion of IAQ in LCA practice.

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PASSIVE ENVIRONMENTAL STRATEGY GUIDELINES AND DESIGN PARAMETERS FOR ENERGY EFFICIENT ARCHITECTURE AND SUSTAINABILITY IN HONG KONG AND SOUTH CHINA REGION - PARTICULAR RESEARCH AND APPLICATIONS TO PUBLIC SECTOR BUILDINGS

Man-kit Leung[1], Bernard V. Lim[2] ,
[1]Committee on Environment & Sustainable Development, The Hong Kong Institute of Architects, PO Box 20334, Henessy Road Post Office HONG KONG
[2]Department of Architecture, The Chinese University of Hong Kong, ShaTin, N.T.

INTRODUCTION

The climatic and urban context of Hong Kong poses particular challenges to the environmental design. Hong Kong's winter is generally comfortable (14 to 19°C; RH=68 to 78%). In early summer and autumn, RH may go up to 83% which require relatively high wind speed (around 2 to 3 m/s) for comfort. In city area, urban obstructions are severe and the wind conditions are complex, rendering the sole reliance of natural ventilation for comfort inappropriate. Furthermore the urban heat island effect may bring the ambient temperatures up to uncomfortable level, most notably in evenings of late summer. Mechanical ventilation/cooling becomes necessary and, a mix-mode environmental strategy (passive/active) is considered appropriate. Buildings should be designed to maximize the potential of passive strategy deployment while having the adaptability for active strategy mode.

This paper focuses on daylighting and natural ventilation design of public buildings in Hong Kong and South China Region. A new built prototype of public housing for single senior citizens is studied to evaluate relevant environmental strategies. Similar to most public buildings, it is located in high-rise/high-density context The building adopts an arrangement of an enclosed, top-lit atrium and inward-looking hostel rooms.

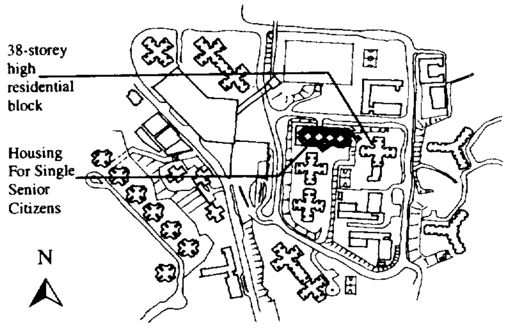

Figure 1: Master layout plan

ENVIRONMENTAL DESIGN STUDY

The Atrium

Based on the focused group interviews and the research team observations, the atrium was found to be comparatively hot during most of the noontime in summer. Hard edge shadows and discomfort glare on stainless steel railing are noted. Measurements of illuminous levels across the atrium are illustrated in Figure 2.

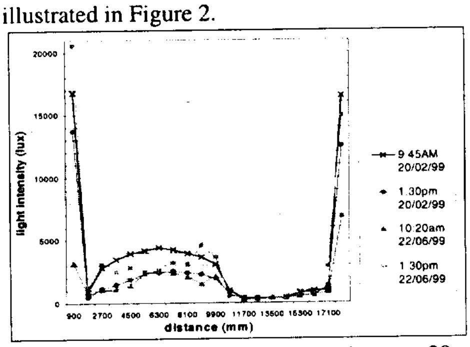

Figure 2: Light intensity in the atrium on 20 February and 22 June 1999

Sunpath diagram study of the atrium has also been carried out and reveals that, during winter, the adjacent high-rises obstruct most of the direct sunlight to the atrium which accounts for the even illuminance distribution of the 20 February data. During summer, as the sun moves north, the atrium is subject to sunlight penetration.

A few variations on the building design are simulated for evaluation of their environmental significance. These include doubling the skylight beam depth and applying louvres on the skylight. Doubling the beam depth from 0.72m to 1.44m helps to reduce sunlight penetration. The overall lighting intensity is decreased by about 9.8%. Applying louvres shows comparatively better performance as compared to the change of skylight beam depth. The average relative illuminance is decreased down to 24.31%. The even diffusion luminance contributed a better lighting rendering within the atrium space with much reduced glare.

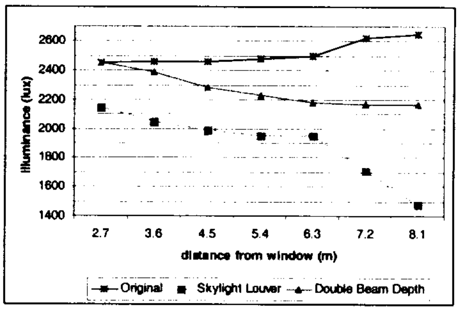

Figure 3: The original atrium illumination level plotted against the proposed design variations

The Hostel Room

The standard hostel room is about 3.8m by 1.9m having 2.9m headroom. Our occupant survey and on-site measurements reveal that the natural ventilation situation inside hostel rooms is generally unsatisfactory. This seems particularly severe in those rooms in the eastern cluster which, in fact, is located right adjacent to the two 38-storey residential blocks. This explains why there are more window air-conditioners installed by tenants in the eastern end as compared to the other.

Two design variations are studied for their effect on cross ventilation and airflow pattern. Different headrooms and door louvres opening configurations are simulated in CFD study. It is observed that for the hostel room natural ventilation does not significantly benefit from a increase of clear headroom from 2.9m to 3.2m. Increased airflow happens only at the upper portion of room which is above the activity zone of the users. When the use of assisted mechanical ventilation means is to be further considered, a clear headroom of 3.2m or more would then allow ceiling fan installation, which are better than wall-mounted ones as they have bigger and slower blades and hence much quieter during operation.

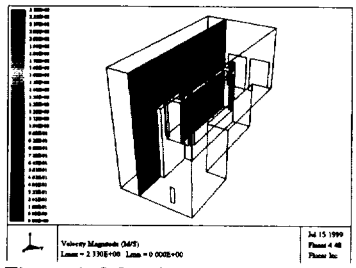

Figure 4: 2.9 m headroom scenario

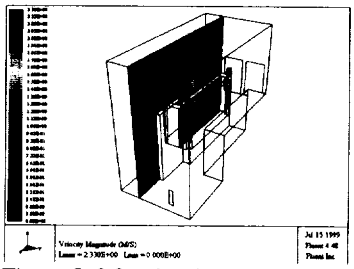

Figure 5: 3.2 m headroom scenario

The existing louvres on the door (100mm x 400mm) was observed to be insufficient to achieve desirable cross ventilation for physical comfort. The case for an enlarged lourves (775mm x 260mm) was then simulated and an increased airflow speed was noted. The larger sized opening showed similar improved crossed ventilation, but for the size tested the shape proportions did not show significant difference in the ventilation performance. In the future detailing, such door louvres could be enlarged and the detailing should also to take account of other factors such as visual privacy and noise effects.

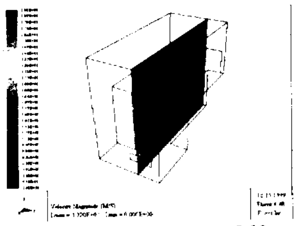

Figure 6: 775 mm x 260 mm door lourve scenario

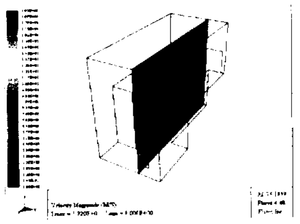

Figure 7: 400 mm x 500 mm door lourve scenario

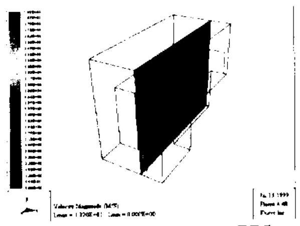

Figure 8: 260 mm x 775 mm door lourve scenario

CONCLUSIONS

In our climate with relative high ambient temperatures and humidity, our main environmental objectives are to minimize solar heat gain and to maximize natural ventilation. Direct sunlight must be intercepted in the first place. By simple architectural interventions like extension of beam depth and addition of louvres for a top-lit skylight, as illustrated by our daylighting visualization studies, glare and hard shadows due to direct sunlight penetration could be avoided.

With regard to the natural ventilation design strategies, the proximity of high-rise building blocks has significant effect on the windflow pattern/speeds within the courtyard spaces of the prototype building. Acute wind turbulence is found when the degree of obstruction is the highest. We must note that urban wind conditions are extremely complex and architects/designers are recommended to construct computer/scaled models to visualize the urban wind field context in their site analysis/massing study.

