Association of Expanded Polystyrene Manufacturers (AEPM)

The Association of Expanded Polystyrene Manufacturers (AEPM) gathers as its members experienced manufacturers of thermal and acoustic insulation for the building sector.

For 50 years now expanded polystyrene has worked perfectly as material used for insulation of walls, roofs, ceilings and floors in residential and office buildings, schools and hospitals, industrial facilities, warehouses and cold stores. Each year, millions of square meters of partitions are constructed using thermal or acoustic insulation of expanded polystyrene.

Expanded polystyrene is becoming increasingly popular due to its numerous advantages the most important of which include:

- excellent insulation properties in low temperatures and high humidity
- low density (which in practice means low weight)
- minimal water absorption
- no harmfulness to human health confirmed by the attestation of the material for contact with food products
- durability (resistance to ageing)
- resistance to mildew, fungi and bacteria
- ease to work with (ease of cutting, fitting and transport on building sites)
- safety in use (expanded polystyrene does not dust, and does not require personal protective devices)
- environmental friendliness (low consumption of primary energy needed for manufacturing expanded polystyrene, various recycling options)
- value for money.

Those and many other of its qualities make expanded polystyrene continue to increase in importance and popularity.
The secret of the exceptional attainments in energy savings in construction is the combination of building insulation systems with the application of expanded polystyrene. The insulation of walls using the wet method (SSI – System of Seamless Insulation of external walls) with the use, as thermal insulation, of expanded polystyrene sheets has the following advantages:

- considerably reduces the costs of heating, even by 50%
- is inexpensive owing to low costs of the material and its fitting
- does not absorb moisture thus protecting the wall against the condensation of water vapour and creating pleasant and healthy microclimate of the interiors
- eliminates heat bridges, e.g. through the application of milled sheets
- helps achieve the desired effect without reducing the living area
- offers the possibility to attractively shape the facades (finishing the wall to the intended standard – texture, colours)
- enables the polishing of expanded polystyrene with rough walls
- enables renovation of old-style buildings (facades can be made attractive with expanded polystyrene profiles, e.g. cornices, pilasters)

- increases the value of the building
- makes a considerable contribution to environmental protection.

Applied in the light-wet method, expanded polystyrene is one of the least expensive elements and the only one which yields savings through reduced heating bills.

The Association engages in training and informational activities aimed at improving the knowledge about expanded polystyrene – the most popular thermal insulating material in Poland.

Members of the Association include manufacturers of both expanded polystyrene and the raw material that is polystyrene for foaming (22 members who have an 80% share in the market); full list of AEPM members can be found at www.styropian-sps.com.pl).

The AEPM works *inter alia* with the Polish Standardisation Committee, scientific and research institutions, and many building departments of technical universities. These relations have resulted for instance in setting standards for expanded polystyrene sheets or commissioning research into the properties of expanded polystyrene.

The AEPM maintains contacts with Brussels-based EUMEPS (European Manufacturers of Expanded Polystyrene) – the organisation associating representatives of 15 EU Member States – through which it can get access to the world trends in the expanded polystyrene industry.

It should be mentioned that the Polish expanded polystyrene industry is among the most advanced in Europe.

Please visit our website where you can find quite a lot of interesting information about expanded polystyrene – www.styropian-sps.com.pl

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Practical Recommendations for Sustainable Construction
PRESCO
c/o Belgian Building Research Institute
Lozenberg 7
B-1932 Sint-Stevens-Woluwe, Belgium
http://www.etn-presco.net

PRESCO – European Thematic Network on Practical Recommendations for Sustainable Construction brings together representatives of all stakeholders involved in sustainable construction and building. The network seeks to facilitate the exchange of experience and the transfer of knowledge. Three main tasks in particular have been identified. A first activity is to define European Guidelines for Sustainable Building. The guideline should contain widely accepted and scientifically supported practical recommendations for the construction of sustainable buildings for residential, commercial and industrial use. Not only environmentally friendly construction technologies, but also social inclusion of elderly and disabled are considered through the study of adaptable housing and building. A second activity of the PRESCO-network is oriented towards the inter-comparison and benchmarking of LCA-based, environmental assessment and design tools. This work will be a step towards better harmonisation of the existing European environmental assessment tools. Finally PRESCO is concerned with information transfer amongst network members and to the outside world, through a newsletter and a website (http://www.etn-presco.net).

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1826 Establishment of the Preparatory School for the Institute of Technology in Warsaw

1831 November Uprising and the liquidation of the Preparatory School

1898 Establishment of the Nicolas II Warsaw Institute of Technology with the following Faculties: Mechanical, Chemical, and Engineering and Construction (and the Mining Faculty from 1902)

1901 Transfer of the University to new premises — the current buildings of the Warsaw University of Technology

1905 Closing of the Warsaw Institute of Technology

1915 Opening of the Warsaw University of Technology with Polish as the language of instruction

1940–1945 Clandestine courses in the underground University of Technology

1945 Resumption of teaching after World War II

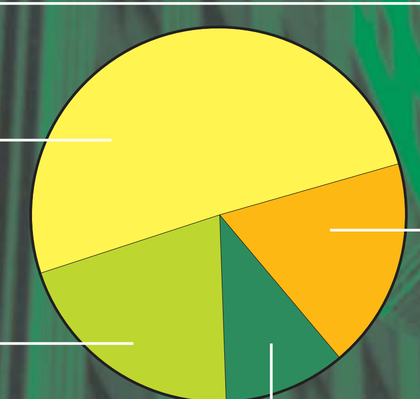
1951 Incorporation of Hipolit Wawelberg and Stanisław Rotwand School of Engineering into the Warsaw University of Technology

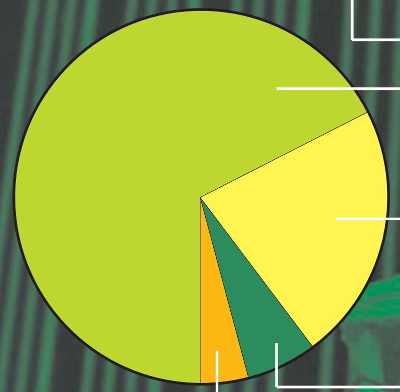
1967 Creation of the Płock branch of the Warsaw University of Technology (The School of Technical and Social Sciences since 2002)

2001 Jubilee Year — 175 years of tradition of the Warsaw University of Technology

The Warsaw University of Technology is the largest technical university in Poland

Professors	448
Assistant professors	1245
Lecturers	503
Other	262
TOTAL	2458





Full time students	21879
Extra-mural students	7243
Part time students	1992
PhD students	1341
TOTAL	32455

In the Warsaw University of Technology students have a choice of 23 disciplines (shown right)

- There is an option of studying in English in the Faculties of Mathematics and Information Science (The Department of Computer Science) and of Electronics and Information Technology
- The Warsaw University of Technology also organises distance studies (via the Internet) in the following Faculties: Electronics and Telecommunications, Computer Science, and Automatic Control and Robotics
- The University participates in European Union educational programmes: *Socrates-Erasmus* (within the Erasmus University Charter), *Socrates-Minerva* and other sections of the *Socrates, Action Jean Monnet* and *Leonardo da Vinci*

Discipline	Faculty/College
Administration	The College of Social Sciences and Administration
Architecture and Urban Design	Architecture
Automatic Control and Robotics	Electrical Engineering Mechatronics Power and Aeronautical Engineering Production Engineering
Aviation and Aerospace	Power and Aeronautical Engineering
Biotechnology	Inter-faculty Biotechnology Centre
Chemical and Process Engineering	Chemical and Process Engineering
Chemical Technology	Chemistry Construction Engineering, Mechanics and Petrochemistry
Civil Engineering	Civil Engineering Construction Engineering, Mechanics and Petrochemistry
Computer Science	Electronics and Information Technology Electrical Engineering Mathematics and Information Science
Economics	The College of Economics and Social Sciences
Electrical Engineering	Electrical Engineering
Electronics and Telecommunications	Electronics and Information Technology
Environmental Engineering	Environmental Engineering Construction Engineering, Mechanics and Petrochemistry
Environmental Protection	Environmental Engineering
Geodesy and Cartography	Geodesy and Cartography
Management and Marketing	Production Engineering
Materials Science and Engineering	Materials Science and Engineering
Mathematics	Mathematics and Information Science
Mechanics and Machine Design	Production Engineering Power and Aeronautical Engineering Mechatronics Automobile and Construction Machinery Engineering Construction Engineering, Mechanics and Petrochemistry
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Transport	Transport

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Recent Advances in Energy Codes in Russia and Kazakhstan. Harmonization of Codes with European Standards

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A ten-year struggle in Russia over a new generation of building energy codes has recently culminated in the passage of a sweeping new federal energy code. This federal code employs approaches and locks in energy-performance targets of innovative regional codes adopted since the late 1990s, based on a model code developed by the author of this paper. These new codes are causing a major shift in the Russian building sector — a transformation without parallel in Russia's other industrial sectors — toward increased energy efficiency. The Russian market has undergone fundamental transformation toward production, sale, and use of energy-efficient building materials and products, and the use of new energy-efficient technologies. Kazakhstan has also started down the path blazed by Russia regarding energy codes.

The proposed article will discuss important recent developments in Russian and Kazakhstani building energy codes, including setting of energy-efficiency criteria and targets for buildings, and development of rating systems and new federal and regional codes embodying these targets. We also discuss oversight over the quality of design and construction, and monitoring of energy performance of buildings during operation. We close by discussing next steps in code development and implementation in both countries, and opportunities for further increasing energy efficiency.

Over the past 8 years we have informed readers of the development, step by step, of a new generation of codes and standards in Russia for energy-efficient buildings (see WEB www.cenef.ru/home-pg/hp-1r_fr.htm, then follow links to publications). The time has now come to reap the results. A new generation of codes has been **created and implemented successfully** at federal and regional levels. The system of codes includes

at the regional level:

codes in 50 regions of the Russian Federation, implemented between 1995 and 2004; and

at the federal level:

the new code "Thermal Performance of Buildings" (SNiP 23-02 [1],[1] adopted late 2003);

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[1] Throughout this paper, we will refer to Russian federal building codes and standards by their commonly used initials – SNiP means *Stroitelnye Normy i Pravila*, or Construction Codes and Regulations, and GOST means *Gosudarstvennye Standart*, or State standard.

the code of practice (supplemental technical manual) “Design of Thermal Performance of Buildings” (SP 23-101 [2]);

the standard “Microclimate Parameters in Residential and Public Buildings” (GOST 30494 [3]);

four standards on building energy audits (GOST 31166 [4], GOST 31167 [5], GOST 31168 [6], GOST 26254 [7]);

a standard on the detection of concealed defects of building thermal insulation (GOST 26299 [8]); and

sections entitled “Energy Conservation” and “Sanitary-Epidemiological Requirements” in two new residential codes (SNiP 31-01 [9] and SNiP 31-02 [10]).

All the documents mentioned above have been officially adopted by the relevant authorizing agencies, have entered into force, and are mandatory. In accordance with the new Russian Federation law “On Technical Regulation,” all GOSTs and SNiPs adopted before the passage of this law will carry mandatory force for 7 years, after which they will become recommended. Regional codes will be in force beyond that time as mandatory documents.

Energy Savings and Market Changes to Date

The results of implementation of this system of codes are evident. Under new regional and federal codes over the past 8 years, energy consumption for heating in newly constructed and renovated buildings has been reduced by 35 to 45 percent, depending on building type. According to data from Gosstroy RF, already 6 percent (170 million sq. m) of the entire residential building stock of Russia complies with the requirements of new codes. There has been a transition from universal use of single-layer and three-layer wall-panel construction to monolithic frame construction with external insulation and unventilated and ventilated facades and light thermal insulation materials. Building designs with widened frames (up to 22-25 meters, in comparison with 12 meters previously) have become widely used. Types of light porous concrete have also been in use. Factories that produce concrete wall panels have made the transition to producing a great variety of products. Buildings made of these components do not differ in outward appearance from monolithic-frame buildings. Meanwhile, in terms of cost, external walls made of panels with triple the thermal performance of previous wall types are also 10-15 percent less expensive than those previous types — for example, in the wall-panel plant in Yakutsk and Tomsk. At the same time, windows with sealed glass units with low-reflectivity glazing and composite wood or plastic frames have begun to be used as well.

One can make an assessment of the effect of code implementation on energy use by considering volumes of residential construction. According to 2002 data, Russia introduced about 14.3 million square meters of single-family low-rise homes and about 19.5 million square meters of multistory multifamily buildings, for a total of 33.8 million square meters of new residential floor area in Russia overall. We have calculated the energy-saving effect as the difference in energy consumption for heating for this volume of buildings built in compliance with 1995 codes, versus those built in compliance with the new system of codes, and calculate a final saving of heat energy of about 11.3 exajoules for residential buildings. If we assume that heat supply systems are 50 percent efficient on average – that is, half of the energy in primary fuel is converted into useful heat energy, with the other half lost en route to the end user — then the energy-saving effect in terms of primary fuel is calculated at almost 23 EJ in 2003, or about US $46-50 million. Annual figures grow cumulatively over a 10-year period up to 1,260 EJ assuming constant construction volumes, and under constant energy prices, reflect a savings of US $2.4 billion. If we assume a 5% growth in residential construction volume, which is highly realistic, then the dollar savings grow to US $2.9 billion.

The New Russian Federal SNiP

The new federal code adopted in 2003 locks in energy savings embodied in regional codes, implements innovations from these regional codes, sets forth additional new elements, and of course, dramatically expands geographic coverage of codes from selected regions to the whole country. Gosstroy of Russia adopted this code by executive order №113 in June 2003, and the code [1], entitled "Thermal Performance of Buildings," entered into force on October 1, 2003. The new code replaces the previous federal SNiP "Thermal Engineering for Buildings," which despite major modifications between 1995 and 1998, still had a variety of deficiencies, in content as well as form.

The new SNiP "Thermal Performance of Buildings" seeks to address these deficiencies by:

establishing numerical values for required performance targets, corresponding to world levels;
classifying new and existing buildings according to their energy efficiency;
encouraging buildings that are more efficient than required by code;
creating a mechanism for identifying low-performing existing buildings and mandating necessary upgrades;
developing design guidelines for both prescriptive and performance-based compliance paths; and
developing methods for oversight and enforcement of compliance in terms of thermal performance and energy efficiency (energy passports), during design, construction, and prospective operation phases.

In its general principles, the new SNiP "Thermal Performance of Buildings" is a completely new document in terms of structure, applicability, criteria, oversight and enforcement, computer-compatibility, linkages with energy audits for operating buildings, harmonization with European standards, and in light of all these factors, its very name. Still, the new document maintains continuity with the code it replaced, and provides for equivalent levels of energy efficiency, while offering wider technical options for compliance. Below we summarize the general principles of the new federal code.

Performance criteria

The code establishes two means for achieving compliance:

a) a prescriptive path, with required thermal resistance values for individual building envelope elements; these values have been defined so as to be consistent with whole-building specific energy consumption requirements, and have been retained from the former SNiP for continuity;

b) a performance path, with required specific energy consumption levels for heating the whole building, allowing for tradeoffs in the energy performance of individual envelope elements (except the buildings for industry), taking account of heating controls and heat-supply system efficiency.

The choice of which of these options to use is left to the owner and/or designer. Methods and paths for achieving these requirements are chosen during the design process. Prefabricated buildings may achieve compliance only via the prescriptive path.

In calculations of design whole-building energy performance, indoor air temperatures are set at the lower limits of optimal ranges. A new standard, GOST 30494-96 [3] "Residential and Public Buildings. Microclimate Parameters for indoor enclosures," has been developed at our initiative and with our participation, in order to define these temperature input data. In accordance with this standard, design indoor air temperature is set at 20 ^{o}C instead of the previous 18 ^{o}C. The resulting change in temperature differences near cold surfaces has been taken into account and applied to new code requirements for windows.

Classification and rating buildings on the basis of energy performance

The new federal code, in contrast to previous codes, applies not only to new and renovated buildings, but also to existing buildings already in operation, with instructions for evaluating and monitoring thermal-performance and energy parameters during both design and operation.

Figure 1 shows a set of rating categories based on the degree to which design or normalized measured parameters for specific energy consumption deviate from required values from the new code. This classification applies both to newly constructed and renovated buildings designed according to the new code, as well as to operating buildings built according to previous codes, even those from before 1995.

Buildings whose designs have been developed according to the new code can be assigned to classes ***A***, ***B***, and ***C***. In the process of real operation, the energy efficiency of such buildings may deviate from design data into better classes (***A*** or ***B***) within the limits shown in Figure 1. Where classes ***A*** and ***B*** are earned, the use of economic incentive measures by local government agencies or investors is recommended.

Classes ***D*** and ***E*** apply to operating buildings, built under codes in force at the time of construction. Class ***D*** corresponds to code-compliant levels from before 1995. These classes give information to local government agencies or building owners on the necessity of immediate or less immediate measures for increasing energy efficiency. Thus, for example, for buildings falling into class ***E***, energy-efficiency renovation is urgently required.

Specific actions regarding the rating of existing buildings, awarding of incentives, requiring upgrades, and levying sanctions are left to regional and municipal agencies, which are responsible for enforcing the federal code.

Figure 1: Classes of Energy Efficiency for Buildings

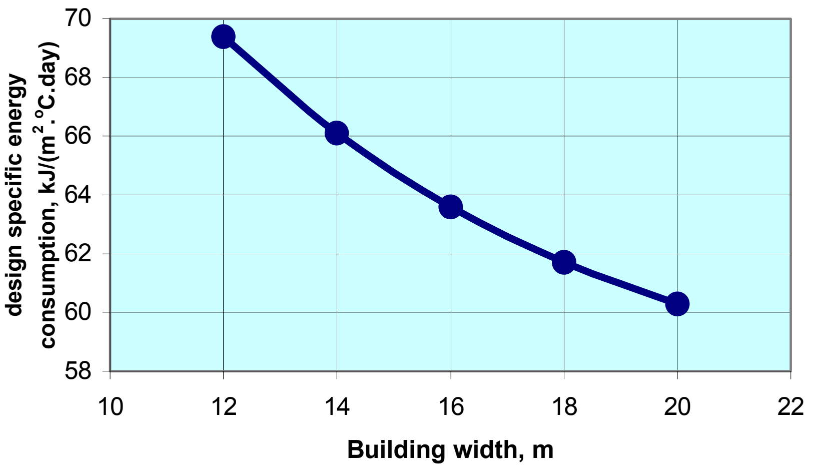
Letter grade and graphical representation	Name of the class	Deviation of design or normalized measured specific energy consumption from code-stipulated level, %	Recommended measures
	For new and renovated buildings		
A	*Very high*	less than –51	economic incentives
B	High	From -10 to -50	as above
C	**Normal**	from +5 to –9	-
	For existing buildings		
D	Low	from +6 to +75	Renovation desirable
E	*Very low*	greater than +76	Upgrades urgently required

Taking account of building geometry
The geometric form of the building has a real influence on energy consumption. In Figure 2, the influence of the width on the building on reduction in specific energy consumption is shown for a nine-story three-section residential building in the city of Orenburg. In this light, geometric criteria for the building compactness have been included in the new SNiP 23-02, as the ratio of the building envelope surface area to the volume that it encloses. The necessary reduction in energy consumption will be achieved by means of building geometry where the following criteria are met: 0.25 m^{-1} for buildings 16 stories tall, and higher; 0.29 for buildings from 10 to 15 stories; 0.32 for buildings from 6 to 9 stories; 0.36 for 5-story buildings; 0.43 for 4-story buildings; 0.54 for 3-story buildings; 0.61, 0.54, and 0.46 for two-, three-, and four-story black or sectional buildings, respectively; 0.9 for two-story and single-story buildings with mansards; and 1.1 for single-story buildings. (This parameter has been used in German codes since 1975.)

Quality control and energy audits
The new SNiP also requires the performance of quality control for the thermal insulation in every building by means of thermographic testing, in accordance with GOST 26629 [8] "Method of thermo vision control of enclosing structures thermal insulation quality," upon the building's entry into operation. Such oversight helps to reveal hidden defects and means to remedy them before the departure of the construction crew from the site. The new SNiP also requires selective monitoring of air permeability of the inhabited areas of buildings entering into operation, in accordance with the new GOST 31167 [5].

The new code also has a section on building energy audits, which are defined as a sequence of activities intended to determine the energy efficiency of the building and to assess measures for increasing energy efficiency and energy conservation. The results of energy audits are used for general classification and certification of buildings according to energy efficiency.

Figure 2. Change in specific energy consumption depending on the width of a residential building (9 stories, 3 sections) in the city of Orenburg



The specific elements of an energy audit depend on how the task is defined. For example, an energy audit may be carried out with the goal of rating the building in terms of energy efficiency in accordance with the new SNiP or regional code. The goal of such a step for government enforcement agencies is to reveal those buildings that must urgently be renovated from an energy-efficiency point of view. The other type of energy audit is carried out with the goal of energy-related certification of the building. In this case, the goal is to document that the operating building complies with various code requirements.

In order to confirm that the specific energy consumption for heating for an existing building already in operation corresponds to code-stipulated values and oversight requirements of the new SNiP, three new standards have been developed by a broad team of participants, including ourselves, and confirmed by Gosstroy of Russia in 2003:

GOST 31166 [4] “Envelop constructions of buildings and structures. Method for calorimetric determination of the heat transfer coefficient.”;

GOST 31167 [5] “Buildings and Structures. Method for determination of air permeability of buildings envelops in field conditions.” (made consistent with ISO 9972);

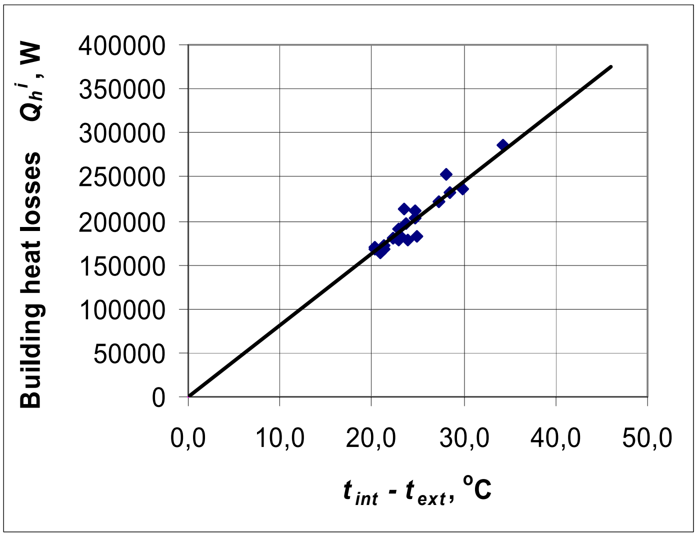
GOST 31168 [6] “Houses. Method for determination of specific heat consumption for building heating.”

The latter two standards are fundamental, providing a method for oversight over parameters shown in compliance documents and energy audits for existing buildings.

These standards have also been adopted in the Republic of Kazakhstan.

The essence of the method for determining specific energy consumption for heating is that during the heating period, over predetermined intervals, energy consumption, average indoor and outdoor air temperature, and the averaged intensity of incident solar radiation on horizontal surfaces are measured, either for occupied areas (such as a single apartment) or a whole building. For the same intervals, values are calculated for overall heat losses through the building envelope, equal to measured energy consumption plus internal and solar gains. Then, for calculated heat losses and corresponding temperature differences between indoor and outdoor air temperature, one can generate a linear regression reflecting the greatest fit to these data (see Figure 3). According to this linear relationship and the internal dimensions of the premises and of envelope elements, one determines the overall coefficient of heat transfer through the building envelope and the specific energy consumption for heating, and also can assign an energy-efficiency classification to the building.

Figure 3 Functional relationships between building heat losses and temperature difference between indoor and outdoor air



Monitoring of energy performance of the eleven storied residential building during preration (see Figure 4) was conducted on March, 2004. The building is built according to the Swiss technology by the “Plastbau” system.

The result of the study is shown in Figure 3. Using the metering data (see the rectangle points in Figure 3) the total heat transfer coefficient of the external building envelops, is equal to 1.044 W/(m^2·°C), was calculated. For comparison, the design value of this coefficient is equal to 0,993 W/(m^2·°C). Thus, obviously the real value of the total heat transfer coefficient practically coincides with the design value. The specific heat energy consumption during the heating season was also calculated by GOST 31168 and is equal to 70,33 kJ/(m^2·°C·day). This energy consumption is a little bit lower than the code-regulated value which is equal 72 kJ/($m^2 \cdot {}^oC \cdot day$). According to building classification on the figure 1 this building is regarded as a "normal".

Figure 4. The residential building for the monitoring of energy performance

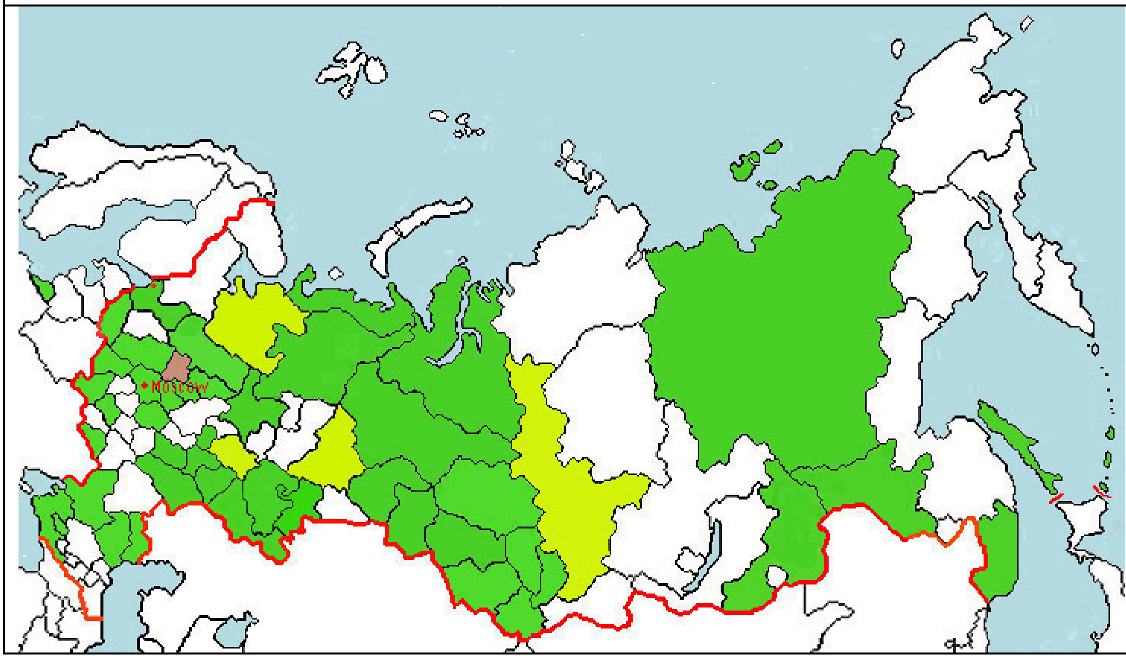
Regional Energy Codes
The legal basis of the regional codes in Russia is set forth in Article 53 of the "Civil Construction Codex of the Russian Federation." At present, 50 regional codes have been adopted and confirmed by Gosstroy RF, and 3 more are in the stage of final editing. See Figure 5.

Regional codes are mandatory for all Russian and foreign entities involved with construction in the given region, even in isolated cases where federal codes do not apply. All regional codes are developed according to criteria described above – they may be consistent with federal codes, or more stringent. Regional codes also contain detailed climate parameters not contained in the federal code, including heating-season degree days and solar radiation under real cloud conditions. In a few regions, climate data are provided on a district-by-district basis.

Energy Passports
The new federal SNiP and regional codes require the completion of an «Energy Passport» for the building, a document intended to verify energy performance in design, construction, and operation. Energy Passports also give potential buyers and resident's information on what they can expect regarding the building's energy efficiency and real costs, helping to stimulate market preferences for high-performance buildings.

During construction, there are often deviations from design – for example, a change in material or components. As a rule, these deviations must be allowed by the design organization. But in practice, there do exist cases where the construction company carries out unsanctioned changes from the original design. Therefore, upon the building's entry into operation, regional codes require that the design organization complete a second, updated Energy Passport with the same goals and content as the one completed during design.

Figure 5. Regional Codes in Russia, 2004



Note: Regions with dark shading have their own codes. Regions with light shading have codes in the final stages of editing.

For existing buildings, the new federal code and regional codes require selective inspection and review to determine compliance with relevant codes, or to assess the need for renovation. The results of this review must reflect technical, energy-related, and thermal aspects, as well as technical and economic analysis of options for renovation.

To help ensure quality in energy-related aspects of building design, the new federal code and regional codes also require the preparation of a special section of the building design, entitled "Energy Efficiency." This section must include summary parameters for energy performance for various parts of the building design. These parameters are presented side-by-side with code-required values. The section is completed at review stages for pre-design and design documentation. The design agency completes the section; funding the work is the owner's responsibility; as necessary, the owner or designer may choose to engage the services of outside specialists.

In issuing final approvals, regional or municipal plan review agencies must specifically confirm the compliance of the pre-design and design energy-efficiency documentation with relevant codes.

Computer tools

To facilitate and standardize calculations, a PC version of the Energy Passport has been developed. This version enables quick calculations, iterative assessment of design variants, and comparison with code values at all stages of design, construction, and operation. It is available upon request to interested organizations.

Three other programs for PC are available, intended to facilitate thermal-engineering calculations in the design of building envelopes. The first program enables the user to carry out complex calculations of envelope performance under conditions of steady-state linear heat transfer, as described in the federal supplemental guidance manual, and helps to verify compliance with code-required values for thermal resistance, thermal stability, air permeability, vapor permeability, and thermal assimilation of floors.

The second and third programs define the overall thermal resistance of heterogeneous elements with two- and three-dimensional temperature fields, under conditions of steady-state heat transfer.

Harmonization of codes with European standards

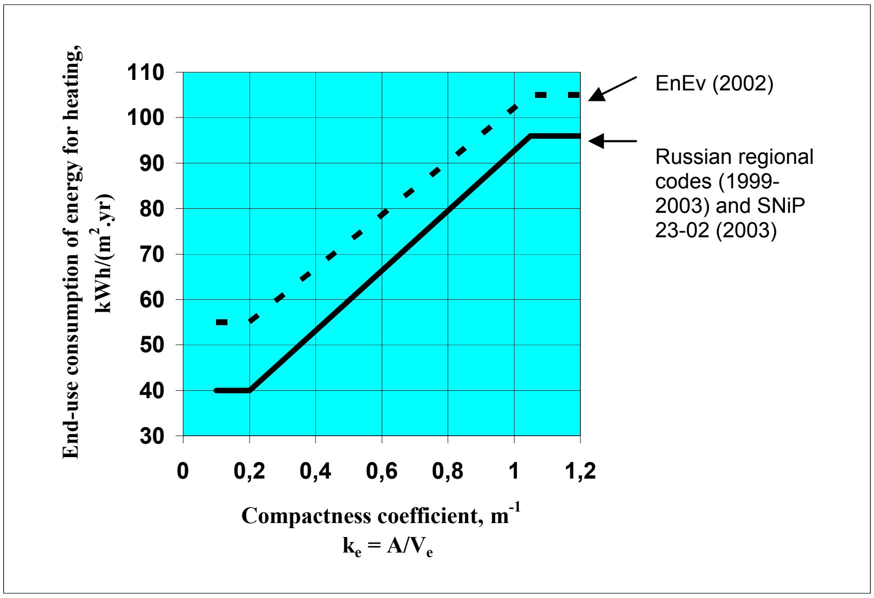
The new federal SNiP and regional codes are consistent with international levels and in particular, with the requirements of EU Directive (law) №93/76 SAVE [11] and EU resolution №647 [12] on a long-term program for energy efficiency in buildings, with the new German executive order EnEV 2002 [13], and with the new EU Directive [14] on energy-efficiency indices for buildings. In terms of approach, the Russian codes even go beyond those of EU countries. It is interesting to compare the code-required energy performance targets of Germany and Russia; German codes stipulate targets that fall between 40 and 96 kWh/(m^2·yr) for baseline heat-supply systems. Values from Russian regional codes and the new federal SNiP, adjusted to Germany's climate conditions fall between 55 and 105 kWh/(m^2·yr). See Figure 6. German codes are clearly more stringent - by 20 to 27 percent for multifamily residential buildings, and 9 to 10 percent for single-family homes.

The Codes are take account according to EU directive on the energy-performance of buildings:

- a system approach to the buildings and the total energy use for heating;
- an energy declaration / energy passport for the energy certification;
- the measures in both new and renovate buildings;
- a general principle of methodology for calculation to obtain the overall energy performance of a building including energy for ventilation, internal heat gain and solar radiation;
- an efficiency of heat supply system;
- a thermal comfort.

  The Codes are not taking account (except Code for Moscow):
- a domestic hot water supply;
- an artificial lighting.

Figure 6. Comparison of Required Energy-Performance Levels of Russian Regional and Federal Codes, and Germany's EnEV-2002



Codes of the Republic of Kazakhstan

New codes have also been developed (SN RK 2.04-21 [15], adopted on May, 2004) in the Republic of Kazakhstan (RK) — one of the most successfully developing central Asian republics of the post-Soviet sphere. The rate of GDP growth of this republic over the past few years has not fallen below 10 percent per year, in comparison with 5 percent in Russia. Thanks to economic reforms and liberal laws, foreign investment in this republic has grown without cease, especially from western countries. The building sector is also growing mightily. But the RK has practically no base of codes of its own for the building sector. Buildings are being built in accordance with the expertise of construction companies hired by the future owner or investor, often according to the codes of the country where hired companies are based, or according to Russian codes. In this light, the government of the RK has set forth a goal of creating its own code for energy efficiency in the building sector and of including in these new code performance targets for civilian buildings that correspond to world levels, as well as methods for oversight and enforcement.

We have been developing this code in close collaboration with the Department of Technical Codes and New Construction Technologies of the Committee for Construction Affairs of the RK, under the support of the U.S. Environmental Protection Agency.

The table on figure 7 below presents required target values for area-specific consumption of energy for heating buildings, as proposed for the RK code, in comparison with levels implied by codes in force between 1980 and 1995.

In establishing target values for energy performance, we proceeded based on a criteria of 40 percent reduction of energy consumption relative to the average level of energy consumption of existing buildings in the republic, assuming connection of buildings to a baseline (centralized) heat-supply system. The average republic-wide level was defined based on Russian construction standards that were in force in the RK between 1980 and 1995.

Figure 7

Specific Energy Consumption for Heating Permitted by Building Codes in Kazakhstan, kJ/(m^2·°C·day) [kJ/(m^3·°C·day)]								
Building type	**Number of stories**							
	1-3		**4-5**		**6-9**		**10 and higher**	
	1980-1995	**2004**	1980-1995	**2004**	1980-1995	**2004**	1980-1995	**2004**
Residential	192	**135**	158	**90**	133	**83**	117	**75**
Educational and Office Buildings	[70]	**[38]**	[55]	**[33]**	[50]	**[30]**		
Medical facilities	[57]	**[34]**	[52]	**[31]**	[50]	**[30]**	--	**--**
Preschools	[75]	**[45]**	--	**--**	--	**--**	--	**--**
Offices	[60]	**[36]**	[45]	**[27]**	[39]	**[23]**	[33]	**[20]**

The expected effect in the first year of code implementation in the RK is almost 600 TJ in avoided energy consumption, and the cumulative effect through 2013 is projected at 33000 TJ. This energy savings implies a reduction in carbon dioxide of close to 600,000 tonnes.

Pilot design according to the draft RK code

Our project team has scarred out a pilot design according to the draft of the new RK code for a ten-story residential building in the educational-scientific complex for "KazGYuU," which will be built on the left bank of the Ishim River in Astana. The design is at the stage of initial sketches.

The general appearance of the building is shown in Figure 8. The designed building consists of four sections and 10 stories, the first of which is nonresidential and intended for an array of service facilities. Construction of the building is monolithic-frame from reinforced concrete, without crossbeams. The attic and crawlspace are unheated, and the floors are directly on the ground. Exterior walls are made of brick with efficient insulation, windows with triple-glazing and paired-sectional frames. Glazing constitutes 18 percent of the surface area of the walls, as permitted by code. The building is connected to centralized heat supply. The energy-efficiency class of the building is normal.

Results of the pilot design

The results of calculations are presented as the components of the heat balance of this building, in Figure 9. The figure shows the following parameters: Q_h^y – overall energy consumption for heating, Q_t – transmission heat losses, Q_v – heat losses via air leakage, Q_i and Q_s – internal and solar gains. From the figure, one can see that the greatest heat losses are through the envelope (Q_t), which is related to the architectural form of the building. Russian building design experience in compliance with regional codes shows that usually, transmission heat losses Q_t are comparable in terms of absolute values with heat losses via air leakage and with internal and solar gains.

Figure 8. The pilot building design

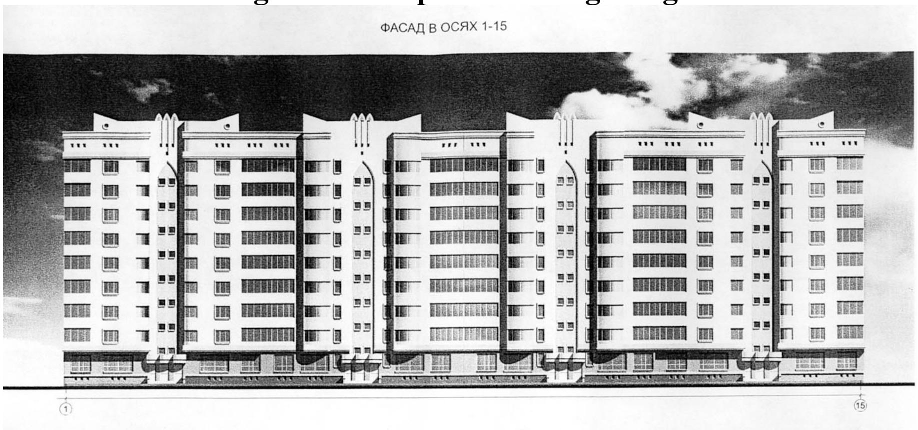
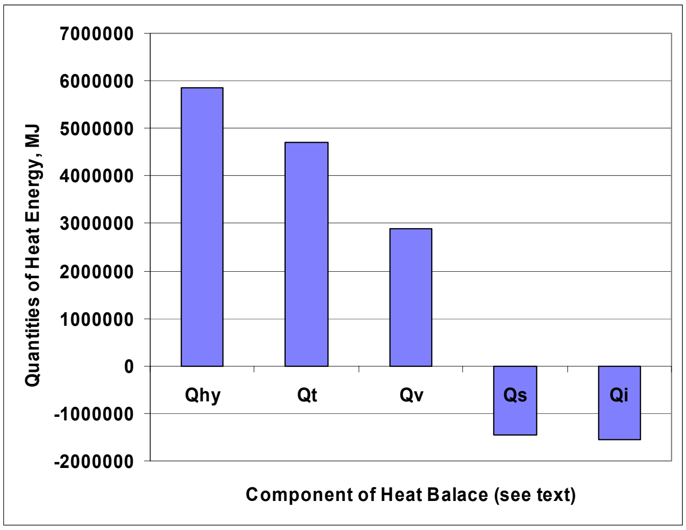


Figure 9. Heat balance
for pilot design of building compliant with new RK Code



Having analyzed the results, we can draw the following conclusions. The building's geometry and floor plan do not comply with the recommended values for compactness coefficient from the RK code – the proposed design of the pilot building has a compactness coefficient of 0.33, while the recommended value is 0.29. This implies that the architectural plan is not sufficient in terms of energy efficiency, though it is permitted by code. This deficiency requires compensation with increased thermal performance of the envelope.

From the thermal-engineering parameters chosen for the design, we get the following code requirements for envelope elements: for walls, 2.65 $m^2 \cdot {}^oC/W$; for windows, 0.55 $m^2 \cdot {}^oC/W$; attic floors, 4.73 $m^2 \cdot {}^oC/W$; ground floor 3.23 $m^2 \cdot {}^oC/W$. For compliance with these requirements, the following wall types would be recommended (layers listed from exterior to interior):

- cement-sand plaster 20 mm thick;

- a red brick layer 250 mm thick;
- a stiff mineral-wool plate 180 mm thick;
- fiberglass netting;
- lime or polymeric plaster 10 mm thick.

Another variant was also considered, involving a change to more efficient windows made of a single-space sealed glass unit and glass with a hard selective coating in separate frames, with a thermal resistance of 0.65 $m^2 \cdot {}^oC/W$. In this case the requirement for thermal resistance of walls would then fall to 2.25 $m^2 \cdot {}^oC/$, equivalent to a wall with a mineral-wool plate 150 mm thick – that is, 30 mm thinner.

The pilot test of the RK building confirms the real practicability of the proposed codes.

What Next?

Reduction of energy consumption in the building sector is a complex problem, the most important element of which is designing and verifying thermal performance. Over the next ten years, further improvements in envelope thermal performance will probably not be readily achievable; instead, further savings will come from more efficient ventilation systems (systems that deliver air on demand, heat recovery from exhaust air, and so on) and from improved control systems, including nighttime automated temperature setback. Furthermore, perfection of an algorithm for calculating energy consumption in public (nonresidential) buildings is also needed.

Performance-based code-compliance methodologies for prefabricated buildings are needed, though heat losses through the envelopes of these buildings is relatively small compared with inefficiencies of HVAC systems. The other part of the heretofore unresolved problem is determining the level of thermal performance for buildings with mechanical cooling. Future code methodologies will also be developed in this area. In this case, the level of thermal performance required from the point of view of energy efficiency may be higher, than determined based on heating alone. This means that for northern and central regions of Russia, code requirements may be based on heating considerations alone, but in southern regions, requirements may be driven as much (or more) by cooling as for heating. It will evidently be worthwhile too to create integrated code requirements for energy consumption for domestic hot water, electricity consumption for lighting and other needs, and also for gas – thus leading to a code that is based truly on whole-building energy performance.

Conclusion

- A new generation of codes has led to real results in design and construction of efficient buildings, and accompanying standards have helped clearly define key parameters for code-compliance inputs and assessment of energy performance of operating buildings. New code methodologies were first approved and implemented in great numbers at the regional level in Russia; the experience gained from regional codes has confirmed the applicability of these new approaches, and has made possible the development of codes with similar innovative elements at the federal level in Russia and in Kazakhstan. There is no precedent for such change in codes in Russia, Kazakhstan, or the former USSR.