All in all, our study shows that the internal environmental quality of the prototype building has much been affected by the siting of the courtyards in relation to adjacent tall buildings, and internal detailing such as louvres, window openings and any restrictions on furniture layout. The careful and systematic evaluation of these has been lacking in Hong Kong and should be required as design parameters to produce energy efficient, healthy and comfortable living environment.

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ASSESSMENT OF CHEMICALS IN CONSTRUCTION PRODUCTS

Krogh, Hanne, Senior researcher B. Sc. (Chem. Eng.)[1] and Stig Olsen, Biologist Ph.D. [2]
1 Danish Building Research Institute, SBI, Dr. Neergaards Vej 15, DK-2970 Hørsholm, Denmark
(e-mail HMK@SBI.dk)
2 Institute for Product Development, IPU, Technical University of Denmark, Building 424, DK-2800 Lyngby, Denmark (e-mail sio@ipt.dtu.dk)

INTRODUCTION

The building sector uses a lot of products (several thousands) and many of these contain chemicals, some of which have harmful effects on human and environmental health. Due to the restricted knowledge of data, the impacts of chemicals can be overlooked e.g. in eco-profiles of building elements.
The reasons for that are lacks of product-specific emissions by manufacturing of chemical products, e.g. waterproofing systems and sealants. Besides, most LCA-models do not include assessments of emissions in working environment, in indoor environment or from disposal processes. It was therefore in the project *Assessment of Chemicals in Construction Products* decided to adapt an existing score method for assessing the chemicals.

As the European countries had agreed on a score Method for Risk Ranking chemicals (EURAM), it was decided to use this method to assess chemicals in construction products for two LCA phases, indoor environment and disposal phase.
The score method was used on two water-proofing systems. Waterproofing systems are used for making a water-impermeable layer in a bathroom wall. Results from the score method for indoor environment were compared to results from a screening method. Due to lack of data the screening method could not be used for the disposal phase.

ECO-PROFILE OF A BATHROOM WALL

The eco-profile of a wall in a bathroom is given in Fig.1. The figure shows the contribution from the different products to the most important impacts during the whole lifetime. The input data were amount of products, lifetime of the products and energy consumption for manufacturing these products.

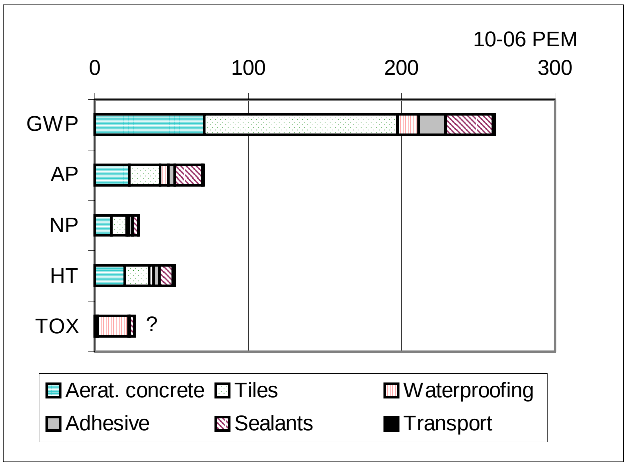

FIG. 1. THE ENVIRONMENTAL IMPACTS FOR BATHROOM WALL (1 m^2), LIFETIME 40 YEARS.

GWP: Global warming potential, AP: Acidification potential, NP: Nutrient enrichment potential, HT: Human toxicity potential TOX: Toxicity potential of chemicals, in the future results from the score method.
PEM (Reduction targets adjusted Person Equivalents).
All impacts are normalized and weighted.
The results were calculated by using the tool *Building Environmental Assessment Tool BEAT 2000* (Petersen, E., 1999) which is based on the Danish LCA model, *Environmental Design of Industrial Products, EDIP* (Wenzel et al., 1997).

WATERPROOFING SYSTEMS

These systems consist of a surface conditioner and a membrane, see table 1.
The project assesses two waterproofing systems, one with a two component epoxy conditioner and one with an acrylate conditioner, both with a membrane of acrylate. The two component conditioner contains several hazardous chemicals and the acrylate conditioner contains some organic solvents. As the surface conditioners differ very much in chemical composition these two waterproofing systems were selected for assessing the chemicals using a score method.

TABLE 1 MAIN COMPONENTS IN WATERPROOFING SYSTEMS.

Surface conditioner	Membrane
Acrylate polymers *	Acrylate polymers *
Bitumen	Acrylate polym.-cement
Two component epoxy *	Rubber/bitumen
Styrene-acrylate polym.	Styrene-acrylate polym.

* Used in this project as cases.

METHODOLOGIES

In general, assessments of the chemicals may be done at several levels:

- Indicating the occurrence of substances on various lists of hazardous substances (i.e. lists of substances, the use of which should be restricted due to their hazardousnes, persistence or other properties), possibly exclusion of these substances if they occur below a certain concentration, e.g. 0.1%.
- Indicating the amount of substances in specific hazard categories, e.g. undesirable, problematic and non-problematic.
- Screening/scoring methods (several methodologies have been developed (Davies et al., 1994)). The European Risk Ranking Method, EURAM had been used in this project.
- Calculation of potential impacts on human toxicity and ecotoxicity (due to lack of information and resources a detailed assessment is only possible for a few substances on the market).

EURAM is developed to rank high production volume chemicals, which afterwards should go through a risk assessment. EURAM employs a score for exposure and a score for effect and these scores are multiplied.
The principles for calculating scores in EURAM had been adopted for construction products. Scores were developed for the important life cycle phases, indoor environment and disposal phase.

Indoor environment
Score for exposure was calculated from the amount of substance used and some of its properties (vapor pressure/boiling point, octanol-water partition coefficient).

In this project, the effect score was based on odour detection limit. In EURAM, the score for human health is based on the classification of hazardous substances (Risk-phrases).

Disposal phase
Score for exposure was calculated from the amount of substance used and some properties (vapor pressure/boiling point, octanol-water partition coefficient, and biodegradation).

In this project, the effect score was based on the aquatic toxicity (LC50 or the like) as in the EURAM method.

RESULTS

Indoor environment
Due to lack of data it was not possible to apply the method using odour detection limits.
The results in Fig. 2 are based on EURAM method, which uses Risk- phrases for effect score.

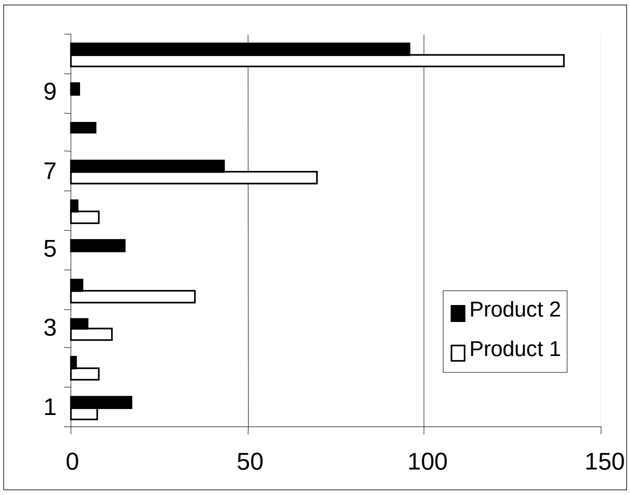

FIG. 2. RESULTS FOR HUMAN HEALTH USING EURAM-METHOD.
The top bars show the total score, the other bars show the results for the individual chemicals (1 to 9).

The results show that product 2 has a lower score than product 1.
For comparison, the EDIP screening method had been employed on the same products
As Fig. 3 shows product 2 has the highest score.

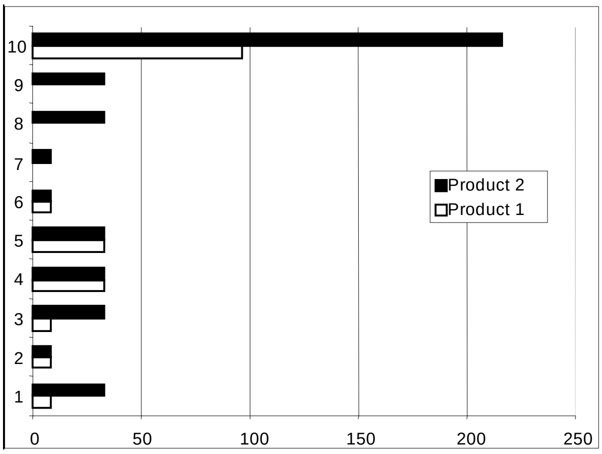

FIG. 3. RESULTS FOR HUMAN HEALTH USING EDIP SCREENING METHOD.