- New codes have made a wider range of compliance options available to designers, including building geometry as well as selection of materials, components, and heating systems, thus leading to improved overall building design quality. But taking advantage of these options requires more effort and expertise. To simplify the use of the performance approach, the Energy Passport was developed. Designers have met this documentation system and its computer version with enthusiasm, and in general, complaints about the complexity of new codes dissipate after demonstration of automated compliance calculations.
- The principal methodological basis of the new codes and their basic requirements are consistent with advanced international levels, and these codes are harmonized with European codes and standards.
- Russian codes and standards for energy efficiency, despite pessimistic predictions, have created conditions for market transformation for new construction technology, have made possible a construction boom, have increased employment, have led to real energy savings, and have increased indoor comfort.

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Recent Advances in Energy Codes in Russia and Kazakhstan. Harmonization of Codes with European Standards

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A ten-year struggle in Russia over a new generation of building energy codes has recently culminated in the passage of a sweeping new federal energy code. This federal code employs approaches and locks in energy-performance targets of innovative regional codes adopted since the late 1990s, based on a model code developed by the author of this paper. These new codes are causing a major shift in the Russian building sector — a transformation without parallel in Russia's other industrial sectors — toward increased energy efficiency. The Russian market has undergone fundamental transformation toward production, sale, and use of energy-efficient building materials and products, and the use of new energy-efficient technologies. Kazakhstan has also started down the path blazed by Russia regarding energy codes.

The proposed article will discuss important recent developments in Russian and Kazakhstani building energy codes, including setting of energy-efficiency criteria and targets for buildings, and development of rating systems and new federal and regional codes embodying these targets. We also discuss oversight over the quality of design and construction, and monitoring of energy performance of buildings during operation. We close by discussing next steps in code development and implementation in both countries, and opportunities for further increasing energy efficiency.

Over the past 8 years we have informed readers of the development, step by step, of a new generation of codes and standards in Russia for energy-efficient buildings (see WEB www.cenef.ru/home-pg/hp-1r_fr.htm, then follow links to publications). The time has now come to reap the results. A new generation of codes has been **created and implemented successfully** at federal and regional levels. The system of codes includes

at the regional level:

codes in 50 regions of the Russian Federation, implemented between 1995 and 2004; and

at the federal level:

the new code "Thermal Performance of Buildings" (SNiP 23-02 [1],[1] adopted late 2003);

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[1] Throughout this paper, we will refer to Russian federal building codes and standards by their commonly used initials – SNiP means *Stroitelnye Normy i Pravila*, or Construction Codes and Regulations, and GOST means *Gosudarstvennye Standart*, or State standard.

the code of practice (supplemental technical manual) “Design of Thermal Performance of Buildings” (SP 23-101 [2]);
the standard “Microclimate Parameters in Residential and Public Buildings” (GOST 30494 [3]);
four standards on building energy audits (GOST 31166 [4], GOST 31167 [5], GOST 31168 [6], GOST 26254 [7]);
a standard on the detection of concealed defects of building thermal insulation (GOST 26299 [8]); and
sections entitled “Energy Conservation” and “Sanitary-Epidemiological Requirements” in two new residential codes (SNiP 31-01 [9] and SNiP 31-02 [10]).

All the documents mentioned above have been officially adopted by the relevant authorizing agencies, have entered into force, and are mandatory. In accordance with the new Russian Federation law “On Technical Regulation,” all GOSTs and SNiPs adopted before the passage of this law will carry mandatory force for 7 years, after which they will become recommended. Regional codes will be in force beyond that time as mandatory documents.

Energy Savings and Market Changes to Date

The results of implementation of this system of codes are evident. Under new regional and federal codes over the past 8 years, energy consumption for heating in newly constructed and renovated buildings has been reduced by 35 to 45 percent, depending on building type. According to data from Gosstroy RF, already 6 percent (170 million sq. m) of the entire residential building stock of Russia complies with the requirements of new codes. There has been a transition from universal use of single-layer and three-layer wall-panel construction to monolithic frame construction with external insulation and unventilated and ventilated facades and light thermal insulation materials. Building designs with widened frames (up to 22-25 meters, in comparison with 12 meters previously) have become widely used. Types of light porous concrete have also been in use. Factories that produce concrete wall panels have made the transition to producing a great variety of products. Buildings made of these components do not differ in outward appearance from monolithic-frame buildings. Meanwhile, in terms of cost, external walls made of panels with triple the thermal performance of previous wall types are also 10-15 percent less expensive than those previous types — for example, in the wall-panel plant in Yakutsk and Tomsk. At the same time, windows with sealed glass units with low-reflectivity glazing and composite wood or plastic frames have begun to be used as well.

One can make an assessment of the effect of code implementation on energy use by considering volumes of residential construction. According to 2002 data, Russia introduced about 14.3 million square meters of single-family low-rise homes and about 19.5 million square meters of multistory multifamily buildings, for a total of 33.8 million square meters of new residential floor area in Russia overall. We have calculated the energy-saving effect as the difference in energy consumption for heating for this volume of buildings built in compliance with 1995 codes, versus those built in compliance with the new system of codes, and calculate a final saving of heat energy of about 11.3 exajoules for residential buildings. If we assume that heat supply systems are 50 percent efficient on average – that is, half of the energy in primary fuel is converted into useful heat energy, with the other half lost en route to the end user — then the energy-saving effect in terms of primary fuel is calculated at almost 23 EJ in 2003, or about US $46-50 million. Annual figures grow cumulatively over a 10-year period up to 1,260 EJ assuming constant construction volumes, and under constant energy prices, reflect a savings of US $2.4 billion. If we assume a 5% growth in residential construction volume, which is highly realistic, then the dollar savings grow to US $2.9 billion.

The New Russian Federal SNiP

The new federal code adopted in 2003 locks in energy savings embodied in regional codes, implements innovations from these regional codes, sets forth additional new elements, and of course, dramatically expands geographic coverage of codes from selected regions to the whole country. Gosstroy of Russia adopted this code by executive order №113 in June 2003, and the code [1], entitled "Thermal Performance of Buildings," entered into force on October 1, 2003. The new code replaces the previous federal SNiP "Thermal Engineering for Buildings," which despite major modifications between 1995 and 1998, still had a variety of deficiencies, in content as well as form.

The new SNiP "Thermal Performance of Buildings" seeks to address these deficiencies by:

establishing numerical values for required performance targets, corresponding to world levels;
classifying new and existing buildings according to their energy efficiency;
encouraging buildings that are more efficient than required by code;
creating a mechanism for identifying low-performing existing buildings and mandating necessary upgrades;
developing design guidelines for both prescriptive and performance-based compliance paths; and
developing methods for oversight and enforcement of compliance in terms of thermal performance and energy efficiency (energy passports), during design, construction, and prospective operation phases.

In its general principles, the new SNiP "Thermal Performance of Buildings" is a completely new document in terms of structure, applicability, criteria, oversight and enforcement, computer-compatibility, linkages with energy audits for operating buildings, harmonization with European standards, and in light of all these factors, its very name. Still, the new document maintains continuity with the code it replaced, and provides for equivalent levels of energy efficiency, while offering wider technical options for compliance. Below we summarize the general principles of the new federal code.

Performance criteria

The code establishes two means for achieving compliance:

a) a prescriptive path, with required thermal resistance values for individual building envelope elements; these values have been defined so as to be consistent with whole-building specific energy consumption requirements, and have been retained from the former SNiP for continuity;

b) a performance path, with required specific energy consumption levels for heating the whole building, allowing for tradeoffs in the energy performance of individual envelope elements (except the buildings for industry), taking account of heating controls and heat-supply system efficiency.

The choice of which of these options to use is left to the owner and/or designer. Methods and paths for achieving these requirements are chosen during the design process. Prefabricated buildings may achieve compliance only via the prescriptive path.

In calculations of design whole-building energy performance, indoor air temperatures are set at the lower limits of optimal ranges. A new standard, GOST 30494-96 [3] "Residential and Public Buildings. Microclimate Parameters for indoor enclosures," has been developed at our initiative and with our participation, in order to define these temperature input data. In accordance with this standard, design indoor air temperature is set at 20 ^{o}C instead of the previous 18 ^{o}C. The resulting change in temperature differences near cold surfaces has been taken into account and applied to new code requirements for windows.

Classification and rating buildings on the basis of energy performance

The new federal code, in contrast to previous codes, applies not only to new and renovated buildings, but also to existing buildings already in operation, with instructions for evaluating and monitoring thermal-performance and energy parameters during both design and operation.

Figure 1 shows a set of rating categories based on the degree to which design or normalized measured parameters for specific energy consumption deviate from required values from the new code. This classification applies both to newly constructed and renovated buildings designed according to the new code, as well as to operating buildings built according to previous codes, even those from before 1995.

Buildings whose designs have been developed according to the new code can be assigned to classes ***A***, ***B***, and ***C***. In the process of real operation, the energy efficiency of such buildings may deviate from design data into better classes (***A*** or ***B***) within the limits shown in Figure 1. Where classes ***A*** and ***B*** are earned, the use of economic incentive measures by local government agencies or investors is recommended.

Classes ***D*** and ***E*** apply to operating buildings, built under codes in force at the time of construction. Class ***D*** corresponds to code-compliant levels from before 1995. These classes give information to local government agencies or building owners on the necessity of immediate or less immediate measures for increasing energy efficiency. Thus, for example, for buildings falling into class ***E***, energy-efficiency renovation is urgently required.

Specific actions regarding the rating of existing buildings, awarding of incentives, requiring upgrades, and levying sanctions are left to regional and municipal agencies, which are responsible for enforcing the federal code.

Figure 1: Classes of Energy Efficiency for Buildings

Letter grade and graphical representation	Name of the class	Deviation of design or normalized measured specific energy consumption from code-stipulated level, %	Recommended measures
For new and renovated buildings			
A	*Very high*	less than –51	economic incentives
B	High	From -10 to -50	as above
C	**Normal**	from +5 to –9	-
For existing buildings			
D	Low	from +6 to +75	Renovation desirable
E	*Very low*	greater than +76	Upgrades urgently required

Taking account of building geometry

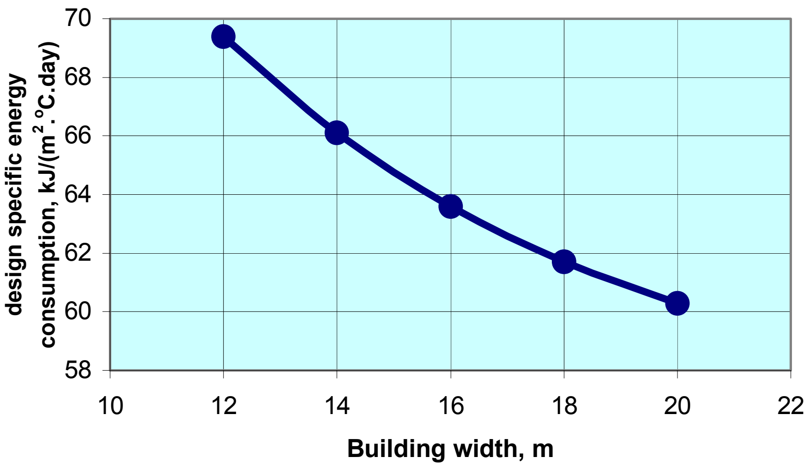
The geometric form of the building has a real influence on energy consumption. In Figure 2, the influence of the width on the building on reduction in specific energy consumption is shown for a nine-story three-section residential building in the city of Orenburg. In this light, geometric criteria for the building compactness have been included in the new SNiP 23-02, as the ratio of the building envelope surface area to the volume that it encloses. The necessary reduction in energy consumption will be achieved by means of building geometry where the following criteria are met: 0.25 m^{-1} for buildings 16 stories tall, and higher; 0.29 for buildings from 10 to 15 stories; 0.32 for buildings from 6 to 9 stories; 0.36 for 5-story buildings; 0.43 for 4-story buildings; 0.54 for 3-story buildings; 0.61, 0.54, and 0.46 for two-, three-, and four-story black or sectional buildings, respectively; 0.9 for two-story and single-story buildings with mansards; and 1.1 for single-story buildings. (This parameter has been used in German codes since 1975.)

Quality control and energy audits

The new SNiP also requires the performance of quality control for the thermal insulation in every building by means of thermographic testing, in accordance with GOST 26629 [8] “Method of thermo vision control of enclosing structures thermal insulation quality,” upon the building’s entry into operation. Such oversight helps to reveal hidden defects and means to remedy them before the departure of the construction crew from the site. The new SNiP also requires selective monitoring of air permeability of the inhabited areas of buildings entering into operation, in accordance with the new GOST 31167 [5].

The new code also has a section on building energy audits, which are defined as a sequence of activities intended to determine the energy efficiency of the building and to assess measures for increasing energy efficiency and energy conservation. The results of energy audits are used for general classification and certification of buildings according to energy efficiency.

Figure 2. Change in specific energy consumption depending on the width of a residential building (9 stories, 3 sections) in the city of Orenburg



The specific elements of an energy audit depend on how the task is defined. For example, an energy audit may be carried out with the goal of rating the building in terms of energy efficiency in accordance with the new SNiP or regional code. The goal of such a step for government enforcement agencies is to reveal those buildings that must urgently be renovated from an energy-efficiency point of view. The other type of energy audit is carried out with the goal of energy-related certification of the building. In this case, the goal is to document that the operating building complies with various code requirements.

In order to confirm that the specific energy consumption for heating for an existing building already in operation corresponds to code-stipulated values and oversight requirements of the new SNiP, three new standards have been developed by a broad team of participants, including ourselves, and confirmed by Gosstroy of Russia in 2003:

GOST 31166 [4] “Envelop constructions of buildings and structures. Method for calorimetric determination of the heat transfer coefficient.”;

GOST 31167 [5] “Buildings and Structures. Method for determination of air permeability of buildings envelops in field conditions.” (made consistent with ISO 9972);

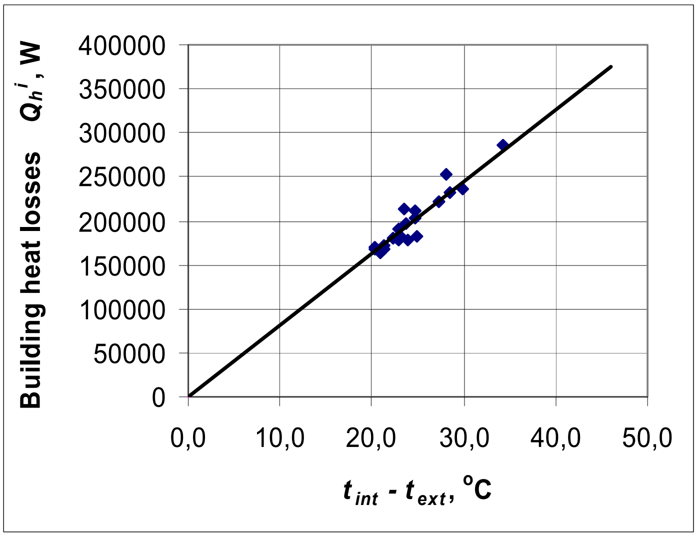
GOST 31168 [6] “Houses. Method for determination of specific heat consumption for building heating.”

The latter two standards are fundamental, providing a method for oversight over parameters shown in compliance documents and energy audits for existing buildings.

These standards have also been adopted in the Republic of Kazakhstan.

The essence of the method for determining specific energy consumption for heating is that during the heating period, over predetermined intervals, energy consumption, average indoor and outdoor air temperature, and the averaged intensity of incident solar radiation on horizontal surfaces are measured, either for occupied areas (such as a single apartment) or a whole building. For the same intervals, values are calculated for overall heat losses through the building envelope, equal to measured energy consumption plus internal and solar gains. Then, for calculated heat losses and corresponding temperature differences between indoor and outdoor air temperature, one can generate a linear regression reflecting the greatest fit to these data (see Figure 3). According to this linear relationship and the internal dimensions of the premises and of envelope elements, one determines the overall coefficient of heat transfer through the building envelope and the specific energy consumption for heating, and also can assign an energy-efficiency classification to the building.

Figure 3 Functional relationships between building heat losses and temperature difference between indoor and outdoor air



Monitoring of energy performance of the eleven storied residential building during preration (see Figure 4) was conducted on March, 2004. The building is built according to the Swiss technology by the "Plastbau" system.

The result of the study is shown in Figure 3. Using the metering data (see the rectangle points in Figure 3) the total heat transfer coefficient of the external building envelops, is equal to 1.044 W/(m^2·°C), was calculated. For comparison, the design value of this coefficient is equal to 0,993 W/(m^2·°C). Thus, obviously the real value of the total heat transfer coefficient practically coincides with the design value. The specific heat energy consumption during the heating season was also calculated by GOST 31168 and is equal to 70,33 kJ/(m^2·°C·day). This energy consumption is a little bit lower than the code-regulated value which is equal 72 kJ/($m^2 \cdot {}^oC \cdot$day). According to building classification on the figure 1 this building is regarded as a "normal".

Figure 4. The residential building for the monitoring of energy performance

Regional Energy Codes

The legal basis of the regional codes in Russia is set forth in Article 53 of the "Civil Construction Codex of the Russian Federation." At present, 50 regional codes have been adopted and confirmed by Gosstroy RF, and 3 more are in the stage of final editing. See Figure 5.

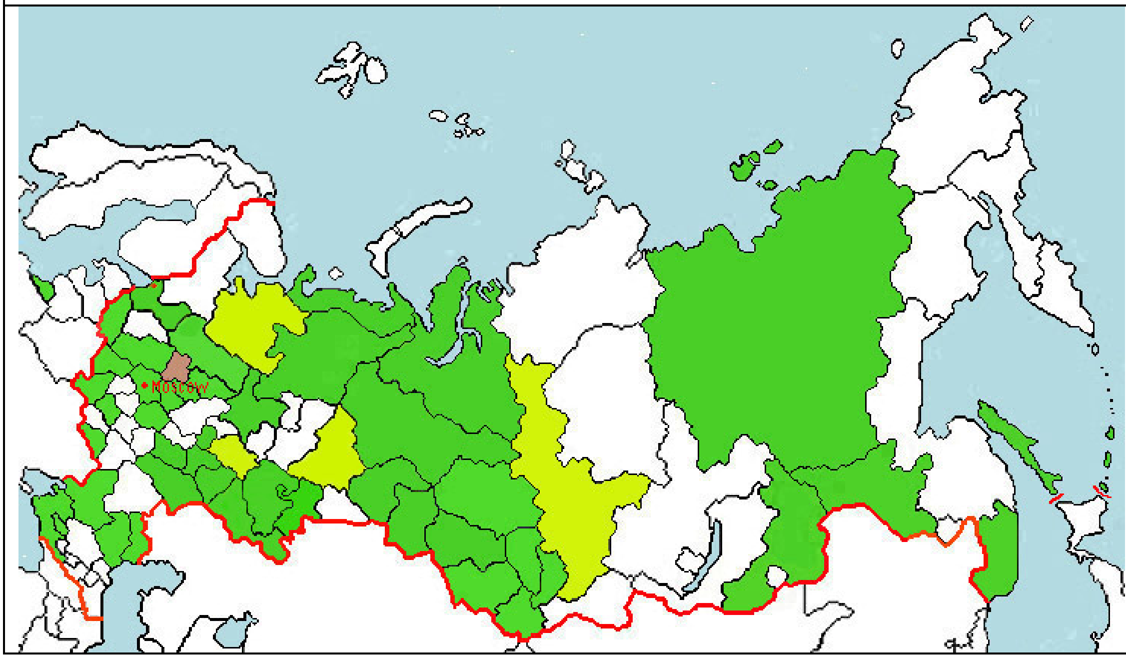
Regional codes are mandatory for all Russian and foreign entities involved with construction in the given region, even in isolated cases where federal codes do not apply. All regional codes are developed according to criteria described above – they may be consistent with federal codes, or more stringent. Regional codes also contain detailed climate parameters not contained in the federal code, including heating-season degree days and solar radiation under real cloud conditions. In a few regions, climate data are provided on a district-by-district basis.

Energy Passports

The new federal SNiP and regional codes require the completion of an «Energy Passport» for the building, a document intended to verify energy performance in design, construction, and operation. Energy Passports also give potential buyers and resident's information on what they can expect regarding the building's energy efficiency and real costs, helping to stimulate market preferences for high-performance buildings.

During construction, there are often deviations from design – for example, a change in material or components. As a rule, these deviations must be allowed by the design organization. But in practice, there do exist cases where the construction company carries out unsanctioned changes from the original design. Therefore, upon the building's entry into operation, regional codes require that the design organization complete a second, updated Energy Passport with the same goals and content as the one completed during design.

Figure 5. Regional Codes in Russia, 2004



Note: Regions with dark shading have their own codes. Regions with light shading have codes in the final stages of editing.

For existing buildings, the new federal code and regional codes require selective inspection and review to determine compliance with relevant codes, or to assess the need for renovation. The results of this review must reflect technical, energy-related, and thermal aspects, as well as technical and economic analysis of options for renovation.

To help ensure quality in energy-related aspects of building design, the new federal code and regional codes also require the preparation of a special section of the building design, entitled "Energy Efficiency." This section must include summary parameters for energy performance for various parts of the building design. These parameters are presented side-by-side with code-required values. The section is completed at review stages for pre-design and design documentation. The design agency completes the section; funding the work is the owner's responsibility; as necessary, the owner or designer may choose to engage the services of outside specialists.

In issuing final approvals, regional or municipal plan review agencies must specifically confirm the compliance of the pre-design and design energy-efficiency documentation with relevant codes.

Computer tools

To facilitate and standardize calculations, a PC version of the Energy Passport has been developed. This version enables quick calculations, iterative assessment of design variants, and comparison with code values at all stages of design, construction, and operation. It is available upon request to interested organizations.

Three other programs for PC are available, intended to facilitate thermal-engineering calculations in the design of building envelopes. The first program enables the user to carry out complex calculations of envelope performance under conditions of steady-state linear heat transfer, as described in the federal supplemental guidance manual, and helps to verify compliance with code-required values for thermal resistance, thermal stability, air permeability, vapor permeability, and thermal assimilation of floors.

The second and third programs define the overall thermal resistance of heterogeneous elements with two- and three-dimensional temperature fields, under conditions of steady-state heat transfer.

Harmonization of codes with European standards

The new federal SNiP and regional codes are consistent with international levels and in particular, with the requirements of EU Directive (law) №93/76 SAVE [11] and EU resolution №647 [12] on a long-term program for energy efficiency in buildings, with the new German executive order EnEV 2002 [13], and with the new EU Directive [14] on energy-efficiency indices for buildings. In terms of approach, the Russian codes even go beyond those of EU countries. It is interesting to compare the code-required energy performance targets of Germany and Russia; German codes stipulate targets that fall between 40 and 96 kWh/(m^2·yr) for baseline heat-supply systems. Values from Russian regional codes and the new federal SNiP, adjusted to Germany's climate conditions fall between 55 and 105 kWh/(m^2·yr). See Figure 6. German codes are clearly more stringent - by 20 to 27 percent for multifamily residential buildings, and 9 to 10 percent for single-family homes.

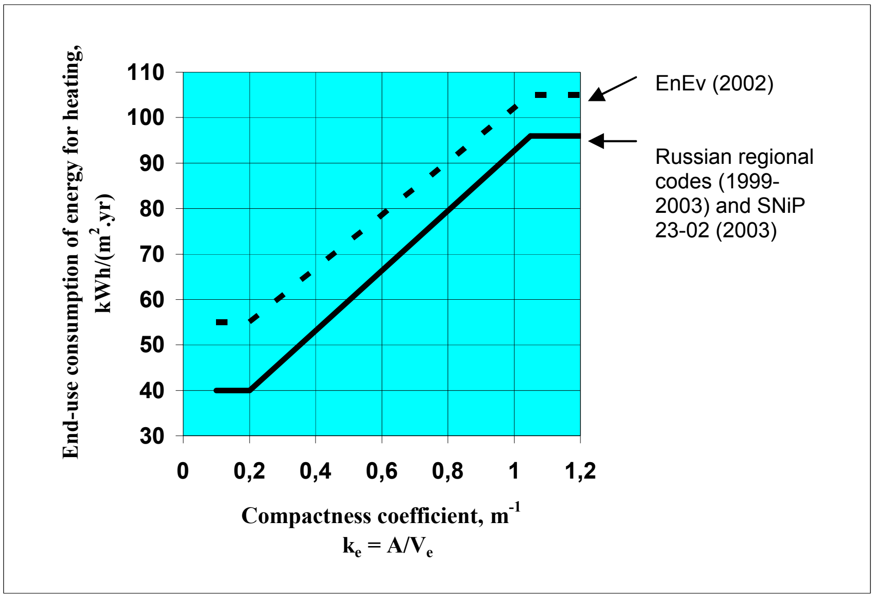
The Codes are take account according to EU directive on the energy-performance of buildings:

- a system approach to the buildings and the total energy use for heating;
- an energy declaration / energy passport for the energy certification;
- the measures in both new and renovate buildings;
- a general principle of methodology for calculation to obtain the overall energy performance of a building including energy for ventilation, internal heat gain and solar radiation;
- an efficiency of heat supply system;
- a thermal comfort.

The Codes are not taking account (except Code for Moscow):

- a domestic hot water supply;
- an artificial lighting.

Figure 6. Comparison of Required Energy-Performance Levels of Russian Regional and Federal Codes, and Germany's EnEV-2002



Codes of the Republic of Kazakhstan

New codes have also been developed (SN RK 2.04-21 [15], adopted on May, 2004) in the Republic of Kazakhstan (RK) — one of the most successfully developing central Asian republics of the post-Soviet sphere. The rate of GDP growth of this republic over the past few years has not fallen below 10 percent per year, in comparison with 5 percent in Russia. Thanks to economic reforms and liberal laws, foreign investment in this republic has grown without cease, especially from western countries. The building sector is also growing mightily. But the RK has practically no base of codes of its own for the building sector. Buildings are being built in accordance with the expertise of construction companies hired by the future owner or investor, often according to the codes of the country where hired companies are based, or according to Russian codes. In this light, the government of the RK has set forth a goal of creating its own code for energy efficiency in the building sector and of including in these new code performance targets for civilian buildings that correspond to world levels, as well as methods for oversight and enforcement.

We have been developing this code in close collaboration with the Department of Technical Codes and New Construction Technologies of the Committee for Construction Affairs of the RK, under the support of the U.S. Environmental Protection Agency.

The table on figure 7 below presents required target values for area-specific consumption of energy for heating buildings, as proposed for the RK code, in comparison with levels implied by codes in force between 1980 and 1995.

In establishing target values for energy performance, we proceeded based on a criteria of 40 percent reduction of energy consumption relative to the average level of energy consumption of existing buildings in the republic, assuming connection of buildings to a baseline (centralized) heat-supply system. The average republic-wide level was defined based on Russian construction standards that were in force in the RK between 1980 and 1995.

Figure 7

Specific Energy Consumption for Heating Permitted by Building Codes in Kazakhstan, kJ/(m^2·^{o}C·day) [kJ/(m^3·^{o}C·day)]								
Building type	**Number of stories**							
	1-3		**4-5**		**6-9**		**10 and higher**	
	1980-1995	**2004**	1980-1995	**2004**	1980-1995	**2004**	1980-1995	**2004**
Residential	192	**135**	158	**90**	133	**83**	117	**75**
Educational and Office Buildings	[70]	**[38]**	[55]	**[33]**	[50]	**[30]**		
Medical facilities	[57]	**[34]**	[52]	**[31]**	[50]	**[30]**	--	**--**
Preschools	[75]	**[45]**	--	**--**	--	**--**	--	**--**
Offices	[60]	**[36]**	[45]	**[27]**	[39]	**[23]**	[33]	**[20]**

The expected effect in the first year of code implementation in the RK is almost 600 TJ in avoided energy consumption, and the cumulative effect through 2013 is projected at 33000 TJ. This energy savings implies a reduction in carbon dioxide of close to 600,000 tonnes.

Pilot design according to the draft RK code

Our project team has scarred out a pilot design according to the draft of the new RK code for a ten-story residential building in the educational-scientific complex for "KazGYuU," which will be built on the left bank of the Ishim River in Astana. The design is at the stage of initial sketches.

The general appearance of the building is shown in Figure 8. The designed building consists of four sections and 10 stories, the first of which is nonresidential and intended for an array of service facilities. Construction of the building is monolithic-frame from reinforced concrete, without crossbeams. The attic and crawlspace are unheated, and the floors are directly on the ground. Exterior walls are made of brick with efficient insulation, windows with triple-glazing and paired-sectional frames. Glazing constitutes 18 percent of the surface area of the walls, as permitted by code. The building is connected to centralized heat supply. The energy-efficiency class of the building is normal.

Results of the pilot design

The results of calculations are presented as the components of the heat balance of this building, in Figure 9. The figure shows the following parameters: $\boldsymbol{Q_h^y}$ – overall energy consumption for heating, $\boldsymbol{Q_t}$ – transmission heat losses, $\boldsymbol{Q_v}$ – heat losses via air leakage, $\boldsymbol{Q_i}$ and $\boldsymbol{Q_s}$ – internal and solar gains. From the figure, one can see that the greatest heat losses are through the envelope ($\boldsymbol{Q_t}$), which is related to the architectural form of the building. Russian building design experience in compliance with regional codes shows that usually, transmission heat losses Q_t are comparable in terms of absolute values with heat losses via air leakage and with internal and solar gains.

Figure 8. The pilot building design

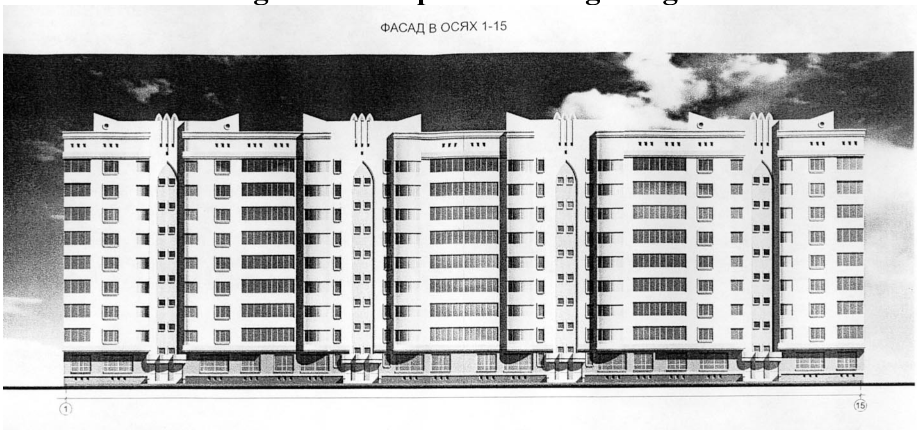
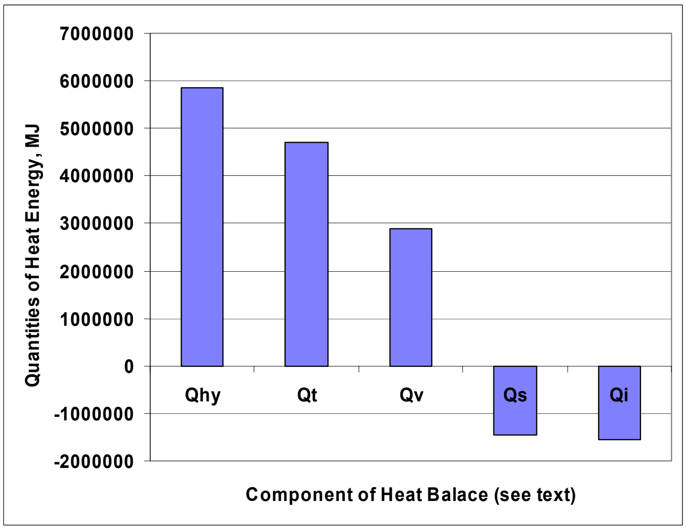


Figure 9. Heat balance
for pilot design of building compliant with new RK Code



Having analyzed the results, we can draw the following conclusions. The building's geometry and floor plan do not comply with the recommended values for compactness coefficient from the RK code – the proposed design of the pilot building has a compactness coefficient of 0.33, while the recommended value is 0.29. This implies that the architectural plan is not sufficient in terms of energy efficiency, though it is permitted by code. This deficiency requires compensation with increased thermal performance of the envelope.

From the thermal-engineering parameters chosen for the design, we get the following code requirements for envelope elements: for walls, 2.65 $m^2 \cdot {}^oC/W$; for windows, 0.55 $m^2 \cdot {}^oC/W$; attic floors, 4.73 $m^2 \cdot {}^oC/W$; ground floor 3.23 $m^2 \cdot {}^oC/W$. For compliance with these requirements, the following wall types would be recommended (layers listed from exterior to interior):

- cement-sand plaster 20 mm thick;

- a red brick layer 250 mm thick;
- a stiff mineral-wool plate 180 mm thick;
- fiberglass netting;
- lime or polymeric plaster 10 mm thick.

Another variant was also considered, involving a change to more efficient windows made of a single-space sealed glass unit and glass with a hard selective coating in separate frames, with a thermal resistance of 0.65 $m^2 \cdot {}^oC/W$. In this case the requirement for thermal resistance of walls would then fall to 2.25 $m^2 \cdot {}^oC/$, equivalent to a wall with a mineral-wool plate 150 mm thick – that is, 30 mm thinner.

The pilot test of the RK building confirms the real practicability of the proposed codes.

What Next?

Reduction of energy consumption in the building sector is a complex problem, the most important element of which is designing and verifying thermal performance. Over the next ten years, further improvements in envelope thermal performance will probably not be readily achievable; instead, further savings will come from more efficient ventilation systems (systems that deliver air on demand, heat recovery from exhaust air, and so on) and from improved control systems, including nighttime automated temperature setback. Furthermore, perfection of an algorithm for calculating energy consumption in public (nonresidential) buildings is also needed.

Performance-based code-compliance methodologies for prefabricated buildings are needed, though heat losses through the envelopes of these buildings is relatively small compared with inefficiencies of HVAC systems. The other part of the heretofore unresolved problem is determining the level of thermal performance for buildings with mechanical cooling. Future code methodologies will also be developed in this area. In this case, the level of thermal performance required from the point of view of energy efficiency may be higher, than determined based on heating alone. This means that for northern and central regions of Russia, code requirements may be based on heating considerations alone, but in southern regions, requirements may be driven as much (or more) by cooling as for heating. It will evidently be worthwhile too to create integrated code requirements for energy consumption for domestic hot water, electricity consumption for lighting and other needs, and also for gas – thus leading to a code that is based truly on whole-building energy performance.

Conclusion

- A new generation of codes has led to real results in design and construction of efficient buildings, and accompanying standards have helped clearly define key parameters for code-compliance inputs and assessment of energy performance of operating buildings. New code methodologies were first approved and implemented in great numbers at the regional level in Russia; the experience gained from regional codes has confirmed the applicability of these new approaches, and has made possible the development of codes with similar innovative elements at the federal level in Russia and in Kazakhstan. There is no precedent for such change in codes in Russia, Kazakhstan, or the former USSR.

- New codes have made a wider range of compliance options available to designers, including building geometry as well as selection of materials, components, and heating systems, thus leading to improved overall building design quality. But taking advantage of these options requires more effort and expertise. To simplify the use of the performance approach, the Energy Passport was developed. Designers have met this documentation system and its computer version with enthusiasm, and in general, complaints about the complexity of new codes dissipate after demonstration of automated compliance calculations.
- The principal methodological basis of the new codes and their basic requirements are consistent with advanced international levels, and these codes are harmonized with European codes and standards.
- Russian codes and standards for energy efficiency, despite pessimistic predictions, have created conditions for market transformation for new construction technology, have made possible a construction boom, have increased employment, have led to real energy savings, and have increased indoor comfort.

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RETHINKING ECOLOGICAL EDUCATION FOR SUCCESSFUL SUSTAINABLE BUILDING

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Abstract

Rethinking ecological education of specialists – architects, designers, builders, and all stakeholders of building process, is necessary for ecological reorientation of their thinking and actions with purpose of successful sustainable building. Absence of ecological thinking of all stakeholders of building process and of all townspeople leads to deviation from sustainable building, to contradictions and casual decisions. These deviations are well appreciable in Russia, in Moscow, and in a number of cities and countries of the world.

For example, designers and city dwellers in Moscow have usually low level of ecological formation and education. This circumstance leads to poor condition of components of landscape, to ecologically unacceptable high-altitude construction of dwelling houses, etc. All soils of city are polluted greatly (centre), middling (majority) or faintly (small sites of periphery), the condition of subsoil waters is those. No vegetation in city is completely healthy; snow is polluted greatly or middling, there is noise pollution. There is no square meter with ecologically favorable environment on map of ecological condition of territory. New kind of gardening has appeared in central part of city - container gardening which has replaced usual gardening in view of destruction of trees because of impurity of ground. At the same time, many new modern buildings are constructing in city (public buildings, "elitist" apartment houses, offices of rich companies, expensive hotels, shops, restaurants and other centers of entertainments). They do not influence essentially on sustainable development of city. Natural environment around Moscow in connection with new "administrative - ecological" separation from city will play the lesser role in improvement of city environment. Visual environment of city, especially in new bedroom communities, as a whole is negative, rectangular high-altitude silhouette prevails in city, with big flat surfaces and the same iterant figures on facades, negative for eyes. The sound and odor environments - basic sensory environments - are negative also. Each evening appear beggars, homeless, alcoholics, outcasts of society, and among them are children. There is growth of "elitist" settlements in which

people live behind high fences. Newspapers are filling with advertising of elitist, rich houses and apartments. Installation of steel doors, steel lattices at windows, signal system on door, on motor vehicles, prospers. Apartments and especially "elitist" private residences become similar to military fortifications. At night instead of birds, squeal disturbed machines. Many things are directing on division, into dissociation of inhabitants. Sustainable development is impossible in such city. New educational courses – “architecturally-constructive ecology”, “ecological infrastructure”, “urban ecology”, - serve purpose of sustainable development. These courses are very topically not only for Russia and Moscow, but also for many other countries and cities with unresolved environmental problems.

1. Introduction in necessity of rethinking ecological education

Why it is very important to teach to future specialists - civil engineers new ecological courses? Why it is important for modern architects and civil engineers to know the architecturally -building ecology and ecological infrastructure for support and preservation of life medium? This position of principle does solely topical problem of making the healthy cities. Making the sustainable biopositive cities is connected with the conservation and restoration of completely natural environment and, consequently, of life on the Earth. Essential principle of sustainable eco-city creation is ecological balance of nature with city. These sciences and their usage will allow creating sustainable healthy cities and settlements, to stop retreat of nature, and to achieve state of sustainable development. The healthy and sustainable cities can become the major achievement of mankind during all its history. The nature recedes under man's impact, and for restoration of ecological balance and natural environment, many researchers offer only one way: it is necessary to reduce the area of the anthropogenic changed and built up territories, to return significant part (about third of used territories) "transformed" and polluted territories in natural condition. Such return is impossible at observed growth of urban territories and increase of number of mankind. In my opinion, it is possible to replace this return by sustainable construction, ecological compatibility of territories, sustainable biopositive reconstruction of places of location, buildings and engineering structures, which will allow creating essentially new biopositive objects, allied to nature, non-polluting nature and included in natural ecosystem. The nature will perceive these biopositive objects (buildings, engineering structures, settlements, country) as natural objects, which gradually will result in achievement of stability, restoration of the broken balance and exception of deviation of nature under anthropogenic pressure of the mankind. (Biopositive objects are objects which positively for animate nature, positively interact with nature, with wildlife).
There are precise contradictions of needs of city and nature, which must be removed by help of ecological education and its rethinking (table 1). Architectural, urban, building ecology and ecological infrastructure will allow receiving condition of ecological equilibrium, and also high quality of life in future ecological sustainable cities. If such result will be received, it will allow considering this new science - architecturally - building ecology, and results of its application in practice of construction, the highest progress of mankind. Therefore new sciences should be taught in all Universities of civil engineering.
Unfortunately the nature and human community are characterized by objective instability of development. Necessary for person and healthy biosphere a resilience of Life environment as socially - ecological system is provided for its ability to adaptations in varying world. Adaptive ability of ecological component of Life environment is connected with preservation of necessary ecological infrastructure, of proved volume of nature, with genetic and biological variety. Adaptive ability of its social component depends on set of factors (equality,

satisfaction of needs, fast reaction, flexibility in decisions of problems, balance of authority between different groups, and so forth).

Table 1. Contradictions of needs of city and nature

City and inhabitants	Contradictions	Animate nature and abiocoen
Satisfaction of biological needs	Satisfaction of practically all needs of cities and inhabitants damages to nature in case of absence of their ecological compatibility and reductions of needs to conformity with natural - resource potential of territory	Maintenance of structure of geosphere
Satisfaction of all other needs		Stability, long existence
Reception of all kinds of resources		Maintenance of homeostasis and natural evolution
Granting of territory for activity		Maintenance of circulation of substances and of stream of energy
Absorption of anthropogenic pollution by nature		Support of biovariety
Minimization of dangerous natural phenomena		Maintenance of ecological niches
Adoption on itself roles of the owner of nature		Satisfaction of needs
Estrangement from harmful flora and fauna		Maintenance of adapted interaction in nature
Development of all inaccessible, dangerous landscapes		Minimization of acting pollution

Resilience of environment of life is its ability to return in initial condition after changes under influence of negative factors, ability to sustain external and internal influences without destruction and changes of basic functions in lifetime period. It has fundamental value as major condition of evolution of nature and person. Life environment is divided on unconditionally invariable preserving parts (nature and its resources), and on variable during development of mankind (medium of cities, socio - economic medium). Nature in all its diversity is unique evolutionally reasonable Life environment. Therefore, conservation of Life environment and its major part - natural environment, in spite of quantity of complexities of solution of this problem, is vitally necessary for mankind.

The possible ways of conservation and restoration of dynamical social-ecological life environment are planned on the basis of wide ecological infrastructure, sustainable building and eco-city creation, ecological compatibility of thinking and activity, constant ecological formation and education with inculcating of new ecological philosophy and ecological ethics. "Soft" adaptive management should allow cooperating with nature in conditions of constant changes and uncertainty.

Fundamental concepts about role of ecological framework and about ecological corridors at different levels play determining role in ecological education (tables 2, 3). Now, due to man-caused activity, ecological framework includes not only the Earth, but also near space. Ecological (natural) framework of Earth is system of large natural territories incorporated and passing each in other (woods, meadows, mountains, plains, bogs, rivers, lakes, seas, deserts, glaciers, etc.), including ecological corridors which the indissoluble interrelation allows to support ecological equilibrium, environment of life, and biovariety.

The optimum ecological framework of big territory is the spatial cellular network covering all territory of country, region, large cities, which cells are large sites of nature (including territories of various degree of safety and mode of use). These territories naturally can pass one in another, naturally contact and cooperate among themselves (for example, land and water pools, seas and rivers running into them, forests and meadows adjoining to them, rivers, mountains, bogs, etc.).