The EDIP screening method is also based on Risk-phrases but do not include the amount of substance. The two methods weight Risk -phrases differently, for example is R 34 (corrosive) weighted higher by EURAM method than by EDIP method.

Disposal phase

The results from the adapted EURAM method are shown in Fig. 4. It was not possible to use the EDIP screening method for this phase because lack of data to classify the substances for their environmental hazards.

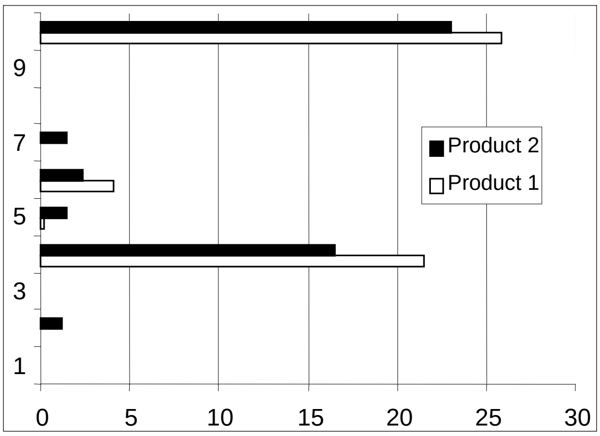

FIG. 4. RESULTS FOR ENVIRONMENTAL HEALTH USING THE ADAPTED EURAM.

Notice that for some substances there is lack of data.

Fig. 4 shows that product 2 had a lower score than product 1.

CONCLUSION

Eco-profiles do not include all potentially important impacts from chemicals because environmental data for chemicals are incomplete. Furthermore, the LCA models most often do not include life cycle phases where chemicals may have impacts, e.g. indoor environment and disposal phase. Therefore, it is necessary to develop other assessment methods for the chemicals.

A method based on EURAM method has been developed and used in these case studies.

It can be concluded that:

- Even in simple methods for scoring the lack of data limits the assessments. Producers/ suppliers of the products are reluctant to disclose data regarding the composition of the products.
- Effect data are scarce. It had not been possible to get odour detection limits for all the components in the two products.
- The effect score defined in the EDIP method for the disposal phase could not be derived, as the substances were not classified for their environmental hazards.

Different score methods may produce different results which can give different conclusions.

At present it seems difficult to use a score method due to lack of data. In the nearest future it may be possible in stead to list substances or to indicate the amount of certain categories of substances in ecolabelling and eco-profiles. However, efforts to obtain more effect data for chemicals and to develop generally accepted score method should be intensified.

ACKNOWLEDGEMENTS

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EXPERT SYSTEM FOR ASSESSING ENERGY AND ENVIRONMENTAL PERFORMANCE OF INDOOR ENVIRONMENTS.

Prof. Eng. Giorgio Beccali, Dr. Eng. Maurizio Cellura, Dr. Eng. Valerio Lo Brano
Organisation: DEAF – Università degli Studi di Palermo – Viale delle Scienze 90128 Palermo (Italy); Phone: ++39-091-236127, ++39-091-236123; Fax: ++39-091-484425; E-mail: beccali@unipa.it fta@unipa.it lo_brano@deaf.unipa.it

Introduction

In building practice the use of environmental indicators that support planning and operative decisions are very rare. Organic criteria are being defined for various choices of possible options for the comparison of energetic and environmental performances of moderated environments. The planning goals are the achievement of a better environmental quality of confined spaces, the minimisation of the consumption of resources and the improvement of the eco-profile of the building.

The expert system

In this work an expert system is presented, that without having to resort to complex systems of intense simulation, is able to put into relation, although approximately, a group of basic constructive choices with some evaluation aspects which are consequences of them. The possibility to use this instrument in an interactive way can allow, through a limited number of attempts and modifications, to orientate some choices of first approximation regarding the characteristics of the environment to build. The system is not only able to make comparisons The system is not only able to make comparisons between alternatives, but also to retrace, allowing to go back to the performances required in terms of indoor and outdoor quality of the building.

The evaluation of environmental performances uses the structure of the Life Cycle Analysis (LCA) adequately modified, through the use of the theory of the fuzzy groups, so to allow the apporto of information and/or judgements formulated by experts. As far as the evaluation of indoor quality is concerned, we resorted to the realisation of a probability Bayesian network. Such a network was made considering a set of quantities that condition from the beginning the investigated aspects (root knots – see figure 1–).

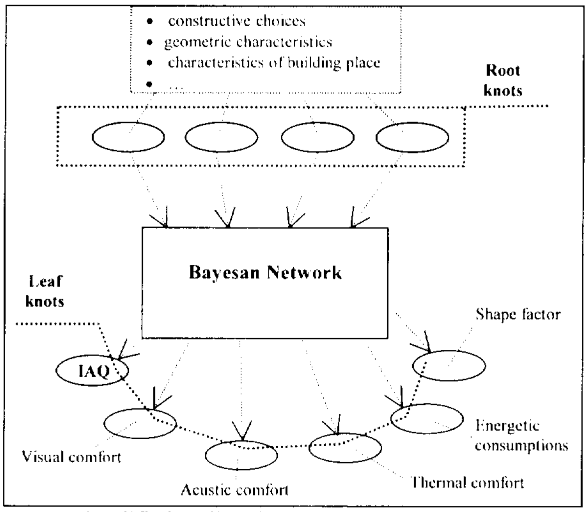

Figure 1: simplified outline that represents the structure of the network.

Preliminary weights have been processed in the group of researchers. We are still investigating methods and scales; expert panel discussions or questionnaires? AHP pair-wise comparisons, simple rating or ranking?

Comparing different forms of discomfort caused by the outdoor environment of the building – a simplified example

The risk of discomfort due to noise, shade, wind and smell respectively is assessed by criteria. The criteria constitute the reference in the comparison of the different forms of discomfort, i.e. when comparing shade with wind the reference is "unacceptable" corresponding to a load value of 3. The criteria for wind and shade are based on results from surveys of outdoor activities and outdoor climate in housing estates, (Westerberg 1989). Noise is either measured or calculated with respect to distance from traffic or number of vehicles. 55 dB is the limit for load value 3, i.e. unacceptable conditions, which is unacceptable also according to planning guidelines for traffic noise in housing areas. The risk of unacceptable smell around existing buildings is assessed by means of a questionnaire.

The *current state* and *change* in the *extent* or *frequency* of a certain form of discomfort is a societal concern. The more frequent the problem is and the faster it is growing, the more attention and weight it deserves. The *tendency of change*, we assume, deserves more weight than the *current state*. *Intensity* refers to the degree of *harmfulness* or discomfort that is experienced by the individual. This deserves much more weight than the frequency. The discomfort on the individual level is *reversible*, i.e. you are assumed to be cured instantly when the exposure is over. *Reversibility* in the case of discomfort refers to the possibility to remove the problem – for an existing building it means sheltering from noise or strong winds or removal of shading obstacles or the source of noise or smell. We have assumed that reversibility is more important than frequency and that harmfulness is somewhat more important than reversibility.

There is little quantitative information on the frequency of unacceptably noisy, smelly, windy or shady environments nor of costs to improve the situation, so "qualitative" weighting is the only way out. Noise might be the fastest growing source of outdoor discomfort. *Harmfulness* can be experienced by anyone, but people's references differ very much in this respect. This was clearly demonstrated in a recent pilot study. 20 colleagues, mostly researchers within the field of indoor climate, were asked to rate the harmfulness of different sources of discomfort on three different scales. Three types of rating methods were used; pair-wise questions as in AHP, a 5-grade semantic scale from no importance to great importance, and finally simple ranking. The individual results differed depending on the scale used, and as a whole there was little accordance in the answers. AHP has been criticised for its linear scale, which does not correspond to most people's mental scale, which is supposed to be logarithmic. Comments supporting this critique were made spontaneously. Moreover, the pair-wise questions were reported to create an uncomfortable feeling of answering inconsistently. In fact almost 50 % of the answers turned out to be unacceptably inconsistent according to the AHP inconsistency test. Just rating on a semantic scale gave the least distinct but probably most reliable result. Smell was considered most and wind least "discomfortable".