The ecological framework should include all spheres of the Earth - lithosphere, hydrosphere, atmosphere, and biosphere as they create conditions for maintenance of ecological equilibrium and counteraction to anthropogenic loadings, through them interrelation of natural territories occurs.

Table 2. Ecological frameworks

Level	Functions	Influence of urbanization
Cosmic		
Ecological framework of near space including the Earth	Connections of physical fields of space and planets: sunlight, ebb and flow, photosynthesis, magnetic storms, and so forth	Greenhouse effect, pollution of near space, negative influence on climate of planet
Global		
Ecological framework of the Earth	Interrelations between all components of landscapes of the Earth, all spheres - geo-, bio-, hydro-, atmo-, and techno sphere, between the natural and transformed territories	Interruption of global streams of substances and energy, global ways of migration of animals and plants, global reduction and division of sites of nature, global destruction of nature, flora and fauna, influence on global natural evolution
Continental and oceanic		
Ecological frameworks within limits of continents and oceans	Interrelations between components of natural and transformed nature, maintenance of streams of substances and energy, ways of migration	Interruption of continental and oceanic streams of substances and energy, ways of migration of animals and plants, reduction and division of sites of nature
Regional and city		
Ecological framework of region, area, city	Joining up of all city and country natural territories with purpose of maintenance of biovariety, ways of migration, improvement of quality of environment	Regional interruption of streams of substances and energy, ways of migration of animals and plants, reduction and division of sites of nature
Block (residential area)		
Ecological framework of city blocks of buildings	Joining up of green territories with the purpose of exception of island effect, improvement of quality of environment, maintenance of biovariety, encouragement of pedestrian traffic	Building up of natural territories, complication of free, not interrupted pedestrian traffic of inhabitants, ways of migration of animals and plants, reduction of biovariety

Table 3. Kinds of corridors

Kind of corridors	Location	Function
Ecological corridor	On surface of ground	Free migration of animals and exchange of plants
	In water	Free, not interrupted movement of all waters, migration of water animals
	In air	Free, natural movement of air, migration of birds
	In ground	Free, natural movement of subsoil waters and animals
	On borders of landscapes	Free moving of animals, waters, air, an exchange of plants
Green corridor	On surface of ground	Association of sites of "first" and "second" nature, free migration of animals, seeds of plants
Bio-corridor	On surface of ground	Free moving of animals under or above artificial constructions

It is necessary to know and to use recommendations of new scientific directions – architectural - building ecology, sustainable ecological infrastructure, and sustainable (resilient) environment of life for rethinking ecological education and for creation of eco-cities. There, where interrelation of these territories is broken or excluded in consequence of anthropogenic influences (construction of cities, roads, and other poorly surmountable or insuperable barrier), is necessary its restoration by creation of connecting ways - ecological corridors, including "green" corridors. In framework allocate the areas with various mode of use and with various level of natural safety, including natural protected territories. This framework is necessary for maintenance of balance of territories of various purpose to provide ecological equilibrium.

Let's note, that in nature there are insuperable and in part insuperable barrier (oceans, seas, rivers, deserts, high mountains) between separate large (continents) and less large territories. Their role in history of the Earth, in natural evolution, is very great: due to this were created unique biocenose, distinguished by specific variety. Artificial overcoming of these natural barriers with help of person has not brought any advantage. Artificial huge barrier on ways of natural migration of animals (big highways, big dams on rivers, large cities, and very long fences) are negative objects for nature.

Natural and improved cultural landscapes are a basis of ecological framework of city – united with help of "green corridors" and "green wedges" the sites of nature of various areas. The ideal ecological framework should look like a network with "cells" of nature including all components of natural and cultural landscapes in regular intervals distributed on the area - forests, parks, rivers, lakes, meadows, hollows, heights, squares, gardens and so forth. "Corridors" (cores connecting cells) can be also natural components - rivers, brooks, forest belt, "wedges" of forests and meadows, and other long and narrow natural objects. At their absence, it is necessary to create cultural green corridors that can be accompanied by formation of new "cells" of framework if their area in territory of city is small or if their number is insignificant.

2. Basic principles of ecological compatibility, which use in new educational courses

Five basic principles of ecological compatibility may be used for creation of biopositive objects and technologies [1, 3-5]:

1. The most important principle is the principle of equivalent substitution. This principle has the following meaning: any artificial objects (city, house, street, etc.), which have replaced a part of natural environment, act as substituted natural environment together with their main functions (for example, they produce biomass, oxygen, purify air and water, allow or no to interrupt natural circulation of matters and energy, let niches for biota, introduce only processed waste in the volume that in replaced environment, etc.).

2. The principle of ecological adaptation: all artificial objects or technologies must be adapted to environment. They don't destroy flora and fauna, must use natural renewing matters and energy, must save matters and energy, must self-decompose and self-destroy after realization of their functions with return of elements in natural circulation or works process; they don't interfere in landscape, etc.);

3. The principle of deep biological analogy (all city techniques and technologies are similar to natural objects and technologies). There are eco- and biotechnology, they do not pollute nature and must give minimum of waste similar waste in biosphere cycle. An analogy must be deep; it must be founded on profound study of construction and function of natural objects. They do not bring harm to nature and do not use nonrenewable natural resources. Buildings and structures must be "soft" and "clever" objects and must self-react on various external influences, must create high quality of life.

4. The principle of ecological support, ecological restoration of nature (bio-restoration): all buildings and structures perform the additional duties of restoration of nature. They help to return formerly excepted matters and energy, to create new "anthropogenic" deposits of minerals, to save high quality energy.

5. The principle of beauty, harmony, proportion with nature: all artificial objects are in harmony with landscape; they conform to sizes of landscape elements and to man sizes; their forms are founded on use of natural forms. The healthy city must contain new buildings, structures, techniques and technologies with application of principles of biopositivity

(ecological compatibility). All buildings and structures allow coexisting total of living organisms. Special constructive measures serve for guarantee of their life.

3. Educational courses for rethinking ecological education

New educational courses are the sciences about ecological, healthy, sustainable and beauty cities with high-quality environment of person's life and with environmental technologies [1, 3-5]. The first course - architecturally - constructive ecology – contains two complexes of ecological knowledge's: complex of general ecology knowledge that allows forming an ecological thinking of builder, and complex of special ecology thinking for ecological compatibility of building. The second course – ecological infrastructure - is devoted to major problem of modern town-planning both construction - conservation and improvement of ecological infrastructure as basis of conservation of healthy life environment of person and ecological basis of environmental engineering of territories. The third course – resilience of life environment – is used for understanding of wide complex of problems of life environment as social-ecologic subsystem and of ways of their decision.

Ecological infrastructure (complex of natural resources, constructions and systems, providing maintenance of environment of human life) at all levels - from the whole country up to cities and to separate buildings and engineering constructions – can be basis of guaranteeing of environmental technologies in future healthy cities, of sustainable building and town-planning (fig.1). Ecological infrastructure in scale of country include the interactive among themselves built and natural territories, necessary quantity of natural protected territories, an ecological framework of territory of the country with ecological corridors, large technological systems of infrastructure, nonrenewable and renewable natural resources, system of monitoring. Social - economic infrastructure in scale of city includes ecological framework of city and green corridors, soil - vegetative layer, biopositive and "clever" buildings, systems of land-improvement and permaculture, ecologically restored landscapes and reconstructed buildings, favorably perceptible city environment, favorable conditions of life.

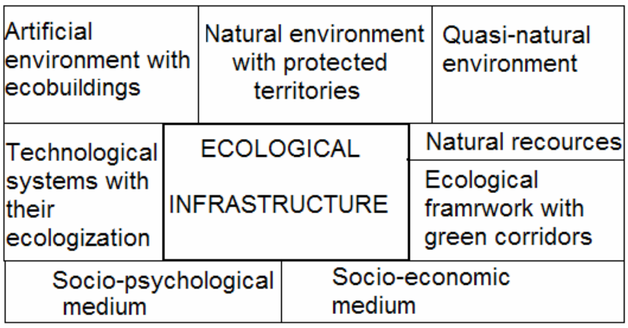

Figure 1. Structure of ecological infrastructure

The ecological infrastructure serves to conservation and support of ecologically proved quality of medium of life at all levels - from whole country up to cities both separate buildings and engineering structures. Ecological infrastructure on national scale include the interacting among themselves transformed and natural territories, the relation between which should be ecologically proved with the purpose of maintenance of homeostasis and ecological equilibrium; necessary plurality of natural guarded territories, ecological framework of territory of the country and ecological corridors, large technological systems of traditional infrastructure, nonrenewable and renewable natural resources, system of monitoring.

Components of ecological infrastructure provide, thus, requirements of conservation of medium of life (fig. 2). Therefore role of ecological infrastructure as base of ecologically supporting, nature-conservative control of territories, is great. Ecological framework of city, ecological compatibility of all traditional technologies, green corridors, quality of life in cities, eco-blocks and apartment houses giving high quality of medium of life, conservation of soil-vegetable stratum, ecological restoration of landscapes and ecological reconstruction of all buildings and engineering structures support a maintenance and conservation of ecological infrastructure of city.

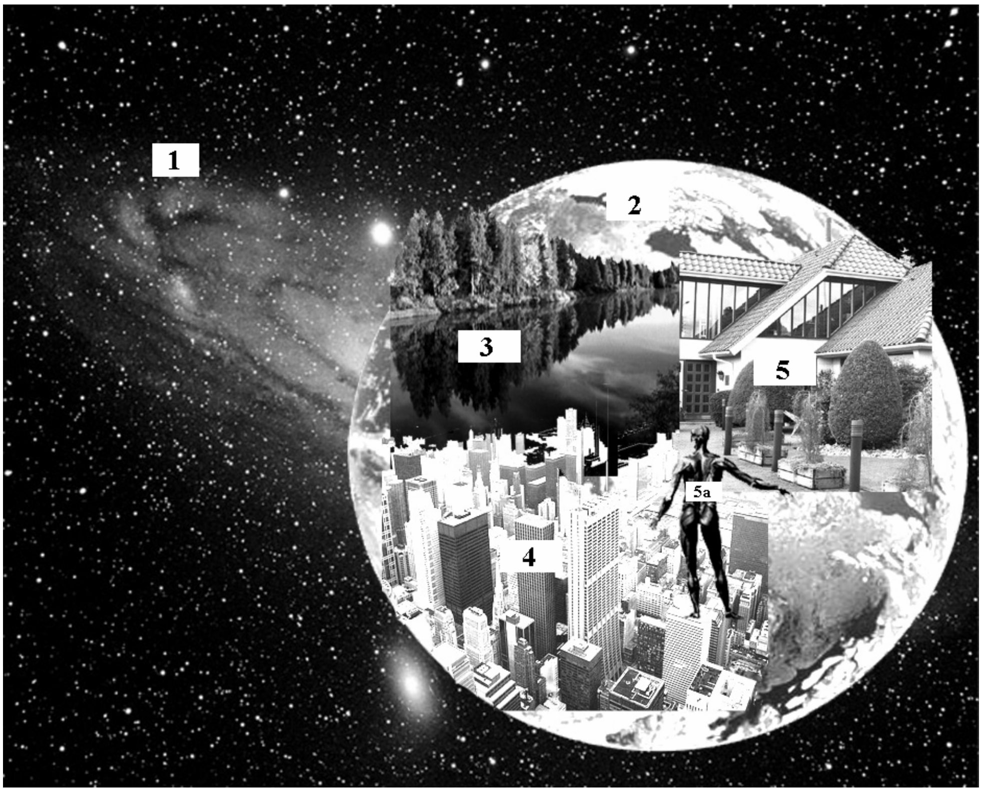

Figure 2. Life environment: 1- cosmic; 2 – global; ; 3 - remote; 4 - near; 5 - nearest; 5a - internal

The architecturally - building ecology is wide area of applied ecology, organically connected practically with all sections of theoretical and applied ecology. Thus, the architecturally - building ecology consists of number of organically connected among themselves and interpenetrative each other of sections. Frequently same problems are considered in different sections, thus the purpose and depth of their consideration varies little. On the basis of this approach we offer structure of architecturally - building ecology (fig. 3):

Landscape ecology Ecorestoration of landscape	Urban ecology. Love to city	Architectural ecology. Ecological beauty of city
Ecoreconstruction of buildings Ecology of building materials	**Architectural -constructive ecology**	Sensory ecology Construction ecology Technological ecology Ecology of litosphere
Energy-active buildings	Intellectual buildings	Energy-saving buildings Human ecology
Theoretical ecology	Applied ecology	

Figure 3. Structure of architecturally - building ecology

Both described above courses serve the purposes of education of architects and builders (first of all of students, and also engineers) in area of ecological compatibility of cities, sustainable designing both construction, and conservation of healthy medium of life.
The architect and engineer - builder as the basic participants of process of creation of environment of man should represent how cities and buildings will influence on environment and on animate nature, how natural environment will cooperate with artificial environment. Knowledge of laws of development of nature, ecological infrastructure and architecturally - building ecology, will be help to exclude negative influence of buildings and structures on nature, to enter them organically in natural environment, to support development of natural systems and simultaneously to increase quality of life. In this connection we shall formulate tasks of architecturally - building ecology [1, 3]:
1. Creation of ecologically beautiful and healthy urban environment, including environment inside buildings;
2. Study of features of interaction of natural environment and settlements (including all kinds of human activity in cities) and development of ways of ecological compatibility of this interaction in view of equal of environmental space of countries, maintenance of sustainable development of settlements;
3. Sustainable designing and construction, maintenance urban, architecturally - ecological and building-ecological means of support of ecological balance between cities and natural environment, sustainable development of cities;
4. Increase of quality of life in cities and apartment houses by help of ecological compatibility of life and activity of man in city, ecological restoration of natural environment, approach by natural environment, land-improvement, and creation of attractive image of city, soft interaction of city with natural environment;
5. Ecological optimization by help of sustainable urban- and architectural planning, design, technological decisions in view of exception of negative influences on environmental nature and restoration earlier broken environment, restoration of anthropogenic landscapes;
6. Use of ecological buildings and structures, and also town-planning, architectural, constructive, technological decisions perceived by natural environment as related to it objects and included by it in ecosystem, assisting to existence, restoration and development of natural environment;
7. Ecological reconstruction the earlier built cities, separate buildings and structures.
8. Economy of all resources, their sustainable consumption, and use in the greater measure of renewal resources, reduction and exception waste, with the purpose of achievement of sustainable development at equal environmental space for all countries;
9. Application of natural and similar to nature ecological materials, and ecologically admitted (ecologically allowed, ecologically allowable) waste of manufacture at manufacturing building materials and products with the purpose of exception of throw-out of waste in environment;
10. Forecasting and estimation of possible negative consequences of construction, operation new and reconstructing of cities, buildings and structures for an environment;
11. Timely exposure of objects, prejudicial to an environment, through ecological-economic monitoring, and acceptance of the appropriate decisions;
12. Ecological certification of materials, products, buildings, structures, with the purpose of revealing them ecological compatibility for cities;
13. The periodic analysis of movement of city to the greater stability of development and to ecological compatibility by comparison of the previous and current meanings of indicators of sustainable development.
The basic problems considered with sustainable constructive and technological decisions of buildings are creation of such designs and technologies, which would allow:

1. To not use the ground, suitable for agricultural, recreational use, creation of reserved zones and sites of natural alive nature, for the purposes of construction;
2. To not close or to close minimally surface of ground to not create below surface of ground of impenetrable screens to not interrupt natural evaporation, movement of storm and earth waters, to not interfere with activity of animals in ground;
3. To return in natural condition sites of territory after ending term of operation of building and its disassembly, and also in process of reconstruction as result of displacement of objects in underground space;
4. To plant trees and gardens all outside surfaces of walls and roof (thus are best for using natural substratum); to use soil filled volumes inside walls and between buildings for creation of the connected among themselves sites of ground on building and under building;
5. Maximum "to enter" buildings in landscape; to use spatial designs at new construction and at ecological reconstruction as much as possible to use the requirements of visual ecology; to apply principle of miniaturization in buildings and in technologies (for example, individual boiler-houses instead of large central, etc.).
6. To utilize all waste, to save up energy and water, to use sources of renewed energy, to make buildings by independent from external networks;
7. To make buildings or structures adapted for existence of animate nature; to create substratum and shelter; this would be adapted to the requirements of animals and plants to place them habitat;
8. To use principles of sensory ecology, intellectual systems in buildings, for creation of high-quality environment in city and within the buildings.
9. To create buildings, structures and whole complex - country, cities - with achievement of condition preservation of natural environment, perception by its natural environment as natural component included by nature in its ecosystem.

The resilient (sustainable) environment of life of person is a number of the conditions providing long, practically endless, satisfaction of essential (prime) and other ecologically proved needs necessary for human life, raising quality of life, forming the harmonious social environment. It is necessary for achievement of ecological equilibrium and high quality environment of life to keep ecologically proved territory of nature in all its biodiversity, to change interaction of person and technologies with nature.

Value of environment of life for the modern person is extraordinary great, and its preservation is an exclusive important task (we shall note complexity of this process for dynamical system; obviously, the part of environment of life cannot be kept in a constant kind as the environment of life is in process of constant and intensive changes).

The man lives in abiotic, biotic and social environment (simultaneously natural, quasi-natural, artificial, etc.). This medium includes the nearest to man medium - housing, family, neighbors, place of operation and actuation medium, in which man will spend most part of lifetime; near medium (near to the house territory, green zones, etc.); remote medium providing the people with the foodstuffs and recreation; global medium supporting and retentive all nature. Life environment of man includes quantity of manifold combinations of "natures" - from almost completely artificial (for example, inside chemical workshop, or in the space ship), up to practically natural environment (fig. 4).

Along with these mediums the man is in materially - spiritual cultural medium that includes all artificial world created by man, his national and ethnic features, knowledge, skills, level of intellectual, ethical and aesthetic development, norm of morals and right, attitude to nature etc.

All factors of sensory ecology - visual ecology, odour ecology and sound ecology - play very important part of life environment (fig. 5).

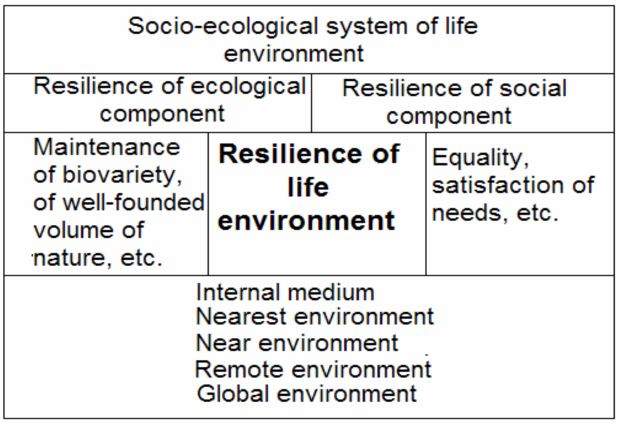

Figure 4. Resilience of life environment

Modern inhabitant perceives all sensory factors on basis of previous conceptions about pleasant and useful sensory influences, but modern sensory medium becomes more and more artificial.

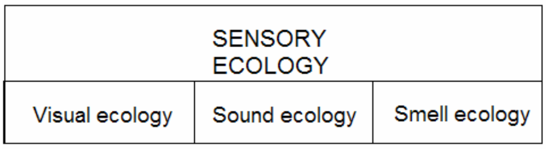

Figure 5. Structure of sensory ecology

4. Conclusion

Rethinking for realization of new ecological thought of all participants and stakeholders of building process on basis of new educational courses suppose new “soft” interaction with nature. “Soft” management during lifetime of buildings and “soft” life-cycle design, which is founded on ecological decisions of buildings and engineering structures, allow reducing negative influences on environment of life. Environment of life is kept with ecological infrastructure; therefore all participants of building process should imagine well structure and role of wide ecological infrastructure in preservation of sustainable and resilient environment of life. New educational courses - "architectural and constructive ecology", "ecological infrastructure", and “resilience of life environment” may help to form new ecological thought of future specialists, may help to preserve and to restore life environment and may help to create environmental technologies and healthy environment of life in all settlements.

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CONCEPTION OF «PROGRAM OF SUSTAINABLE BUILDING» FOR RUSSIA

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Abstract

Enactment and realization of "Program of sustainable construction" for Russia is very important (maybe - vitally important) in view of low quality of life of most people, presence of contaminated settlements, bad use of renewable resources, heavy casualties of energy for heating, and at the same time – in view of presence of heavy stocks of natural recourses and natural environment. Unfortunately Russia moves to sustainable construction very slowly: many town-planners, architects and designers – builders know not about "Agenda XXI on sustainable construction" [1] and about possibility of use of progressive sustainable technologies in buildings and cities. At the same time solar batteries and other solar radiation engineering, heat pumps, etc., are production-run equipment; there is first experience of successful use of geothermal energy in buildings in latitude of Moscow. Russia is passed the new law of heat-protection characteristics of external walls.

Russia has so huge territory with fundamentally various landscapes, geographical natural regions, national (ethnic) features of traditional construction, that the sustainable building for Russia should have especial, complex character. The sustainable building for subtropics differs essentially from sustainable building for tundra, and the sustainable building of traditional Russian villages in areas with abundance of wood is not similar to sustainable building of mega cities. Therefore, development of the conception of Program of sustainable building is necessary for Russia in view of all specific features of big country, as multilevel «Program of plural sustainable building». It must be founded on use of sustainable ecological infrastructure of country and cities.

1. Introduction

The developed conception of "Program of sustainable building» for Russia differs essentially from other programs, both for developed, and for developing countries. First of all, sustainable building is connected to contradictions of socio-ecological development of Russia: there are in Russia the greatest quantity of natural territories that allows to attribute the country to number of the largest countries of the world which territories support the global biovariety and stability of nature of the Earth; there are in Russia largest stocks of many important natural resources - components of ecological infrastructure, which must support the environment of life. At the same time many polluted cities and territories are located in Russia, quality of life in which extremely low. There are not in the country enough means for maintenance of more ecological technologies in industry and in wildlife management; simple ways of maintenance of clean inhabitancy are insufficiently encouraged.

Second, complexity of "Program" is connected with the big size of territory, with variety of geographical conditions - from subtropics up to permafrost, with multitude of natural influences, and with variety of climate. Thirdly, numerous individual barriers of socio-economic and socio-ecological development stand on difficult way of creation and application of «Program of sustainable building» of Russia:

1. Poor ecological and ethical erudition and bad ecological education of population, specialists and managers; it leads to consumer attitude to nature, to depredation of nature, and so forth.
2. Owing to poverty of the most part of population, the problems of a survival stand in the foreground, instead of sustainable development and building.
3. Deepening economic differentiation conducts to stratification of society on classes, which are unable to cooperation in achievement of the purposes of sustainable building.
4. There is as consequences of this economic differentiation an erection inside existing cities behind high fencings small "elitist" settlements for a rich part of society. It is mines of instability pelted in future.
5. Imperfection of ecologically orientable laws and mechanisms of their execution.
6. Homelessness and criminality.
7. Depredation of «new capitalists», who interested in fast extraction of most valuable natural resources for the fastest reception of super profit.
8. There is heavy load of former forcible decisions and pollution, and use of dirty out-of-date technologies, existence of very much-polluted cities and dumps, and absence of means for treatment plants.
9. There is heavy load of imperial thinking, problem of mutual relation of nationalities, military conflicts, and terrorism.

Taking into account complex of all above-mentioned features lays in a basis of the developed conception of multilevel «Program of sustainable building». «Program of sustainable building» for Russia will have termless character, it must be based of creation of effective ecological infrastructure providing the environment of life and «soft» interaction with nature.

Sustainability both sustainable construction and architecture have the special, complex and poorly investigated meaning in huge Russia. Russia is country with the biggest area of territory (17075,4 thousand km^2), with huge variety of landscapes, climatic conditions, geological structure, national features (there are in Russia representatives about 130 nationalities, speaking on 150 languages), and anthropological variety of peoples.

Russia is country with huge stocks of natural resources, influencing on sustainable development, at the same time not possessing the advanced economy. The level and quality of life of the most part of the population do not correspond to requirements of sustainable development. Inclement climate (long frosty winter during which from 4-5 till 9-10 months the ground is covered with snow) predetermines the big expenses for heating and illumination, on cleaning of snow in cities; on more often repair of buildings and engineering constructions.

In Russia all is huge: huge plains (West Siberian plain have the area more than 3 million km^2), permafrost (11 million km^2), bogs (In Western Siberia occupy territory 1,7 x 1,7 thousand km.), freshwater lake Baikal in volume 23000 km^3. The huge mosaic of landscapes has

direct influence on sustainable building – from polar and glacial deserts, tundra, coniferous and deciduous woods, steppes, deserts, semi-deserts and up to subtropics in the south. There are very cold places (the cold pole in Oimyakon), very dry territories, seas, rivers, and lakes.
At the same time, space of the country is single whole as territorially, both economically, and mentally. Therefore, the following concepts should be investigated to become the basis for the future multilevel program of sustainable construction for Russia:
1. Urban-ecological principles of creation of sustainable cities in multitude of types of landscapes - from tundra up to subtropics.
2. Principles of sustainable building and architecture in view of multitude of climatic, landscape and ethnic restrictions.
3. Principles of creation of ecological buildings for multitude of landscape, climatic and ethnic conditions.
4. Principles of land-improvement for multitude of geographical conditions.
5. Principles of sustainable energy, sustainable transport, sustainable industry, other city technologies for multitude of geographical conditions and ethnic restrictions.
Thus, it is necessary to take into account national experience and traditions in creation of settlements with acceptable conditions of life. For example, in territory of the centre and the south of the country can be successfully used as renewable sources solar, geothermal, wind energy, but in the north, in area of frozen earth - wind and solar only. Open gardening of buildings (vertical gardening, roof - lawns) are unacceptable in inclement climate.

2. Russian sustainable building

Territory of Russia can be divided into a number of zones with essentially differing landscapes for which the positions of sustainable building can be applied in different degree (table 1). Thus for diverse conditions of Russia all basic results of researches and development can be used in the field of sustainable building.

Table 1. Parameters of multilevel sustainable building for landscape zones of Russia

R&D of sustainable building	Approximate partition of Russia on territories and landscape zones				
	West and Center	South, subtropics	Ural, West Siberia	East	North, Polar zones, tundra
Ecological framework of country	Joining of all landscapes of Russia in ecological framework (network) with well-founded ratio between natural and transformed territories (making of sustainable ecological infrastructure), with ecological corridors				
Ecological framework of big cities	Joining of all landscapes of big cities in ecological framework (network) with well-founded ratio between natural and built territories, with making of local public centers, with ecological and green corridors				
Quality of air, water	+	+	++	++	++
Energy-saving	++	+	++	++	++
Natural materials	+	+	++	++	++
Sensory ecology	++	++	++	++	+
Ecological corridors	++	++	++	+	+
Reduction of site area	++	++	-	-	-
Ethnic architecture	+	+	++	++	++
Renewable energy	++	++	+	+	+
Recycling	+	+	+	+	+
Collection of water	+	+	+	-	-
Planting of greenery	+	++	+	±	-
Phyto – melioration	++	++	+	+	-
Permaculture	++	++	+	±	-
Natural and intellectual technologies	++	++	++	++	+

New scientific directions – urban ecology, architecturally - building ecology, ecological infrastructure, and creation of sustainable environment of life [1-13] should lay in a basis of creation of concept of program of sustainable building.
Making of ecological framework (network) of country and cities (towns) with well-founded ratio between natural and built territories, with creation of local public centers in big cities may be basis of sustainable building in Russia.
Thus, the theory of creation of sustainable healthy cities is formed now in view of their sustainable development. In view of necessity of simultaneous preservation of nature and maintenance of satisfaction of needs of increasing population, sustainable urbanization of country should be controlled: growth of cities, their local, regional and global influences on nature should not result to deviation (departure) of nature and destruction of its resources. The sustainable urbanization can include following requirements:
1. Preservation and restoration of ecologically well-founded territory of nature within limits of cities, regions, country. The area of this territory should be determined with the account of «footprint» of different cities and country.
2. Creation within the limits of cities and country of necessary ecological infrastructure providing environment of human life.
3. Creation in cities as social - ecological systems of ecologically well-founded sustainable environment of life. Maintenance of stability of social and ecological components of system.
4. Definition and maintenance of ecologically well-founded parity between rural settlements, small and large cities.
5. Definition and restriction of sizes of settlements depending on fragility of city ecosystems.
6. Ecologization of all activity in cities. Ecologization of consumption of resources, technologies, waste management.
7. Ecological formation and education, including with help of ecological and beautiful environment of cities and buildings.
In the final analysis, it is possible to tell, that as a whole there is a multitude of the interconnected factors of creation of healthy city (based on reconstruction, or on new construction). Their full taking into account will be possible in the future, but the partial satisfaction to these conditions is necessary at present (table 2).

Table 2. The interconnected factors of creation of healthy city in Russia

Great number of factors (conditions) of creation of sustainable city:	
Economic	-Level of economic development of the country and city; -Level of perfection of technologies of all branches of facilities (economy); -Negative cargo of the last decisions of cities and environments in them; -Dependence on resources of other countries (the big ecological footprint extending on remote territories); -Presence of economic resources for development, applications of cleaner technologies, elimination of former pollution; -Degree of conformity of level of development and satisfaction of needs to natural-resource potential of territory
Socially-political	-Level of social stability of the country, city; -Equality, equal access to resources, to the social material comforts; -Struggle against criminality, poverty, homelessness
Geographical	-Natural-climatic conditions of region and city; -Efficiency of landscapes; -Biovariety; -Natural renewable resources - solar energy, and so forth; -Presence of various resources
Ecological	-Type of landscape and of climate; -Percent of conserved natural territories; -Degree of planting of greenery of territories; quality of air, all kinds of water, ground;

	-Biovariety and safety of local flora and fauna; -Presence of all kinds of pollution and their reduction; -Approach to condition of ecological equilibrium
Physical	-Area of territory; -Population density; -Degree of maintenance with own resources; -Providing with renewable resources; -Degree of "rigidity" of natural-climatic conditions -Presence of dangerous pollution -Presence of former contaminated territories
Cultural, ethical	-Degree of ethical attitudes to nature, ethical formation and education, acceptance of ecological ethics; -Degree of consent of society with necessity of ecologically well-founded restriction of consumption; -System of ecological formation and education, including by help of ecological architectural - landscape environment of city and dwellings
Ethnic	-Traditions in creation of dwellings and settlements; -Traditional technologies in dwelling and city; -Preferences in parameters of quality of environment and life

In connection with use of positions of sustainable building, there is a new ecological beauty of buildings, engineering constructions, and cities (table 3). Ecological beauty differs from usual beauty a little.

Ecological (natural) framework of Russia must be system of large natural interrelated territories, which connect with each other (woods, meadows, mountains, plains, bogs, rivers, lakes, seas, deserts, glaciers, etc.), including ecological corridors, which allow supporting ecological equilibrium and environment of life to keep a biodiversity. The optimum ecological framework is the spatial cellular network covering all territory of Russia, regions, large cities, which cells are large sites of natural landscapes (including territories of various degree of safety and mode of use).

These territories can naturally connect with each other, naturally contact and cooperate among themselves (for example, land and water pools, seas and rivers running into them, woods and meadows adjoining to them, rivers, mountains, bogs, etc.). There, where interrelation of these territories is broken or excluded in the way of technogenic influences (construction of cities, roads, and other poorly surmountable or insuperable barrier), is necessary their restoration by creation of connecting ways - ecological corridors, including "green" corridors. This framework is necessary for maintenance of balance of territories of various purposes to provide ecological equilibrium.

Therefore, the making of special ecological corridors is necessary for maintenance of developed close interaction of natural territories. Ecological framework of cities is system of natural and cultural landscapes, which connect with each other and with suburb nature by help of green corridors.

Many parameters of sustainable building can be used in Russia: increase of quality of air and water; energy-saving; use of natural ecological materials; sensory (visual, smell, sound) ecology; ecological corridors; reduction of site area; use of plural ethnic architecture; renewable energy; recycling; collection of “gray” water; planting of greenery; phyto – melioration (with planting of greenery); permaculture; natural and intellectual technologies in buildings.

On one of major places in sustainable building there is use of natural technologies (frequently changing a habitual kind of buildings) where all variety ecological decisions enters, starting with natural ventilation and ending with natural water treatment (living machines). This large complex of application of natural technologies will constantly grow, but it can be used not in all territory of Russia.

Table 3. Ecological beauty of buildings and engineering structures

Parameters of sustainable building and ecological beauty		
Shape, material and outward appearance of constructions	Shape	Spatial designs or their presence among flat designs
	Harmony with landscape	Harmonious combination to a landscape, "entering" in a landscape
	Size	Conformity to the sizes of the person and components of a landscape (it is not higher than trees)
	Materials	Ecological materials – brick, wood, ceramic
	Variety of architectural forms and styles	Harmonious variety of forms and architectural styles
Support of flora and fauna: planting of greenery and maintenance of existence of small birds, animal	Planting of greenery of adjoining territory	Ecologically well-founded area and variety of Planting of greenery
	Green corridors	All kinds of green corridors, including above and under roads
	Planting of greenery of roofs and creation of starling- houses on roofs	Planting of greenery on roofs, winter gardens on roofs
	Vertical planting of greenery and creation of starling-houses	Planting of greenery of walls, accommodation among this gardening starling-houses, creation of new spatial details - brackets
	Greenhouses, winter gardens attached to building	Making of attached winter gardens in height 1-2 floors
Application of natural technologies	Ventilation	Natural ventilation with improvement of structure of air
	Illumination of areas removed from windows	Use mirror jalousie and mirrors on ceiling
	Heating	Solar-heat collectors on roof, combined with roof
	Electro- supply	Solar batteries, combined with roof
	Water drain	Independence of external networks, use of individual water drain
	Water consumption	Use of an atmospheric water and "gray" water
Industry, transport and other technologies	Industry and technologies	Use of ecological technologies excluding pollution of environment
	Power	Use of ecological technologies excluding pollution of environment
	Transport	Ecological transport, bicycle, foot movement
Home, dwelling	Size (height of rooms, floor space and apartments)	Ecologically well-founded spacious habitation
	Furnish, furniture	Ecological, natural furnish and furniture
	Household technologies used inside rooms	Maximum clever (intellectual) and saving technologies in dwelling

The size of ecological footprint will play the big role in conditions of multitude and variety of geographical conditions of Russia. Probably, the real ecological footprint is closely connected with satisfaction of multitude of needs of the modern inhabitant (table 4). Ecological footprint for different cities of country will differ essentially in view of various efficiency of landscapes (there are high efficiency of southern territories, average efficiency in the centre and very low efficiency in the north, in tundra, and so forth).

Table 4. Multilevel ecological footprint

Group of needs	Name of need	Detailed elaboration of need	Qualitative adjectives of «ecological footprint»
Natural (biological)	In space, in biological spatial comfort	Closest environment	Well-founded area on one person, absence of high density of population
		Near environment	
		Remote environment	
		Global environment	Preservation of ecological equilibrium
	In comfortable	Wave environment	Volumes of natural resources, re-

	physical environment	Thermal environment Insolation, illumination	quired for creation of comfortable environment
	In pure air	Air in habitation On work In streets of city	Necessary volume of natural resources
	In food and water	Proved volume of pure water and food	Necessary volume of natural resources
	In natural environment	Ecologically proved volume of environment	Volume of the environment acquiring pollution of city
	In continuation of human kind	Certain density, allowing continuation of human kind	Territory with absence of high density and rarefaction of population
	In security from diseases	Absence of high density, presence of environment of necessary quality	Proved volume of clean, close to natural, environment
	In "wild" nature (unexplored wilderness)	Presence of proved volume of wild nature (unexplored wilderness)	Volume providing preservation of a biovariety
	In environment for assimilation of products of vital functions	Presence of proved volume of environment	Volume of environment providing assimilation of products of vital functions
Economic	In food	Proved volume of various food	Necessary volume of natural resources and materials
	In clothes	Proved quantity and quality of clothes, initial materials	Necessary volume of natural resources and materials
	In area of habitation, in furniture	Proved area, volume of furniture, initial materials	Areas of buildings, areas of landscapes for manufacture of materials
	In transport	Proved satisfaction of need for movement	Areas and volumes of ground, water and air, required for transport ways
	In means of work	Proved presence of means of work	Areas and materials necessary for creation of means
	In services	Proved volume of services	Areas, required for satisfaction of services
	In recreation	Proved area, volume and variety	Necessary volume of natural resources
	In security family	Proved volume of resources for life of family	Resources necessary for satisfaction of need
	In provision the information	Proved volume of the information	Areas, required for satisfaction of services
	In recycling of waste products	Recycling of all waste products of activity	Areas and volumes, required for recycling services
Labor	In knowledge, education	Knowledge and education (including ecological)	Necessary areas for satisfaction of need
	In work	Work according to specific features of person	Necessary areas, equipment and materials for satisfaction of need
	In children's game	Game as preparation for work	Necessary areas and materials
Social and socially - psychological	Social background for satisfaction of needs	Certain social background for satisfaction of all needs	Necessary volume and area of territory, presence of resources
	Opportunities of intercourse	Maintenance of intercourse	Presence of territories for maintenance of intercourse
Ethological - behavioral and ethnics	Certain density of groups	Presence of proved density of groups	Necessary volume and area of territory providing density
	Certain degree of disconnexion	Ethnic disconnexion	Necessary volume and area of territory providing isolation

	Ethnic independence, number	Maintenance of ethnic independence and number	Necessary volume and area of territory
	Architectural - landscape environment	Presence of beautiful architectural - landscape environment	Necessary volume and area of architecturally - landscape environment
	Ethological and ethnic native landscape	Presence of native landscape	Necessary volume and area of natural and "second" environment

Great number of peoples living in Russia keeps traditional (ethnical sustainable) architecture of their buildings, which is checked up within many centuries (fig. 1).

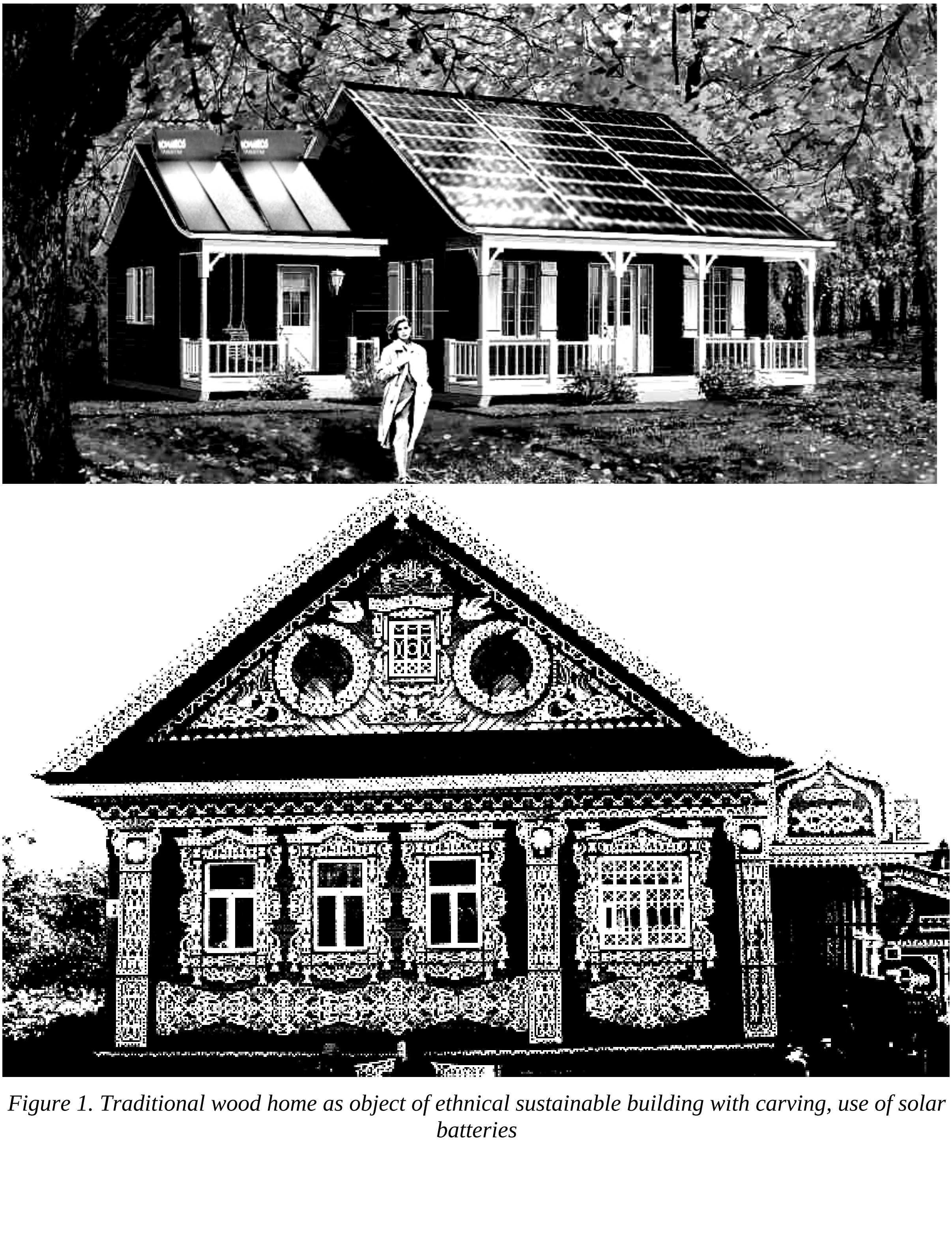

Figure 1. Traditional wood home as object of ethnical sustainable building with carving, use of solar batteries

These buildings essentially differ from new (as a rule, multi-story) buildings, which Russian specialists apply in all territory of Russia, irrespective of ethnic features and climate. They cannot have all complex of modern municipal convenience, and, nevertheless, inhabitants successfully use them.

Ethnic traditional, checked up by time, architecture could be considered as sustainable building even without use of multitude of modern sustainable decisions. For example, wooden peasant's houses in Russian villages, decorated with carving, create the favorable internal environment (wood is ecological material), beautiful external visual environment; they are made from renewal material, which gives in recycling. Addition of some devices (solar batteries, etc.) will allow increasing ecological compatibility.

There are even more interesting from the point of view of sustainable building Chukchi houses in which northern peoples traditionally live, and settlements from terraced homes on abrupt slopes, used in south of Russia in mountain areas. These dwellings are executed from natural local materials, they create habitual for inhabitants environment, do not pollute the nature. Improvements of quality of life, reduction in consumption of energy with the help of modern devices, are possible by their addition to existing traditional designs (for example, installation of solar batteries and heaters, and so forth).

At the same time replacement of these traditional houses by modern buildings with application of concrete, metal, plastic is hardly necessary. Positions of sustainable building should join to rules of ethnic architecture organically.

It is interesting, that modern buildings in Russia frequently cannot be considered buildings with sustainable building, despite of use of modern technologies of their construction and on creation of good conditions for inhabitants inside buildings. For example, high panel houses create the negative visual environment, their inexpressive architecture, as a combination of the same seriated rectangles is negative for eyes (fig. 2). Building experts project more and more high apartment houses, for example, buildings in height up to 60 floors are under construction in Moscow. People still never lived at such height in conditions of a cold climate. It contradicts some laws of ecology.

Ecological literacy is for the present at insufficiently high level. Increase of ecological literacy of experts – architects, constructors and other specialists - is necessary for application of positions of sustainable building in Russia.

Figure 2. Visually negative inexpressive house

Russian specialists as the basic participants of process of creation of environment of man should represent how cities and buildings will influence on environment and on animate nature, how natural environment will cooperate with artificial environment. Unfortunately preservation of environment in Russia hasn't a significant place frequently in process of construction; it leads to deviation from sustainability, from basic ecological laws.

Knowledge of laws of development of nature, urban ecology, ecological infrastructure and architecturally -building ecology, will be help to exclude negative influence of buildings and structures on nature, to enter them organically in natural environment, to support development of natural systems and simultaneously to increase quality of life.

There is insistent need of development of the long-term and wide complex program (Agenda) of sustainable construction and architecture for huge Russia, which will be essential to differ from known programs of sustainable construction for developed and developing countries. In a basis of this wide multilevel program should lay a variety of sustainable decisions for plans of settlements, for energy effective buildings, for ecological infrastructure, for sustainable building materials, economy of water, and so forth, taking into account extreme variety of landscapes, climatic conditions, etc.

3. Conclusion

Wide movement to sustainable construction in Russia did not begin yet. On a path leading to sustainable construction in Russia there is a multitude of barriers - historical, economic, social, geographical, ecological, technological, and so forth. Problems of sustainable construction in Russia are very difficult in connection with variety of geographical conditions, difficult economic situation, etc. At the same time, the country has rich resources, the natural environment in the country was kept; it allows believing quite real transition to sustainable construction. Development and realization wide termless multilevel «Program of sustainable construction» should become the beginning of transition to sustainable construction.

Development of long-term and wide multilevel complex program for Russia is necessary; in its basis should lay sustainable building [1] and new sciences in field of healthy cities creation [2-13], variety of sustainable decisions for plans of settlements, for ecological infrastructure, for energy economy, for building materials, for economy of water, and so forth, taking into account extreme variety of landscapes, climatic conditions, ethnic features.

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«SUSTAINABLE BUILDING» CONCEPT AND BINARY PLURALITY OF UNSTABLE WORLD

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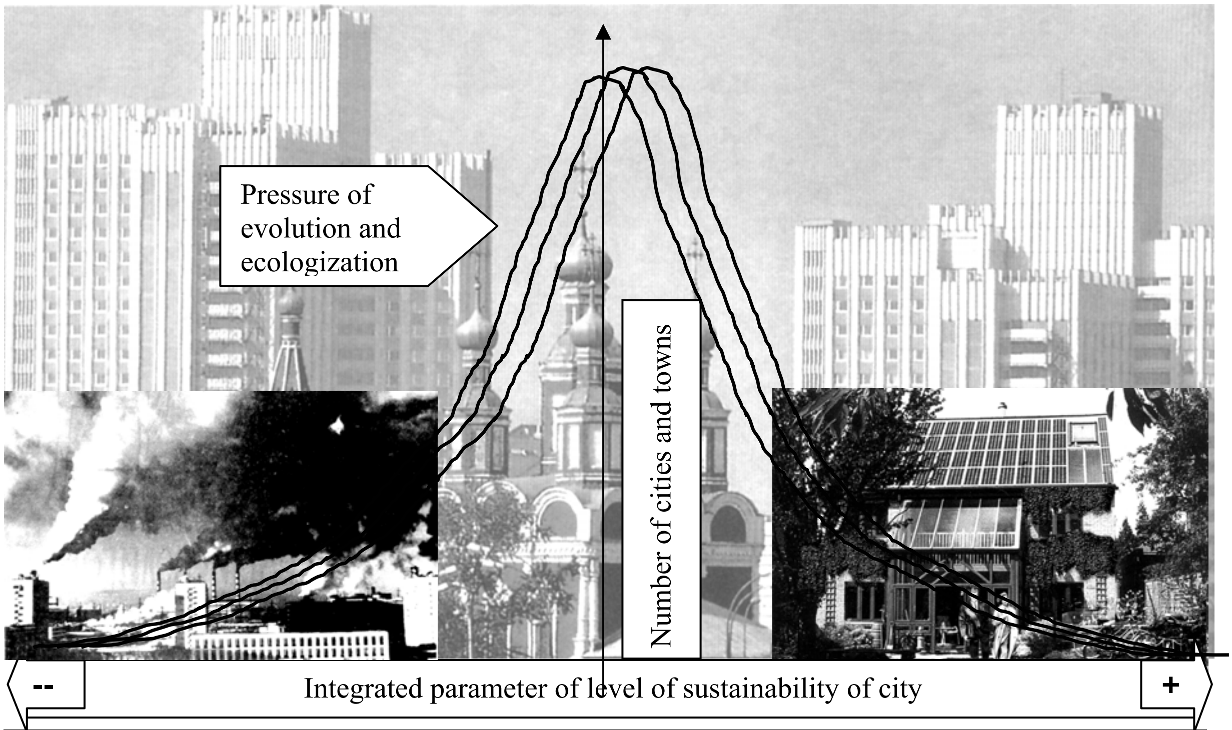
Abstract

Binary multitude of settlements in the world increases – from high growth cities up to stabilized towns, from megapolis and urban areas up to small settlements, from elite small towns up to harmless and unpretentious buildings on architecture, from cities for rich and up to slums. Social - ecological aspects of history of development of cities are dual: quality of life in cities of the developed countries raises, but an area of natural territories is reduced simultaneously, and pollution acting in nature grows. The centers of settling now become cities in which lives more than 50 % of the population of planet. Cities occupy besides the most part of territory of some small countries. Evolution of settlements is developed always with branching. Some settlements became ecological cities; others cities became more and more soiled, third cities combined in themselves harmless and polluted territories. Simultaneously there are settlements with opposite parameters: technically perfect megacities of the developed countries, dirty cities of the poor countries, and even the poorest settlements with houses as ancient tents and huts. Two «Programs of actions on sustainable construction in XXI century» are confirmation of branching development: one for developed countries, another and much more simplified, - for developing and underdeveloped countries. There are recommendations on simplified ways of erection of most simple one-storied dwellings from local materials in the second program of actions (clay, ground).
The humankind during all history aspired to sustainable and steady development, to creation of beautiful healthy cities. However, in a result it received unstable development and polluted cities. Slums recently have appeared even in new fine capital of Brazil. Hoping for sustainable development and equality, humankind collides constantly with military conflicts and inequality. Why? Probable causes of it are laws of binary plurality of nature and of branching development, and feature of thinking of the person.

1. Binary plurality of unstable world

It is necessary to have in view binary plurality of the world of nature, feature of simplified human thinking and objective instability of development during analysis and creation of

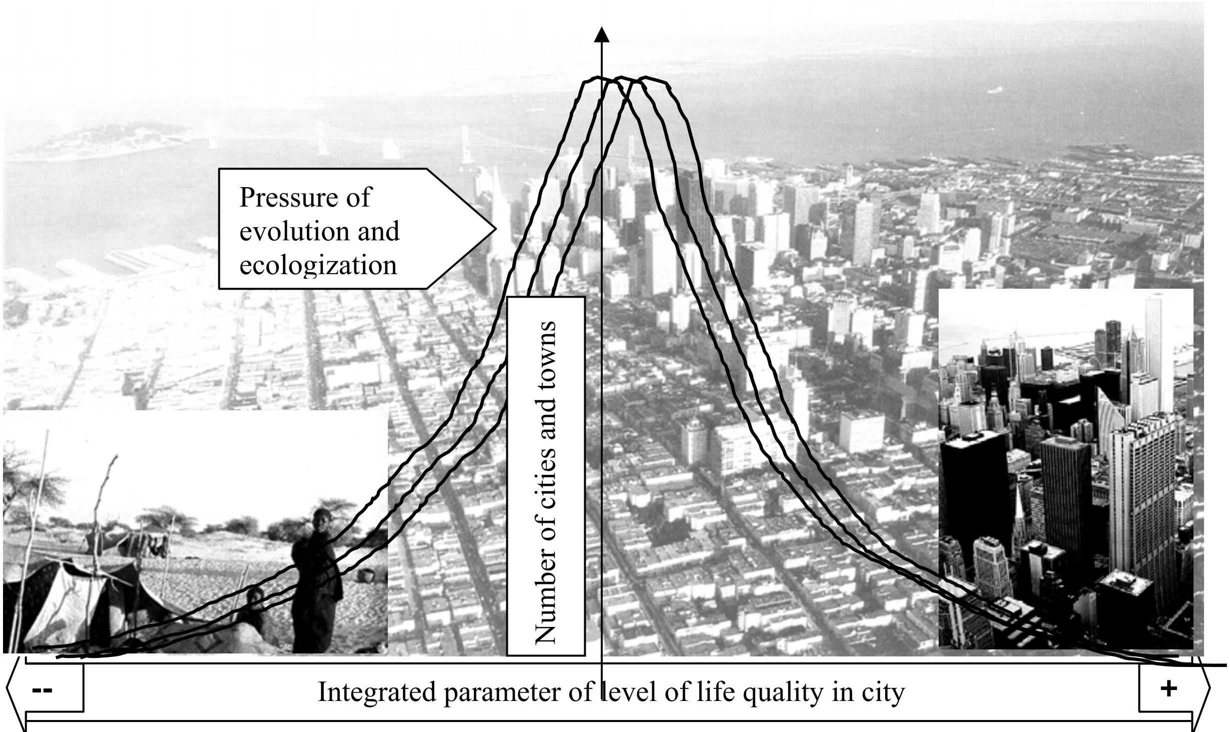
concept of sustainable building for maintenance of sustainable development. Multiplicity (plurality) and duality as one of characteristics of multiplicity are dialectical features of subjects and phenomena of the world. Humankind long ago has paid attention to multiplicity, and duality (as presence of opposite characteristics) of surrounding world, of all phenomena and subjects. Binary, dual multiplicity, variety is not only one of the most important qualities of the world animate and inanimate nature, as well as strategic direction of their evolution. The world develops from simple and monotonous to binary multiplicity, dual variety.
Sustainable building is connected with resilience of environment of life as its ability to return in initial condition after changes under influence of negative factors, ability to sustain external and internal influences without destruction and changes of basic functions. It has fundamental value as the major condition of evolution of nature and person. Decision of this problem is extraordinary complicated, it is caused by features of simplified thinking and complex evolution of brain of person determining interaction of person with nature, and action of objective laws, - such, as law of binary plurality of nature, law of branching development, etc. [1-7]. Binary plurality of the world, nature and person is their dialectic property (this property is reflecting the most general laws). Binary plurality is peculiar to each phenomenon and subject of the world. It shows as their division on properties and qualities on dual subsets, having both minimal, and maximal, sometimes completely opposite polar meanings (fig. 1, 2, 3). Frequently extreme meanings of parameters in these subsets are completely opposite by quantity or quality. Probably, multitudes of binary attributes distributes under normal law being, as is known, model for many physical phenomena.



The most polluted cities with negative environment of life	Cities average on level of stability with connection of healthy and negative environment	The most harmless settlements and buildings creating high-quality environment

Figure 1. Possible variability of integrated attribute of sustainability of cities depending on prospective pressure of evolution, cultural development, and so forth.

Binary plurality of urbanization in modern world is known - from «urbanization of poverty» and slums up to beautiful and convenient dwellings close to nature; from polluted cities with negative environment up to harmless and small towns; from quickly growing mega cities up to practically not growing old settlements, not occupying natural territories. The greatest quantity of settlements in this plurality, probably, occupies average position: in them alongside with polluted there are also clean territories, beautiful buildings and cultural landscapes adjoin with ugly, etc. Small amount of cities is characterized by practically harmless and beautiful environment, and, on the contrary, by completely polluted and not aesthetic environment. Modern city creates more high quality environment, especially in connection with growth of area of apartments, with their modern municipal convenience. Separation of inhabitants from natural environment, its replacement by artificial environment, by pollution of all kinds - physical, chemical, visual at the same time grows. Cities as a whole pollute the natural environment, supersede nature from its natural niches, and at the same time, they give inhabitants high-quality environment inside dwellings for life. Technogenic evolution of cities is dual: humankind has received the impressing positive results concerning growth of quality of life in cities alongside with its negative consequences. However, these achievements are characteristic for cities of the advanced countries whereas in the underdeveloped countries very low level of satisfaction of needs of inhabitants is kept.



The most poor settlements with negative environment of life	Average cities on level of quality of environment with connection of good and poor dwellings	The most wealthy settlements and buildings creating high-quality environment

Figure 2. Possible variability of integrated attribute of life quality in city depending on prospective pressure of evolution, cultural development, and so forth.

Evolution of settlements always developed with branching. Now there are simultaneously opposite settlements on key parameters: technically perfect mega cities of advanced countries, dirty cities of poor countries, and even the poor settlements with houses as ancient tents and huts. Social - ecological aspects of history of development of cities are dual: quality of life in cities of developed countries raises, area of natural territories is reduced, and pollution acting in nature grows.

Therefore, the concept of sustainable building should be plural, it should take into account objective plurality of the world, features of simplified thinking, and it should have adaptive character. The concept of sustainable building should be dynamical, sustainable building should adapt to nature and to person. Uniform for all countries and peoples, for all geographical and national features, «Program of sustainable building» has no future.

The whole history of development of mankind is accompanied by hopes on the improvement of surrounding world and Homo sapiens, on creation of more decent, peaceful, ethical,

communicative, good and industrious person, on the full eradication of all vices. However, the vices actually do not abandon a person; they even increase as quantitatively, so and qualitatively. From unrealized hopes on radical improvement of person, humankind goes over to hopes on the greater equality of people, on the equitable relations in the society, on sustainable countries, which are in friendly relations between itself.
Aspiration to one-polarities comes up against conjectural law of binary multiplicity and against reality. Instability and crisis carry germs of development in itself. How writes I. Prigogine in book with the typical name "Philosophy of instability" [1], "notion of instability is freed from negative tone now. Instability is an evil, that must be removed, or certain annoying trouble. Instability can be a condition of stable and dynamic development. Only systems distant from the balance, systems are in conditions of instability, capable spontaneous to organize themselves and to develop. Stability and equilibrium, so to speak, are dead ends to evolution. Without instability is no development". However, attitude to instability must be careful: "If … nature is kept instability, as an essential element, we must its respect, because we can not predict that can occur" [1]. Therefore, crisis and instability are conditions of possible development, but attitude to this condition of nature must be very careful, since consequences are unpredictable.

There is quite probable existence of law of binary plurality as one of the most general laws of being (fig. 3). This law supposes that one of the general features of all phenomena and subjects of the world is their multiplicity, formed by binary subsets, being in "evolutional network" of varied interactions.

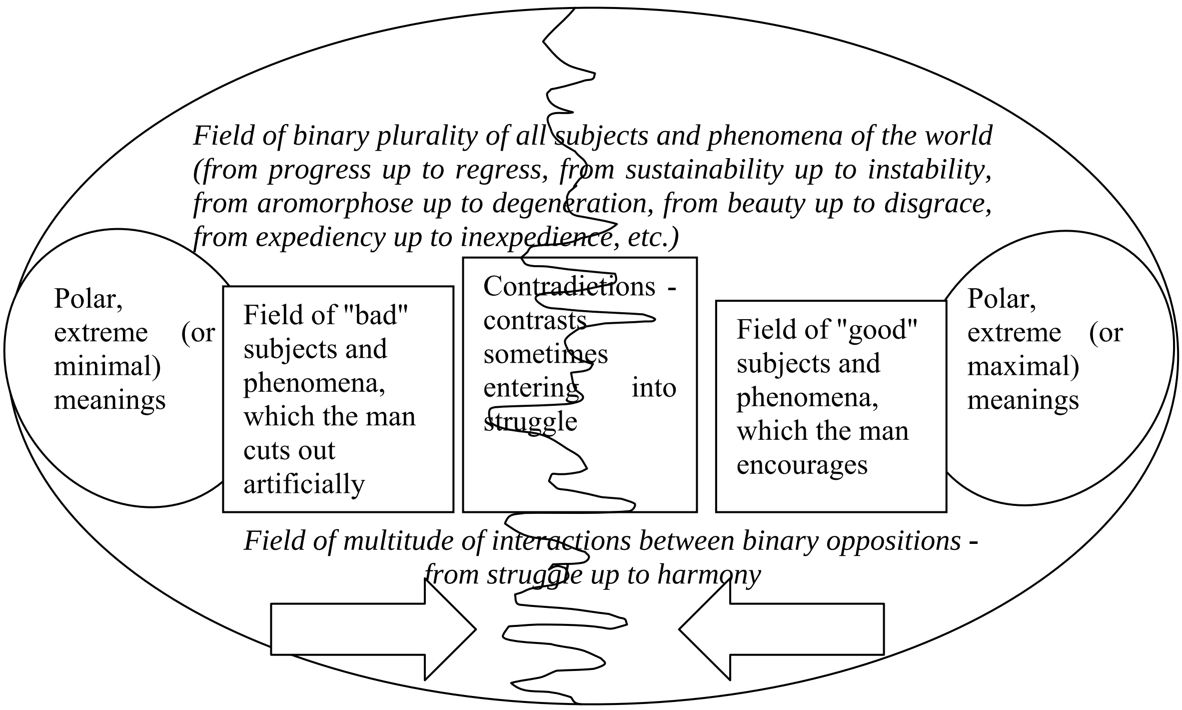


Figure 3. Binary plurality of the world

Binary plurality of all subjects and phenomena is basis of evolution. The dynamical holistic world consists of binary multitude of subjects and phenomena. All subjects and phenomena of the holistic world are binary plural; it is a basis of its development. Binary plurality of the world consists of subsets, in which enter as equivalent components all subjects and phenomena, good and bad from the point of view of person.

The evolution of the world generates binary plurality of subjects, phenomena and their properties, and this plurality, its duality and opposites provide existence and development of the world. The role of duality of all subjects and phenomena therefore is very great, and at aspiration to exception of plurality or its duality to some extent unpleasant inconvenient for man, it is necessary always to remember about dialecticism of these properties. Plurality and its duality are caused by evolution of the world and are dialectic means for its maintenance, for existence of the world. Without binary plurality the world, probably, can not exist and evolve.

2. Development with bifurcations

Evolution of nature, society, and person proceeds with bifurcations, sooner or later balancing "positive" and "negative" (from the point of view of the person) branches. Only such evolution supports existence of holistic binary plural world, which can exist due to binary plurality of subjects and phenomena. Thus, holism (integrity) of the plural world is expressed in dynamical combination of mutually counterbalancing subjects and phenomena making the general mosaic picture of integrity, including, for example, any "norms" of one or another kinds of landscapes – woods, deserts, ice, bogs and so forth; dynamical counterbalancing combination of human qualities – for example, in morbid equilibration of genius, and so forth. Determinism of holism of world, as a rule, is not perceived by person as for him is characteristic propensity to simplified dual (and even unilateral) and to emotionally painted perception of complete world, to simplified estimation of subjects and phenomena from two sides, by principle «yes – no», «good – bad». Possible reason of it is limited volume of short-term memory, in which the person "lives". Sources of it lay in evolutionary caused necessity of fast reaction and of survival.

The one of main problems in conception of development with bifurcations is opportunity of one-sidedly positive development. Whether there can be subjects and phenomena completely positive for the person? Whether there can be existence of mankind completely good, far from most complicated problems (such, as military conflicts, danger of destruction as result of use of powerful weapon, approaching shortage of resources, global ecological crisis, finiteness of individual life, incurable illnesses, etc.), and full of pleasure and happiness?

Is it possible one-polar life without binary multiplicity? Whether there can be changed natural evolution to artificial, one-polar anthropogenic evolution? This question become actual therefore that is presently observed all increasing speedup of technogenic evolution, most strong technogenic pressure of person on environment (and, consequently, on itself). Multiplicity presently reveals itself as in natural, so and in technogenic world. All subjects and phenomena of anthropogenic world are dual or many-sided; their qualities are often opposite. This allows speaking about general dialectical nature of binary multiplicity, on its objective character.

Typical examples of hopes on one-sided improvement of the world are technological great advances made by the person. Every time, when was decided some big problem, humankind highly was inspired, that this time it will get only positive results (consequently, one-sided). However, every time removed negative consequence (multiplicity) were not taken into account. Each great advance in technologies, each appearance of most up to date technologies in the beginning have approached the person to role of founder, to alluring role of "creator", but afterward caused a new headache. Difficulty of new problems because of large technological great advances sharply increased. Knowledge of dialectic multiplicity and of its duality can help to determination of more correct ways of development, including sustainable development and sustainable building.

Multiplicity and its duality accompany the whole evolution of person. On the one hand, person aspires to stable existence and sustainable development. On the other hand, exactly instability is a condition of dynamic development. This duality is typically of many aspects of evolution of person. Evolution of person takes place in the field of restrictions and conditions, which are superimposed by history of development and natural laws. Most important in history of mankind processes continue with growing intensity: growth of negative influences of person on natural environment, that resulted to global ecological problems and to global anthropogenic ecological crisis first in history of planet; retreat and death of nature; leaving a person from useful for it field of natural selection, speed increase of artificiality of person life.

Law of binary multiplicity of all subjects and phenomena of the world have important role in evolution of the whole world and person as part of world of nature. Many phenomenon and subjects of the plural world are unpleasantly to the person; person is far from cognition of all-embracing nature of being, together with negative qualities of subjects and phenomena are organic part of whole. Person aspires to removing (cutting) of unpleasant and to separation of

pleasing from unpleasant. Person separates all "beautiful", young, strong, growing, and sustainable from "ugly", old, perishing, decomposing and unsteady.
Binary multiplicity, inseparability of world and being, are their objective characteristics. All positive and negative, beautiful and ugly, pleasing and unpleasant for the person factors of binary plural world inseparably linked between them and are in organic interaction. Negative grows from positive, and vice versa. If each object have an opposition, and each law of dialectic too must have it. For instance, opposition of law of negation of negation is not negation of negation. Opposition of law of unity and struggle of oppositions is law of not unity and not struggle of oppositions. It is necessary deep study of characteristics of all subjects and phenomena of the world as its organic parts, without artificial separation of bipolar or pleasing one-polar subjects and phenomena, without gap between evolutional binary multiplicities. Binary pluralities of whole world, whole being, inorganic and organic nature, are most important factors of life and evolution. To drain marshes, to transform deserts in flowering gardens, to unfreeze glaciers and to do instead of ever-frozen soils certain oasis, to remove a forest, to cut mountains, to change a current of rivers, completely to destroy types of species, extirpate predators and unpleasant species, to change a biovariety to a monotony of cultural and useful for the person of plants, - that is an aspiration to going away from natural and necessary duality (evolutional multiplicity) of world. On artificial cutting off one of the poles, the nature will answer by generating of new and opposite pole. It seems nature does not tolerate one-polarities; it will restore artificially violated balance.
Any development (of nature, society, city, and person) proceeds with branching, that equilibrates early or late all "positive" and "negative" branches (from the point of view of the man). The basic driving force of development of the most part of humankind is the aspiration to satisfaction of needs and, hence, to achievement of appropriate positive emotions. Therefore, multitude of senses and passions, for which are responsible ancient (wholly "animals") structure of man's brain, in many respects determines not only perception and thought, but also evolution of the person and of all nature of the Earth, controlled by it. In realization of process of thought of the man, the role of ancient parts of brain is important. Information enters in stratification of ancient structures, including ancient (palaeocortex) and old (archaecortex) cortex from sense organs and proceeds from them, that emotionally paints it and provides comprehension of results of such emotional thought and receipt of the appropriate signals on the executive mechanisms - effectors. The short-term memory, in which the person "lives", is limited on volume. The sources of it lay in necessity of fast reaction and survival. Therefore simplified rating of subjects and phenomena from two parties is characteristic for the man, by principles "yes - not", "good - bad". The propensity, inherited from an animal, to the simplified dual and emotionally painted perception of the reality and its analysis does not allow comprehensively estimating subjects and natural phenomena in their complex interrelation and does not give an opportunity to reveal its objective laws deprived of emotional human coloring. This thought does not allow foreseeing the remote consequences of man's activity. The contradiction between aspiration to simplified dual and even to one-polar perception of the reality and real binary plural world of nature leads to complexities of mutual relation of the man with nature and to crises. The man is compelled to manage the complex world of nature with the help of simple methods. In compliance with features of simplified thought which is not allowing to foresee consequences of activity, the humankind can survive and keep itself as specie only in the event that it will not realize (will fail, reasonably will prevent, etc.) essentially new and powerful scientifically - technological break (advance), which equilibrated negative consequence will result in impossibility of continuation of life.
The smaller part of humankind that thinks ecologically and ethically, aspires to humane co-evolution with nature, which realizes only on very small territory of any countries. Other majority of humankind using the nature for satisfaction of needs supersedes and pollutes it on the most part of planet. Real and, perhaps, most difficult problem of modern civilization, which has resulted in negative consequences of its interaction with nature of planet, is the strong fastening in human thought and invariability of propensity to simplified perception of reality, to dual and even to one-polar performances. The person is not guilty of this probable imperfection of thought: it inherits it from ancestors, and it was not by lack, and, on the contrary, it helped to person to survive as a usual animal in dangerous world of nature.

3. Features of thought of man

The human thought is characterized by multitude of perceptible (and multitude not perceptible) features, which connected mainly with multiple (simplistically – triple, triune) brain including ancient structures and new cortex, united by neuron networks and cooperating among them [2]. Among them are simultaneous going of impulses from receptors of sense systems through multitude of ancient, old and newer (but arisen from old) structures, their active participation in analysis of information and distribution of decisions, important role of emotions in thought and consciousness (coloring of thoughts by feelings), limitation of short-term memory, not realized analysis of majority of incoming information and realized analysis of minimal information, etc. These features result more often in the simplified perception of reality, which is not perceived as lack; the simplified analysis completely is acceptable for the man, as the simple - from two - three sides - rating of subjects and phenomena is most simply and clearly. The centuries-old experience of humankind transmitted in fairy tales, proverbs and sayings, is completely based on opposition two, is very rare - three, subjects or phenomena. The brightest statements of the great people are dual, and shortest of them are perceived as most ingenious (though real life is plural). The abstract "human" thought is painted brightly by "animals" emotions and feelings.

The simplified thought and perception are incorporated in complex brain of the person bearing in itself all history of its animal origin. The ancestors of the man were usual animals, and the appeared humankind interacted with indefinitely various world of nature of the Earth at first as one of multitude of species, and then - as the highest creation is situated above the world of nature, as arbiter of fate of the world.

As justification of necessity of such management of a nature, which is "imperfect", unadapted, dangerous to the man, multitude of ideas and concepts were offered - beginning from divine origin and sharp distinctions of the man as highest creature having culture, and ending with necessity of expansion of own niche for allocation of growing humankind and most complete maintenance of its constantly growing needs. It was possible to manage a nature, all other animals and plants, and to determine necessity and forms of their existence for satisfaction of requirements, for example, under condition of recognition of all other animate nature as certain insensitive machine serving for satisfaction of needs of the man. Therefore, remaining the representative of fauna, the person (with the exception of tribes, stayed on a low level of development) made all possible as much as possible to emphasize own sharp distinctions from other animals, creating with the help of the powerful mind new artificial environment and earlier unknown culture in the nature. This essentially new cultural environment has allowed creating high quality of life in essentially new places of life - cities. At the same time its creation became possible due to the nature and its resources, it exists only at the expense of the environment.

By intermediate result of the simplified thought and appropriate activity of humankind become occurrence of threat of fast exhaustion of resources, pollution of nature and its crisis status, sharp differentiation in quality of life and in incomes, social tension, constant wars, ousting of nature of the Earth. "Homo Sapiens", the reasonable man, has not executed a task of reasonable management of nature, not only not having created healthy environment for itself and steady (sustainable) future, but also essentially having worsened conditions of life of the majority of animals and plants. What are reasons of so irrational co-evolution with nature, and unreasonable, shortsighted behavior of the man in relation to itself? As is known, the sources of all crises are in features of thought, in work of brain.

From the very outset of life of the first people and their groups (tribes, hordes, families, clans, etc.) among pristine environment of planet the mutual relation between nature and people, and within small human community, were brightly painted by multitude of feelings and consequently differed by variety, - from organic interaction up to complete aversion and counteraction. The development of humankind from occurrence of the first people and up to its modern status passed under strong influence of emotions, which conducted to its exclusive complexity and unpredictability, spontaneity. Reason and logical thought did not participate in definition of ways of rational interaction with nature and among themselves; their place was occupied by bright "animal" emotions.

Therefore, many major steps of humankind are consequences of casual, superficial choice, without a rating of distant consequences ("at first we shall get involved in fight, and then we shall look"), significative about absence of multilateral analysis. Strange on the first sight the propensity to emotional acts, to simplified and fast passing of doctrines, to passivity to the tyrants and destiny, to underestimation of prevision of more remote consequences, to limiting simplicity of interaction between the people and with nature, resulted in deep mistakes in development. It is possible to attribute to the major steps many technological breaks, which negative consequences arose, were estimated and corrected after application of achievements. Among very first and simple steps is "agriculture with brand" - burning out, when natural vegetation was burned out for reception of pastures and croplands. Further was creation of the more and more perfect weapon and constant wars for capture of territories, values and people, as it was a way of the fastest satisfaction of needs. Further was replacement of nature, including mass destruction of large animal, down to disappearance of the separate valuable and poorly protected species within several decades. Now there are technical revolution, multitude of entropic engineering creation, euphoria from more and more powerful machines and mechanisms varying an environment. Last in this line are huge hopes assigned on the computerization, on the virtual world, on intervention at genetic level, on more and more large changes of natural environment and life in the side of their artificiality, and possibility of favorable huge built environment creation on the Earth.

Strategic direction of development of the man was the simplified way of "trials and errors". In any negative interaction, the humankind at first reached edges of precipice, and then reflected above change of way. Emotionally painted aspiration to the simplest decisions dominated always and everywhere. If the beauty of own face and body is insufficient, person used simple methods to correct this defect of evolution, to paint own body, to add animal parts - plumes, teeth, skin, to suspend to ledges on a body "beautiful" subjects (it is good, that on a body of the man there are some ledges). The person deformed a skull, extended parts of body, etc. Any people, which have been not subject general doctrine, are necessary for destroying. If is insufficient the capacity of the weapon, - the humankind raises it down to occurrence of an opportunity of repeated destruction all alive on planet. If there is small speed of extraction of minerals, - person creates huge mechanisms capable to change shape of the Earth. If the man intends to amaze imagination of contemporaries the largest, long, high, or fast objects, - the man constructs huge buildings, ships, planes, bridges, etc. If are insufficient properties of animals and plants, useful to the man, person realizes the intervention in the most thin natural mechanisms, without a rating of the remote consequences. At the same time, in compliance with aspiration to the simplified emotional perception of the reality, the man in every possible way encourages exception from analysis and from memory, all negative things, which are objective parts of the world.

Meanwhile in process of deepening of researches all becomes known the large complexity of life of animals, plants and of all world of nature, which components are interconnected in united "global network of life" [5, 6]. Some neuro-biologists believe that the cardinal changes of brain were not required at transition to the man: the human consciousness became result of rectilinear perfection of brain of animal [6]. The person and other creatures of animate nature have much common, the differences even in thought sometimes do not have basic character (some primates are trained to intelligent actions and simplified speech with the help of gestures), the separate animals use instruments of work, make quite reasonable acts. It is quite possible, that the further profound study of animals will bring yet one interesting feature approaching them to the man.

Though the thought of animals also has simplified character, animate nature is diverse, it manages itself by the natural laws that are taking into account this variety and complex interrelations. The human perception is inclined to simplified duality and even to one-polarity, to most simple analysis such as "good - bad", "yes - no ", "iny - jan", etc.; simplified duality of perception is objective reality caused by evolution and features of a structure and functioning of man's brain and nervous system. It is quite possible, that many complexities of development of humankind and crises, caused by it, are explained by contradiction between inclined to simplified duality and even to one-polarity perception of external world and real variety of the world of nature. The man cannot manage a most thin, complicated and various mechanisms of nature with help of simplified and consequently rather rough rules and actions.

The world of nature is characterized by binary plurality of all subjects and phenomena, by presence of two subsets with multitude inconsistent, including negative, positive, and neutral properties (from the point of view of the man) [5]. In the world of nature, all subjects and phenomena are in huge network of interactions. This huge multitude of subjects, phenomena, including unpleasant, and dangerous to the man, cannot be perceived, acquired, and analyzed by their inclined to simplified duality thought. The human memory is dual; it has long and short-term duration [2]. The long-term memory is capable to store the large files of the information, last experience. Thus ability quickly to find in memory the necessary information, answer to the put question is more important for functioning of organism than capacity of this memory. But the person "lives" in short-term memory [2], which part is most short-term iconic memory of "decision" with capacity 3-5 elements (holding during 0,1 - 0,5 sec a complete and exact picture perceived by sense organs) [2]. Sense memory of just working stimulus belongs to short-term with maximal capacity only 7 - 9 elements, with storage period 5 - 60 sec. The information with longer term of storing goes into long-term memory. A number of the researchers believe that the consciousness can simultaneously perceive no more than seven units of information (law of «magic seven plus - minus two» of J. Miller [2]. "Living" in short-term (quickly) memory and remembering the limited number of units of information not comparable with its real volume, the person is not capable to analyze all complexity of the world. Probably, in compliance with this feature of sense memory in files of universal knowledge (myths, proverbs, sayings, fairy tales, etc.) are fixed simplified dual (less often - with application three - seven elements) "memos", units of useful information. It is quite possible, that is heritage of animal origin of the man; this feature is united for many animals, which behavior frequently is reaction on dual "releasers" - key stimulus on K. Lorenz, and releasers are divided precisely on positive and negative, and reaction on them can be fixed genetically [3].
Simplified duality of perception was feature, natural and necessary for survival. Also in subsequent development of humankind, this feature of perception of reality has appeared extremely useful and acceptable. The dual perception is most simple and understandably, it does not require significant mental work, as the man thinks ready dual "releasers", "memos", images, "gestalts". Aspiration to one-polarity allows satisfying need in ideal, only positive, subject or phenomenon, which raises stability of existence.
Limbic (wholly "animal") brain system gives emotional coloring of information. Stimulus of emotions can be biological, cognitive, information factors. Functions of emotions are reflection (generalized estimation of events), rating (prompting to action), fastening during training, and anticipation of decision, switching, and communications. Many emotions are not connected to work of cortex and consciousness. However, the emotions on significant stimulus unite affective and cognitive processes. As some researchers believe, the emotional sphere plays large and even determining role in thought [2]. Probably, there are very many emotions in their different combinations and intermediate values; by the researchers are offered “six universal feelings".
Brain of the man is extraordinary complex organ, in brain is included multitude of new, old is and most ancient structures. Moreover, at the same time, many old structures is intended for performance of the same functions, as newest structures, and consequently the signals from sense organs act to many addresses and are analyzed simultaneously. The ancient structures carry out this analysis as parts of brain of different animal ancestors, whereas new cortex works as part of brain of highest animals and man. The brain of the man for a long time does not grow, that has resulted in absence of growth of the newest top part cortex, and most difficulty arranged and responsible for the most complex function of brain.
These features of work of man’s brain necessary for survival of the man as of one of species came in the contradiction with reality, when the man has occupied a situation above the world of nature. In mutual relation of humankind with other nature, there was insufficient simplified emotional and dual perception and response. The rating of all binary multiple environment according to dual and emotionally painted thinking (passed through the filter of ancient "animals" structures of brain) was be used with principles "usefully - harmfully", "yes - not", "friend - enemy", “good - bad", "beautiful - ugly", etc. This rating was far from a reality from the point of view of objective, rational, viable mutual relation with nature. Using of more ancient emotional brain, the humankind extraordinary simplified and consequently precisely

has differentiated animals both plant on useful and harmful, landscapes - on beautiful both ugly, useful and harmful, and began to concern to them according to this ridiculous duality.
The especial interest in this process represents satisfaction of constantly growing on to number and complexity needs, limited in natural environment by the factors of homeostasis. Aspiring to fast reception of positive emotions the man according to the simplified thought was not capable to analyze the remote consequences of satisfaction of new needs. When the requirements of the analysis of many parameters, simultaneous storing and handling by multitude of units of the information, understanding of plurality of nature and its interrelations were presented to the man, - the human thought has appeared unable to this. Inclined to the simplified interaction with nature the man has appeared unadapted to real binary multiple outward things. Features of this "crisis" thought and appropriate actions conducting to crisis are in phylogenesis, in structure and functioning of complex brain of the man. From here expires also aspiration to circumcision of all negative part of the world, to exception from consciousness of negative branches of development, to notion about an opportunity of achievement of "paradise" with completely positive subjects and phenomena and absence of huge negative half of the world.

4. Conclusion

The binary multitude of settlements grows: from rapidly growing up to stabilized cities, from megalopolises and urban areas up to small settlements, from elitist small towns up to harmless and unpretentious buildings on architecture, from cities for rich and up to slums. The binary multitude of human settlements differs with quality of environment given to the person, beauty, harmony with landscape, degree of impurity, ecological compatibility, level of pollution for nature and so forth. Modern development of cities goes in directions, which, as well as all technologies of person, are not harmless, and with negentropy. Cities continue to replace the environment; they are the basic sources of pollution. However, according to representation about branching development very complex stage of ecologization of cities now begins.
In mutual relation of humankind with other nature, there was simplified emotional and dual perception. The rating of all binary multiple environment according to dual and emotionally painted thinking was used with principles "usefully - harmfully", "yes - not", "friend - enemy", “good - bad", "beautiful - ugly", etc. This rating was far from a reality from the point of view of unbiassed, rational, viable mutual relation with nature.
"Instability not always is an evil, that must be removed, or certain annoying trouble. Instability can be the condition of sustainable and dynamic development. Only systems distant from balance, systems are in conditions of instability, capable spontaneous to organize themselves and to develop. Stability and equilibrium, so to speak, are dead ends to evolution. Any development cannot be without instability" [1].
Therefore, the concept of sustainable building should be plural, it should take into account objective plurality of the world, features of simplified thinking, and it should have adaptive character. The concept of sustainable building should be dynamical, sustainable building should adapt to nature and to person. Uniform for all countries and peoples, for all geographical and national features, «Program of sustainable building» has no future.

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ENVIRONMENTALLY APPROPRIATE HIGH STRENGTH AND HEAT-INSULATING CONCRETES FOR CONSTRUCTION OF HIGH-RISE BUILDINGS

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For construction of high-rise buildings new concrete types are needed, which differ by high crack resistance, increased dynamic strength and higher compressive strength in comparison with other concretes.

In the middle of 80s the high performance concretes (HPC) appeared in the international construction practice. It is specific for them that high (55-80 MPa) and ultrahigh (more than 80 MPa) compressive strength, low permeability, corrosion resistance and durability are achieved by using of high-moveable concrete mixtures.

The technology of such concretes is based on application of microsilica and superplasticizer.

The examples of such technologies application are known as high-rise buildings in Chicago, bridges in Canada, Japan, stadium “Lokomotiv” in Moscow and etc.

In works [1-4] the action of microsilica and superplasticizer additives is explained by changing of hardened cement paste structure: the quantity of gel pores $(1…5)\cdot 10^{-3}$ mcm in diameter is increased, the quantity of capillary pores $5x10^{-3}$ …4x10 mcm is decreased. General porosity remains on the level of the ordinary hardened cement paste. Changing of gel and capillary porosity is connected with changing of structure of cement paste hardened phase: increasing of cement hydration degree and quantity of dispersed low-alkali calcium hydrosilicates.

The multi-purpose modifier of concrete properties of multifunctional action "Geokon-G", which is a powdery composite material on organic-mineral basis, was developed and studied by Ukrainian company "Georesurs" together with Research institute of building constructions. Mineral part of modifier consists of high-active combination of microsilica and alumina (dehydrated kaolin) and organic part is presented by superplasticizer and other additives.

The optimal temperature of kaolin baking, milling fineness, modifier structure are found, the influence of additive-modifier on cement mortar and concrete properties. Testing results of modifier "Geokon-G" are presented in the Table 1 and 2.

Optimal temperature of kaolin baking, milling fineness, modifier content was found, the influence of modifier additive on properties of the cement mortars and concretes was investigated. The test results of modifier "Geokon-G" are presented in the Tables 1 and 2.

Table 1. Influence of modifier quantity on physical and mechanical characteristics of cement mortar (Slump =const=7…8 cm)

Indices	Numbers of mixtures			
1	2	3	4	5
	1	2	3	4
"Geokon-G", %, C	-	5	10	15
W/C	0,625	0,52	0,516	0,53
Slump, cm	7	7	7	7,5
Water reducing effect, %	-	16,5	17,5	14
g, kg/m^3	2100	2080	2150	2120
Strength, MPa, days Ordinary hardening				
$R_{comp.}$ 3	-	8,8	10,0	9,7
7	9,3	15,0	19,4	16,8
28	10,6	19,6	21,1	25,6
R_{bent} 3	-	2,05	2,79	2,63
7	-	2,75	3,79	3,45
28	2,6	4,32	4,59	5,0
1	2	3	4	5
TMC				
$R_{comp.}$ 1	10,0	17,4	16,2	18,4
28	17,0	23,7	24,8	24,5
R_{bent} 1	2,3	2,89	2,4	3,54
28	2,45	3,8	5,4	3,6
Water absorption, %	7,9	-	4,7	-

Table 2. Influence of additive "Geokon-G" on physical and mechanical characteristics of the concrete mixtures and concrete strength (concrete composition: C – 500, S – 650, CS – 1150 kg/m^3)

Indices	Number of mixture		
	1	2	3

Additive "Geokon-G", % C	-	3	6
W/C	0,46	0,39	0,36
Slump, cm	12…16	18	19…20
Strength MPa, Natural hardening 3 days	26,4	35,4	43,5
7 days	36,6	51,4	56,4
28 days	48,2	60,5	74,2
TMC (thermal-moisture curing) 1 day	33,1	46,8	56,3
28 days	55,5	69,2	66,6
Water absorption, %	3,2	2,1	1,9
Lime effloresces	Absent	Absent	Absent
Concrete water proofing grade	W4	W6	W10

The investigations carried out in a number of Research Institutes and application of "Geokon-G" at the leading enterprises of construction industry of Ukraine showed that based on Portland cement M400 and M500 and ordinary aggregates from the hard rocks one can obtain the following:

- high-strength (compression strength 60-80 MPa) and ultra high-strength (> 80 MPa) concretes;
- concretes with high early strength at hardening in natural conditions (25-30 MPa per day);
- concretes of low permeability for water and gases;
- high-movable (CS = 22-24 cm) long-living concrete mixtures of high cohesion;
- concretes of high water proofing, frost and heat resistance;
- concretes with decreased shrinkage and creep;
- concretes with decreased temperature of self-heating at hardening in massive structures.