It is quite difficult to justify any weights for discomfort because of the lack of hard facts and its contextual nature. A qualitative but systematic argumentation accompanying the weighted assessments, however, helps to interpret the result and to change the weights according to another rationale or context.

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From these beginnings, a net of casual relations that lead, in the end, to the terminal knots (called "leaf knots") that represent the seeked parameters, has been deduced. The leaf knots present in the net are the following: acoustic comfort, IAQ, visual comfort, the shape factor, the grade of local "discomfort", the "cooling load", and the overall energetic consumptions.

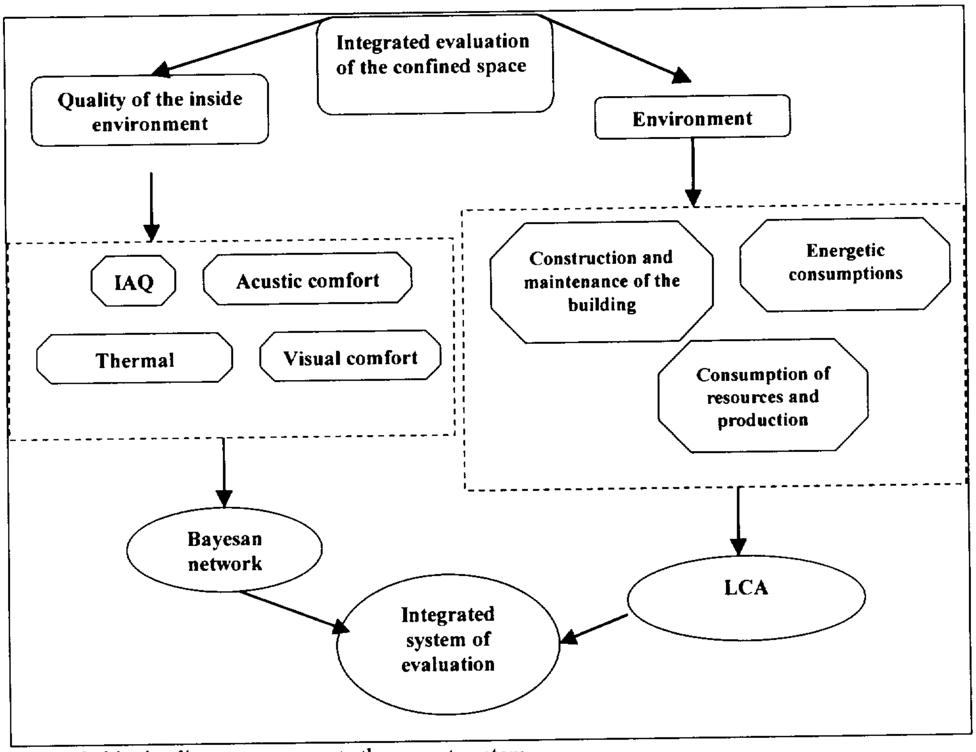

Figure 2: blocks diagram represents the expert system

Each of these depends, in general, on the probability values associated to the other knots; consequently, the net describes the relations between the various aspects taken in exam, analysing them simultaneously. During the process of interrogation of the net, in fact, such relations intervene during the calculation of the distribution of probability of the investigated knot, conditioning the final result according to the theorem of Bayes whose general form is the following: $P(B|A)=\frac{P(A|B)\cdot P(B)}{P(A)}$. There are many types of knots that are used in the networks. In detail, an algorithm is represented by analytical knot, other type of relationship and databases are represented by generic knots.

Symbol	Meant
	Generic knot
	Analitic knot
	Knot that is present in other table
	Leaf knot

Table 1: meant of the symbols used in the graphic description of the Bayesan network.

In figure 3 the portion of Bayesan network that interests Indoor Air Quality(IAQ).

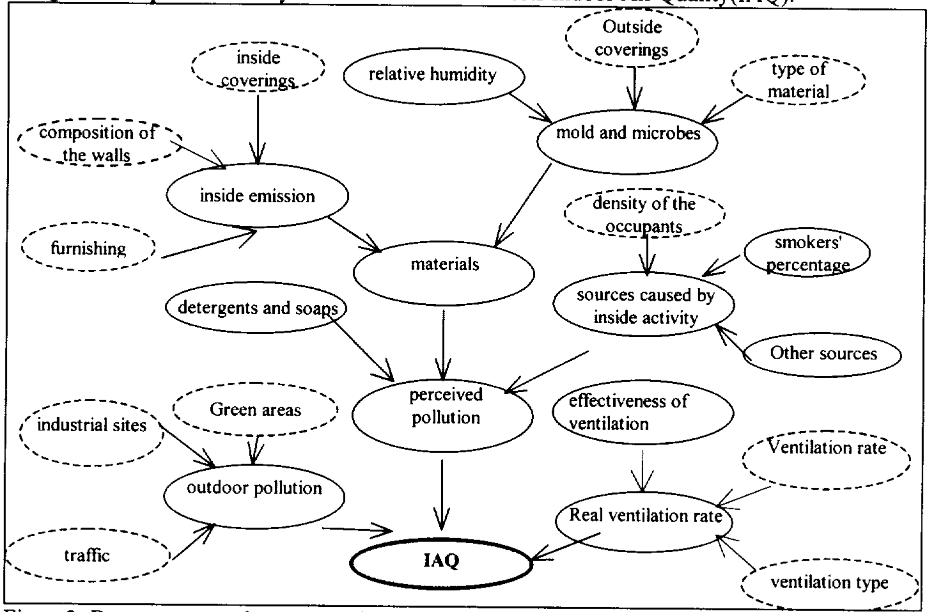

Figure3: Bayesan network structure that interest IAQ (leaf knot)

Conclusion

The system allows the expert to hypothesize probabilistic relations between various leaf knots. This allows to establish, on the base of the users knowledge, to correlate the aspects of indoor environmental quality which to this day are still examined in a loose manner. For eventual knots on which the calculation model is not probabilistic (for example the cooling load), the user can insert the calculated data directly in the net. The possibility to use this instrument in an interactive way can allow, through a limited number of attempts and modifications, to orientate some choices of first approximation regarding the characteristics of the environment to build.

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ASSESSMENT OF INDOOR ENVIRONMENT IN PLANNED BUILDINGS

Marie Hult, (marie.hult@white.se)
White arkitekter AB and Chalmers University of Technology,
Department of Building Services Engineering, Sweden.

INTRODUCTION

An environmental assessment method for real estates, called EcoEffect, is under development in Sweden (ref. 1,2). One of the main areas taken into account in EcoEffect is impact on health caused by the indoor environment (I E). Other areas assessed are Energy use, Materials use and Outdoor environment. Life Cycle Costs can be calculated in an associated program. The method has been developed for and tested in existing multi-family houses (ref 3,4) and is now being developed for the assessment of planned multi family buildings. This paper presents the principles of the indoor environment assessment of *planned* buildings. A test assessment of three planned multi-family buildings has been carried out during springtime 2000. The buildings are presented at the SB2000 conference in the Swedish exhibition

PRESENTATION

The basis when assessing indoor environment is the risk for the users to become sick or experience discomfort in the building.

Ten main groups of health effects are taken into account: SBS (Sick Building Syndrome), intensified allergy, cancer, eye problems due to poor lighting, infections, intensified joint annoyance, reduced comfort, enhanced sensitivity of environment and poisoning, corrode- or reproduction injuries.

The risk to become affected is estimated in load values on a scale from 0 to 3, where 0=Negligible impact, 1=Little, 2= Moderate and 3= Large impact. The assessment system will be computer based and transparent. This means that all input values and used weights for parameters and sub parameters will be easily accessible.

Two steps in the procedure of assessment

The documents describing the planned building is scrutinised at two occasions in the building process:

1. Programme phase: *The I E goals* (functional demands) set up by the client in his programme document are scrutinised. In this phase only load value 1 or 2 are used.
2. Design phase: The *performances* of the constructions, installations and building materials as they have been presented in the tender documents are scrutinised concerning indoor environment aspects. In this phase load values 0-3 are used.