The special concretes and mixtures were developed using additive "Geokon-G":

- for joints sealing between panels and blocks, which are characterized by high adhesion, acceptable deformability and non-shrinkage;
- for sealing of leaks in the underground structures, which are characterized by high rate of hardening and water proofing;
- for repair of reinforced concrete structures.

The polymeric redispersive powders, microfiber and regulators of setting speed were used in special concretes and mortars together with "Geokon-G".
All above-mentioned concretes and mortars were used at construction and repair of a number of objects such as frames of residential buildings, elevators, tunnels and etc.

One shall note that additive "Geokon-G", which is produced in Ukraine on the basis of domestic raw resources, is in several times cheaper than additives, of a similar effectiveness, which are produced by the European and American firms.

A new extra light mineral material is developed in Ukraine, which is produced as round gravel porous granule, the properties of which are the following:

- high heat-insulating capacity;
- incombustibility;

- nontoxicity, absence of harmful substance emission;
- shrinkage absence during operation.

Table 3. Basic characteristics of "SIOPOR"

	Unit measure	Large faction	Middle size faction	Small faction
Granules size	mm	2,5-10	0,63-2,5	up to 0,63
Bulk density	kg/m^3	60÷20	90÷20	120÷20
Compressive strength	kg/?m^2	0,6	0,5	-
Termal conductivity L_{dry}	W/mK	0,047	0,05	0,053
$L_{operation}$.	W/mK	0,053	0,065	0,07

"SIOPOR" is used in construction as:

- frost backfill;
- filler for light concretes;
- filling agent of plaster mixtures and masonry mortars.

For different kinds of frost backfills "SIOPOR" is used as in pure form and the half-dry "SIOPOR" as cement mixture (SCM)

Table 4. SCM Basic characteristics

Types and application sphere of SCM	Density, kg/m^3	Operational heat conductivity W/mK
SCM-130 for filling of light masonry blocks	130	0,07
SCM-180 for filling of well masonry	180	0,08
SCM-220 for heat insulation of attic floors, and floors above basements and passages	220	0,088

«SIOPOR» is used to obtain sioporconcrete and within range of densities from 250 up to 810 kg/m^3 to obtain masonry blocks of various purpose.

Hollow blocks from sioporconcrete are widely used, which are produced on completely automated lines.

Table 5. Block basic characteristics

Block, 390?190?190 mm	Unit measure	Index
Block reduced density	kg/m^3	250-300
Block reduced heat conductivity:		
in dry condition	W/mK	0,08
In conditions of operation moisture	W/mK	0,091
Compression strength	kg /?m^2	5
Permitted load on 1 r.m. of the wall	t	5
Weight of one block	kg	3,5
Quantity of blocks for 1 m^3 of masonry	piece	71
Quantity of blocks for 1 m^2 of the wall	piece	13
Thickness of brick wall, equivalent by heat characteristics	m	1,6

The performed investigations showed that application of «SIOPOR» as a filler for gypsum and cement «warm» plaster and masonry mortars allows obtaining more effective materials than at using other light fillers (for instance, pearlite).

Summing up the report one can note that Ukraine possesses environmentally appropriate constructional and heat-insulating materials for construction of high-rise buildings and structures in ? ? ? century.

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ASSESSMENT OF RIGA DISTRICT HEATING REHABILITATION PROJECT IN ASPECTS OF ENERGY SAVINGS

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Riga District Heating Rehabilitation Project (RDHRP) has been implemented on base of "Law of Energetic of Republic of Latvia", resolution of Riga City Council 23/12/1997 #5438 "Conception of Riga City Heat Supply Development" and Riga City Council Resolution 21/01/1999 #6981 "Resolution on Riga Centralized District Heating Rehabilitation Project"

The District Heating system in Riga is divided in to 5 major geographically separated regions, plus three systems outside the city core, Bolderaja, Vecmilgravis and Daugavgriva. The present heat supply comes from a number of sources, such as the Combined Heat and Power (CHP) plants TEC-1, TEC-2, the Heating Only Boiler (HOB) Plants Imanta, Zasulauks and Ziepniekkalns. In addition to these plants a number of smaller boiler plants and the individual systems are connected to the system.

The goal for the Riga District Heating Rehabilitation Project is to:

- Allow for optimization of the heat production in favor of Co-generation;
- Optimize the utilization of the distribution system by operating at other temperatures and pressures than today;
- reduce heat and water losses;
- Have the customers' installations improved for even distribution within the buildings so that the customers receive heating and hot water service according to the demand and to what they have to pay. Any measures for saving energy in the building will thus be reflected their heating bill.

Rigas Siltums purchasing of energy is reduced by lower heat losses and lower energy usage by the customers.

In the interconnected Rigas Siltums district heating system the only safe alternative for reconstruction of customer substations is to replace the elevator points by automated individual Heat Substations (AIHS) comprising heat exchangers for both the domestic hot water and for the space heating. This results in major benefits for the District heating system. First, it is a natural boundary between the district heating system and the building internal side, and the responsibilities can be easily defined. As the primary and the secondary sides will be separated by heat exchangers, the distribution system can be operated at the higher pressure if required for optimized utilization of the plants. The temperature level in the building radiator system is independent of temperature in the distribution system. All water losses in the building will be the responsibility of the building owner, and he will have all the incentives to prevent leaks. Any water leakages from the building heating system will only result in rather small amounts of water compared to the volume available when the whole district heating system is directly connected.

It is advised to take the make-up water from the district heating water. It is treated sufficiently, and will not cause further corrosion to the radiators and internal pipes, should frequent refilling be required.

AIHS includes the following major components:

- isolation ball valves for the district heating primary side;
- isolation ball valves for the building heating system;
- isolation ball valves for the Domestic Hot Water (DHW);
- thermometers and pressure gauges as required;
- differential pressure control valve required;
- strainers for protection of the heat exchangers from the DH primary side, from the building heating system, from the domestic cold water, and from the recirculated domestic hot water;
- control valves for space heating and DHW;
- safety relief valves;
- circulation pump for the building inside heating system;
- re-circulation pump with isolation valves and a check-valve for the DHW;
- cold water isolation valve, and a flow meter;
- required service valves for partial isolation of heat exchangers;

Savings are mainly connected with abandoning the 4-pipe systems. The avoided costs for the replacement of the pipes are significant. In the calculations of savings from lower losses (water losses included) the DHW part of the annual energy is determined to be 30%. The heat losses from pipes in the ground are estimated to 20-25%. Out of these it was assumed a saving potential of 25%. There are also savings due to lower maintenance costs for the (Centralais siltuma punkts - Central heating point in latvian) CSP. Another benefit of switching from four to two pipe systems is that the metering of energy is simplified and can be carried out for each building in the substation.

Installing of AIHS is the only most profitable among the others. It will control the supply temperature for the individual building as the function of the outside temperature and the building's real heat demand. The supply temperature from the heating plant can be higher if required for optimized pumping strategy, the electric control valves will operate independently and provide the right temperature for heating of the building. The electric control valve will, in most cases, cover the range of the differential pressure variations. The valve control will not be perfect at all times. In some locations the differential pressure variations are too high, and a separate differential pressure control valve will be required.

By introducing a heat exchanger for the space heating no energy savings can be expected from the customer's side. The benefit is that the district heating system and the building radiator system are hydraulically separated from each other. This means that there are no static or dynamic pressure limitations due to low rated or poor radiators, and the distribution system can be operated more efficiently. Also it provides the building system (and the district heating system) with increased safety in case of leakage. If a leak occurs in a hidden location of the building, the directly connected system will pump out almost unlimited amount of water with resulting huge damages. On the other hand, small leakages in the radiator system, or in the substation will always be replenished and paid for by the heating company with real incentive for the building owner to prevent them.

The energy saving potential for implementing individual active temperature controls has in other rehabilitation projects been proved to be between 10-15%. It was assumed 12% in calculations.

The benefit from the separation of the building heating systems and the district heating distribution system are not included in the savings. Th immediate energy saving is expected to a smaller part and will rather make the expected saving of 12% even more conservative. The not priced benefits including the pressure separation and the improved situation water leakages will have an increased potential in the future when the responsibilities for each party is more defined than presently.

The radiator thermostatic control valves can be used when electric pumps have been installed. There are two reasons for installing Balancing valves and Thermostatic valves. The first is to balance the radiator system to overcome a situation where some risers (and apartments) are overheated while others do not receive enough heat. If the temperature to the radiators is kept at level where the "coldest" apartment has the desired room temperature, than the supply temperature must be kept high. For approximately every 3 degrees the supply temperature can be lowered by, there is a 5% saving of the annual energy for space heating. The second reason is to overcome the problems arising from the fact that one side of the building is exposed to the sun and thus temporarily overheated. Of course any unbalance between rooms and apartments will improve, i.e. apartments located "inside" the building and with only one or two outside walls will not require as much heat as a corner located apartment. The installation of the valves will also allow the tenants to individually control the room temperature. The saving potential is around 2-5% when applied as described. (This will be calculated from the energy usage included in the overheated side or location of apartments in the building).

The utilization of radiator thermostats has been limited to buildings not higher than five stories because of the size of available equipment. Recently the manufactures have developed new design that will allow the installation of thermostats in buildings up to 16 stories. When thermostatic valves are introduced, the heating system should be equipped with balancing valves for the risers. The valves can be of the kind that automatically adjust the differential pressure for the riser, or the traditional balancing valves that are adjusted to the maximum flow.

The CSP (Central Heating Point in Latvian abbreviation) and the connected 4-pipe systems require a lot of maintenance. Rigas Siltums is aware of this and have made calculations for the present situation and when replaced by individual substations. Table number one shows the calculated savings when keeping the CSP and the 4-pipe system, and if new ISP's are installed and connected via 2-pipe system.

For the elevator point in each building the heating company makes visits once a month with two persons. The normal maintenance requires for district heating substations is not more than one man twice a year. The savings are estimated to $200 for each unit.

As the CSP's will be abandoned, there will be significant savings in maintenance for Rigas Siltums. The new substations will be inspected once in two years or on call, when something has happened. The inspections can be carried out together with reading the heat meters. All substations will have an inspection and operation card, where everything that has happened will be recorded.

The new controls will operate automatically on the building's individual demand for heating and hot water. The operation staff will monitor the achieved room temperatures and the common return for optimum values. Fine tuning of the controls for each building is very important to achieve the expected savings.

Table 1. Savings in operation and maintenance with and without CSP

	With CSP	With ISP
CSP maintenance	Ls 4000	Ls 900
Network maintenance	Ls 4600	Ls 1220
Total	Ls 8600	Ls 2120

The total annual savings for replacing the CSP's with ISP's is Ls 6480 for each CSP.

During years 1998-2001 RDHRP has been realized as follows (with attached heat energy consumption changes) in the tab. 2.

Table 2. Dynamics of Heat Energy Consumption after CSP liquidation and AIHS installing.

Year of CSP liquidation	Number of liquidated CSP	Number of installed AIHS	Reduction of Heat Energy consumption in comparison with former heating season	
			kWh	%
1.	**2.**	**3.**	**4.**	**5.**
1998	14	64	7634	16
1999	53	672	39940	13.2
2000	59	957	24858	8.2
2001	61	1309	12182	3.78

Reduction of heat energy consumption performed in tab. 2 confirms the strategy of RDHRP, therefore in first steps the less effective CSP have been retrofitted. Analyses are based on District Heating System structure, connected to CSP. But for AIHS performance verification the Thermo dyna mical Properties of buildings should be separately evaluated [1]. Serial types of existing buildings have been placed in the tab. 3.

Table 3. Serial types of buildings

Serial type	Construction period	Floors	Construction material	Main location
1-316	1957-1964	4-5	Lime and sand bricks	Riga
1-318	from 1964	5	Lime and sand bricks	Riga
464	from 1959	5	Lightweight concrete with expanded lay aggregate	Riga
464A	from 1961	5	Lightweight concrete with expanded lay aggregate	Riga
467A	from 1967	5	Aerated concrete	Riga
647B	from 1976	9	Lightweight concrete with expanded lay aggregate	Riga
602	from 1967	9	Lightweight concrete with expanded lay aggregate	Riga
104	from 1969	5-6	Lightweight concrete with expanded lay aggregate	Liepaja Ventspils
103	from 1969	5-6	Lightweight concrete with expanded lay aggregate	Valmiera
119	from 1980	6-9	Three layer panels	Riga (Zolitude)

After RDHRP implementation a limited functions of AIHS have been investigated. In presented paper the dynamics of night temperature reductio n is analyzed as a function what directly impact hydraulic regime of DH network. In fig. 1 changes of water volume in AIHS as dynamic impact is performed.

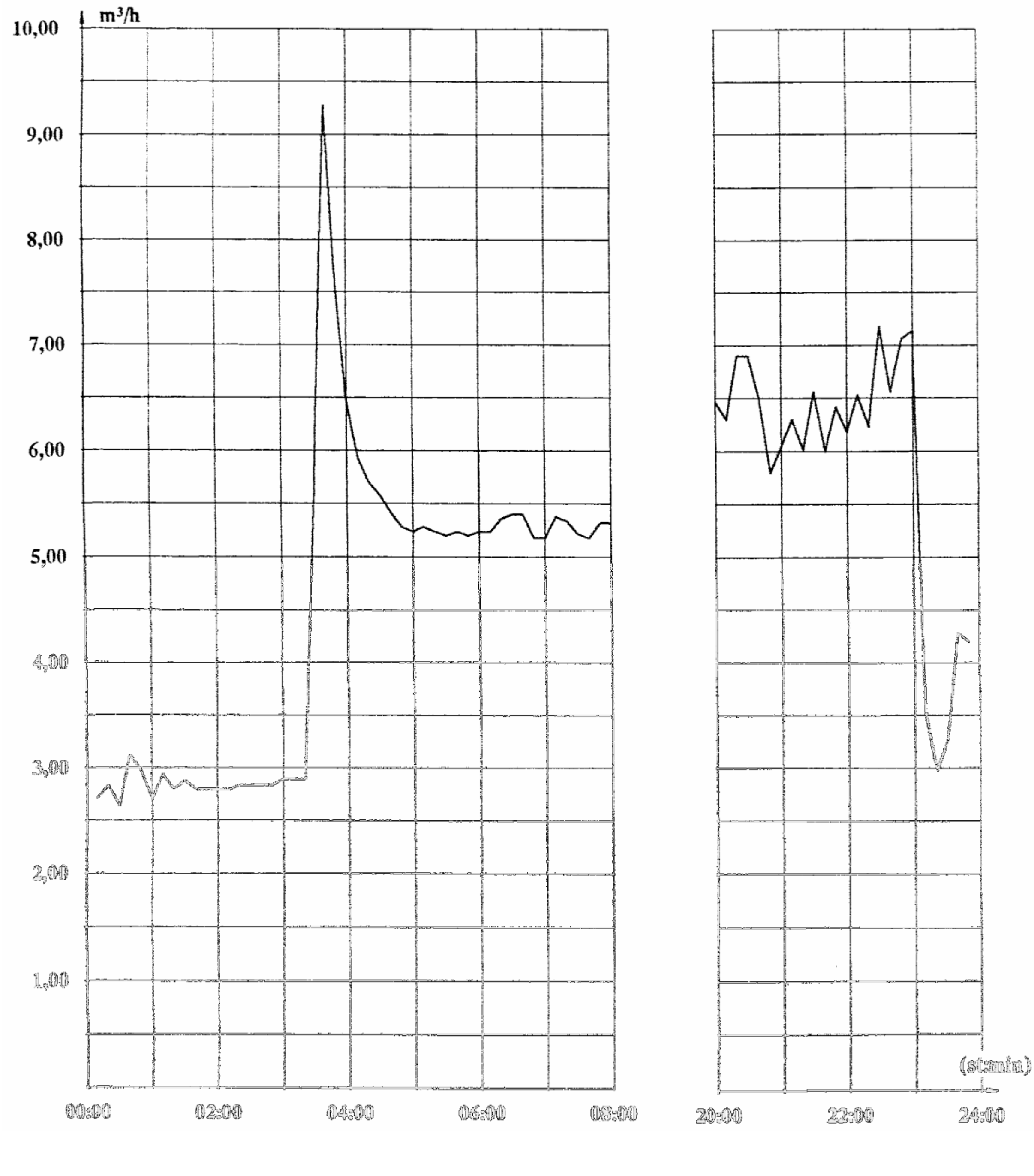

Figure 1. Performance of volume dynamics for morning boost (a) and night reduction (b).

More difficult periods for hydraulic regime are morning boost and evening adaptation. Relative values of transfer processes are compacted in the tab. 4. [2].

Table 4. Transfer process as result of night time temperature reduction.

Number of consumers to reduced temperature regime	Consumption in DH Network					
	Q – heat load; kwh V-water morning value; m3/h					
	Day average		Night average		Max. in morning boost	
	Q (%)	V (%)	Q (%)	V (%)	Q (%)	V (%)
0%	100	100	96	98	103	105
30%	100	100	89	85	105	112
50%	100	100	81	75	112	120
70%	100	100	73	65	119	128
100%	100	100	60	50	130	140

As a result the following hesitation of heating and hot water changes are recommended in tab. 5.

Table 5. Recommended time intervals for night reduction.

Technology type	Night reduction	Morning boost	Reduction in temperature
Heating	21:00-23:00	3:30-4:30	1-2 ^{o}C
Domestic hot water	0:30-1:00	4:30-5:30	7-8 ^{o}C

Resume:

1. stand above controllers available in RDHRP provide possibility of heating curve and night regime choose.
2. Possible reference sensor or adaptive self timing function adding is necessary to estimate.
3. Realization of operation maintenance and use program on computerized local area network is estimated as closed step in Riga city DH development.

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SAFEGUARDING OF THE CULTURAL HERITAGE DURING REDEVELOPMENT PROJECTS

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1. Summary

One of the results of the post-industrial economy is the closing down of factories and the abandonment of numerous sites. According to international documents, technical, industrial and civil engineering heritage constitutes an integral part of historic cultural heritage. Historical buildings or sites are often recognized as assets suitable for redeveloping and investment, and sustainable development policy supports such activities. Developers, contractors, construction companies and related SMEs are turning their attention from building anew onto existing building stock which is sometimes of historical significance. As far as historical preservation is concern, the state-of-the-art requires that we take into account tangible and intangible values. The whole redevelopment project in relation to a historical fabric or site should be studied and respectively assessed on different levels from the top thinkers to the bottom of doers and users, e.g. between 'policy' and 'practice'.

Landscape management today means appropriate action in order to provide a balanced and harmonious relationship between contemporary social needs, economic activities and the environment. The process of transition which has occurred in Poland has brought a danger of abandoning, destroying or losing valuable features of the cultural landscape. To sustain the diversity of the Polish cultural landscape and to promote its values call for promotion and enhancement of safeguarding principles.

Three pillars support the concept of sustainable development: social progress, economic growth and environmental protection. Heritage constitutes a non-renewable resource that contributes to the social identity with its richness and diversity. The cultural heritage is a sort of non-renewable asset, thus any redevelopment project addressed to it should observe the rules of sustainable use of built environment. Those assets embody a variety of numerous cultural and socio-economical values. The

preservation of cultural heritage means to preserve those values for future generations, and it may be understood as a legal procedure and as a moral response to them. At the Faculty of Civil Engineering of Gdansk University of Technology such approach is performed since 1993.
In practical terms any preservation project requires a certain sequence of activities: initiation, examination and diagnostics, project formulation and approval, execution of intervention, monitoring and results evaluation, documentation, maintenance and preventive conservation. All these tasks should be performed in accordance with the professional code of ethics and with the principles of good practice. Indeed, the rehabilitation or revitalisation projects deal with conservation and restoration, and they need to be supported by applied technical and social sciences, particularly exploring the offer of information and communication technologies. In order to convince society of cultural heritage as an indispensable value, the mass media and educational institutions should promote the concept of sustainable heritage.

2. Introduction: considering cultural heritage

Cultural heritage today is understood as a result of a process which relates to the whole built environment and the development of contemporary society, its values and its requirements. Because it contains the signs that document the activities and achievements of human beings over time, the use of cultural heritage should be understood as the use of non-renewable, irreplaceable assets. Landscape that embraces a diversity of manifestations of the interaction between humankind and its natural environment is called the **cultural landscape**. Features of the cultural landscape reflect the development of mankind and some of them play a crucial role as a key element of individual and social well-being, [1]. Organically evolved continuing landscape retains an active role in contemporary society closely associated with the traditional way of life. That landscape consists of significant material evidence of social and environmental evolution over time, and this evolutionary process is still on-going. As far as the built environment of industry is concerned, cultural heritage resources include such immovable objects as buildings, structures, industrial installations along with movable objects like equipment, machinery, interior arrangement and furniture. According to international documents, **technical, industrial and civil engineering heritage** constitutes an integral part of historic cultural heritage and according to the cultural landscape categories named by UNESCO, it can form "the organically evolved continuing landscape that exhibits significant material evidence of its evolution over time". Landscape management is an action seen from a perspective of sustainable development, [1], with an assumption that the „technological and other developments, which occur to meet the needs of the present, will not compromise the ability of future generations to meet their needs with respect to the production, provision and exchange of cultural diverse services, products and practice", [2].

Intangible heritage is demonstrated by intangible values which cannot be seen or touched, whereas the values of tangible heritage can be measured, recorded, quantifiably compared, physically maintained and so on. In other words, the tangible cultural asset is physically represented and has physical presence, e.g. archives, artefact, building, equipment, installations, object, plant, property, structure, tools, traces of ageing - patina, traces of history; while intangible cultural heritage deals with oral tradition and expressions, *spirit des corps* or corporate identity, social practices, rituals and festive events (ethnology), traditional craftsmanship, knowledge and practices (intellectual property). Tangibles are often empowered to visualize the corresponding intangibles, but this phenomenon needs to be unveiled throughout the proper interpretation. Intangible heritage directly relating to the themes under consideration at this conference consists of two items, [3]:

- Traditional knowledge and skills related to tangible cultural heritage, e.g. all the skills associated with vernacular architecture;
- Relationships between different ages in the construction industry community at large; for instance, respect and appreciation for the expertise and experience collected during a lifetime of working practice, which should be transmitted to the younger generation by traditional apprenticeship systems.

Unfortunately authentic intangible heritage once gone disappears for ever, but it can be replaced by another sort of heritage - a new one created and implanted into the social space.

*Figure 1. Gdansk, impressive monument of civil engineering - the Stone Sluice 1618-1623: before and after **restoration**, 1997 (photo: W. Affelt)*

3. Assessment of cultural heritage values

The process of transition which has occurred in Poland has brought a danger of abandoning, destroying or losing valuable features of cultural landscape housing resources being exploited by the industry, nationally owned farms and military zones, including former Red Army properties. To sustain the diversity of the European cultural landscape and to promote its values means in practice the need for a clear and comprehensive method of their cultural values assessment. Both tangible and intangible values must be taken into consideration in each redevelopment project, which should fulfil the requirements of good conservation - restoration practice in compliance with international norms. Exclusively, those projects can profit from EC 5th or 6th Framework Programme financial support, tax deduction, sponsorship, commercials and advertising PR campaigns, official recognition, etc., only under the condition that they truly represent the vivid conservation approach. It is worth reminding oneself of the present definition of the **conservation-restoration** undertaking, that is "any action, whether direct or indirect, on an object or a monument, performed in order to safeguard its material integrity and to guarantee respect for its cultural, aesthetic or artistic significance", [4]. In all other cases a proper name of certain so-called re-type project should be applied respectively and it should inform honestly all parts involved about the developing domain and the enterprise target. From an economic perspective, the intangible asset is a component of total enterprise value, similar to monetary and tangible assets, and it should have to generate economic income and/or enhance the value of associated assets, [5]. Within the scope of economy intangibles are currencies of value, that can be exchanged for other types of value (e.g. knowledge for money, knowledge for knowledge,

knowledge for loyalty). Intangible heritage presents the diverse ways in which people understand the world around them, [6]. By analogy one may come to conclusion that intangible heritage can reinforce measurable values of associated tangible heritage and enhance public appreciation.

Cultural and socio-economic values assessment is based on nine criteria, [7]:

- social identity: ties of society to the object or site;
- relative artistic value reflects historical styles or periods and tradition of artisan schools;
- historical technical and scientific value related to epistemology: evidence of history of technology, field of STS research and studies, cultural anthropology or geography;
- rarity value: representativeness or uniqueness;
- economic value generated by the heritage resource;
- functional value: continuity or compatible use;
- educational value: cultural tourism, historic resource in present-day life;
- social value: providing fulfilment of present demands of local society, that can be achieved by regeneration, rehabilitation, revitalisation, etc.; NGO's, local Amenity site; social services like elderly day care, civic centre, third age university, therapy workshops, etc.;
- political value: monument of national, regional, local scale; nationalistic context; multicultural or international significance.

Scholarly analysis will answer basic managerial questions concerning the primary actions for preventive conservation of cultural landscape values and the selection of appropriate environment-friendly conservation techniques within the strategic plan for integrated conservation.

Figure 2. Gdansk, historic moats and earthen fortifications from XVII c. ***regeneration****: heritage and spatial planning in relation to the environment and the lifestyle (photo: W. Affelt)*

Identity value of cultural heritage relates to the emotional ties of society to specific object or sites is based on recognition. Perhaps, just that value is the one of the most novel and much less applicable in comparison with the traditional pattern of thinking about heritage. On the other hand identity better than others values express the core issue of sustainability in a genuine society-oriented context. One may find identity related to the age, tradition, common memory, legends or some special meanings like symbolic, political, patriotic, nationalistic etc. Somebody's emotions related to the object may have a religious and spiritual nature or can be driven by wonder and sentiment. Discovering one of those ties serves as a trace leading to intangible heritage and its values. Intangible heritage cannot be legally passed over or purchased; to survive, it must be transmitted from generation to generation and constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, providing them with a sense of identity and continuity, [8]. Intangible value has an ideal or rational character of meaning, presence of knowing mind - thoughts and memories. But on the other hand the intangible value is associated with the objects, artefacts, cultural spaces with open or restricted access; destruction of those objects, artefacts and spaces may lead to diminishing or vanishing of this heritage and its intangible value.

4. Safeguarding of the tangible and intangible heritage values

The concept of sustainable heritage is derived from Agenda 21 of the Rio Earth Summit and Our Creative Diversity, the final report of the World Commission on Culture and Development. It is "based on the capacity for urban and natural heritage to adapt itself to the current needs and requests (adaptation of structures and functions), without creating long periods of non-activity or obsolescence, and without having actions susceptible of destabilizing its environment", [9, p. 89]. Sustainable preservation requires the observation of **conservation good practice principles** wherewith reliable treatments should have shown evidence of their non-harmful and environmentally (e.g. cultural, social and natural) friendly technologies:

- minimal losses of historic substance – applying non-destructive high-tech testing methods;
- minimum intervention - saving built-in energy and extending life cycle of materials;
- retreatmentability - ability to repeat treatments in future if necessary;
- reversibility - ability to apply better treatments and conservation techniques perhaps available in future;
- providing distinction between a newly applied materials and authentic historic substance - to pass appropriate recognition of monument towards future generations.

Figure 3. Gdansk, site of former gas plant before and after dismantling of the riveted iron gas tank
*– landscape changes caused by **revitalisation** (photo: W. Affelt)*

Those rules should be applied literally and fully in all projects entitled 'conservation' or 'restoration', whereas all other redevelopment projects (see: paragraph no. 5) should take into account the proper conservation policy to some extend, but as far as possible.

The safeguarding measures affect different stages of project undertaking like, for example, feasibility study, planning, programming, designing, execution, control, monitoring, including every technical phase such as structural design and construction site management. Basic steps of the redevelopment project are listed within following **checklist for safeguarding the cultural heritage**:

- identification: Have the cultural heritage resources of the territory (building, site, buffer zone) been studied and defined sufficiently? Are their tangible and intangible values in danger?

- documentation: Is that cultural heritage recorded or listed in a national register or inventory?
- research: What is the function of defined heritage in society? What is the level of uniqueness and rarity of defined heritage? What is the best feasible method to conserve the heritage within the redevelopment project scheme? How are issues concerning the protection of natural spaces and places of memory presented in curricula?
- preservation: Are the principles of good conservation practice being applied in the project?
- protection: How should the legal duty of protection and financial assistance be reconciled?
- promotion: What is a position of stakeholders regarding that heritage? Are the educational, awareness-raising, promotion and information programmes adopted?
- enhancement: How should the inertia and absenteeism of interested parties be avoided?
- transmission: Are the human resources as intergeneration transmitters of the intangibles available?

Figure 4. Gdansk University of Technology; ***relocation*** *of the iron cooling tower (1902-1994) (photo T. Chmielowiec).*

Due to the 'fragile' character of tangible heritage and 'hypersensitivity' of intangible heritage, the following **general principles of conservation** are presented, [7]:

- Cultural heritage combines its tangible and intangible resources which contain all the signs that document the activities and achievements of human beings over time.
- Conservation of cultural heritage aims to safeguard the quality and values of the resources, protect its material substance and ensure its integrity for future generations.
- Prevention is the highest form of conservation.
- The aim of conservation-restoration treatment is to prolong the life-span of any materials or elements that exhibit the evidence of the workmanship, and to guarantee that this is not falsified by contemporary interventions.

5. Redevelopment activities in context for sustainable preservation

The re-type project always combines some kind of activity that results in changing the *status quo* of an existing building substance or space. It relates somehow to the existing built environment, which perhaps bears cultural values and may be considered as a monument of historical significance. Various re-type projects can be named as below (source is stated in brackets; otherwise definition is given by the author):

- **rearrangement** deals with alterations and minor changes of surrounding or interior of historical building often addressed as comeback to its arrangement in the past;
- **re-assembling** or anastylosis of existing on site but dismembered original parts of structure in course of natural (earthquake) or human disaster (terrorist attack);
- **reconstruction** is understood as development of purely new structure without any relation to heritage preservation policy or the state-of-the-art of conservation-restoration;
- **recovery** or **recreation** means the conjectural reconstruction of a place, [10];
- **redevelopment** is any kind of investment performed on previously explored site;
- **regeneration** is considered as **replacement** of decayed structural members; consolidation and **reinforcement** of materials or structural elements of reduced strength; conservation principles of good practice should be observed as far as possible;
- **rehabilitation** means the physical improvement that are necessary in order to provide an appropriate use to an empty or inappropriately utilized structure, [7];
- **re-housing** is a kind of development in old housing estates requiring modernisation, adaptation, refurbishment and alterations;

- **re-integration** is the filling of lost parts (lacunae) of existing structure in order to enhance the potential unity of the whole, [11];
- **relocation** requires transfer of the building or structure, that often includes its dismantling; non recommended in case of important cultural significance;
- **renovation** is considered as a type of regular maintenance aiming on external appearance improvement of the object of concern: treatments include cleaning, surface minor repairs (plastic repairs), re-pointing masonry, application of water-repellents to porous materials, re-plastering walls, repainting architectural surface, redressing stone;
- **repair** is considered as a type of regular maintenance aiming on building shell improvement;
- **replacement** of decayed materials and non-structural elements, roof dewatering performance, sealing window and door frames and related fittings;

- **replication** tries to reproduce the work which no longer exists and attempts to form an exact copy that may damage the site's present authenticity, [10];
- **restitution** means kind of recovery or recreation with stress on intangible values of such project due to its political or social meaning;
- **restoration** aims to preserve and reveal the aesthetic and historic value of monument and is based on respect for original material and authentic documents, [11];
- **retrofit** is a new investment directly tied or closely related (in physical terms) to the substance of historical significance;
- **retro-version** is a new investment that follows historical size or shape of past structures known due to archival sources or iconography;
- **reuse** means adaptation and modifying a place to suit proposed compatible uses, [10];
- **revitalisation** improves the social and economic activities of an historic area or an historic town, which has lost its original functional vitality [7];

The aim of any action undertaken for preserving the resource of cultural heritage (obviously non-renewable) is to conserve its tangible values and associated intangible values. Indeed, to achieve that goal it is necessary to know what it means. Limited knowledge in society in general, and in construction industry professionals in particular, does not offer a promising starting point. For many of them, the notion of sustainable development sounds like a meaningless Western slogan. In almost every sector of activity and production in Poland, one may observe the misunderstanding of the concept of sustainable development. The author hopes to contribute to that know-how demand by supplying relevant information at professional conferences, [12, 13].

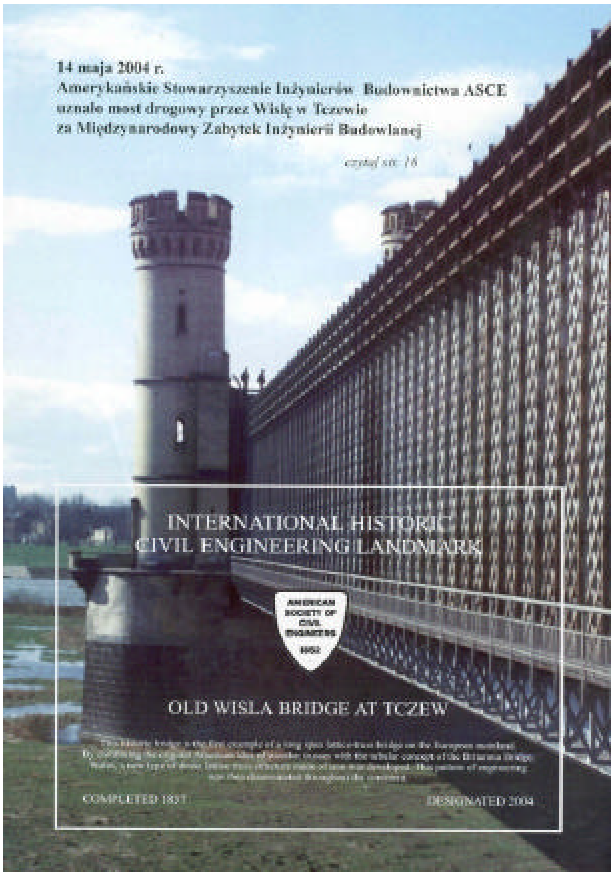

*Figure 5. Tczew, road bridge over the Vistula river after **repair** as shown on the cover of the Gdansk UT Newsletter "Pismo PG", No. 6 (100) 2004 (photo: W. Affelt).*

6. Sustainable heritage management framework

The framework of sustainable preservation of cultural heritage can be understood on different levels from top of thinkers to bottom of doers, e.g. between „policy" and „practice":

- **policy** - public authorities express the general principles, strategies and guidelines that permit the taking of specific measures aimed at the protection, management and planning of cultural heritage and landscapes;
- **strategy** (economy) - conservation of cultural heritage assists in defining sustainable patters of production and consumption relying on management of space and resources, economy of energy, and recycling of materials and waste;
- **cultural strategy** - cultural tourism should avoid overexploitation of the resources, but can help to upgrade less popular cultural properties like industrial, technical and civil engineering heritage;
- **social strategy** - fiscal and legal options to encourage job creation in connection with the use, upkeep and restoration of the built environment resources; providing solution for urgent needs of local society;
- **management** - decision-making criteria which highlight the long-term investment value of heritage programs and the fact that profitability in this area cannot be evaluated solely in economic terms but as a gain for society as a whole;
- **methodology** - assessment of socio-cultural and socio-economical values of the heritage resources helpful for spatial planning, urban development and any redevelopment projects.
- **method** - assessment of environmental impact of rehabilitation of old buildings or revitalisation of sites compared to construction technology according to modern production methods based on building stock life cycles;
- **practice** - the conservation of cultural heritage resources in general and preventive conservation in particular include various strategies for indoor and outdoor resources, especially, when modern composite materials and technologies are applied.

It must be mentioned that an important economic function of heritage is **sustainable cultural tourism**. This is travelling to experience the places and activities that authentically represent the stories and people of the past and present. Well-interpreted sites teach visitors their importance. For that purpose all resources should be managed such a way that economic, social and aesthetic needs can be fulfilled while maintaining cultural integrity, the essential ecological process, biological diversity and life support systems, [14]. Managerial guidelines were put on the Internet for the purpose of fulfilling "dreams of a society that has pride in and respect for its heritage and culture, a society that values cultural and ethnic diversity, that is conscientious and ethical, that respects itself and the rights of others, that promotes a sense of self identity among peoples and nations, that encourages sustainable development that grows both inwards and outwards, and that encourages growth within an equitable framework", [15]. These **managerial guidelines** ask us to:

- "build awareness by ensuring local involvement;
- develop a knowledge base of the resources by identifying, classifying, and inventorying;
- demonstrate the intrinsic and monetary value of the heritage resources by valorisation;
- safeguard the heritage resources in the long-term by local protection, preservation, and conservation;
- reduce conflict of interest by legislating of protection to heritage resources;
- enhance value and build local capacity by integrating local communities in development projects."

Whilst those guidelines were addressed to citizens of Latin America and the Caribbean countries, they are equally applicable in Poland or elsewhere.

7. Gdansk UT's contribution to sustainable heritage

The author has undertaken safeguarding action and international promotion of the unique worldwide heritage of technology and civil engineering in Northern Poland, and recently in Ciechocinek – the historic saline producing salt from cooked brine since 1832, [16, 17]. In 1993, regarding the Council of Europe Recommendation No. R (90) 20, [18], the Faculty of Civil Engineering of Gdansk University of Technology adopted strategy for the promotion of technical heritage awareness. For this purpose several events were held, and the author was on secretary duty to their committees. The new **student course on Cultural Aspects of Construction**, an outcome on the international TEMPUS-Phare project, was developed and introduced within the standard curriculum. This program, guided by a specially written course handbook, [19], helps to educate a sustainable heritage-friendly engineer by improving his or her ability to undertake responsibility for safeguarding values of the built environment, [20]. During the conference in 1993 the state of dereliction and negligence of an area adjacent to the old fortifications and moats on the south-east outskirts of Gdansk was brought to public attention. In 1997, the authorities of the city began a **long-term revitalisation project** there, [21]. The next example of successful promotional action undertaken during the conference in 1999 is the monumental bridge over the Vistula river in Tczew, opened in 1857, [22]. It was closed for traffic and pedestrians in 1998 due to its poor technical condition. International research recognized the unique cultural values of this bridge on a world scale. Also its socio-economic value was recognized as the main provider of easy access to jobs for villagers from the other bank of the river in the city of Tczew. In 2000 the bridge was listed on the national monuments register and financial sources necessary for maintenance were provided. So far, the monument has been saved and moreover recently has became recognized as an **International Historic Civil Engineering Landmark** by the American Society of Civil Engineers. The next conference on "Heritage of Technology – Gdansk Outlook 4" is announced for 4-7 May, 2005, [23]. All those activities and their results confirm the mission undertaken at Gdansk UT several years ago respecting the following statement: „Present generations have the responsibility to identify, protect and safeguard the tangible and intangible cultural heritage and to transmit this common heritage to future generations", [24].

8. Conclusion: towards sustainable heritage

The process of economically restructuring the Polish economy caused long periods of non-activity and obsolescence of plants and other properties that have degraded rapidly and lost not only their cultural values but feasibility for any redevelopment whatever (e.g. fire, uncontrolled dismantling, vandalism, burglary). On the other hand redevelopment projects often cause diminuition of cultural heritage and given assets values due to a lack of related knowledge and a commitment to safeguarding. The dichotomy of nature and culture obscures the understanding of the notion of sustainable development that is still often recognized as just environmental protection. Based on my experience and observations I feel confident to say that the call for **national action for sustainable development** is necessary and urgent. Task force group should be born from the academic teachers who guarantee to encourages the appropriate sustainable heritage education, [25].

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ENVIRONMENTAL IMPACT ASSESSMENT: DEVELOPING BUILDING SITE DISTURBANCE INDICATOR

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1. Site disturbance and sustainability

Building activities unavoidably introduce disturbance into the environment [1]. Alterations to the building site at various stages of site preparation, construction, landscaping and use can be seen in this context as the beginning of a long chain of changes, which bear a direct impact on sustainability. Nevertheless, while caring about biodiversity and striving to improve our buildings in terms of their environmental performance, site disturbance is seldom found in discussions of sustainable practices except for fairly detailed Life Cycle Assessment (or LCA) models [2]. This paper suggests an approach where potential disturbance to the original site is measured and can thus be taken into account for the environmental impact assessment at early stages of planning and design. The offered method analyses modifications to biotic and abiotic components of the site in terms of measurable changes and their cultural, historical, aesthetic, biological, economic and social values can also be included. It starts with an assumption that any change to the site is undesirable and uses a fairly simple algorithm. The matrix calculation, built with weighted values representing the predicted changes, results in the Building Site Disturbance Indicator or BSDI: a numerical value representing extent of the disturbance, and open to further interpretation. It can be seen as a relatively accurate measure of what may be expected after the work on the site commenced.

There are many assumptions built into the Indicator. The most important of them is the detrimental effect of any change, as already mentioned. Based on the precautionary principle, it was considered prudent to reject any notion of ‘improvement’ to the site or even ‘restoration’ of the ‘original’, that is, the landscape features, soil composition, fauna and/or flora. Complexity of the processes involved in creating biotopes and some yet unknown impacts of geomorphologies make their precise evaluation nearly impossible. Moreover, all such ‘improvements’ and ‘restorations’ include our subjective judgments by definition. For instance, marshlands sometimes can be described as wastelands (and, as a result, potentially ‘improvable’) while in fact representing extremely rich and very complex environments. Millions of years of evolutionary changes resulted in the current make-up of available biotopes and any change is displacing long established niche organisms. Even deserts have their place in the global ecology and deserve our protection if we really care about sustainability. Still more prominent is our carelessness displayed in the attitudes towards animals: it is much easier to gain support to protect koalas than cockroaches.

Building Site Disturbance Indicator is not meant to deliver a value judgment. It can be used for asserting site value but, in principle, it was devised as a prediction tool revealing to the planner or designer the extent of environmental impact that their development could potentially have in terms of the modified ecosystem base. Thus, it should not be expected that the outcome would grade the design as ‘good’ or ‘bad’. Unfortunately, we can’t stop building and with our building activities come site disturbances, environmental impacts and threats to sustainability. Instead, we can opt for a design solution that will create less site disturbance, have a lesser impact on the environment and extend our hopes for preserving it for posterity.

2. BSDI methodology

The method used in Building Site Disturbance Indicator is well established and documented in, for instance, business literature as multivariate regression analysis [3][4][5]. Regression analysis in planning is a technique of estimating the contributions by independent variables to the variation in the dependent variable. It also helps to predict relationships among the variables to show how changes in one affect the others. Similar to market planning, we can present site planning as having a single dependent variable that we are interested in, namely environmental impact, caused by a range of independent variables. In BSDI, the dependant variable can be defined as the site disturbance potential outcome and changes to site-specific attributes are the independent variables influencing that outcome. The essence of regression analysis is to develop a formula that systematically relates the dependent variable (site disturbance) to the independent variables. These factors are considered in three matrices. The result is a fairly objective measure of changes to the site in terms of relative volumes and distances rather than qualitative verbal descriptors.

BSDI differs from similar efforts (for instance, a multi-criterion landscape analysis method PROMETHEE [6]) in its localised application. The method proposed in this paper is not only limited by the site boundaries but also attempts to provide its objective evaluation. It would be unrealistic to stay away from any subjective assessment at all (cf. [7]). The method presented below provides for our anthropocentric needs by introducing Landscape Value Modifier (or LVM), which may be used separately or in conjunction with the Indicator.

2.1. Matrix factors

The first of the three matrices represents thermal and hydrographical conditions influencing formation of biotopes and abiotic elements, such as soils. It was possible to reduce these factors to just four measures: slope gradient, slope orientation, overshadowing and drainage potential. They were found in literature as necessary conditions of biodiversity or indeed supporting landscape sustainability [8][9]. Some methods consider slope, soils and surface waters only in a narrow understanding purpose of preventing disturbance as

> to protect property, surface water, and ground water against significant adverse effects from excavation, filling, clearing, unstable earthworks, soil erosion, sedimentation and storm water runoff and to provide maximum safety in the development and design of building sites, roads, and other service amenities. [10]

The four factors are introduced into the BSDI matrix as percentage figures reflecting the extent of changes posed by the development averaged per area unit. Thus, no change to incline equals 0.50 while increasing it produces a number between 0.51 and 1.00 (vertical) and reducing it produces a number between 0.49 and 0.00 (horizontal). It is suggested that the area unit is $1m^2$ for sites up to $1000m^2$ in size, $10m^2$ for sites up to $10{,}000m^2$ and $100m^2$ for larger sites.

Similarly, no change to hydrology of the site results in a figure 0.50 entered into the matrix, while increased drainage produces a number, representative of change potential, between 0.51 and 1.00 (all water removed from the site) and reduced drainage produces a number between 0.49 and 0.00 (all water retained on the site). Thermal conditions (insolation and wind exposure) are strongly influenced by orientation of the slope. Hence the third factor in the matrix relates to changes in orientation of the terrain. In this instance, solar exposure was arbitrarily considered more important than direction of prevailing winds and numbers introduced into the BSDI matrix represent change in relation to North and South orientations: no change would again equal 0.50, while re-orientation towards midday sun direction would produce numbers between 0.49 and 0.00 (due South in the northern hemisphere) and moving away from the sun would result in numbers between 0.51 and 1.00 (due North in the northern hemisphere). This factor is also indexed based on area unit. Finally, an overshadowing factor is introduced to indicate change to the size of shaded area, based on the area unit as above. The arbitrarily selected time for asserting the overshadowed area was the noon on spring/autumn equinox day. The increase in overshadowing will produce numbers between 0.51 and 1.00 (100% shaded) while the decrease — numbers between 0.49 and 0.00 (no shadow). No change is recorded as 0.50. The shadows considered here can be cast by landforms, vegetation and/or buildings introduced to or removed from the site.

The Index would have limited value if it did not look at a structure itself. The second matrix is built with values representing built-up area. Human intervention on greenfield sites can go in only one direction by increasing the percentage of ground covered with the structure and/or landscaping (numbers from 0.51 to 1.00 for the site entirely built-up). However, brownfield sites also support (admittedly, artificially created) their own ecosystems. The removal of previously existing structures creates a disturbance to such ecosystems. This is acknowledged by possibility of values between 0.49 and 0.00 (the site stripped of all artificial structures) appearing in the matrix. The structure is not just the area covered. The depth, to which the site can be affected, is not only disturbing its original hydrology but also dislocating floral and faunal communities occupying underground habitats. This is the only open-ended entry to appear in the matrix. It is proposed that number 0.50 is assigned to a site untouched by a building. To arrive at 1.00 one would have to put the structure's foundations at the average depth of square root of the site area, that is building to the depth of an imaginary cube touching the site with its top surface.

Finally, to complete the picture, there is the construction process to be assessed. It is not good enough to disturb the site and then mend the damage. Any change to the ground is permanent as the composition of the soil and its layering take eons to form. Precise recreation of the original in its minute detail is virtually impossible. Thus, any movement of the ground, at any stage of the construction, should be accounted for and entered into the BSDI matrix database. It is proposed that the movement is considered separately for vertical and horizontal planes. For the purposes of the assessment, the imaginary cube would once again be invoked, this time consisting of unit cubes varying in size dependant on the size of the site (based on the area units: $1m^3$ for sites up to $1000m^2$, $33.3m^3$ up to $10{,}000m^2$ and $1000m^3$ for larger sites). If the average unit cube is not moved at all, the figure of 0.50 is entered into the matrix. Moving it to a distance equal to or larger than the length of the imaginary site cube's side in either horizontal or vertical direction produces 1.00 in the matrix.

2.2. Landscape Value Modifier

The disturbance to a site can also be subjectively evaluated by comparing values attached to the original site (landscape) and its amended form in terms of their cultural, historical, aesthetic, biological and economic values. The matrix consisting of those purely utilitarian comparable values can offer evaluator's view of maintained (entered as 0.50) and 'improved' (between 0.49 and 0.00) or 'worsened' (between 0.51 and 1.00) qualities. An additional factor, which can be added to the matrix, is the contextual quality understood as how well (or how poorly) the site blends with the neighbourhood. The scale applied to this factor is the same as for other qualities in this matrix. The resultant Landscape Value Modifier can be used to reinforce the BSDI result or separately. It is suggested that in any instance the qualities are considered for the entire site.

A large body of existing research on landscape ecology can provide thorough and detailed analyses of spatial differentiation of landscapes including considerations of number, volume, spatial distribution, neighbourhood and form of units, which make up a given landscape, for instance matrices–lobes–corridors method [11]. As long as the numerical result of the landscape evaluation is brought to the same scale, and any method output can be used as a modifier. This applies also to other subjective assessments regarding a range of issues perceived by a valuer as relevant in terms of a particular site.

3. Conclusion: BSDI limitations

The main question to be addressed for BSDI to be effective is the selection and use of the variables being assessed and, even more importantly, the use and assessment of weighting or choices between those variables. Once the components to be considered are established, matrixes for calculation of the BSDI can be built with relative ease. The term 'selection' introduces certain seeming subjectivity. In this instance, however, it only describes necessary preparatory steps taken in the formation of the Indicator. Once all contributing factors have been agreed on, BSDI can be used in any project evaluation. If a certain factor were found inapplicable, it is put in a matrix simply as 0.50, which is 'no change'.

The Building Site Disturbance Indicator is not comprehensive in its elucidation of changes to the environment. It takes a snapshot of the site, deliberately limited in scope, temporal aspect or larger scale context. It does not take into account any effects of operating the building intended for the site, effects of grade and vegetation cover change manifested as air or water erosion of the soil, acidification due to air pollution, salination following removal of vegetation or impacts of generating construction waste (cf. [12]). This has been left to other methods, such as Eco-indicator 99 [2]. Those effects are not included due to the sheer complexity of possible pathways and implications. BSDI is similar to the 'ecological footprint' concept, except for extent and scope of the issues being covered. They may be different in this respect but the basic principles should still hold.

BSDI calls for considering building/land interface to minimise disturbance to site character, skyline, vegetation, hydrology, and soils. Its outcome favours consolidation of functions or segmentation of facilities to reduce footprint of individual structures to allow sensitive placement within existing landforms (cf. [13] and [14]). Like all other considerations of Environmental Impact Assessment, it improves the information-base of decisions made by building designers [15]. BSDI is not perfect and will require several years of fine-tuning. But it provides an important link between the proposed building activity and its consequences for the site extended well beyond the immediate future. In this way it supports the concept of sustainability by extending it to considerations of impacts previously neglected.

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SUSTAINABLE DEVELOPMENT THROUGH EDUCATION

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Introduction

In contemporary Europe an increasing number of buildings is designed with the aim of achieving an equilibrium between the optimum of the user needs, conservation of the natural resources and ecosystem requirements. However, there often exists a gap between the environmental and architectural quality.

Environmentalism reaches well beyond Architecture, and the ideas are applied through a global interdisciplinary strategy affecting all aspects of our lives. Designers, developers, politicians, financial organisations and associations and the general public bring their own logic and priorities – priorities which may not be consistent with sustainable development. All these players must be brought together and encouraged to adapt changes in behaviour, with a view to protect the surrounding environment and ecosystems. In turn, a number of objectives come into being, these may be formulated as the needs to:

- Increase the awareness of the environmental issues for all age groups
- Prepare a frame for the environmental education programme at each age level
- Establish support and train individuals able to carry out such education programme.

It is evident that it is very important to remember the vital meaning of education within sustainable development. Education for sustainable development was first described in Chapter 36 of Agenda 21. This chapter identified four major areas: improvement of basic education, reorientation of existing education to address sustainable development, development of public understanding and awareness, as well as required scope of training. In order to promote basic education, communities and nations must have the skills, acquire values and have perspectives that encourage and support this new perception of the surrounding environment. This can be achieved especially through reorientation of the formal education so that it will address sustainability and will educate a population with sustainable goals and sufficient knowledge to contribute into new development. We have to ensure that the interconnections between the environment, economy and social structures form an integral part of the education, starting from the kindergarten and continuing through elementary and secondary school, college and university as well as professional levels.

Presently, environmental education has to overlap with other priorities, such as integrated or comprehensive services, incorporation of advanced technologies in the classroom and parent involvement. These can only be achieved through a continuous transfer of data, not just within the traditional context: designer-client-contractor, but also in a wider sense. Concerning issues having intermediate influence on the construction and utilisation of buildings.

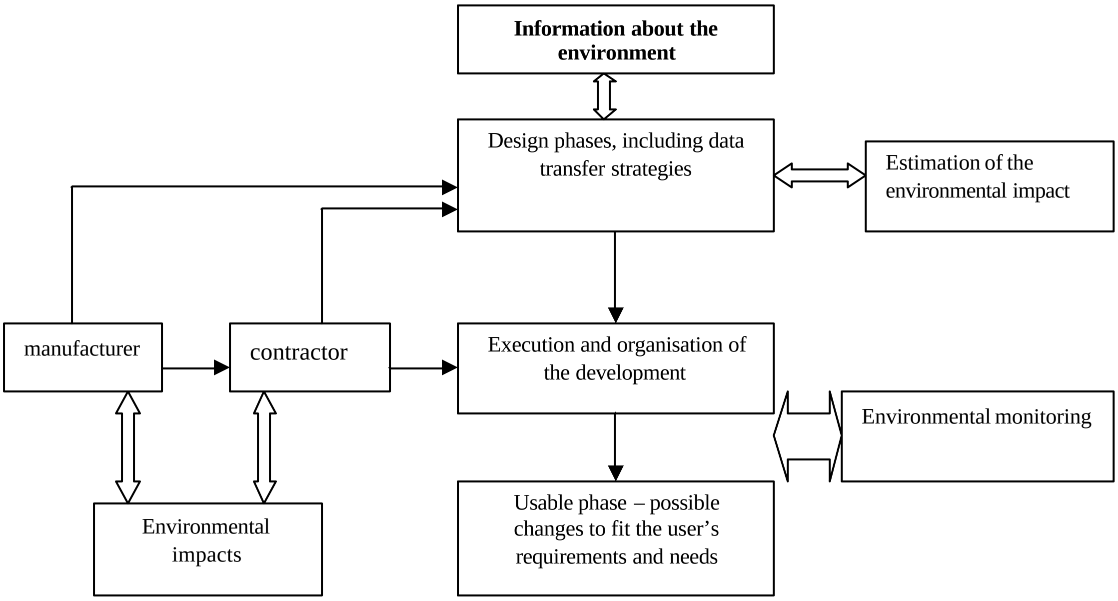


Figure 1. Transfer of data between all participants of the investment process

Hence, to provide our environment with sustainable Architecture, all parties have to follow the same aims, and have an interest in the parameters achieved during the building's performance. Environmentally friendly construction requires motivation and communication between the developers, designers and contractors.

The Context and the site

The rigours of the climate along with strong architectural traditions, have given Norwegians a long standing awareness of the relationship between humans and their natural surroundings. Environmental protection policies are based both, on strict laws and on ideas of individual responsibility – the right of all to benefit from the natural environment.

These aspects are clearly distinguished in the Kvernhuset School. Designed by PIR II Arkitektkontor as and Duncan Lewis et Associates. An R&D project was initiated to assist the planning. Scientists at SINTEF and NTNU took part in the programme and early design phases. The school opened in January 2003. The school building has usable area of 6.865 m^2, plus a sports hall with an area of 1.913m^2. The number of pupils varies from 450 to 500. Construction costs were 201 mill NOK (app.24 mill Euro). The main aims of the Fredrikstad municipality was to build a school building in accordance with Local Agenda 21 and to gain a practical knowledge on the environmentally friendly schools, disseminate the information to designers and municipalities as well as increase the pupils' awareness on the environmental issues.

Several aspects were considered as vital in the design brief. These are as follows:

- The building was to be efficient and flexible in use.
- The school was to achieve the highest grade of quality in the areas of «Exterior environment», «Resources» and «Indoor climate», when assessed using the Norwegian EcoProfile methodology.
- Use of energy for the heating purposes, ventilation and lighting was to follow strict energy efficiency considerations. Renewable energy sources were to be utilised.
- The school building and yard was to acquire the values of an environmental teaching tool.

The school is situated in the suburbs of the Fredrikstad city, on a site within a pine forest. The area is characteristic due to a long uncovered granite outcrop forming a 3 to 5 m high shelf in the northern part of the plot (figure 2).

One of the important goals was to enable all pupils to reach the school on their own, hereby reducing the need for car transportation. This resulted in the construction of various bicycle paths, sub passages and pedestrian crossings. The building layout was designed to preserve the existing trees as much as possible.

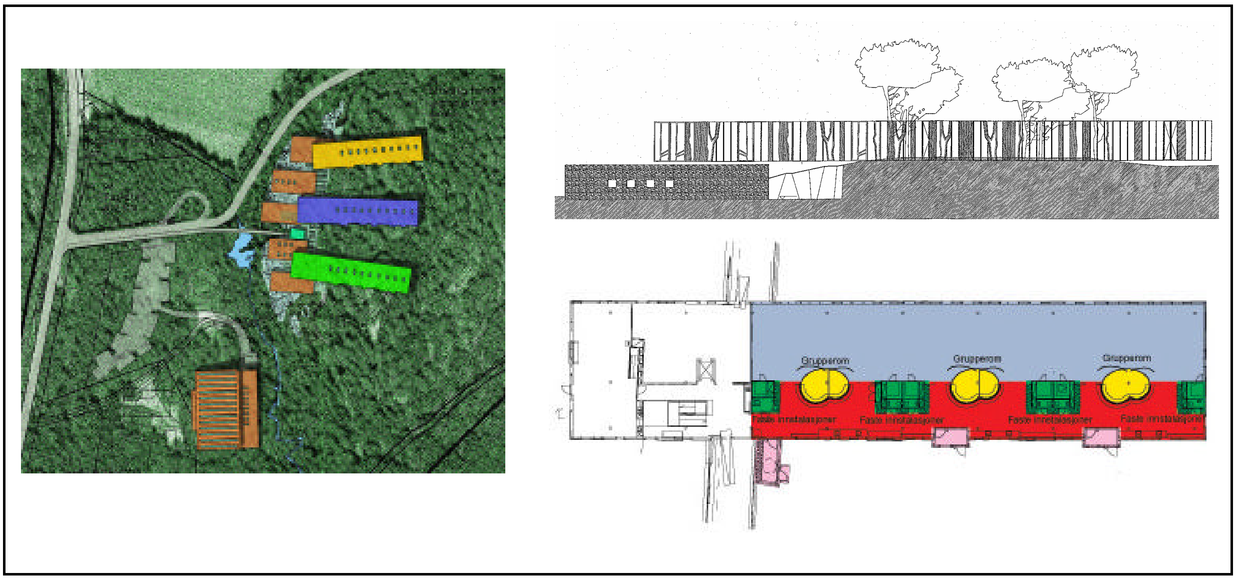


Figure 2. Site plan, South facade and plan of pupils' base area

The main design idea of the school building is based on the active use of the site qualities: the rock, the forest and the light filtering through the trees. Wood and granite from the site were used as building materials.

The ground floor of the building cuts straight through the granite rock. Stone debris acquired during the construction of foundations was gathered in gabions and used as external finishing surface for the ground floor of the building. In this way “a men-made” structure was formed to supplement a natural feature. On top of the rock, three rectangular, long and narrow wings almost float over the ground floor. The wing façades express the design inspiration with the surrounding trees (figure 2), each wing has a slight touch of one of the colours: yellow, blue or green. They have a light architectural appearance creating a strong contrast with the ground floor.

Figure 3. View of the main entrance. Photo T. Heen

One of the aims, when designing the pupils’ base areas, was to create flexible buildings adaptable to different functions. The school was to have a possibility to experiment with different pedagogical settings, and have the rooms and furniture adaptable to various working methods. The wings with the pupils’ base areas consist of three zones: the class area, «a spine» and the common area.

- The basic design assumption for the class area is a free plan which can be divided into conventional or double classrooms, school landscapes and pupils «offices», a combination of mentioned alternatives is also possible. The design challenge was to create a technical support which favours flexibility.
- The changing rooms and areas with fixed technical installations are located in the «spine» which also serves as a separating element between the class areas and the common areas.
- The common area contains a zone along the facade equipped with workbenches, washing troughs, aquariums and «window gardens». The common area is meant as a supplement to the class area.

Walls can be placed along the structural axes; the rooms are connected to the ventilation inlet and outlet valves. This means that an individual room has to be placed next to the spine to get the inlet air, and at the same time have access to the dampers for the outlet air in the base of the skylights. Large rooms may be divided into zones by means of light walls, book shelves, screens, plant cases, aquarium and trees. Changes may easily be accomplished and the pupils and teachers themselves can arrange and rearrange the lay-out of their area.

Materials and finishes

The choice of the materials is an attempt to balance the recyclable concerns, embodied energy requirements, use advantages, maintenance, quality, cost and availability. In general the main idea for the choice of materials was the **R**educe-**R**euse-**R**ecycle principle.

The main load bearing walls are made from prefabricated reinforced concrete. The ground floor façade is faced with gabions of unprocessed local granite encased in stainless steel mesh cages. The mass of concrete and stone increases the building's thermal inertia. The building's « spine » has been constructed from reused brick.

The facades' of the pupils' wings are faced with untreated pine wood taken from the trees which had to be cut on site in order to clear sufficient place for the building. Large areas of façade glazing, along with high quality glazed sections in the corridors, maximise the access of natural lighting.

The green roof system (sedum) requires only a shallow substrate. It adds to the creation of the local microclimate, as well as absorbs CO_2. The plant species need minimum of maintenance and provide a green carpet with a changing of the season aspect.

Recycled materials are widely used. The opaque elements (ISOFLEX) inserted in the fully glazed facades are made from recycled polyethylene inserted between two layers of glass. This solution allows for the access of additional daylight, while possessing good thermal values. A number of furniture units are made from recycled plastics. Many areas have been left without any surface finish, or are protected with semi-processed materials (e.g. particle boards are used as suspended ceiling elements).

In the common areas, the designers allowed that the natural rock formations to play the part of pupils' furniture.

Energy and climate control

Environmental features include:

- A 360 kW heat pump utilizing the ground heat for the heating of the tap water and the premises, and for the pre-heating of the in-taken air. In the summer, this equipment works in reverse and is used for cooling purposes. The heat is collected from 28 wells (depth: 175m).
- Use of the daylight resources
- A natural ventilation system in the upper floor
- Low emitting materials used in the building (to reduce the ventilation demand)
- Energy efficient lighting equipment and control (daylight sensors and timers)
- A central control unit for the building's energy systems
- Natural on-site purifying treatment of the grey and black water
- Water saving sanitary equipment
- Wood and granite debris from the site (gabions) are used as building elements and decorative details
- Adaptation to and utilization of the natural surrounding resources.

In addition, there has been a strong focus on the educational features. The school comprises of three wings, each focusing on a separate topic: The yellow, blue and green wings representing respectively the sun, water and growth.

A 750 W photovoltaic system has been installed on the wall of the yellow wing for demonstration purposes.

Internal environment parameters are sustained through a centrally controlled BMS unit. Still, for the ease of use manually operated light control and window blind systems operable both by the teachers and pupils have been installed.

Daylight is used to reduce the consumption of the high-grade electric energy for artificial lighting and, at the same time, enhance architectural values. Separately operating zones for artificial lighting, and control by daylight sensors contribute to the energy efficiency.

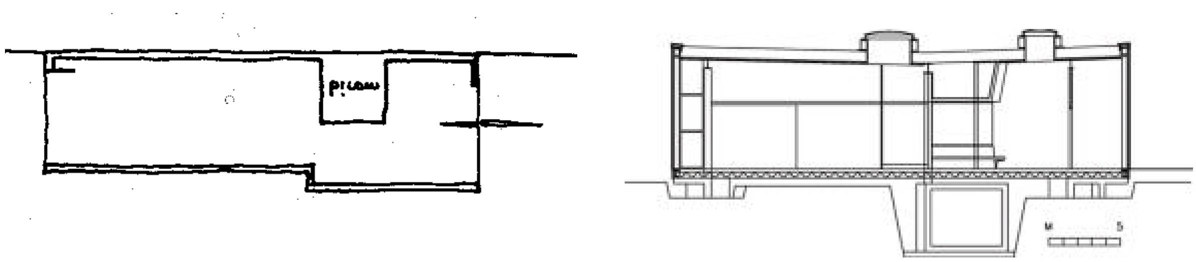
Examination of the alternative cross section solutions was conducted in order to achieve higher daylight standards (when compared to a base case). Requirements to daylight levels were set for this project as shown in the table below.

Table 1 Requirements to daylight levels

Space category	**Average daylight factor**	**Minimum daylight factor**
All education areas Gymnasium	5 %	2 %
Workplaces for teachers Offices for the administration staff	3 %	1 %
Secondary rooms	(2 %)	-

Parametric studies for each alternative was carried out to find the minimum glazing area allowing to achieve satisfactory daylighting requirements, including the best form and location of the additional window openings. The daylight simulations were made using the LesoDial computer program.

Analyses showed that the simplest and the most effective alternative for the base area was a combination of large windows and skylights situated over the rear part of the class area. Large windows facing north and skylights allow achieving high daylight levels.



North to the left

Figure 4. Vertical cross section of pupils' base area. Drawing from the architect's competition design (base case) to the left. As built, with additional skylights, to the right.

The external walls are a compound of opaque wall elements, clear glass elements and elements with the transparent insulation material ISOFLEX.

Table 2. Specification of the wall elements in the North facing walls in base areas

Element	**Light trans-mission factor**	**Per cent of wall area**
Clear glass elements made of two layers of glass	76 %	30 %
Elements with ISOFLEX, semitransparent material placed between the glass layers	36 %	30 %
Light opaque wall elements made from wooden elements	-	40 %

A second parametric study was carried out to find how the size of the skylights may influence the minimum area of the transparent part of the wall, i.e. clear glazing and ISOFLEX glazing. The clear glass area and the ISOFLEX area were calculated for different numbers and areas of the skylights in order to find a solution giving high daylight levels and at the same time the lowest possible heat loss.

The building is provided with a **ventilation** system based on culverts. The airflow rate will be adjusted for the various seasons. In plan 1 there is a diagram of a mechanically driven ventilation system. In plan 2 natural driving forces, buoyancy and wind are used for ventilation to reduce the demand for power for auxiliary fans. Demand control of airflow and low-emitting building materials will further contribute to the energy efficiency. Heat recovery unit is installed for the mechanically driven system.

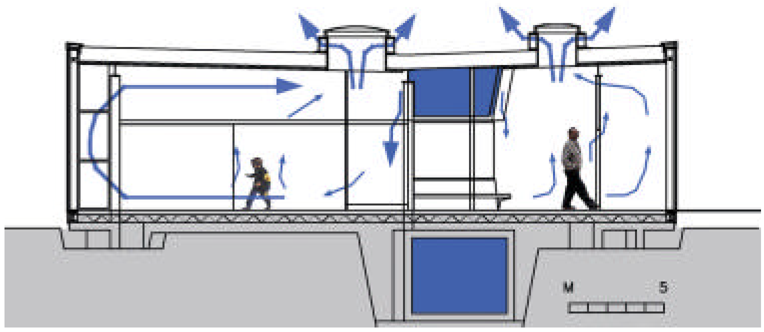


Figure 5. Section through pupils' base area, plan 2. Ventilation air is led from the culvert via shafts to a distribution chamber over the secondary rooms ('spine'). The inlet air will sink to the floor because it is a few degrees colder than the internal air. The exhausted air is evacuated via the base of the skylights.

Both **grey and black water** undergo on site purification treatment. A NAVA Bed plant cleans the wastewater according to nature's principles. Micro-organisms in the bio-filter break down the organic materials in the wastewater, and the phosphorus is deposited in the filter on special extruded concrete pellets. When the pellets are saturated with phosphorus, they are replaced with new ones. Used pellets, containing large quantities of absorbed calcium and phosphorus, are used as soil fertilisers.

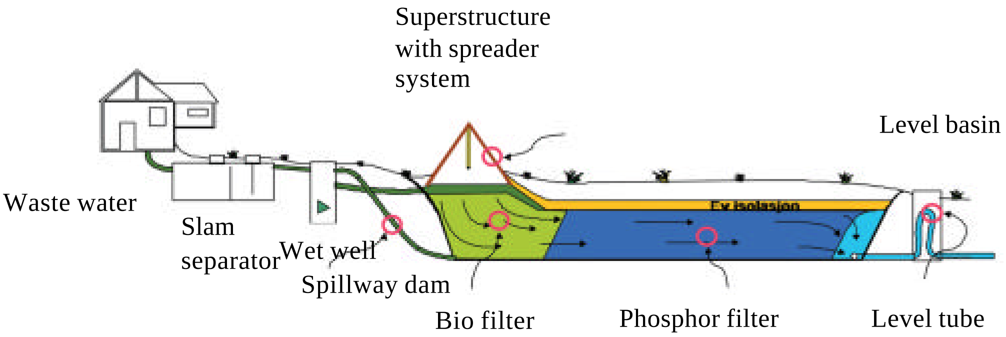


Figure 6. Sketch of a NAVA Bed plant

Energy analyses

The energy demand was simulated with a Norwegian computer program *Energy in Buildings*, version 3.0, ProgramByggerne ANS, 2001. This program is based on a dynamic calculation model that takes into account the thermal mass of the building and simultaneous loads. The total energy load is comprised of the energy required for the heating, cooling, ventilation, lights, and equipment. The efficiency of the equipment and the energy sources also have been included. Control systems for the heating, ventilation and light fixtures were also part of the simulation.

The weather data from the nearest meteorological station (which is Halden), was used. This included mean temperature, solar radiation, humidity and wind speed.

The simulations show that the purchased energy is 120 kWh/m^2/year per heated floor area, of which 100 kWh/m^2/year is electricity and the rest is based on oil. This is well below data acquired from other similar buildings, which have an average annual energy use of 200 kWh/m^2.

The teaching tools

From a wide educational perspective, it is important that every sustainable building should include the user participation procedures. Therefore, early during the concept stage, the representatives of the Norwegian administration involved the local population, requesting their comments, needs and wishes which later, to a large extent, were imbedded into the urban and architectural solutions. This project additionally proved that the residents' respect for the environment and amenities depends on their awareness and sense of ownership, arising from the fact that people are consulted before decisions affecting their environment are made. Final "product" included such wishes, which in fact can only be described as environmental urbanism solutions - where it is essential to maintain the local ecosystems, reduce the travel distances and limit urban noise and pollution of the environment.

It was also vital, that the school building would satisfy the demands of the contemporary teaching methods including ability to insert and utilize an educational sustainable frame programme required for the increased and stimulated awareness of the environmental issues within the pupils' groups. The latter was achieved through various functional and thematic solutions such as:

- division of the pupils' areas into three wings dedicated towards water, energy and natural growth issues

- placement of additional substantial and technological features allowing the pupils to learn through observation, utilisation and enhancement of diversified interests, as well as adapt their perspective to a sustainable way of life
    - the energy (yellow) wing has been equipped with solar batteries, there are some places inside the building where the insulation has been simply screened with glass allowing the children to inquire why, and for what reason this solution was made
    - the aquatic (blue) wing discusses water environments – both from the point of view of water inhabitants, and human needs. The large aquariums play the role of a teaching tool as well as give the pupils a chance to learn through observation. In some places inside the building, the water and sewage pipes have been screened with glass partitions, again allowing for the necessary questions to appear
    - the green wing is dedicated towards natural growth and surrounding nature; here the green roof has been used as additional education feature. In some places the designers left the structure uncovered to show that the manmade structures differ from the natural ones
    - throughout the building, places where pine trees were growing on the site are shown as cut tree elements imbedded in the floor. Additionally some of the tree trunks have been left intact giving an appearance of an internal forest, further enhanced by a small artificial lake and numerous plants. As pointed out earlier, the common area has been "furnished" with natural rock formations. These features indirectly teach the pupils the need to preserve our existing ecosystems, enhancing the idea that we are simply part of a wide and differentiated environmental network required for our very existence
    - some knowledge about Norway and its characteristic environment, both natural and men made can be acquired by the means of perception and the need to inquire as to the state of things. Hence, part of the floor in the common area has been made from the rocks excavated in various Norwegian regions. The stones have been placed in the order of their location (from North to South) – allowing the pupils to learn more about the geology of their country. There are also various small glass screened openings left in various parts of the floor. These contain various artefacts – skeletons of different types of fish and animals, fragments of stones, wood, plants and men made products. They unravel a complex story attracting the pupils' attention and again providing the need to ask questions
    - the external features also continue with the sustainable education – the external walls are either made from the local stone quarried on site, or clad with wood from the trees which had to be felled in order to place the school building. This also has an education aspect – teaching, that it is possible to use local recyclable building materials without using additional energy for the transport needs. The pupils are in close contact with surrounding landscape which forms part of their playground, and most of the classrooms have a direct access into the open area. An artificial lake in front of the building is not only a reminder of the water's value in our life, but also educates on the environmental and water management.

Since social aspects form a part of the sustainable future. The school functional layout is designed with classrooms which can be used by both larger and smaller groups of pupils allowing for contacts between individuals. Sliding doors between the classrooms allow doubling of the working area. This, together with a small teaching room connected to each section and the common area, meets different teaching requirements. These solutions seem to have been accepted, and except for some acoustic problems in the small rooms, no complaints have been noted. Additional effort has been made to make the open library space a cosy place, while allowing for its free accessibility, a meeting point and a “proper library atmosphere”. At least once a week, the common area is easily transferred into a theatre. It also serves an important and cultural function.

This school receives a lot of attention from various visitors. The pupils are very well informed about the environmental features of their school, including contemporary building management system. It is their responsibility to guide the visitors through the building complex, and serve them food and drink. After the tour, the visitors are invited to meet some of the staff. While acting as guides, the pupils have to acquire a lot of information not only on the history of the building and its making, but also on the way it is managed and kept economically and environmentally viable. To a certain degree, giving information to others convinces them that their building is a special one, and that the different solutions which they describe should be repeated and valued in their future education and the way of life.

Figure 7. View of the «blue» wing, south façade. Photo J. Havran

Summary of results

When conducting an analysis from the life cycle perspective, space efficiency and building flexibility are probably the main factors that contribute the most to the low consumption of resources.

The energy consumption has been estimated as 120 kWh/m^2 of the heated area per year. The estimates are based on simulations prepared with a Norwegian computer program called «Energy in buildings». Average energy consumption for corresponding buildings is 200 kWh/m^2/year. According to the official guidelines, energy consumption for new buildings of this kind in this climatic zone should not exceed 129 kWh/m^2/year.

Energy efficiency should not be benchmarked by consumption per square meter alone, but should also include the number of users and the annual rate of working hours. Unfortunately, this kind of measurements is rarely used and the reference figures do not exist. Actual energy consumption has not yet been recorded.

A simplified environmental assessment has been performed during the design of the building. The assessment was based on the Norwegian EcoProfile methodology. Due to the fact that EcoProfile is primarily used for existing dwellings and office buildings, some adjustments of the method have been done in order to make it suitable for school buildings when still under design.

EcoProfile classifies a building based on three main criteria: *Exterior environment, Resources*, and *Indoor Environment*. These main criteria have many sub-criteria. The criteria are assessed in three classes: class 1 is «low environmental loading», class 2 is «medium environmental loading» and class 3 is «high environmental loading».

The environmental assessment shows that the school design performs relatively well on all environmental criteria. An evaluation of the finished building shows that the environmental goals have been fulfilled. The bar graph shows the result of the EcoProfile analysis. The project is classified in the best category: «low environmental loading» for all the main criteria. The star diagrams allows more detailed information on the sub-criteria.

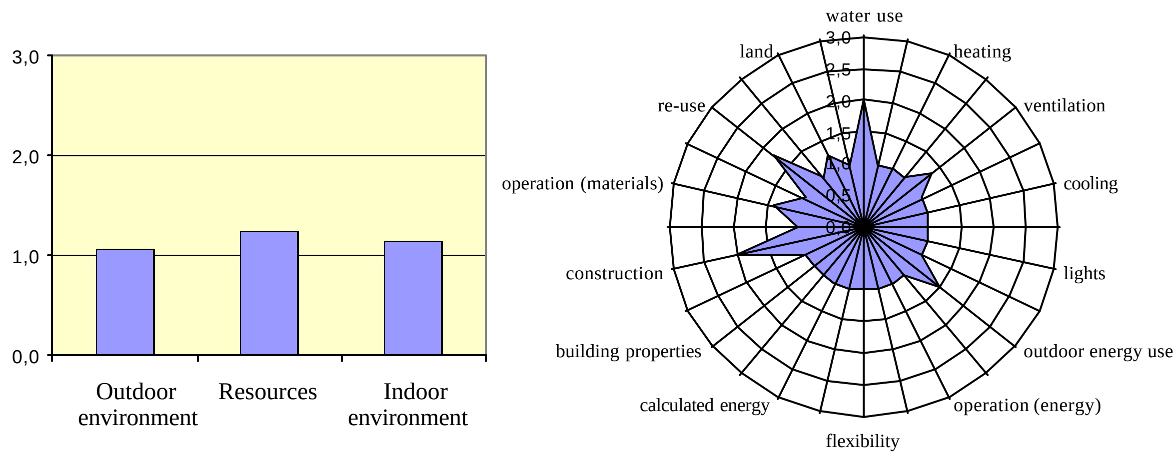


Figure 7. Results of the assessment. EcoProfile star diagram for Resources to the right.

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THE EVALUATION OF ECO-COMPATIBILITY PROJECTS EXPECTED WITHIN THE STRATEGIC ENVIRONMENTAL ASSESSMENT OF THE XX OLYMPIC WINTER GAMES TORINO 2006

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1 SUMMARY

The Organising Committee (TOROC) is committed to organise the XX Olympic and IX Paralympic Winter Games according to the principles of environmental sustainability, as a consequence of the recommendations issued on the basis of the Strategic Environmental Assessment (SEA).

The Olympic Winter Games Torino 2006 represent the first case in Italy - and one of the first in Europe - of the application of the SEA: a tool aimed at evaluating the ecocompatibility of plans and programmes before these become executive.

The paper deals with some activities, in charge of the Environmental Department expected within the SEA aimed at assessing the ecocompatibility of permanent venues, facing the issues of design and construction phases and their environmental effects.

The above mentioned activities have been carried out through the development of the following tools, described in the paper:

- *Guidelines for project sustainability as regards the construction and management of Olympic and Multimedia Villages*;
- *System aimed at evaluating the Eco-compatibility Projects within the Quality Settlement Indicator as provided in the Monitoring Plan foreseen by the SEA*.

Such system, highlighted in the paper, is subdivided into performance indicators, methodologies and assessment criteria developed in cooperation with Piedmont Region and transferred for the operative assessment to Polytechnic University of Turin. Pictures concerning the representation of results carried out throughout a Geographic Information System (GIS) are also included.

2 THE XX OLYMPIC WINTER GAMES

More than a century has passed since the first edition of the modern Olympic Games (Paris, 1894). During that time, many changes have been made to the policies of the International Olympic Committee (IOC). Over the last ten years environmental protection has become an increasingly important issue for the Olympic Movement and the environment is now the third dimension of the Olympic Games, alongside sport and culture.

The work of the Organising Committee for the XX Olympic Winter Games – Torino 2006 (TOROC), and of its Environment Department, is based on a number of political-strategic commitments and legal requirements.

The former constitute the foundations for initiatives such as the Green Card, presented during the bidding phase, the Olympic Movement's Agenda 21, adopted by the IOC in 1999, and the Charter of Intent whereby, in 2002, the TOROC ratified the IOC's Code of Ethics.

The latter have led to the implementation of the Strategic Environmental Assessment process to evaluate the impact of the Olympic programme.

These are some of the reasons why Torino was selected to host the XX Olympic Winter Games. They reflect the aim of leaving a positive legacy, not only during the two weeks of competitions, when the world's attention will be focussed on the Olympic sites, but also before and after the event.

2.1 The Environmental Mission

TOROC is a private, non-profit foundation responsible for organising the Olympic Games, including the sporting events and the Opening and Closing Ceremonies, for managing the Olympic Villages hosting the athletes and technicians, the Press Village, the Press and International Broadcasting Centres, and for providing television and radio services. It will have the task of coordinating the activities of the Olympic Programme in order to guarantee that the deadlines for planning and completing the works are respected. The Committee will also coordinate transport and medical services, set up the temporary structures necessary for athletes and spectators, plan and promote the cultural programme, and arrange accommodation and transport for the athletes, technicians, sports staff, media and personnel involved in the events. Lastly, it will prepare a Marketing Programme in collaboration with the IOC and CONI (the Italian National Olympic Committee).

The Olympic and Paralympic Games will leave many tangible and intangible sign on the area where they are hosted, and TOROC, being aware of the public responsibility of its mission, has implemented a wide range of innovative measures and initiatives aimed at building a valuable Olympic heritage for the area.

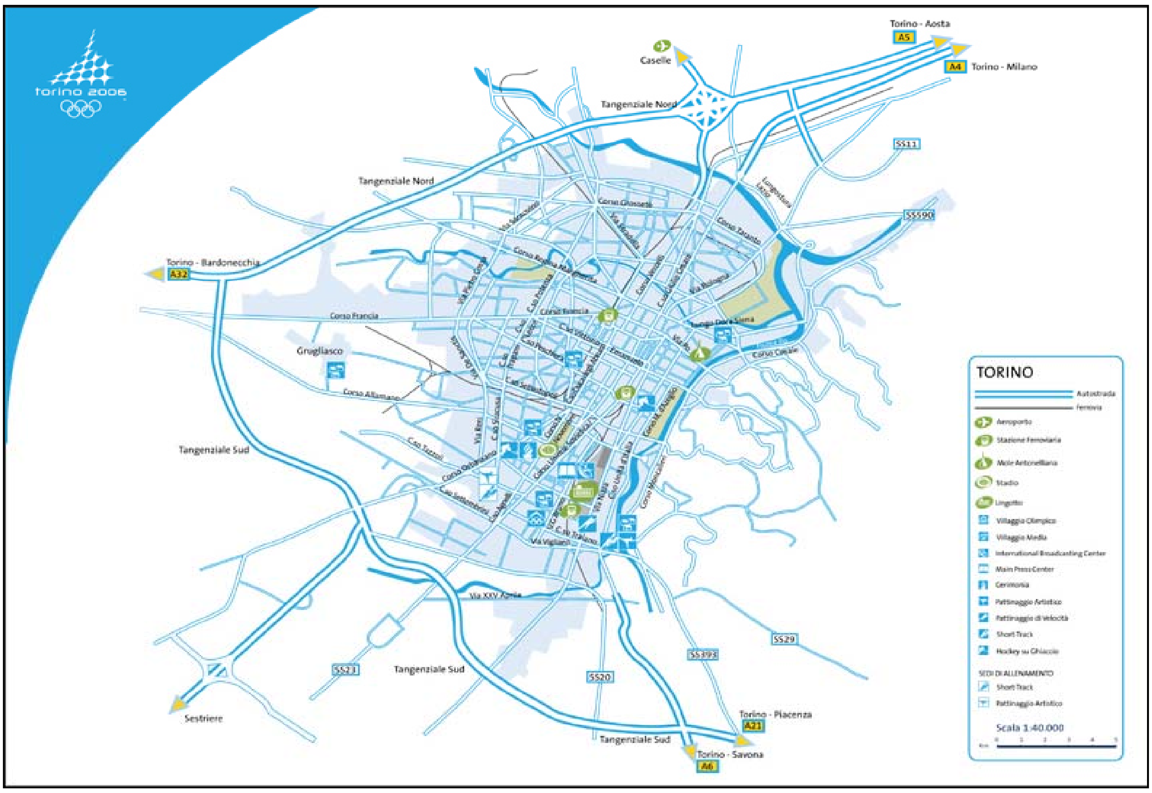
Tangible examples of this commitment are the *environmental programme* which defines the basic ethical, social and environmental code of conduct that TOROC intends to follow whilst carrying out its tasks.

3 AREAS FOR THE EVENTS

The Olympic Programme requires a wide range of initiatives to be organised by TOROC and the local institutions and communities, aimed at running the Games, adapting the functionality and accessibility of the Territory, and developing the sporting and tourist facilities for the Games as well as for their longer-term use.

All of the sport and training facilities, the operational and logistical centres and the reception structures are being developed in two local sub-systems; that in the metropolitan sites (Torino – see figure 1 -, Pinerolo and Torre Pellice) and that in the mountains where the venues for the high-altitude events are located (the Susa, Chisone and Germanasca Valleys and Sestriere, Bardonecchia, Cesana, Pragelato and Sauxe d'Oulx Districts, including the training sites at Claviere, Prali and Chiomonte).