The criteria assessed

In the program phase a *Target Tool* is used to assess the functional demands set up for the indoor environment by the client. The Target tool lists indoor environment parameters and sub parameters. Those are compared with the functional demands for indoor environment set up by the client. The tool contains two standard levels for each sub parameter, related to health effects. The lower level is related to "normal standard" or benchmark in the Swedish building code. It gives a load value = 2 (moderate health risk). The upper level is more ambitious and means less risk of health effects or discomfort. It gives a load value=1 (little health risk).

The parameters are arranged under the following indoor environment factors: indoor air quality, thermal comfort, sound environment, lighting, electricity environment, tap water quality and surface layer quality. Each parameter is associated to one or several health effects.

In the design phase a *Performance Tool* is used to predict if the functional demands of indoor environment set up in the program will be fulfilled. The Performance tool lists criteria, or indoor environment relevant performances. They are arranged under the same indoor environment factors as in the Target Tool.

The tool is used to control the performances set up in tender documents by the architect and the consultants of construction, ventilation, heating and electricity. Special attention is paid to avoid moisture problems, emissions from building materials and to get quality assurance of the ventilation system. The Performance Tool uses four standard levels of performance demands, related to the load value scale, 0,1,2,3, where 0 is the best performance and 3 is the worst (not reaching normal standard).

Assessment and weighting
In the Target Tool, the indoor environment sub parameters and parameters are related to indoor problems and to one or several health effects. This makes it possible to link the relevant sub parameters, parameters and indoor problems to a certain health effect. In the assessment program input thus can be arranged in a tree structure for each health effect (Illustrated in Figure 1). Each sub parameter is classified in two levels of load values related to measurable values of the sub parameter, e g sound level in dB(A) or concentration of formaldehyde in room air in mg/m^3. (Figure 2). Relative weights make it possible to summarise the input data to one load value. (Figure 1).

The link from the Target tool to the Performance tool is the indoor environment parameters. In the design phase each of the listed performances has a weight and are weighted together to an estimated load value for the parameter. This gives a tree structure for each indoor parameter. The procedure to translate the load values of parameters to health effects is then the same as in the program phase.

The described procedure constitute the method to summarise partial load values to a total load value aimed to reflect the risk of getting health- or comfort problems in the building.

CONCLUSIONS

More tests are needed in the future, especially to develop the assessment of other types of buildings than multi-family buildings. The next step is to make the indoor assessment of planned buildings computer based in accordance with the assessment of existing buildings.

Judging from the tests carried out the method is quite easy to understand for the client, since the indoor environment parameters are also expressed as "indoor problems for the users of the building" (See Figure 1, the column "Indoor Problems"). Those problems are asked for in the questionnaire used to assess existing buildings (ref 5,6). This makes it easy for the client to see that the aim of the assessment is to predict the building users' opinion of the indoor environment in the future building. This also makes it possible to follow up the results with a new assessment based on the questionnaire in the completed building. A simplification of the system that makes the assessment procedure faster is also an aim for the future.

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	Environmental factor	Weight	Environmental parameter	Weight	Indoor Problems	Weight	Sub parameters	Weight	Load Value 1 or2
Sleeping problems	C. Sound conditions	1,0	C.1 Sound-insulation	0,50	*C.1.1.a "Music, voices, steps from neighbours"*	*0,50*	C.1.1.b Air borne sound insulation	0,25	1
							C.1.1.c Step borne sound insulation	0,25	1
			C.2 Sound-level	0,50	*C.2.1.a "Noise from the ventilation, cocks and radiators"*	*0,25*	C.2.1.b Noise from installations	0,25	2
					C.2.2.a "Noise from outside"	*0,25*	C.2.2.b Noise from outside, traffic e g	0,25	1
Total estimated risk to get sleeping problems due to noise			**0=Neglectable risk, 1= Little risk, 2= Moderate risk, 3= Large risk**						**1,25**

Figure 1: An extraction from a tree structure (Sleeping problems due to noise) used in program phase to assess the risk of getting sleeping problems due to noise.

		Scale for load value – Sleeping problems		**Health effects/ Comments**
		Little risk	**Moderate health risk**	
		1	**2**	
Indoor environment factor	**C. SOUND CONDITIONS**			
Indoor environment parameter	**C.1 Sound insulation**			
Indoor environment problem	C1.1.a *"Music, voices, steps from neighbours"*	5 - 10% dissatisfied	10 - 20% dissatisfied	**Comfort disturbance Sleeping problems**
Indoor environment sub parameters	C.1.1.b Airborne sound insulation Flat – Flat	Class B $R'_w + C_{50\text{-}5000} \geq 56$ dB	Class C $R'_w \geq 52$ dB	Swedish standard SS 02 52 67
	Stairwell-Flat	$R'_w + C_{50\text{-}5000} \geq 44$ dB	$R'_w \geq 39$ dB	
	Room-Room in flat with more than 2 rooms.	$R'_w + C_{50\text{-}5000} \geq 40$ dB	-	

Figure 2: Example of the scale for load values specified for different measurable values of indoor parameters in the Target Tool. The example concerns the indoor parameter Air borne Sound Insulation, appearing in Figure 1.

High-lights of GBC `98 Case Study Buildings

Dr. Günter Löhnert, sol◦id◦ar architects and engineers, Berlin, Germany
- German National Team Leader -

Preface

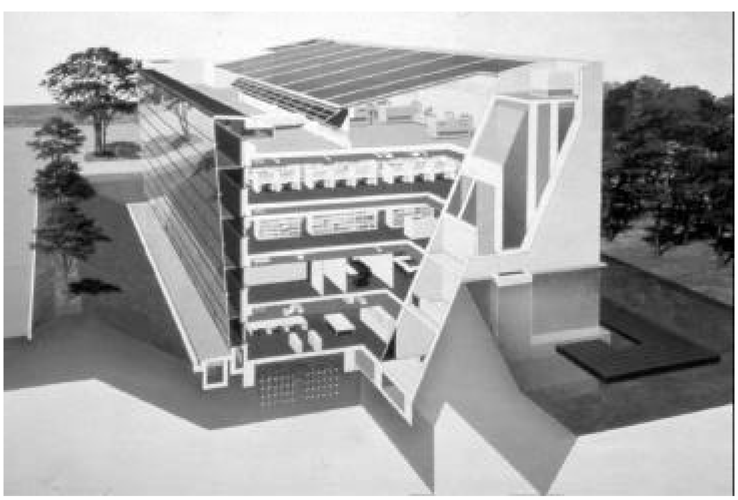
This contribution is a summary presentation of the international building projects which have been analyzed by GBA tool and documented within the GBC`98 program. The presentation will highlight mainly the design and architectural features and qualities of the projects.

During the conference these case studies will be presented and discussed within individual sessions during the next three days when the responsible planners and engineers of the individual building projects will present detailed information. The main objective will then be the assessment procedures and their corresponding results and needs for further development and activities.
Since the conference attendants will hardly be able to join each of the parallel sessions, this summary will give a brief overview of what they can expect during the case studies sessions.

The case study sessions always group two or three countries for presenting their projects. Selection and configuration of the groups is primarily related to the climatic, cultural and geographic situation of the countries.

Besides the case studies projects, attention should also be paid on the numerous and high quality poster projects presented separately during the conference. These buildings also represent and will complete the scope of the national levels regarding environmental and energy conscious design. Although the buildings shown in this valuable collection have not been analyzed by the Green Building Assessment Tool, they offer comparable architectural and environmental high quality design solutions.

The high-lighting of selected building projects is intended to provide cross information and assistance in pre-selecting the audience`s interest in individual case study sessions.



Main Building of Obayashi Corporation, Japan

This building was completed in 1982 and represents 98 energy conservation techniques including double skin, solar heating and cooling, different thermal storage systems, daylighting strategies, photovoltaic panels and rainwater utilization.

Building cost are about 20% higher whereas the operating energy is only 27% compared to a common reference building design in this country.

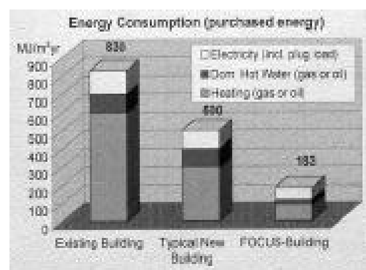
Overview

Regarding the overview is worth while:
Fourteen countries representing 3 continents with different cultures, building traditions, different climatic conditions and resulting requirements for building design have collected a remarkable set of building projects.