Figure 1. Map of the Olympic Layout in Torino.



4 THE STRATEGIC ENVIRONMENTAL ASSESSMENT

The Torino 2006 Olympic programme represents the first case in Italy - and one of the first in Europe - of the use of the Strategic Environmental Assessment (SEA) process, a tool aimed at evaluating the sustainability of plans and programmes in a specific geographic area before these become executive.

Pursuant to Law No. 285 of October 9, 2000, "Works for the Olympic Winter Games - Torino 2006", the SEA process included submitting the Olympic programme to an "environmental compatibility study". At the beginning of 2001 the TOROC presented the results of this study to the Piedmont Region for approval, in accordance with the above-mentioned law. After consultation with the Ministry for the Environment and Territory, the Piedmont Region passed resolution No. 45-2741 of April 9, 2001 recognising the compatibility and "overall sustainability" of the Olympic programme, subject to observance of a series of recommendations regarding technical aspects, procedures and programmes aimed at further improving the environmental performance of the programme.

These recommendations, together with the actions aimed at protecting the environment that were outlined in the results of the study presented to the Region, constitute the framework for the environmental activities of those involved in staging the Games, namely:

- The TOROC, as the body responsible for organising the event pursuant to the contract with the International Olympic Committee;
- The Agenzia Torino 2006, as the state-funded organisation responsible for awarding contracts to design and construct the infrastructures and facilities specified in Law 285/00 that are needed to stage the competitions;

Piedmont Region, Province and City of Torino and the Regional Environmental Protection Agency - ARPA) plays a fundamental role in evaluating and monitoring the environmental compatibility of Olympic works and must also work with the TOROC to implement actions and environmental programmes to guarantee sustainability even after the Olympic Games.

Within the framework of the SEA process, the TOROC was required to define a set of general planning tools to be used by the Agenzia Torino 2006 in the various stages of construction works. These Strategic Plans address the following issues:

- Inert waste from excavations and worksites;
- Sustainable mobility;
- Safety of workers and local inhabitants (defined in conjunction with the Piedmont Region and the Health Department, in agreement with all the parties concerned);
- Water management (defined directly in conjunction with the Province of Torino);
- Prevention of natural risks;
- Environment and landscape.

Furthermore, on its own initiative, the TOROC defined:

- The *Guidelines for project sustainability as regards the construction and management of Olympic and Multimedia Villages*;

These tools, and the others developed by TOROC, are proving to be highly effective in guiding the choice of projects and creating close synergies among those involved in the Olympic programme.

Relating to the guidelines for the sustainability of Olympic Villages: the Agenzia Torino 2006 included these in the competition to design the Olympic Village on the site of the former wholesale market and they represented the core criteria in the appraisal and selection of the winning project, which is characterised by the widespread use of sustainable architecture and the rational use of energy.

5 GUIDELINES FOR PROJECT SUSTAINABILITY AS REGARDS THE CONSTRUCTION AND MANAGEMENT OF OLYMPIC AND MULTIMEDIA VILLAGES

The Guidelines can be assumed as an overall strategic tools concerning a design approach aimed at guaranteeing the sustainability of Villages in their entire life cycle.

The guidelines provide information on materials, technologies and techniques for an environmental conscious design.

Within the manual are available references on methodological tools that can be assumed in order to assess if the design options are coherent with an environmental approach.

The correlation between sustainability and design process means that architects and building contractors have to relate their activities to several items connected on multidisciplinary knowledge. At this aim the guidelines have been organised in different topics related to: use of local climate resources, environmental quality of outdoor spaces, relations with urban areas, reduction of resources consumption and pollutants, indoor air quality and maintenance.

Regarding the assessment tools, they contemplate: drawings, lighting, thermal and acoustic technique calculations, labelled materials, outcoming of laboratory tests and the monitoring activities.

The Agenzia Torino 2006 has acknowledged the guidelines contents in the Preliminary Design Reports (PDR). Within those reports are established requirements aimed at realizing sustainable architectures and sustainable urban settlements.

With reference to the environmental performance indicators foreseen in the guidelines, the projects were developed by taking into account:

- surface temperature of exposed facades to solar radiation;
- exposure to winter prevalent winds;
- usage of energy efficient equipments;
- usage of photovoltaic and solar collectors;
- recovering of rain and grey water;
- usage of materials requiring low energy consumption and a reduction of pollutant emissions;
- environmental load due to construction phase - Construction and Demolition (C&D) waste and acoustic, atmospheric and water emissions;
- quality of natural and artificial internal lighting;
- protection against atmospheric and acoustic pollution;
- thermohigrometrical comfort and the best level of indoor air quality;

Architects had to define since the preliminary design the specific sustainable objects to reach and, as consequence, the related requirements, detailing the:

- qualitative project requirements;
- quantitative projects requirements;
- technology and material solutions aimed at testing the above mentioned requirements.

6 THE ENVIRONMMENTAL MONITORING PLAN FOR THE OLYMPIC GAMES TERRITORY

On the basis of the findings of the SEA process and as agreed upon with the Piedmont Region and the Ministry for the Environment, the TOROC is managing the environmental monitoring plan in the areas affected by the Games.

During the development of the Olympic Programme, TOROC must guarantee a overall positive environmental balance sheet, through the continuous monitoring for achieving the above mentioned environmental objectives by means of specific indicators to be organised chronologically during the different phases:

- before and during the planning stages;

- during the building stages;
- during the testing stages;
- during the event;
- after the event.

The Environmental Monitoring Plan, already launched by TOROC, must take into account, and must interface with, the existing monitoring activities carried out in the relevant territory by the Piedmont Region, the Province of Turin and ARPA according to their organisational tasks, and each phase must be followed up with the compilation of an environmental balance sheet together with a verification of progress versus targets, from which indicators for effectively reaching the objectives can be derived.

The SEA has identified the Monitoring Plan as the instrument that provides, on the one hand, a constant updating of the state of the environment useful to orienting the Olympic Programme planning process, with the purpose of guaranteeing, through subsequent fine-tuning, a overall positive environmental balance sheet, and on the other hand makes sure that the predefined goals are punctually achieved.

The Environmental Monitoring Plan is based on a set of 16 indicators, defined in agreement with the Regional Authorities of Piedmont and the national Ministry of the Environment, which makes it possible to assess the overall changes to the state of the environment at any time during the implementation of the Olympic Programme. This set was published by the Piedmont Region in the 2nd supplement to BURP no. 37, dated 12 September 2001, and consists of sixteen indicators related to the following thematic areas:

- Water system,
- Air quality,
- Soil use,
- Energy consumption,
- Waste production,
- Ecosystems,
- Landscape,
- The urban and topological quality.

The methodology for calculating and assessing the indicators was developed by TOROC in cooperation with the Piedmont Regional Environmental Protection Agency (REPA) and was shared with Piedmont Region and the national Ministry for the Environment.

The indicators are quantified and characterised periodically in order to achieve the following objectives:

- assessing and monitoring the environmental impacts (positive and negative) of the organisational process;
- guarantee, at the end of the Games, overall sustainability for the environment and the area.

The Strategic Environmental Assessment procedure requires that the direct and indirect, cumulative, synergistic, short-term and long-term, permanent and temporary, and positive and negative effects on the territory are assessed, for the purpose of verifying the environmental sustainability of the Torino 2006 Olympic Winter Games works plan.

6.1 The Environmental Monitoring of the urban and topological quality

The SEA provides the following key factor aimed at assessing the environmental quality settlement:

- Urban renovation (reclaiming of neglected spaces in urban area);
- Topological renovation (improvement of mountain areas through naturalizations and hydrological adjustment);
- Building Renovation (restoration work on obsolete constructions and technological reclaiming of existing infrastructure);
- Activities allocation foreseen within the Olympic Programme;
- Reclaiming of road network;
- Bio-architectonic techniques used in constructions;
- Building ecocompatibility and potential pollution of materials used for infrastructures.

Concerning the environmental sustainability of building design the above mentioned thematic areas affecting the sixteen indicators were related to a methodology detailed in the *Peretti-Grosso's paper*. A large part of the Italian National Standard approach sustainability requirements described in the paper were assumed as a reference. Thus Torino Olympic Village was chosen as one of the representative case studies to validate the methodology developed.

The evaluation of the performance scheme of a building project is carried out on the basis of pre-defined classes of performance values to be applied to the indicator/s related to each requirement. The number of classes is 6, ranging from 0 to 5.

These ranges of classes of values, i.e., environmental performance scores, are related to predefined benchmark qualities defined as follows:

- baseline benchmark (score 0/5) – related to current practice and regulation standards;
- best practice benchmark – related to the best environment-conscious practice in the local context (score 3/5);
- optimum target benchmark (score 5/5) – the highest possible target performance values compatible to the local technology state of the art as well as social acceptability and economic conditions.

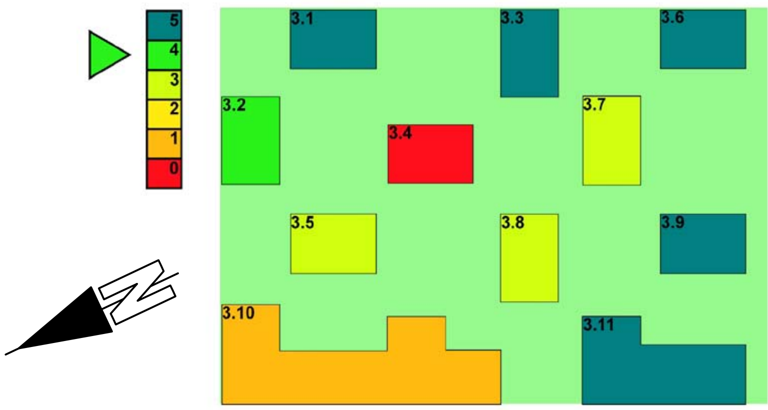
The Table 1 shows the sustainability assessment for a requirement assumed as example. The requirement is linked to a qualitative or quantitative check system. Furthermore the environmental performance score is also included.

Table 1. Check system and range of classes assumed as reference for assessing the winter solar radiation control requirement.

MONITORING PLAN FOR THE OLYMPIC GAMES TERRITORY		Turin – Olympic Village Lot 3	
REQUIREMENT			
Winter Solar Radiation Control			
GENERAL OBJECTIVE			
Use of Climate Resources			
LIFE CYCLE PHASE			
Use phase			
ASSESSMENT			
Check System	Quantitative	e = solar form efficiency Asol = area of windows located on south facade Atot = total windows area $e = \frac{Asol}{Atot}$	
	Qualitative		
Range of classes		**0**	e < 0,1
		1	0,1 <= e < 0,2
		2	0,2 <= e < 0,3
		3	0,3 <= e < 0,4
		4	0,4 <= e < 0,5
		5	e > 0,5

The check system has been carried out for the Olympic Village buildings. A schematic plan referred on a lot of the Village shows the value obtained for each building while the overall assessment has been calculate as an weighed average. (see figure 2).

Figure 2. Schematic plan of performance values of buildings for an Olympic Village lot. On the left the score based upon the weighed assessment of overall site area. (Requirement: Winter Solar Radiation Control)



7 A SUPPORT FOR THE ENVIRONMENTAL MONITORING PLAN: THE GEOGRAPHIC INFORMATIVE SYSTEM

A Geographic Informative System has been implemented in order to carry out an analysis of the information collected for the environmental monitoring. Such tool allows to link for each information gathered about urban and mountain area an appropriate geographical coordinates. This data processes determine the state of environment in spatial and chronological terms. In order to have a clear conception of the activities carried out, is important to highlight that a GIS software is suitable to:

- Identify for each information collected the relevant area of influence;
- Process query to submit to database selected.

Concerning the environmental monitoring foreseen within the XX Olympic Winter Games the database is characterized by specific key factors linked on each of sixteen indicator above mentioned. Such key factors are very different in term of contents, chronological updating and units. This is the reason why the geographical reference system adopted has become the standardising factor. Moreover a geographical data analysis allows to check:

- The development trend for every key factor in a time period;
- The relationship with other correlate key factors in a boundary area.

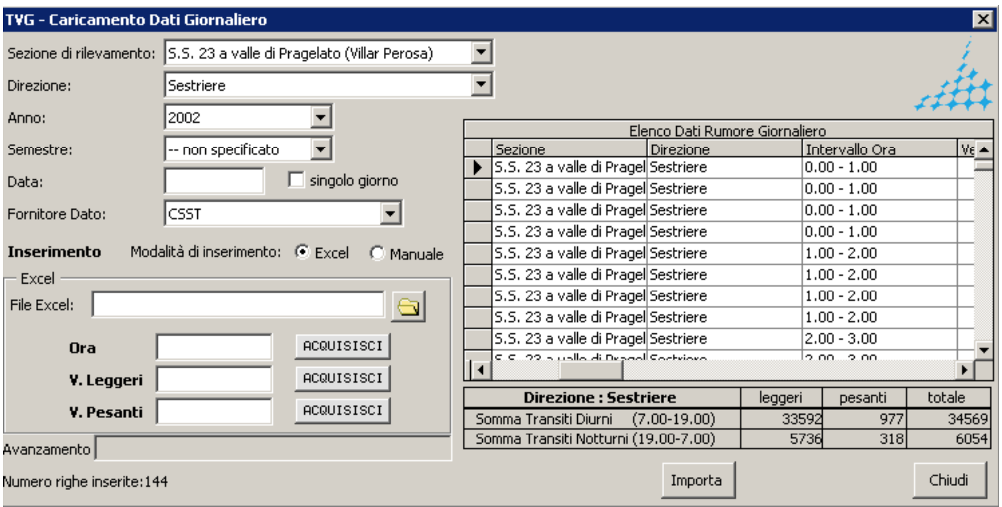
Crucial in the geographical analysis was to make use of an proper reference scale related to data processed. Concerning TOROC Monitoring Plan the cartographical support assumed as reference is the Regional Technical Map, scale: 1:10.000. Such rate scale is due to the assessment of Indicators significance, mainly measurable on territorial map. Aerial-photographs are periodically provided and included as cartographical support within the GIS system developed. These aerial-photographs check - year by year - the topological changing within the Olympic Programme.

The database is developed through SQL SERVER and the data entry has been carried out as follows:

- "direct data" – through measurement tools placed on mountain and urban areas;
- "indirect data" – through database provided by public authorities.

Such data are filled in a specific format aimed at working with different interfaces (i.e. excel and access database) thus no further data processing are required. (see figure 3)

Figure 3. Data entry format.



Concerning the key factors affecting the settlement quality assessment they can not be monitored only through the Regional Technical Map. According to goals of the research activity was required a different rate scale.

In urban areas the Turin Technical Map (scale: 1:1000) was the suitable choice, instead for extra urban and mountain areas, in consideration that the information analysis is not oriented on buildings but on wider areas, was adopted a cartographical support provided by the Province of Turin with a 1:5000 rate scale.

For both cases the key factors were assessed through:

- A graphic work organized into several layers, where the project files were georeferred;
- A database where layers were characterised.

The figure 3 shows a thematic map drafted by GIS technology based upon the developed database for one of the urban area considered.

Concerning the mountain area the comparison of key factors carried out through GIS system allows to demonstrate some critical state - i.e. number of daily vehicles measured as average each year- that public authorities could take into account in order to control road traffic and gathering the main objectives defined within the SEA procedure. The figure 4 shows the GIS map relating to a road bypass on Torino – Sestriere SS 23 road . The data collection of number of vehicles on the SS 23 road was an useful support to allocate the proper place where the road Bypass could be realised as it shown in figure 5.

Figure 3. Thematic map related to allocation of activities drafted by GIS technology – Torino Olympic Village.

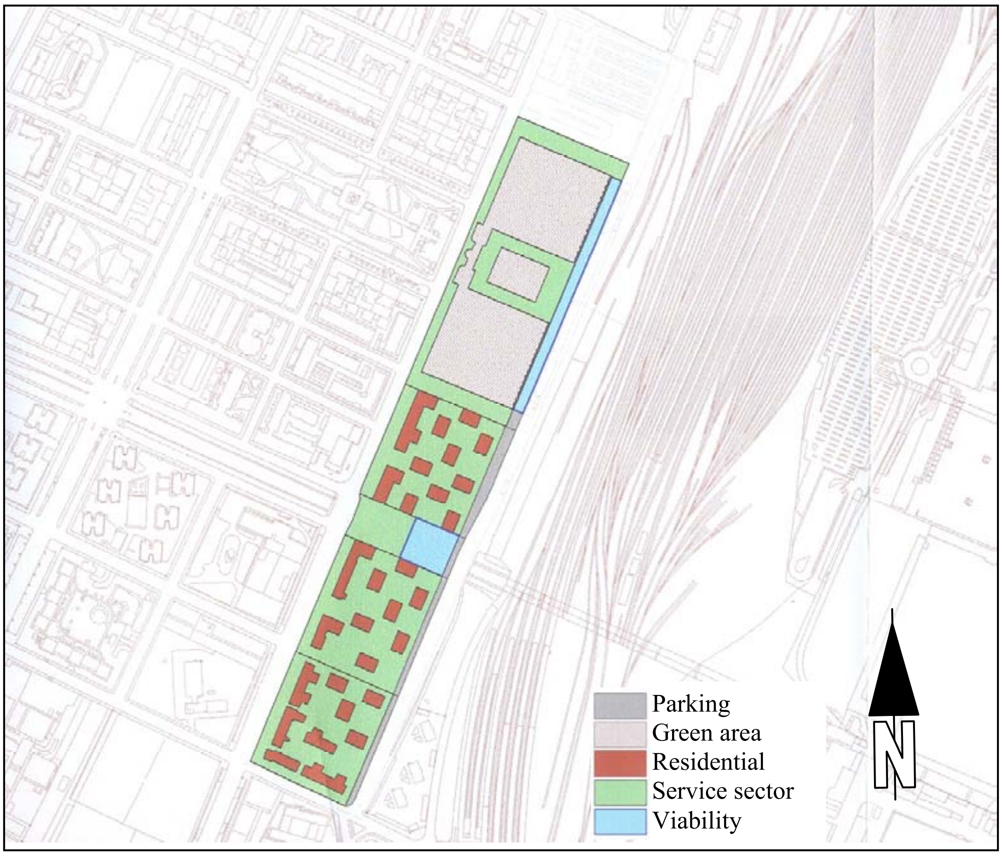


Figure 4. Thematic map related to number of vehicles - average daily traffic – measured each year from 2001 to 2003 on SS23 Torino Sestriere.

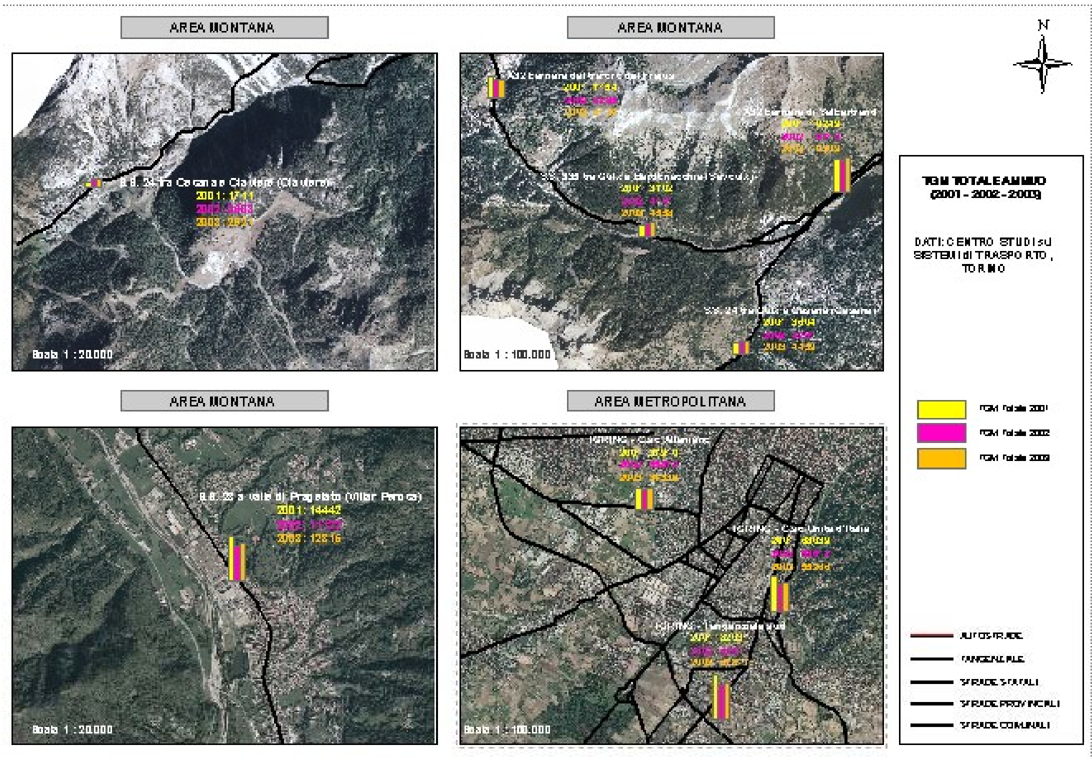
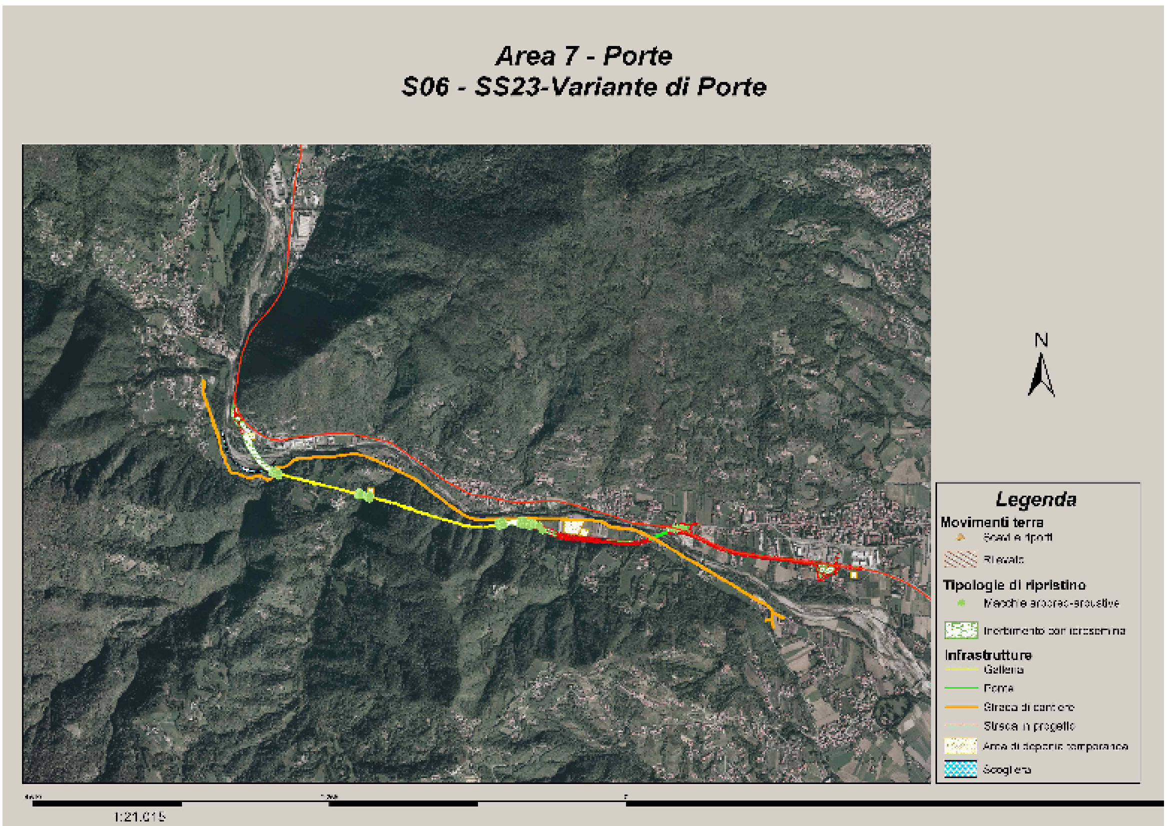


Figure 5. Project of bypass road on SS23 Torino Sestriere based on GIS analysis and evaluation.



8 CONCLUSION

In conclusion, GIS can be assumed as the most suitable tool aimed at evaluating a huge number of key factors that have to be taken into account within the monitoring plan. Through related database, updated constantly, each changing at topological and urban scale can be assessed and displayed with suitable thematic maps. Furthermore both graphics and database works are the results of an agreement with Public Authorities that at the end of the games time will be the final users of the GIS system. Thus such system will be implemented in order to provide strategic information for town and territorial planning activities.

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The potential for the use of crop based materials in construction

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1. Abstract

It is widely recognised that the use of materials in construction has a large impact on the environment, due to the effects of embodied energy and other environmental impacts, and the problems of disposal of some materials. This applies particularly to non-renewable materials whether they are oil based liked plastics, or quarried.

One option for reducing the impact of construction is to make greater use of materials that are produced from crops, either grown for the purpose or as by-products of other products. This paper reports on the findings of a research project carried out in the UK, with the aim of promoting and encouraging the wider use of these materials.

The main products considered are insulation; geotextiles, paints, floor coverings, thatch and light wall construction. In addition options for future development are discussed, particularly relating to plastics from plants and bio-composites. The paper will summarise the main findings of the research project, and the areas where further work is needed to help these products to help reduce the impacts of construction.

2. Introduction

This paper sets out the key findings of a research project into the use of crop based materials in construction. The project aims to enable the use of products from agricultural crops by those in the mainstream of the UK construction industry. This paper covers the main outcomes of the research in terms of:

- The benefits of using crop-based materials in construction
- The current options for products
- Possible products for the future
- How to use key products.

The main output from the project will be a handbook containing more detail on all of these aspects, and a range of supporting information. The target audience is those who commission, design and build construction projects, and have an interest in reducing the environmental impact of the process.

The main focus of this paper and the handbook it summarises is on products that are available now, and how these can be used in successful construction projects. There is also coverage of products that are being developed and should be available in the near future.

There is great potential for crops and by-products of animal husbandry to reduce the environmental impact of construction. At the same time construction can help to improve the economic viability of agriculture in the UK and world-wide through the adding value to existing crops, using waste agricultural materials or developing new crops.

In addition to environmental benefits in production, many of these products bring environmental benefit in use. These relate to better air quality, natural management of moisture levels and reductions in allergic reactions. The 'natural building' sector has been aware of these benefits for many years, but it is only now beginning to enter mainstream construction thinking.

2.1. Materials covered

From the research that led to the handbook, it is felt that the following applications are currently available and use significant quantities of crop based materials:

- Insulation
- Light structural wall materials
- Paints and varnishes
- Floor coverings
- Bio-based geotextiles
- Thatch

There are also a number of areas where there is potential for significant future use, but that development is needed before successful application can take place. These include:

- Board products
- Bio-polymers and bio-composites
- Expanded starches
- Bamboo in structure

All of these materials are covered in the handbook, with greater depth given to the 'main' materials, reflecting their greater potential for short-term impact on the construction sector.

For the purpose of this work the term crops covers all materials deliberately planted / reared on farms, and these need not only be in the UK. However because there is a substantial literature on timber and related products, these are not covered. This is not, of course, to suggest that timber based products are not of environmental value.

3. Benefits of crop-based materials

3.1. Environmental benefits

All crop-based materials have the potential to bring benefits relating to the environmental impact of both the production and eventual disposal of the products they make up. These benefits are typically due to the low embodied energy of the material, reduced pollution of different types, and ease of disposal through composting.

In mass terms, it has been estimated that the UK construction industry uses around 300 million tonnes of material each year, or some 5 tonnes per person [1]. However this headline figure can be misleading as it is dominated by 'quarry products'. This Mass-Balance report gives a wide range of useful information on material flows, summarised in the table below

Product group	'000 tonnes	
Quarry products	125,871	42.6%
Wood products	9,241	3.1%
Finishes coatings adhesives etc	1,477	0.5%
Plastic products	1,402	0.5%
Fabricated metal products	3,938	1.3%
Cabling wiring and lighting	190	0.1%
Glass-based products	1,415	0.5%
Ceramic products	4,313	1.5%
Bricks and other clay based products	5,979	2.0%
Cement, concrete and plaster products	97,992	33.2%
Stone and other non-metallic minerals products	43,631	14.8%
	295,449	100.0%

Table 1: Primary materials used in construction, 1998 [1]

These figures are very large, but are clearly dominated in mass terms by the stone and cement materials, for which crops are not usually a substitute. However the quantities of other types of materials where crop based alternatives have the potential to replace non-renewable sources are still very large.

The environmental benefits of crop based materials need to be considered on a product by product basis, and several examples are given in section 4.

3.2. Economic / Social

The UK is a major net importer of building products, including many that could be replaced by those grown in our climate. This could then bring benefit to the economy as a whole through the creation of jobs, and an improved balance of trade. Furthermore the development of new markets for agricultural products could improve the economics of farming.

In 2002, DEFRA published a strategy for the future for agriculture, entitled 'The Strategy for sustainable food and farming – facing the future' [2]. This described options the Government will pursue in the coming years to help achieve its vision for agriculture. It provided a vision that saw an agriculture and farming industry that is vibrant, competitive and sustainable, with high environmental and welfare standards, playing its full part in contributing to the economy, to rural communities and in sustaining an attractive countryside.

Consequently, this highlights opportunities available for developing the agricultural industry to expand into and provide the construction industry with agricultural crops which could be used in different aspects of construction material. This could include the production and marketing of new or non-mainstream crops or livestock products, to be used for mainstream construction products. At the same time this can also help to improve the economic viability of aspects of agriculture in the UK.

3.3. Performance

The performance requirements of a product are a complex combination of features dependent on its purpose. For some products the crop based material will achieve the basic required level of performance, and will be sold on the basis of environmental benefits. In other cases the crop based material will perform better than the alternatives in some conditions, and it will therefore be the best choice for a number of reasons.

Some of these examples are discussed in the next section.

4. Examples of crop based products

4.1. Example 1: bio-degradable geotextiles

Geotextiles have a variety of potential applications in ground stabilisation, prevention of soil erosion and promoting plant growth. Where the main aim is to stabilise the soil whilst allowing plants to become established, a bio-degradable geotextile has major advantages. It is usually cheaper, it looks more natural, it absorbs more moisture to help plant growth, and it will gradually disappear through bio-degradation as the plants become established and it is no longer needed.

Figure 1: Slope supported by geotextiles (Andrew Cripps)

Figure 2: Close up of geotextile (Andrew Cripps)

4.2. Example 2: Low air quality impact paints and floor-coverings

<table>
<tr>
<td>Many people are concerned about the smell of paints and floor-coverings, and the possible effects they may have on health. However for some sensitive groups of the population the concerns are very real, for example those with asthma, allergies or other medical conditions. Where a project serves these groups, the choice of crop-based materials, combined with other natural materials, can ease air-quality concerns. Further for those whose job involves painting, the long term benefits of the choice of paints could be significant.

Natural floor coverings are also generally produced in low income areas of the world, and therefore their use can be of direct development benefit.</td>
<td>
Figure 3: Sisal rug on lino floor (Andrew Cripps)</td>
</tr>
</table>

4.3. Example 3: Insulation allowing moisture control

<table>
<tr>
<td>
Figure 4: Flax insulation (Construction Resources)</td>
<td>Besides the differences due to embodied energy, the main difference between natural and synthetic insulation materials is in their handling of moisture. The natural insulation materials must not become wet, but can absorb and re-emit modest levels of moisture without affecting either their stability or their insulation effect. However synthetic insulation materials do not absorb moisture, and this can lead to a reduction of thermal insulation due to a build up of water. Further, in a timber frame building, the use of an absorptive material helps to protect the timber from the effects of moisture, whereas a synthetic insulation will not be able to provide any buffering of moisture.

An additional and important benefit of natural fibre insulations is that they are safe to handle, and can be installed without the concerns about skin complaints that are common with other products.

Finally a natural fibre insulation will be able to be left to compost at the end of its life, rather than having to disposed of to landfill.</td>
</tr>
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5. How to use crop based materials

For most cases the approach to using the material will become clear once the properties of the products are understood by a competent tradesman. For this reason this section of the paper is short, although more information is given in the Handbook.

For some products it is sufficient simply to substitute for the equivalent product and use it in a similar way. Examples include boards and some floor coverings.

However for most other products it is necessary to adapt the approach to suit the material being used. An example would be natural paints, where the absence of chemical drying agents results in longer drying times, which must be accounted for when planning work. All natural fibre insulation materials need to be built into breathing constructions that allow moisture to escape should it once collect there. Light structural materials (either light earth or straw bales) need to be treated differently to conventional brick walls, and thatch is an art in itself.

6. Emerging products: bio-composites and polymers

There are a number of areas where a lot of research effort is being made, to introduce new, improved crop based materials to the construction sector. This section focuses on the use bio-composites, but there is also work on the use of expanded starches for packaging and possibly insulation, and the use of bamboo outside its normal climatic regions.

There are four classes of materials to consider under the general heading of bio or eco composites and polymers:

- Natural fibre – oil based resin
- Glass fibre – plant based resin
- Natural fibre – plant based resin
- Bio-polymers or plastics

Figure 5: Examples of boards made from bio-composite (Andrew Cripps)

Figure 6: Model boat made from bio-composite (Andrew Cripps)

These materials could be used to replace a wide range of existing board products, reinforced plastics or even the ever present plastic materials. Examples of what can be made are given in figures 5 and 6, but there is very little constraint on what could be produced. In principle anything that is currently made from GRP (glass reinforced polymer) could be made from some form of bio-composite.

There has been extensive research work in this area, and substantial investments by some of the big chemical manufacturing firms, which is only touched on briefly here. However the relevant properties are worth revisiting, to understand where information is lacking.

	Fibres							
Properties	E-glass	Hemp	Jute	Ramie	Coir	Sisal	Flax	Cotton
Density g/cm3	2.55	1.48	1.46	1.5	1.25	1.33	1.4	1.51
Tensile strength (MPa)	2400	660-900	400-800	500	220	600-700	800-1500	400
E-Modulus (GPa)	73	70	`10-30	44	6	38	60-80	12
Elongation at failure (%)	3	1.6	1.8	2	15-25	`2-3	1.2-1.6	`3-10
Moisture absorption (%)	-	8	12	`12-17	10	11	7	`8-25

Table 2: data on natural fibres used in composites [3]

Fibre in PP matrix, ~30% fibre by volume	Tensile strength MPa	Flexural strength MPa
Hemp	~50	~54
Glass	~30	~60
Sisal / kenaf / jute	25-30	25-35

Table 3: Data for selected representative composites [3]

Data lacking from this simple representation would include:

- Costs
- Sensitivity to environmental attack
- Flammability
- Rate of moisture absorption
- Lifetime
- Method and rate of bio-degradation
- Opportunity for recycling
- What standards it meets
- Embodied energy
- Life cycle analysis (LCA)

It would be wrong to suggest that none of this information is available, but it is not available in forms that are easy to obtain and use by the design profession. Further it is most important to realise that in spite of a wealth of published research information, there is very little available in terms of commercially available products.

In order for designers to specify products made from bio-composites then this full range of data requirements needs to be addressed to sufficient extent. The final points are relevant because, although it seems obvious that a bio-composite will be better environmentally than a 'conventional' one, it is not certain to be the case. There may be less obvious environmental costs, and poor performance will lead to waste of the product itself, and possibly also other components around it, and this should be considered in the LCA.

7. Conclusion

Through this research we have seen that there is enormous potential for crop and animal based products to help to make UK construction more sustainable, and at the same time bring benefits to the UK agricultural sector. Further there is increasing interest in using materials with reduced environmental impact. However most users do not know enough about the choices available to them, nor how to obtain and use them in their projects.

By using the existing crop-based products now, the industry can help to change this situation. Without the take up of what has been developed already, there will be reduced incentives for new ideas to be brought forward, and the opportunity may be lost. But if the current products are seen to be successful, then the possibilities raised as future products are more likely to come through. Investors will see there is real potential, allowing new ideas to become reality.

In the future we can hope to see that an ever-increasing proportion of the products used by the industry will be produced in the most renewable way possible, as products of agriculture. The first step for this lies in the take up of proven technologies by the main-stream construction industry.

8. Acknowledgements

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The handbook will be published in late 2004 by CIRIA, Classic House, 174-180 Old St, London, EC1V 9BP.

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EXAMINATION TO THE ADDITIONAL COSTS FOR THE CONSTURCION OF LOW ENVIRONMENTAL IMPACT HOUSES: A REAL CASE OF STUDY.

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ABSTRACT

Environmental performance of buildings is based on social, human, technical and economic aspects to promote sustainability. The technical actions, such as bioclimatic design, adequate flows of energy and water in heating and cooling systems, a specialised selection of construction materials, etc., involve a no conventional way to build, and so, its costs are unknown. An approach focused on the economical influence of these specific criteria would make possible that owners and other public and private sectors put these products into service and place it on the market.

This case study provides an analysis and economic evaluation of different alternatives, specifying separately the influence of each criteria. Therefore the study includes a cost evaluation of all processes, passive and active systems of solar energy, items of bioclimatic design, the use of low environmental load construction materials, rain water system, solar heating, natural and passive cooling, plants as fence and microclimate effect, etc. The analysis comprises the real cost obtained from three low environmental impact houses, recently finalised, compared with the standard building in the city of Valladolid, in Spain.

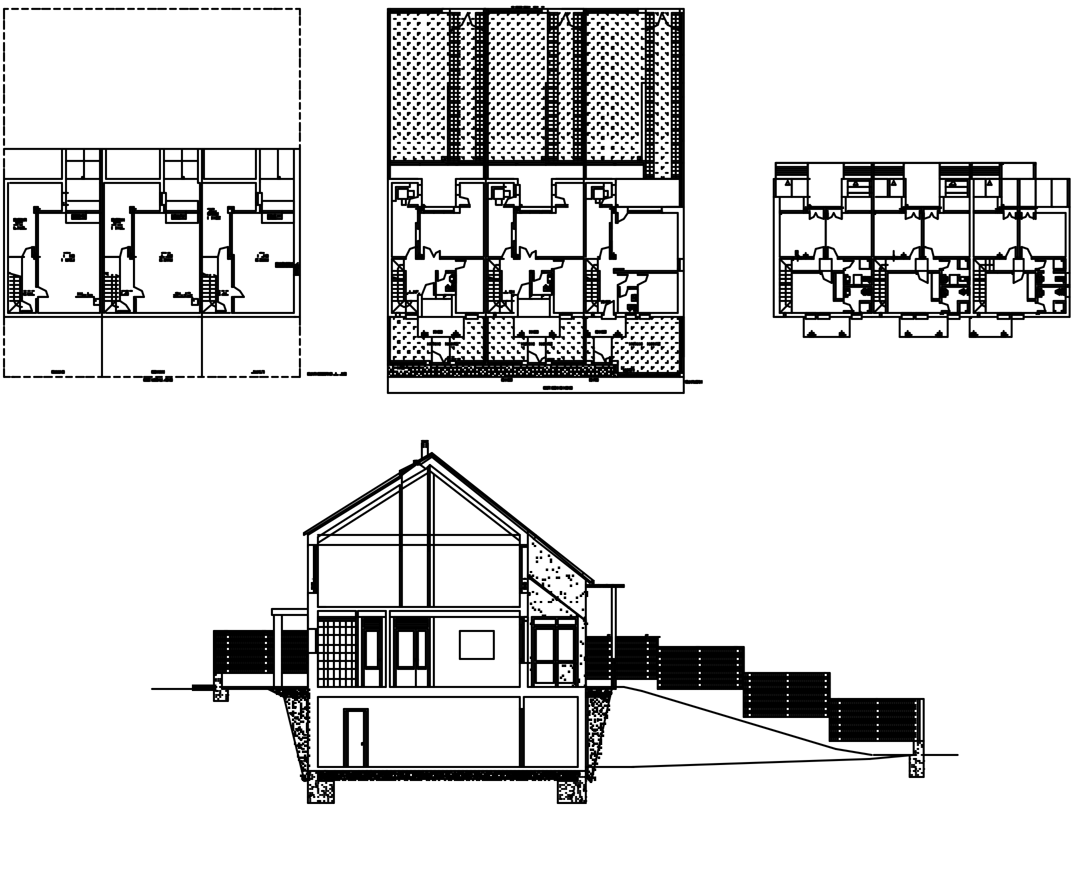
Keywords: environmental housing, economic evaluation, bioclimatic design, selection materials.

1. INTRODUCTION

Sustainable construction is a widely noticeable aim to reduce pollution and other environmental problems. The main criteria about how to build in a sustainable way increase every day step by step. At that moment we can define the sustainability of a building, through numerous and different evaluation methods such as GBC and GBTool [1], BREEAM [2],CASBEE [3], etc.

Recognised but unusual, this practice is yet rare. One of the main drawback to build in a sustainable way is the lack of economical references and evaluations in terms of over cost on budget. Owners, architects, technicians and qualified persons in construction guess or imagine an increase of the cost over the usual budget. The diary practice shows us how difficult is to find out specific researches about how much the economic evaluation of a project can rise, due to the introduction of sustainable criteria. Increasing the cost, that is the case we are supposing. But, How much is this increasing cost in comparison with a conventional building? Do all the parameters increase the same? Does any criteria reduce the cost?

The present research work tries to answer these questions. The conclusions can be very different depending on the circumstances: place, social and economic levels, typology, use and size of buildings, etc, which can change the summary-up. That is the reason why the development of the present research work starts describing the specific circumstances and hypothesis of this case study, thorough the followed research lines.



Picture 1. Basement, ground floor and first floor. Section. Three houses in Valladolid, Spain.

2. RESEARCH LINES
2.1. DESCRIPTION OF THE PHYSICAL RANGE

The present research work has been carried out on a real construction case which has recently been finished. The place is a medium size Spanish city, medium social class type. The case of study is located on a construction composed of three terrace houses of 175 m2 each one, with conventional family program, from a private promotion in a residential area. The technical construction level is an average between light or high techno.
The climate in this place of the centre of Spain (Valladolid) is an extreme continental. All the specific standards of national range and compulsory regulations have been applied in the construction, so as the conventional level of appliances and interior quality. (Graphical definition in picture 1 and 2)

2.2. DEFINITION OF GREEN DEVICES AND SUSTAINABLE CRITERIA

All the tools known about sustainable construction have been applied in this construction.
Many references have been used in order to define the green criteria, such as Wooley, Kimmins and Harrison ("Green Building Handbook")[4], Anink, Boonstra ("Handbook of sustainable building")[5], ("Guía de la edificación sostenible")[6], González ("Arquitectura sostenible y aprovechamiento solar")[7].These references have been also used to define the inputs of the data table.