This collection is an exemplary reflection of the contemporary state-of-the-art considering environment-oriented and energy-conscious design in the different countries.
In other words: the case studies illustrate the national approaches towards sustainable building design, how it can be realized at time and what the future intentions could be.

On the other hand, we should also be aware that this scope of exemplary designs does not represent the common design and building practice in these countries. It is almost quite the opposite: compared to ordinary architectural design in many countries th case studies shown at this conference are still highlighting representatives of “green philosophies” in the countries they come from.

And it is true that more than 95% of the building volume that is been built all over the world will still never get in touch with this scope of environmental and energy-related issues focused in the GBC`98 program and during the next few days at the conference.



FOCUS
Multi-Residential Swiss Contribution
An example which is ample evidence for a successful environmental and cost-efficient building design:
Without any extra cost for sustainability, the clear architectural design reduces 50% of the operating energy consump tion and the operating cost by 42%.

Fortunately, there is an increasing demand for the requirements on sustainability all over the world among persons responsible including planners, architects, engineers, developers and clients.

And hopefully, this conference will encourage further dissemination and acceptance of energy and environmental building design. The case studies will prove that this design approach is compatible with economical regards and does not contradict to cost-efficient design solutions.

Building Category, Size and Type

Building categories are represented by different building volumes. The smallest project is a residential retrofit building “Mutschellenstrasse” in Switzerland, the largest, “US Environmental Protection Agency Research Facility” represents an office and laboratory building development under construction containing more than 100,000 m² of usable area.

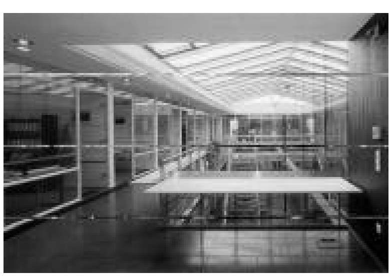
GBC`98 Case Studies Categories vs. Size and Type

Building Size (m²)	1 - 4.000	4 - 10.000	>10.000	Total	Type of Building		
Building Category	SMALL	MEDIUM	LARGE	NUMBER	NEW	RETROFIT	DESIGN
OFFICE	6	5	4	15	11	2	2
RESIDENTIAL	7	3	2	14	7	3	4
SCHOOL	1	2	2	5	4	0	1
TOTAL	15	10	8	34	22	5	7

22 of the case studies are new projects and 7 projects are still under design or under construction respectively. 5 refurbishment examples have been assessed as well. Most of the new buildings have recently been built during the last few years and provide better conditions and a more innovative potential for assessment results, documentation and promotion.

Nevertheless, future building refurbishment will gain importance at least in most European countries and for densely populated areas to revitalize urban locations and neighbourhoods.

Future focus will be drawn on the huge number of buildings erected during the building periods after World War II and during the sixties and seventies. These buildings are almost too young to be demolished but too poor in energy and environmental building performance and quality.



WAT low energy office building, Karlsruhe, Germany
Sustainability and innovative building energy design approaches within restricted cost limitations.

Characteristics of 34 international GBC`98 case studies according to building categories

(x) characterizes the building as a project under design or under construction, * characterizes the project as (part of) retrofit design

No	COUNTRY	Σ	OFFICE		MULTI-RESIDENTIAL		SCHOOLS	
1	**Austria**	2	**0**		**1 (1)**	Comparison of a typical 10 storey multi-unit residential urban block and a suburban luxury development (design)	**0**	
2	**Canada**	3	**1**	Modern office building concept addressing multiple-tenant usage and superior indoor environment	**1**	Sustainable community project for an innovative group of moderate-income environmentalists	**1**	Replacement High School designed as a next generation school type of Private-Public Partnership (PPP) concept
3	**Denmark**	1	**(1)**	Design project to investigate environmental building performance of a common Danish office building	**0**		**0**	
4	**Finland**	1	**0**		**1**	Suburban project addressing energy efficiency and decrease of operating cost not exceeding average initial cost	**0**	
5	**France**	2	**0**		**1**	High energy efficiency labeled multi-storey public housing project of a national demonstration program	**(1)**	One of four Green High Schools addressing 60% energy saving potential and selection of building material
6	**Germany**	3	**3**	Projects selected due to innovative design concepts, cost limitation, size and transferability regarding real market conditions without funding	**0**	One of the case studies is characterized by mixed use including office, retail, shops, apartments and kindergarden	**0**	One school building extension and retrofit will be presented as a poster project
7	**Japan BCS**	3	**1**	Typical 11-storey office tower selected for assessment to provide recommendations for future design projects	**1**	First environmental-friendly 4-storied multi-family development addressing energy, health and comfort	**1**	Downtown Boys` School within a typical urban Tokyo neighbourhood focussing the improvement of daylight use
	Japan IBEC	2	**2**	High/low-tech representative buildings using considerably different strategies / systems of environmental design	**0**		**0**	
8	**Netherlands**	2	**1***	New atrium building extension and retrofit project focusing daylighting natural ventilation and building mass	**1***	Pilot project for sustainable and energy efficient urban housing including social aspects and user participation	**0**	
9	**Norway**	2	**1**	Environmental and regional adapted architectural design solution for a contaminated site at the harbour of Horten	**(1)**	Pioneer and reference urban residential project for future housing focusing on overall ecological design approach	**0**	
10	**Poland**	2	**0**		**(2)**	Ambitious housing projects developed for improvement and trend-setting for the real residential building market	**0**	
11	**Sweden**	2	**0**		**1***	3-storied retrofit addressing the preservation of building construction and the use of sustainable material	**1**	2-storied building also serving for educational purposes by demonstration of the applied environmental strategies
12	**Switzerland**	2	**0**		**1 (1)**	Very successful cost and energy efficient housing project for a co-operative house building society	**0**	
13	**U.K.**	2	**2**	Exemplary buildings designed for remarkable reductions in energy consumption and serving for model projects	**0**		**0**	
14	**USA**	5	**2* (1)**	One large scale new research building and two medium size retrofit office conversions foc. on resource efficiency	**1**	Infill townhouse and service facilities project focusing on minimum energy and environmental resources	**1**	Energy and cost-efficient Middle School with specific respect on daylighting and energy saving of 50-60%
	Total	**34**	**15**		**14**		**5**	

Case Study Selection

The case study presentation will highlight a selection of international buildings according to architectural and economic features that represent examples of the different building categories and types based upon the information about the projects which has been delivered so far.

Obviously not all buildings can be shown during this presentation and the examples in this paper will not be the final selection for the conference slide presentation. It should be mentioned that all case study buildings have their individual quality within the type and category they belong to and of the importance to act as an exemplary building, encouraging and assisting future building design in their particular countries.

Most of the case study buildings have been selected according to the following criteria:

- Scope and efficiency of energy and environmental building concept, strategies and systems
- Magnitude of innovation and exemplarity and typicality of the project
- Availability of building data necessary for the execution of GBA-tool in concert with the readiness of project representatives to participate in the assessment procedures.

The summary building presentation will also give insight to particular design intentions and architectural philosophies the case studies will address and which will also be reflected by the building performance. An attempt for cost and energy considerations, comparisons and compatibility will be done as well.

Designers` Intention and Approaches
While some of the case studies serve as prototype and / or pioneer and pilot buildings. More or less "exotic" they will remain exceptions dedicated to be monitored and investigated for potential future transferability. However, most of the buildings represent projects which are very close or even meet the corresponding country specific situation of the real estate and tenants market conditions. They show very clearly that the demand for sustainability, energy conscious design and overall environmental approaches is increasing and supported by reasonable cost in comparison to conventional and traditional building design. This is also true for the most of the poster project collection.

BRE Environment Office, Garston, U.K.: *Highly engineered future role model for environ-mental office design. The building had been pre-assessed by BREEAM with a rating of excellent. The energy and environmental strategies include natural ventilation assisted by wind towers, groundwater-assisted cooling, BMS, electric lighting control and photovoltaics. Attention has also been paid to recycled concrete and brick material from the previous building on the site.*

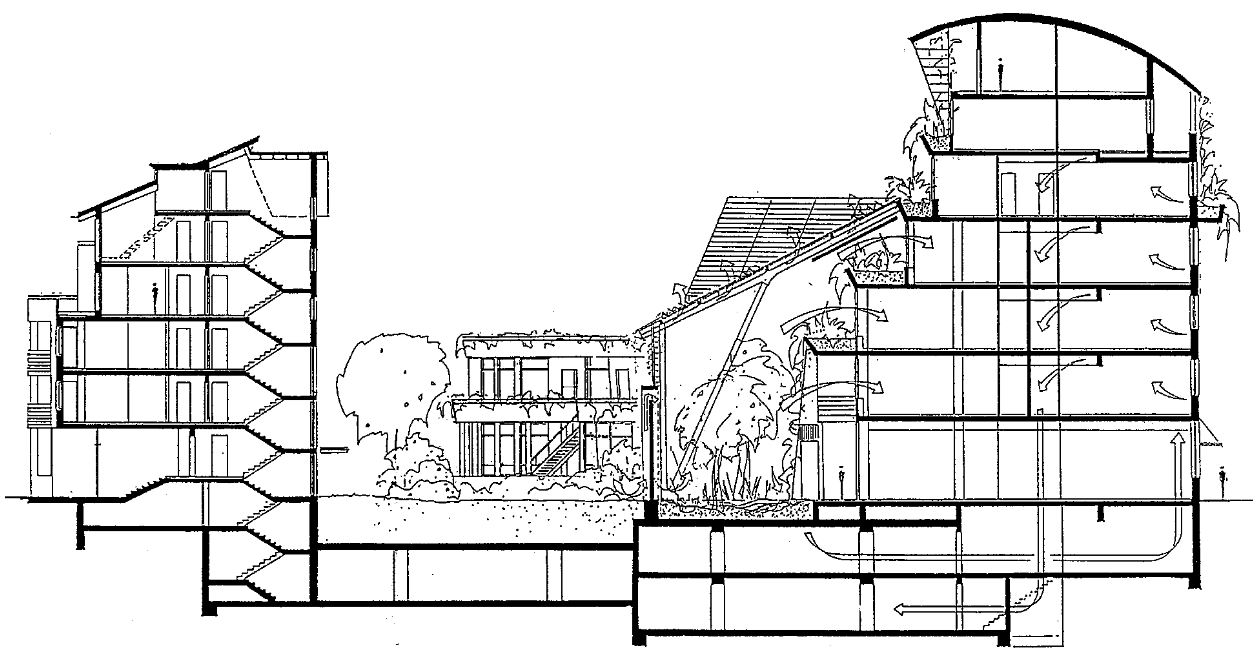
The German national case studies, for example, focus on office buildings including one mixed-used project. The selection criteria included energy and environmental approaches, project size and type (new buildings) in order to get reasonable results by comparing the buildings with each other. Moreover, the case studies should represent typical requirements for contemporary office design such as

- energy and cost efficiency: in two cases defined cost limits had to be achieved
- transferability: the building had to dispense with public funding of building or surplus cost
- typicality: the projects should represent a typical challenge of contemporary design tasks

Planners intentions of the international case study contributions are similar in terms of the targets on energy and environmental building design in each of the building categories.
Aside from specific criteria regarding individual functional requirements the intentions include

Scientific and technical approaches such as
- Pioneer / pilot / prototype building testing innovative building concepts and technical systems
- Transfer of technologies to an other building type or scale
- Moderate refurbishment by far-reaching preservation of existing structures

Image-related aspects such as
- Competitive reasons for individual or national image promotion
- Image setting and representation by innovation for the client and user



PRISMA Nuremberg Germany

Urban mixed use development of a new city block providing energy and cost efficient urban functions and services such as offices, flats, retail, shops and kindergarden - a proto-typical commercial property.

The heart of the energy concept is a 15,000 m³ atrium space serving as a natural air conditioning system for pre-heating and pre-cooling supply air for the adjacent spaces. Attention has been paid to building material, energy conservation and passive ecological principles.

Promotion and marketing strategies such as

- Promotion of environmental building qualities towards a selected market potential
- Attempt and execution of new marketing strategies

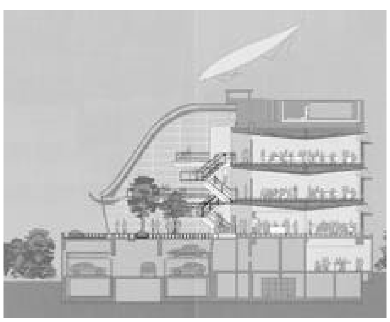
Setting future standards by

- Investigation of building performance by monitoring
- Demonstrating that sustainability in building design is compatible with economics needs

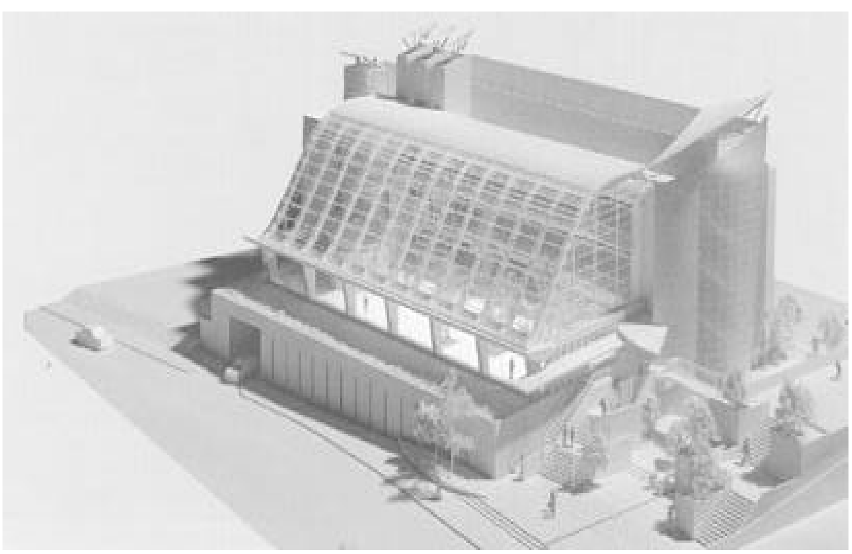
User-related expressions including

- Creation of human living conditions by new future design and sustainability standards
- Supply of highly motivated environmentalists including social, cultural and economic issues
- Distinctive improvement of working place quality by optimization of daylighting
- Improvement of indoor climate conditions and thermal comfort

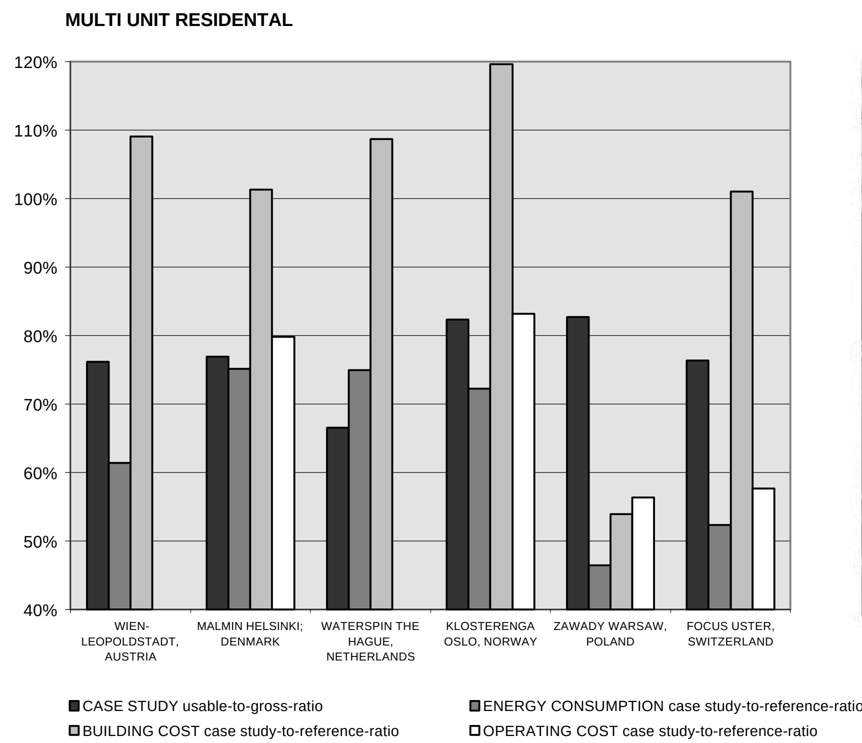
The building presentations during the case studies sessions will focus on energy and environmental features of building design and performance. Both qualitative descriptions and quantitative hard energy and emission data will be shown which have been the base for the application of the GBA-tool and the assessment results.



Atrium building concepts provide attractive spatial amenities for occupants and benefit from energy and environmental qualities:
below: PRISMA ATRIUM, Germany



EARTH PORT Tokyo Gas, Japan
Design philosophy of the Tokyo city gas supply company office building adresses “life cycle energy saving” by energy conservation and by optimizing natural ventilation and daylighting. Remarkable reductions of energy consumption and operating cost have been paid by moderately increasing initial cost.



Core atrium of WAT serving as an engine for passive ventilation by a glazed blackwall and as a natural light source by daylight optimization including transparent stairs and galeries

Comparability of the case studies

It is almost impossible to compare buildings which have been built at different countries all over the world and are characterised by different climatic conditions, building practices and traditions, cultural backgrounds, social and economic systems.

Moreover, the different building categories have significantly different user profiles, and new buildings can not be compared to retrofit building projects. While for new buildings cost and energy calculations or determinations can easily be provided, retrofit buildings can not or only hardly be related to reference numbers because refurbishment is a too complex and building specific matter of design. Thus, retrofit case studies are left out of these considerations.

Nevertheless it is worth to analyse environmental-oriented new case study buildings of a particular category versus its national corresponding reference building in terms of

- area conscious design efficiency by the net-to-gross area ratio
- energy efficiency building concept
- specific (extra) building cost for innovative design technologies and system application and
- reductions of operating cost that have hopefully been achieved by the overall design approach

The reference figures which these ratios are based on have been provided by the individual countries and may have different sources. In some cases a virtual reference building has been created for the specific location of the case study. Most of these determinations represent average statistical numbers which are commonly available through governmental reports or published by other national or federal institutions.

These relations serve as a suitable approach to evaluate the entire success of building in the particular country in terms of

- economic acceptance of surplus cost for environmental strategies and system applications
- cost-efficiency of initial cost versus operating cost
- reasonability of extra cost versus energy conservation potential
- transferability to other projects within the corresponding category

Usable-to-Gross Area Ratio

The relation between usable and gross area of a building is one indicator for cost efficient design. It describes more or less how much of the overall built volume can be used, rent and/or sold. The higher the ratio the more economic the design.

All building categories have different average or common practice ratios which are important planners targets as a reaction to clients` requirements. Because of the different definition of usable area, these numbers will of course vary among the different countries. However, with regard to this background, buildings within a certain category will give information about individual design qualities in their countries.

EKOPORTEN in Norrköping, Sweden

Multi-unit residential retrofit project addressing overall environmental and energy measures including energy, land and water, material and sewage issues.

Refurbishment of buildings is characterized by higher energy demands in modt cases because of the increasing comfort level compared to the situation before retrofit.

Thus, energy saving in retofit design is a big challenge and has to be paid by significantly higher initial cost for energy and environmental techniques.

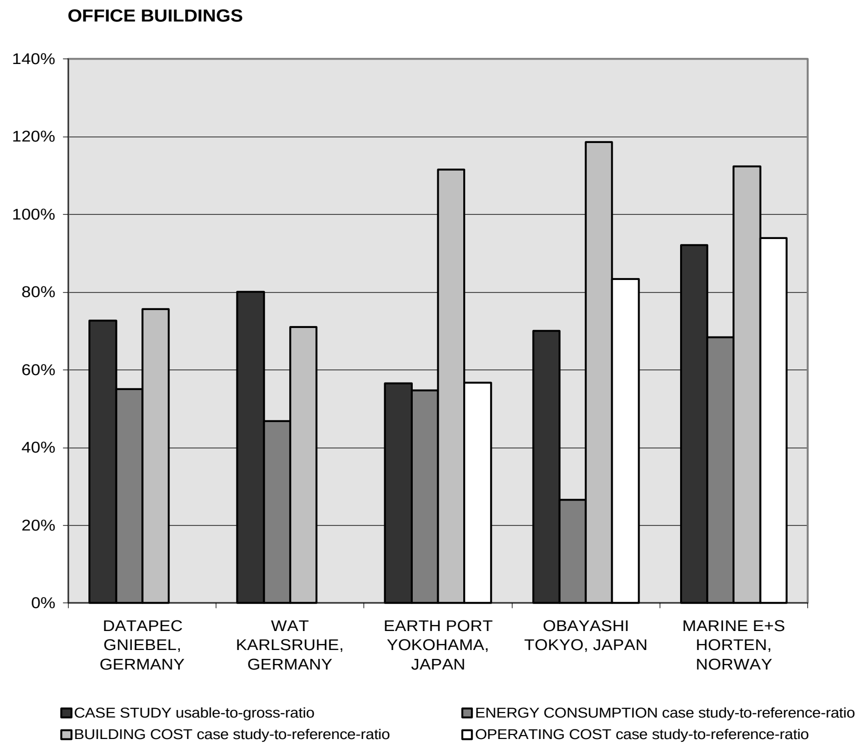
Energy Performance

Energy saving potentials are characterized by overall building design, energy conservation techniques and renewable energy utilization. The energy saving potential can be expressed by comparing the case study building to a reference and / or standard common practice building. In many countries this relationship will even categorize for instance low-energy-standards and subsidizes may depend on a certain limiting number.

For case study interpretation attention has to be paid to the data base of energy determinations whether including energy demand or actually monitored consumption, including or excluding electricity, expressing operating energy related to use or prime energy.

Initial Building Cost

Building cost are commonly expressed in specific numbers related to usable, net or gross area. As true as for the criteria mentioned above, building cost determinations may also differ within the scope of countries regarding the in/exclusion of design cost and/or taxes which vary extremely from country to country.



Core atrium of DATAPEC building acting as an integral part of the overall ventilation strategy: Pre-conditioned fresh air supply from hollow foundations is transported via the atrium space

Operating Cost

The increase of operating cost becomes more and more important for building occupants. In most countries commercial spaces are rented on net rent level excluding operating cost which have to paid separately and which differ very much even within the same building depending on individual user profile. Operating cost represent a wide scope of cost elements including energy, water, cleaning and other services, waste and other charges, central technical facilities, services and security, taxes, etc. Therefore, serious and comparable data even within one country and one particular building category for new buildings and reference projects can hardly be obtained. Those case studies providing numbers for this category including reference values mostly relate to energy cost solely because it is almost impossible to indicate reference figures which cover the whole collection of operating cost elements seriously. This matter of fact clearly shows that more attention should be focused on operating costs which are increasingly important for the overall success of an innovative building concept and the acceptance by occupants and clients.

DATAPEC Office Building, Germany

The cylindric building is designed as an efficient organisme using innovative building and climate engineering strategies to dispense with mechanical air conditioning for a building providing high internal loads by extensive screen work.

Architectural and technical approaches of daylighting, heating and ventilation concepts have been developed collectively during a consequently multi-disciplinary design process.

The client and user of the building benefit from this innovative building in a many-fold way:

Reduction of initial building cost, decrease of operating cost, remarkable energy conservation and saving potential and the increase of working place and indoor qualities.

Conclusion

All building examples which will be shown and discussed during this conference represent their national and individual importance and value for the countries they come from. The projects serve for multiplication and can be transferred to other building designs.




Last but not least attention should also be paid to poster presentation. These building examples have not been analyzed in detailed by GBA-Tool as the case studies. Nevertheless this collection does not diminish their architectural, energy and environmental quality at all. Most of the projects presented in this collection are real highlights setting future standards within the building category they represent. By this way the poster exhibition is a high quality building documentation and an indispensable enrichment for the discussion and promotion of the necessary change in design and building culture towards future sustainability.

Despite of the enormous effort which has been made for analysis, assessment, evaluation and documentation of the case studies, a great deal of work will remain after this conference.
Both on the international and the national level as well as on regional and local level the experiences of sustainability, environmental design and energy conservation must be promoted and pushed into the field of design professionals.

Besides the already planned products such as print media and CD-ROM documentation material it is recommended to disseminate the results and experiences of the GBC`98 program by direct ways of interactive communication activities including

- Mobile exhibitions linked to national / regional conferences
- Organization of national. regional and local workshops addressed to clients and developers
- Support and improvement of multi-disciplinary architectural competitions

The objective and main task for all GBC`98 members will now be to develop these future activities in their countries. The presented building projects have shown that sustainability design is compatible with cost-efficiency. Thus, dissemination and application of information and experiences should address planers including architects and engineers, building authorities and municipalities, and most important: developers and clients as responsible decision makers.