The sustainable criteria have been got in groups through four chapters (A,B,C,D) in order to evaluate the over cost separately. Those are:

2.2.1. Chapter A. Bioclimatic design solutions.

This chapter joins all the different strategies to adapt the building geometrically to the particular climatic conditions, such as South orientation of living spaces, orientation of windows, minimum shape openings on the North and maximal on the South, optimised shape and size and factor, shading devices, etc. Passive solar energy systems are included in this chapter: the *trömbe* walls and the greenhouse. They are also provided natural strategies for summer conditions, such as a grill for natural cross ventilation above windows and doors, both internal and external, in order to maintain the quality of interior air and to ensure good internal comfort in the hot summer months.
[All data are summarized in chapter A of table 1.]

2.2.2. Chapter B. Selection of construction materials of less environmental impact.

A thorough selection of materials used on buildings has been carefully carried out by applying the same tools as the previous chapter, through methods based on life cycle analysis, always looking for the low environmental impact. A great quantity of them has been forgotten now on the conventional construction, but they were very common in the past. That is the case of wood on roof structure, windows and frames, flow and wall tilling of low burning, paintings water based, varnished non derived from oil and chemicals, etc. Other are new, such

as no PVC in pipes, insulation ducts and electrical connexion boxes, using an electric wiring low in halogens. PVC has not been used for the plumbing and services, using polythene and polypropylene instead. Natural cork has been selected as thermal insulation, in walls, floors and roofs. The cork used has a conductivity coefficient of 0.034 Kcal/hºCm. The thermal insulation glass is 2.8 Kcal/hºCm2. Other thermal coefficient for the essential constructional elements are 0.38 Kcal/hºCm2 (external walls); 0.71 Kcal/hºCm2 (floor); 0.29 Kcal/hºCm2 (roof); 2.8 Kcal/hºCm2 on window frames, and 1.20 Kcal/hºCm2 for internal partitions among properties. The global thermal coefficient of transmission of the houses is 0.494 Kcal/hºCm2.
[All data are summarized in chapter B of table 1.]

2.2.3. Chapter C. Active solar energy systems.

The buildings are also provided with thermal solar energy to produce hot water and electric energy by means of photovoltaic solar energy, with a connexion to the mains. Each house has a 3.8 m2 surface thermal collector, and 300 litre capacity tank. The photovoltaic system is a complete system, integrated in roof, triple-junction thin film silicon technology, total capacity 4,608 Wp. Both systems are not very common in the city.
[Data are included in chapter C of table 1.]

2.2.4. Chapter D. Water and plants systems.

The recollection of rain water in a tank in the basement is also planned to be later used, as well as low consumption sanitary fittings and air valves in the taps. The aim of water consumption is 100 litre per inhabitant and day, including dripping-irrigate system. Plants and vegetation carry on a very important role in the design of the buildings. The landscape architecture with sunshades, pergolas, canopies and the gardening to separate and design the free garden space, is used as architectural barrier to separate the building, provide shades and create microclimate.
[Data are included in chapter D of table 1.]

2.3. DEFINITION OF CONVENTIONAL CONSTRUCTION

The definition of what a “conventional” material is, depends to a great extend on the parameters. The daily professional practice, nevertheless, demands no special explanation on the issue of defining “conventional materials” since it is given for granted. In a systematic way, the construction of small-to-medium sized buildings for residential use in this place, is developed with a reinforced concrete structure, vitrified ceramic walling, polyurethane or polystyrene foam insulation, aluminium or PVC windows and door frame, ceramic floor finishing of high burning gres, parquet floors with PVC finishing, chemical and plastic paintings, interior plywood treatment in PVC. Nothing about rain water system, plants as architectural element, is used. The alternatives are scarcely used, due to an hypothetic increasing level of budget. All works out of regular methods or carried on in an unconventional way are more expensive. Other possibilities in the structure or load bearing walls, such as wood, or the use of other materials naturally found as cork, etc, have almost disappeared from the conventional construction today and can only be found in very special cases.
The list of conventional alternatives is related comparatively with those used in the real case, on Column A and Column B.
[All data are summarized and detailed in Column B –1]

2.4 APLICATION AND COMPARISON OF COSTS.

The cost of the real construction is related on the Column A. In this column are related just the elements conventionally used, substituted in this low impact building. The total cost of a conventional operation is calculated in about 780-800 € per m2. Although, the total cost of this low impact building reaches 991 € per m2. The listing of the work units and its cost come from the real documents of the project, Measurements, Estimated cost and Certifications of the Construction work, and they are the ones used in the real construction. On the other hand, the costs of conventional works are related in Column B, those which belong to a referential way to build or "bench marc", are the average of common used in conventional construction. The sum of this kind of construction is already related in chapter 2.3. So, the reference building has been made in hypothesis to be compared to the analysed ones, in order to obtain the reduction or increase of cost.

The balance between real cost and conventional cost are summarized in column C. In case of positive quantity in column C, there is an over cost in relation to the budget of the referential building, that would be built with conventional construction materials. In case of negative results in column C, to build with these particular sustainable devices is cheaper .

The last column, D, shows the conclusion of the research, in a proportional percentage with the general cost of the building.

Table 1. Economic evaluation

	COLUMN A.- LOW IMPACT BUILDING (all the three houses)		COLUMN B.- REFERENCE BUILDING		C	D
	CHAPTER A. BIOCLIMATIC DESIGN	€		€	BALANCE	% budget
1	SIZE AND SHAPE	0,0	CONVENTIONAL SIZE AND SHAPE	0,0	0,0	**0,00**
2	SOUTH- NORTH ORIENTATION	0,0	ORIENTATION ON SITE	0,0	0,0	**0,00**
3	CROSS VENTILATION	4.391,0	NO CROSS VENTILATION	627,6	3.763,4	**0,74**
4	TRÖMBE WALL	9.762,3	CONVENTIONAL WALL	2.422,0	7.340,3	**1,44**
5	GREEN HOUSE	9.313,2	NO GREEN HOUSE	0,0	9.313,2	**1,83**
6	SHADING DEVICES	1.134,6	NO SHADING DEVICES	0,0	1.134,6	**0,22**
	SUM. CHAPTER A	**24.601,1**		**3.049,6**	**21.551,5**	**4,23**
	CHAPTER B. MATERIALS	€		€	BALANCE	% budget
1	WOOD FRAME	58.617,4	CONCRET STRUCTURE	36.143,3	22.474,1	**4,41**
2	WOOD FRAME WINDOWS	21.623,9	ALUMINIUM FRAME WINDOWS	8.156,3	13.467,6	**2,64**
3	NATURAL WOOD DEVICES	24.776,9	ALUMINIUM/ PVC DEVICES	10.264,3	14.512,6	**2,85**
4	PP AND PE SEWERS	1.345,7	PVC SEWERS	1.482,5	-136,8	**-0,03**
5	NO METALS GUTTERS ANS DRAINPIPES	6.974,9	ALUMINIUM,COPPER, PVC	5.716,6	1.258,3	**0,25**
6	FLOORING SYSTEM LOW BURNING	12.605,4	FLOORING SYSTEMS HIGH BURNING	15.429,8	-2.824,4	**-0,55**
7	CORK INSULATION	6.090,1	PUR INSULATION	4.245,9	1.844,2	**0,36**
8	ELECT. INST. NO PVC	22.772,3	ELECTRIC INSULATION PVC	14.100,0	8.672,3	**1,70**
9	NATURAL WOOD WARNISH	2.719,2	SYNTHETIC WOOD WARNISH	3.147,6	-428,4	**-0,08**
10	EXTERNAL NATURAL STONE	14.254,2	SYNTHETIC STONE	17.839,2	-3.585,0	**-0,70**
11	WATER-BASED PAINTWORK	6.533,7	ALKYD PAINTWORK	9.291,6	-2.757,9	**-0,54**
	SUM. CHAPTER B	**178.313,7**		**125.817,1**	**52.496,6**	**10,29**

	CHAPTER C. ACTIVE SOLAR ENERGY	€		€	BALANCE	% budget
1	THERMIC SOLAR ENERGY	12.993,0	NO THERMIC SOLAR ENERGY	0,0	12.993,0	**2,55**
2	PHOTOVOLTAIC ENERGY	54.226,4	NO PHOTOVOLTAIC ENERGY	4.300,0	49.926,4	**9,79**
	SUM. CHAPTER C	**67.219,4**		**4.300,0**	**62.919,4**	**12,34**

	CHAP.D. WATER AND PLANTS SYSTEM	€		€	BALANCE	% budget
1	SAVE WATER DEVICES	275,0	NO SAVE WATER DEVICES	0,0	275,0	**0,05**
2	RAIN WATER SYSTEM	875,0	NO RAIN WATER SYSTEM	0,0	875,0	**0,17**
3	PLANTS AS MICROCLIMATE EFFECT	4.722,3	NO PLANTS	0,0	4.722,3	**0,93**
4	GARDEN PARTITIONING	16.545,4	MASONRY PARTITIONING	20.457,2	-3.911,8	**-0,77**
	SUM. CHAPTER D	**22.417,7**		**20.457,2**	**1.960,5**	**0,38**

TOTAL SUMMARY	**27,24**

3. CONCLUSION

Quantifying the over cost can be useful in relation to the selection of particular tools to build in a sustainable way. All of these items (bioclimatic design; selection materials; active solar energy; water and plant systems) can save an appreciable quantity of energy, in long period terms, as all the methods said (GBC [1], BREEAM [2], CASBEE [3]). But the decision about to provide some of them in industrialised buildings depend on the previous budget.

The general conclusion is that building in a sustainable way has increased the price more than a 27 % than a conventional system, in this particular case and circumstances. The total cost of a conventional operation is calculated in about 780-800 € per m2. Although, the total cost of this low impact building reaches 991 € per m2. Granted that, some comments must be done:

First of all, we must split up the conclusion in two different parts. One of them, those which do not mean an over cost, such as an adequate size, shape and orientation North-South. All of them are bioclimatic solutions of design.

Secondly, those which can reduce construction cost, such as PP and PE sewers (which reduce a small 0.03 % of total budget), flooring systems of low burning (0.55 % of reduction of total budget), natural wood varnish (0.08 %) , natural stones (0.70%) , water based paintwork (0.54 %), and gardening partitioning instead masonry partitioning (which saves 0.77% of total budget).

In opposition of that, those which are related inside the chapter of active solar energy have an unavoidable over cost, near to 12.34 % of total budget. The cost of green house and the *trömbe* wall increases the budget in a 1.83 % and 1.44 % respectively. Other inputs are more related to wrong policies and market changes than with materials cost themselves, as it is the case of wood frames, which support an over cost of 4.41% of budget. The practice of building with this materials is now absolutely forgotten, due to the widely use of concrete, market changes and the lack of specially trained workers.

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Picture 2.South facade and atrium

The End

DEMONSTRATION PROJECTS: AN EFFECTIVE STRATEGY FOR SUSTAINABLE BUILDING?

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1. INTRODUCTION

Demonstration projects and 'good examples' are increasingly common features in the contemporary work being carried out aimed towards sustainable development. In Sweden and in the Netherlands, as well as in other European countries and the rest of the world, during the past decade numerous demonstration projects for sustainable building have transformed the abstract notion of sustainable building to both a tangible and a visible concept. However, successful demonstration projects have so far made little influence on mainstream building [1]. This can be illustrated by a recent study by Nässén and Holmberg [2] which shows that contemporary demonstration projects for energy efficient housing have proved to result in reduced energy utilisation. Nevertheless does mainstream building not approach these lower levels of energy utilisation. Evidently there is a gap between good results from demonstration projects and what is diffused into mainstream building. Furthermore, the study of Nässén and Holmberg shows that the energy utilisation in new multi-residential housing in Sweden in later years even tends to exceed that of the housing stock in general. Accordingly, this also indicates a gap between contemporary ambitions for energy efficient and sustainable building and what has been built to date.

This paper discusses demonstration projects for sustainable building as a potential strategy for supporting processes towards sustainable development in the building sector. The perspective is that of Europe and the industrialised world based on experience in Sweden and the Netherlands. The paper addresses actors in the building sector, mainly key actors the architects and the clients, as well as researchers and authorities in position of initiating and supporting demonstration projects. The aim is to contribute to the enhanced understanding and use of demonstrations projects, both from a theoretical and a practical angle. The paper discusses the issues of production and the dissemination of reliable and useful information from demonstration projects as well as factors that will affect the influence of demonstration projects on mainstream building.

1.2 Methodology and approach

The paper is based on findings from four empirical studies carried out in Sweden and the Netherlands, exploring demonstration projects for sustainable housing from different angels [3], [4], [5], and [6]. These are: 1) case studies of demonstration projects, 2) qualitative interviews with key actors in the Swedish and the Dutch building sectors, 3) a study of the image of demonstration projects conveyed by the Swedish trade press, and 4) a study of the image of demonstration projects conveyed by *The Swedish Architectural Review*.

Sustainable building as a research field within the architectural domain is still relatively new. There are no clearly defined frames of reference or theories to relate to. The theoretical basis for the study presented in this paper has been chosen in order to provide useful frameworks for the analysis and discussion of the findings from the empirical material. On a broad level, the demonstration project is discussed in relationship to the concepts sustainable development and sustainable building. Furthermore, theory has been selected from among other sources design theory, organisational theory, and innovation theory. Together with a description of the routines and the organisation of work in the building sector, this theory also provides a basis for discussing the conditions for the diffusion of experience and findings from demonstration projects to mainstream building practices. Moreover, the research has been inspired by discourse analysis for discussing the construction of meaning and the interpretation of the main concepts of demonstration projects and sustainable building, both among actors in the building sector and in the Swedish trade press.

2. AN INSTRUMENT IN A STRATEGY FOR SUSTAINABLE BUILDING

The contemporary discourse regarding sustainable development is dominated by ideas of mainstream sustainable development and ecological modernisation [6] [7]. The mainstream sustainable development developed through several United Nations publications on development over the last decades, as well as the Rio conference, is based on a free market, the continuation of growth and on the application of technology. Mainstream sustainable development shares the dominant ideas of modernisation and economic growth in the modern world, and does not suggest any fundamental or radical changes. The fact that mainstream sustainable development has been within reach of conventional tools and environmental and market regulation has contributed to the persuasion of governments all over the world [6]. Moreover, mainstream sustainable development offers good opportunities for the market of clean technologies.

During the last decade, both in Sweden and the Netherlands national investments have been made for sustainable development and sustainable building in line with the ideas of mainstream sustainable development and ecological modernisation, cf. [8],[9]. Investments for an agenda for sustainable building as well as measures to arrive at sustainable development have also been made on a building sector level. Among these investments the demonstration project has had a prominent role, especially in the Dutch approach. Initiated by national authorities in the Netherlands a demonstration project programme has resulted in 44 demonstration projects spread over the country. In Sweden, demonstration projects for sustainable building have been carried out within the frames for local investments for sustainable development supported by national authorities. Besides these national investments, European funding (Thermie, SHINE, Meduca, etc) has supported demonstration projects in both Sweden and the Netherlands.

As a strategy for authorities, the demonstration project is a positive instrument. The demonstration project will be appealing to an offensive strategy among actors in the building sector whereas a defensive strategy would need other kinds of instruments such as regulation. Accordingly, the demonstration project would mainly sustain the ‘front-runners’ while regulations are needed for the ‘laggards’.

3. THE DEMONSTRATIONS PROJECT AS PART OF A DEVELOPMENT CHAIN

Earlier research point out the necessity of building experiment and demonstration projects as part of innovation and development in the building sector [10], [11], [12], and [13]. The experiment and the demonstration project are seen as necessary parts of a chain from development of new technique and concepts to the diffusion of the same in the building sector (Figure 1). The experiment is followed by a demonstration project in the last stage before the diffusion. The demonstration should usually not be accomplished until the second or the third full-scale trial plant in order to avoid negative demonstrations of untried technologies and concepts [10]. However, the research and development chain is seldom chronological in the building sector. Furthermore, the research and development chain can give the idea that research is a driving force for development, while instead development is usually triggered off through the search for problem solutions in practice [14].

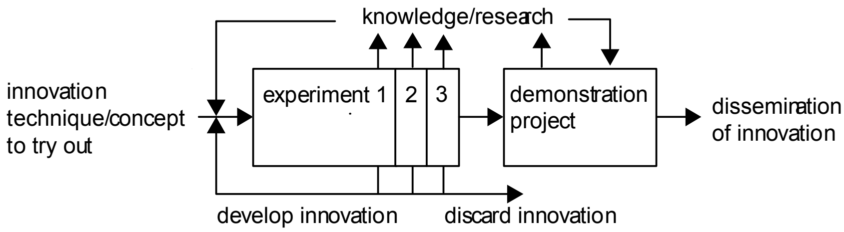

Figure 1. The research and development chain adopted after [10].

There exists no clear definition of the term demonstration project. Instead the definition of the term can be understood through its application. The etymological derivation of the term 'demonstration' means to exhibit and show while the term experiment means to try a hypothesis. A study of literature in the field [5] shows that demonstration projects are seen as a way to show but also to try out new technology and concepts in full-scale projects under realistic conditions. The demonstration projects are distinguished to the experiment in involving less risk. However, in both kinds of projects focus should be on clear objectives, evaluation and dissemination of results. It can be noted that whereas the term demonstration project is increasingly used in the discourse of sustainable building the term experiment is seldom mentioned. 'Demonstration' is often seen as one characteristic in building experiments while the 'experiment' does not seem to be part of contemporary demonstration projects for sustainable building.

The dissemination of technologies and concepts to mainstream building practices is an important part of successful demonstration projects. However, earlier studies in the field show that the dissemination from demonstration projects often have deficiencies. Many authors bear witness to failure in systematic documentation and evaluation. This also shows a problem with allocation of finances as documentation and evaluation often has a smaller budget than the actual investments for innovations. Furthermore, there are seldom long-term evaluations effected on demonstration projects. Several authors also point out the need for 'change agencies' [13], [15] with the task of communicating experiences from demonstration projects.

Concerning the influence of successful demonstration projects on mainstream building there are other factors than the organisation of the demonstration project, the information production and dissemination, which will venture the reproduction of successful results. These are for example: economical conditions, risk, governmental policies etc. cf. [13]. Furthermore, the introduction of new technologies is often delayed by time lags as new technologies imply changes in routines and systems and will demand education etc. cf. [15].

4. CONDITIONS FOR LEARNING, DEVELOPMENT AND INNOVATION IN THE BUILDING SECTOR

The building sector is a large societal sector within the European Union with considerable importance for the national economies of its member states. The building sector is largely national, diversified and fragmented. Knowledge in the building sector is mainly developed through the practice, through the construction of projects. This empirical-practical knowledge building process is not systematic or controlled by scientific methods. It is subjective and contextual. The knowledge build-up, as well as all changes, in the building sector is usually characterised as being slow and taking place in small incremental steps. Knowledge building is a long process of planning, construction, evaluation and feedback, which can take many years from start to results.

Several factors challenge the efficiency of the knowledge build-up within the building sector [16], [17], [18]. One factor is the temporary nature of the building project, which has no organisational memory. The building project is usually considered as a unique event, and there are seldom long-term relationships between actors. A second factor is the fragmentation of the building process involving actors from different professional cultures. The fragmented building process has several clearly defined phases and knowledge is lost as actors in the project team enter and exit the process during its course. A third factor is the decentralised decision-making process and the ad-hoc problem-solving on the spot, which does not encourage long-term thinking. A fourth factor concerns the individual actor's interest and attitude to learning.

Theoretically, the building sector provides an optimal ground for technology diffusion through multiple connections and interfaces with different actors, technologies and practise. The building project can be seen as an 'experimental workshop' [16], [19]. However, in practice the development and innovation dynamics is influenced by a number of factors that will impede sustainable development [2], [19], [20]. The prevailing short-term thinking in the building sector, due partly to the highly cyclic demand, as well as the focus on the production has led to a concentration on small innovations with quick yield. Initiatives taken by a single actor will meet resistance as this may challenge the effectiveness of existing networks. Innovation is not economically defensible for first-movers and this could also lead others to bear the risk for implementing new innovations. Accordingly, potential adopters of new technology are risk averse and cautious concerning the cost and efficiency of changing established procedures. Moreover, the building sector is rather conservative, characterised by static competition, and does not change its procedures. A renewal of the company stock does not lead to the introduction of new techniques, products or organisational forms. Consequently, productivity will develop more slowly in the building sector than in other sectors where existing and new companies need to innovate in order to be able to compete. Moreover, in such a system investments in research and development strategies for the future are not interesting [21]. Nor is there any interest to employ highly educated personal. Consequently, the educational level among employees within the Swedish building sector is low in comparison with other sectors cf. [22]. This also affects the level of interest in research and development. In Sweden not more than 1% of the annual turnover in the building sector is invested in research and development projects [22]. Furthermore, there are other contextual factors that will have an influence on the development and innovation dynamic in the building sector. These are: fiscal systems, regulations and laws, energy prices, loaning institutions and the fact that the building sector is has an important role in the national economy.

5. THE RELEVANCE OF THE DEMONSTRATION PROJECT

The empirical studies show that demonstration projects for sustainable building have an important role in the process towards more sustainable building. The demonstration projects make the complex problem of sustainable building both a tangible and a visible concept, and as such the idea of sustainable building will be physically present and represented in everyday situations as well as in discourses at a building sector level, at a national programme level and the general public level.

For the building sector, the demonstration projects provide real-world data, and can be attributed the function of reference objects for sustainable building both concerning the product, that is to say what sustainable building is and the process, how this can be implemented. The demonstration projects provide arenas for developing learning through doing in which actors in the building sector can try out new or more established sustainability concepts, environmental technologies etc. in practice. The practical experience performed in the demonstration project arena can also be observed by actors in the rest of building sector. The demonstration project is theoretically a potential strategy that provides good possibilities for supporting learning and development processes towards sustainable development in the building sector as well as a knowledge build-up relating to sustainable building. However, the empirical studies show that demonstration projects have deficiencies regarding a strategy for making mainstream building more sustainable and as a basis for a knowledge build-up. Such a strategy has to be improved in order to become effective and influential.

5.1 Deficiencies in contemporary demonstration projects

One of the main ideas with the demonstration project is to provide learning experience for the actors involved and to become educational cases for the rest of the building sector. Even so, the empirical studies show that the opportunities for learning offered by the demonstration projects are not made use of. There is often a lack of systematic evaluation, feedback and dissemination of results from demonstration projects venturing the internal as well as the external learning processes. This will also venture the learning process among the actors involved in the project as well as the reliability and usability of the experience from the demonstration projects outside the project organisation. Ultimately, this in some cases will also contribute to the creation of negative demonstrations as for example rumours about failures cannot be refuted. The demonstration project should be carried out in an open manner so that observing parties can recognize the demonstration project as ‘a fair test’.

Accordingly, many contemporary demonstration projects reveal a waste of opportunities with regard to learning and knowledge build-up for the implementation of sustainable building. On the one hand, this can be explained by deficiencies in the organisation of these demonstration projects concerning evaluation, the production of reliable results and the internal as well as the external dissemination of experiences. On the other hand, this can also be explained by the general lack of interest and incentives for learning and generation of knowledge in the building sector.

5.2 The need for reliable and functioning ‘change agencies’

Another factor that impedes learning from demonstration projects is the lack of formal ways of communicating knowledge in the building sector. The empirical studies point out the lack of formal institutions and organisations for the dissemination of experience; both internally, from the temporary organisations involved in the demonstration projects to the home organisations, as well as externally, from the demonstration projects to the rest of the building sector.

The study indicates that neither research reports nor the trade press function satisfactorily as change agencies regarding the communication of experience and information from demonstration projects. Respondents in the interview study that has been carried out within this study, complain about the lack of reliable and also easily accessible information about sustainable building. The respondents seldom use research as source of information, which they find difficult to access, irrelevant for their practice or even non- existent. The fact that the actors do not use existing research is a general problem in the building sector see for example [22]. The most commonly used sources are personal contacts and informal and formal networks.

The Swedish trade press has been studied as one easily accessible and often referred to source of information about demonstration projects and sustainable building in general. The study show that the trade press can function as an eye opener during the early stages of an adoption process for new concepts and technologies cf. [15]. However, the Swedish trade press fails to provide consistent information applicable in design or decision-making situations.

Furthermore, the information provided in the Swedish trade press about the demonstration project is scanty and lacks background information. Consequently, the trade press fails to create an understanding of the problem complex of sustainable building and the background to the decisions and measures taken in the demonstration projects presented. For example, the tangible aspects are often overemphasized leaving aside the important experience of the non-tangible dimension, the process of fruition. The lack of information about the background to decisions taken in the specific demonstration project implies a risk that already defined solutions and closed images or ideals of sustainable building can become normative. When these normative and closed solutions or ideals fail to address the interest of the building sector they may instead have a negative impact on the development of sustainable building cf. [24]. This applies for example if the demonstration projects are understood as not being able to be reproduced on a larger scale, or when the introduction of sustainable concepts or technologies are beyond the feasibility of present building practices or if the architectural design of the examples are not regarded as being aesthetically attractive. When ideals for sustainable building are beyond the reach of the individual actor or the organisation in everyday practice, sustainable building risks being set outside the main agenda of the building sector.

6. SUSTAINABLE BUILDING – A PLACE APART

So then what can explain the absence of influence from demonstration projects for sustainable building on mainstream building practice? As already discussed in this paper, this can be attributed the structure, organisation and the routines in the contemporary building sector that is not very favourable for development, learning and change. In this paper several specific reasons for the lack of influence for demonstration projects have been discussed. Firstly, it can be seen as being the lack of incentive and interest in the building sector to learn from experience. Secondly, that there is a lack of compilation and dissemination of reliable and useful findings from demonstration projects. Thirdly, many demonstration projects fail to appeal to actors in the building sector, as the ideals of the demonstration projects do not correspond with the ideals of the actors. A fourth reason is that demonstration projects are considered as being special projects and sidetracks from mainstream building. In the demonstration project, the actors involved make a commitment before the observing building sector and public to achieve a more sustainable building. The empirical studies show that when involved in such commitments, the building sector also approaches towards more sustainable building. However, successful demonstration projects often demand extra time in the process due to a more thorough planning: interdisciplinary tasks, the education of those involved, the involvement of expert knowledge etc. It can be seen as being a contradiction in that the ambition of many demonstration projects is to attain sustainable building under the rather ‘normal’ conditions of the building sector, which are characterised by short-term thinking and a focus on the quick yield from investments. After the completion of the demonstration project, the majority of the actors involved return to their normal procedures and projects where there are fewer resources for continuing the development of sustainable building. The demonstration project then becomes a sidetrack or a one-off monument over initiatives taken at a certain moment. Consequently, demonstration projects fail to become part of a continuous development process towards more sustainable building. The special project or the 'research event' has little chance of surviving in the real world where extra resources concerning time and money for fulfilling explicit objectives are missing or less present cf. [19].

6.1 The contradiction of distinction or acceptability

This study indicates that there is a contradiction between the acceptance of the necessary changes to accomplish sustainable building among actors in the building sector, and the idea that this should be within reach without greater changes in contemporary building practices. In order to become influential and to become normative on a broad level, sustainable building has to become the mainstream building practice. The empirical studies shows that many actors, both in Sweden and in the Netherlands is against the idea of distinguishing sustainable building as being a special kind of building project – sustainable building should be mainstream building. The empirical studies also show that actors within the building sector are opposed to the extraordinary or ideological experiment that fails to address the majority of the actors in the sector and that consequently falls outside the sector's main agenda. Instead, the empirical studies point out the advantage of an incremental and successive development through realistic (and economically justified) projects using technology and methods applicable on a broad scale. In addition the study of *The Swedish Architectural Review* reveals a preference for a pragmatic and unobtrusive 'ecological' architecture. The study shows an aversion against the special and sometimes even symbolic examples of sustainable building. However, the study of *The Swedish Architectural Review* indicates that some architects idealise the merits of simply 'good' architecture and consider that good architecture in itself is sustainable. The same ideas are revealed among several respondents in the interview study, and are confirmed in an earlier study [25]. This view of sustainable building focuses on durability, and underestimates the importance of for example environmental issues.

The idea of mainstream sustainable building is in conflict with the fact that sustainable building has to point towards the future. The demonstration project has to be more sustainable than mainstream, and even much more sustainable considering the state of the world. Accordingly, this discussion indicates the problem of using a special label for the distinction of sustainable building. On the one hand, by addressing sustainable building as something special there is a risk it will be set outside the main agenda of the building sector. This is what characterises the development of sustainable building at the beginning of the 21st Century in the Netherlands and also in Sweden. The building sector and also the public have lost interest in sustainable building. On the other hand, if sustainable building is not distinguished from mainstream building there is a risk that the concept will be watered down. There is a risk that the concept can mean anything, include anything, and in the most negative scenario even be 'business-as-usual'.

7. DISCUSSION AND CONCLUDING REMARKS

This study indicates that the demonstration project for sustainable building has the potential for becoming a strategy for successive and incremental development in order to achieve the long-term objectives for sustainable development through realistic advancements. Demonstration projects for sustainable building tend to become quickly dated, as research and technology advances, and as cultural, societal and sector systems and values develop. Accordingly, the one-off demonstration projects should be seen as part of a development process; as concrete and tangible steps on the path of the long-term process towards the abstract objectives of sustainable building. Furthermore, the successive development adapts to conditions for learning and development in the building sector and could encourage its actors to initiate and carry out demonstration projects as part of a learning process.

In order to make the strategy more explicit a stepwise model is proposed in which the demonstration project represents one level of innovation (Figure 2). The model distinguishes four levels of practice cf. [26]: 1) ‘basic’ practice, which means ‘business as usual’, 2) ‘best practice’, which is the best that can be achieved with present technology and methods, 3) demonstration projects that are more innovative than best practice, but nevertheless less innovative and risky than the experiment, and 4) the experiment or front-line project that uses the technology and methods of tomorrow. Accordingly, the model acknowledges the need for, on the one hand, ‘best’ practice examples and demonstration projects showing the way on a broad level, and on the other hand, building experiments or ‘front-line’ projects that have a much higher innovation level than the former. The model proposes that tomorrow’s ‘best’ practice and demonstration practice will become mainstream, while new higher levels of innovation towards sustainable development will be sought for in new demonstration projects and building experiments.

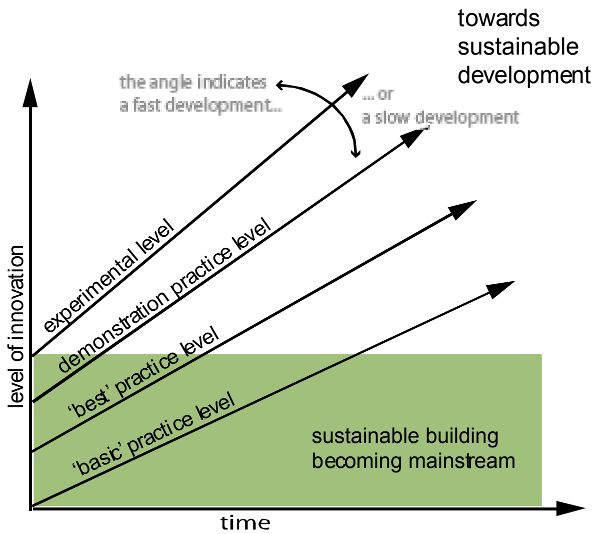

Figure 2. The successive development of demonstration projects based on [x].

The idea of the demonstration project as part of a successive development could be helpful in encouraging actors in the building sector to initiate and commit themselves to such projects. Through the empirical studies it has been revealed that some of the hindrances for the implementation of sustainable building are the lack of consistent images of the problem and the lack of reliable information. This can also be a question of the actors in the building sector having difficulties in transforming existing information into useful and living knowledge able to be used in practice. Sustainable building when addressed in its total complexity can be paralysing. Several respondents in the interview study have difficulties in describing the characteristics of sustainable building and some even find it impossible to imagine the ideal sustainable building in practice. Confronted with this huge and abstract task, and without any clear recipes on how to act, some actors will react by avoiding the task and persist with old routines. The ideal situation would be if demonstration projects could be seen and used as a strategy for incremental learning and development without the fear of making mistakes. All experience, good as bad, should be encouraged. The ideal would also be if the demonstration projects could function as arenas for mutual exchange between research and the world of practice in order to build up knowledge, based on real world data, able to be scientifically tested and spread outside the project team.

The findings show similar experience from demonstrations projects for sustainable building in Sweden and the Netherlands. Supported by the governmental authorities, the Netherlands made larger investments in demonstration projects in the late 1990s. However, both countries at the moment experience a backlash in interest for sustainable building as well as what concerns the development of demonstration projects. The demonstration project as a strategy for supporting the process towards sustainable development in the building sector should be seen as one important part of a larger investment. Investments for sustainable building have to be made at a national and political level, at a building sector level and at the level of the organisations and individuals in the building sector, not least that which concerns education. Changes are needed in technological systems as well as in non-technical systems, such as the values and frames of reference among the actors and professional groups, and possibly also in systems outside the reach of the actors in the building sector, such as in economic systems, legislation etc. The paper presents the building sector as a large and complex system and supports the idea that changes towards sustainable development in this sector are processes that will need time.

The contributions from all the individual actors in the building sector involved in this process are indispensable. There is a need for a better understanding of issues regarding sustainable development among the actors within the building sector. In order to support such development, there is also a need for a better understanding of the factors impeding the actors from becoming involved in this development. These factors can be the problem with lack of information or lack of good examples, or the fact that the building sector is stuck in old structures and routines that impede development and change. The empirical studies indicate that the actors in the building sector are willing to accept the challenge of sustainable building, but there is some kind of paralysis to overcome in order to advance. An interview study, that was carried out within this study, shows that the actors often think that there are other actors in the building sector that should take the first step for development, or that the responsibility is on the politicians, or the trade press. However, it could be argued that all individual actors in the building sector should take a larger responsibility for sustainable development. In order to attain a higher level of individual as well as organisational learning and development this will also demand a critical view of the governing ideas and procedures in the daily practice of the building sector, both those of tacit and explicit character within organisations and professions.

The demonstration project as presented in this paper is built up on the idea of a more mainstream sustainable building with broad applicability in line with the ecological modernization of society in Sweden and the Netherlands. The paper has also shown that actors in the building sector more easily accept the challenge of mainstream sustainable building, as well as the idea of the successive development of the demonstration project, compared to more radical changes in contemporary building practices. However, it can be argued that there is a need for complementary demonstration projects or experiments that reach a higher level of innovation and that would demand more radical changes in building practices. The concept of sustainable building is still vague for many actors in the building sector, and accordingly open for personal interpretations. There is a risk that the concept will be watered down and become mainstream in order to be in compliance with other interests in the building sector. This study indicates that there is still a need for further developed analysis of what sustainable building is, as well as how this can be accomplished.

8. ACKNOWLEDGEMENTS

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ENVIRONMENTAL ANALYSIS OF RESIDENTIAL BUILDINGS – LIFE CYCLE ASSESSMENT

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1. Introduction

Issues of sustainable development became an undisputed part of majority research projects in the World and in the European research area. Within priorities of research orientations dominate problems related to quality of a built environment. Buildings - the most significant part of the built environment – have a large-scale potential for achievement of required qualitative improvement in environmental, economical and socio-cultural parameters i.e. in basic areas of sustainable construction. Buildings in EU consume on average about 40% of all produced energy and produce approximately 30% of CO_2 emission and 40% of total waste [1]. Modernization of existing buildings and construction of new buildings oriented on reduction of environmental impacts can significantly contribute to improvement of quality of the built environment as well as condition of the environment in general.

One of the key topics of the of the long-term project "Building Construction and Sustainable Development" supported by the Ministry of Industry and Trade of the Czech Republic [2] was analysis of an existing housing stock in the Czech Republic and consequential evaluation of possibilities to improve their environmental parameters from the long-term perspective. The main goal was to verify the potential of reduction of environmental impact of residential buildings when implementing principles of sustainable construction in the refurbishment of the existing housing stock in the specific Czech conditions.

The presented case study shows results of a complex environmental assessment of a set of selected residential buildings. Different approaches to maintenance, reconstruction or complex modernization (i.e. different life cycle strategies) have been considered in evaluation of selected buildings. These results are compared with current state of existing residential buildings. Environmental parameters such as consumption of non-renewable material sources, consumption of energy sources, consumption of potable water, waste production etc. were considered in the evaluation process.

2. Selection of representative set of residential buildings

Four representative buildings have been selected for assessment within the project framework. Chosen buildings represent the most frequent types of residential buildings used in the Czech Republic in the 20^{th} century (see Fig. 1)[3]:

I – *Traditional multi-storey apartment house*

The structure of the most apartment buildings built before the year 1945 is from traditional brick masonry and mainly timber joist floor structure.

- Selected representative building: Five storey apartment house in Prague built around 1930.

II – *Masonry multi-storey apartment house from late 40s and 50s*

A brick masonry structural system with steel or RC joist beams and concrete fillers has been frequently used after 2nd World War (in Czech so-called "dvouletka").

- Selected representative building: Two storey apartment house built in Prague 6 around 1950.

III – *Precast panel building*

The development and use of concrete precast technology started in the late 50s and continued up to the mid of 90s. More than one half of all current flats have been built using precast concrete technology during this time period.

- Selected representative building: Four storey large panel apartment house in Moravske Budejovice – structural system T06B – built in 1984

IV – *Single family house – traditional masonry construction*

Most of single family houses have been built using traditional brick masonry technology with timber or RC floor slabs or later with other types of prefab or composite beam and filler floor structures.

- Selected representative building: Detached two storey single family house in village Babina (north of Pilsen, CZ) – built in 1957

Pictures of four representative buildings selected for evaluation are presented in the Figure 1.

Fig. 1 Selected representative buildings used in evaluation

3. Evaluation methodology and criteria

3.1 General principles

The problem of sustainability of buildings is very complex and includes a large number of parameters and criterions from different areas of technical as well as non-technical sciences. Sustainable construction should be based on the effort to (a) decrease exhausting of primary raw materials and energy, (b) regulate consumption of renewable resources, (c) decrease the amount of harmful emissions and wastes, while (d) increasing the structure's serviceability, durability and reliability throughout its entire life. These goals should be achieved while keeping the total cost on a reasonable (minimum) level and social and cultural aspects at a feasible (maximum) quality.

The evaluation methodologies have to be complex, considering all relevant flows (material, energy and other) and covering the corresponding most important essential environmental criteria. However, the admissible simplifications of the model are usually needed. The evaluation methods and models should be preferably based on the following characteristics and essential qualities:

- complexity - the method should cover the most important environmental criterions,
- time dependency - the method should consider the whole life cycle (ISO 14040),
- probability - the evaluation method should respect the probability feature of the time dependent problem (implementation of maintenance and refurbishment strategies - scenarios).

The environmental assessment model used in the case study was based on the above-specified principles considering common principles of ISO 14040 international standard.

3.2 Maintenance and refurbishment scenarios

Two presumptive maintenance and refurbishment scenarios within particular phases of the life cycle of each alternative of residential building were considered. Following principles and concepts in the technical solution of maintenance management and refurbishment design and construction were considered in the evaluation process:

- Reduction of energy use in operation of building.
- Use of renewable energy sources and renewable material sources.
- Use of high-performance construction materials (high performance concrete, composite materials etc.).
- Use of recycled materials.
- Implementation of intelligent control systems for control of quality of internal environment.
- Use of energy efficient house appliances.
- Implementation of water saving systems.

The LCA evaluation was performed for existing stage (scenario 0) of each representative building and for two proposed scenarios of complex modernization - scenario A and B:

Scenario 0 represents existing stage of building. The current technical standard corresponds to the basic maintenance of the building. No major refurbishment within elapsed steps of the life cycle has been done until now. From energy point of view U value of outside wall is typically more than 0.7 $W.K^{-1}.m^{-2}$.

Scenario A represents standard approach used in typical contemporary renovation process. From energy point of view such technical standard of the building fulfils current standard requirements (according to ČSN 730540-2 - 2002 and Reg. 291/2001 Sb.). Current requirement for massive outside wall is: $U \leq 0.38\ W.K^{-1}.m^{-2}$.

Scenario B represents complex modernization using best available technologies (BAT). From energy point of view the modernized building using BAT approach fulfils low energy standard and is getting close to the passive energy standard. Current requirement for outside wall designed according to low energy standard is: $U \leq 0.15\ W.K^{-1}.m^{-2}$. It is supposed that sustainable principles should be used during modernization process. The preferred approach is flexibility and low maintenance in the consequent life cycle after the refurbishment step.

3.3 Evaluation criterions

The typical set of environmental criterions has been used in the assessment process of four selected residential buildings. Main groups of used assessment criteria:

- environmental criteria associated with material use: weight of materials, embodied energy, embodied $CO_{2,\ eq.}$ and $SO_{2,\ eq.}$, material input (amount of renewable sources, use of recycled materials etc.), material output (amount of recyclable materials, waste etc.),
- environmental criteria associated with utilisation phase: heating, DHW, cooling, primary energy consumption, CO_2, SO_2, NO_x emissions associated with operation of building etc.
- other parameters: floor area, heated area, building size, number of occupants etc.

A characteristic environmental profile for each evaluated alternative has been compiled from above specified sets of criterions. The environmental profile consists from four groups of criterions:

- Embodied energy, embodied CO_2, embodied SO_2.
- Specific heat use, use of primary energy (from non-renewable sources).
- Operating emissions of CO_2 and SO_2.
- Weight and volume of used materials in the building structure (renewable materials, recycled materials, recyclable materials, primary natural sources), materials from demolition of building (fully recyclable materials, partially recyclable materials, non-recyclable materials - waste).

Environmental data needed for a calculation of embodied values were derived from [4], [5]. A calculation of operating emissions was performed using the tool GEMIS [6].

4. Results of environmental assessment

Each of four selected buildings were analysed for existing stage (scenario 0) and two maintenance and refurbishment scenarios A and B. This represented in total detailed evaluation of 12 particular cases.

The composed environmental profiles of each assessed building I to IV are presented in the following figures Fig. 2 to Fig. 5. On the horizontal axe is the percentage of decreasing/increasing values of each criterion for both scenarios A or B. 100% means the current stage of existing representative building – scenario 0 (vertical red line).

There are two graphs for each evaluated building. First graph represents built in and embodied characteristics like volume and weight of used material and embodied emissions and embodied energy. The difference to 100% represents what we have to add during the maintenance or refurbishment in order to achieve required qualitative standard according to scenario A or B. The second graph shows the improvement of technical parameters of building in operating phase – especially decrease of heat use and primary energy consumption as well, again based on qualitative standard given by scenario A and B.

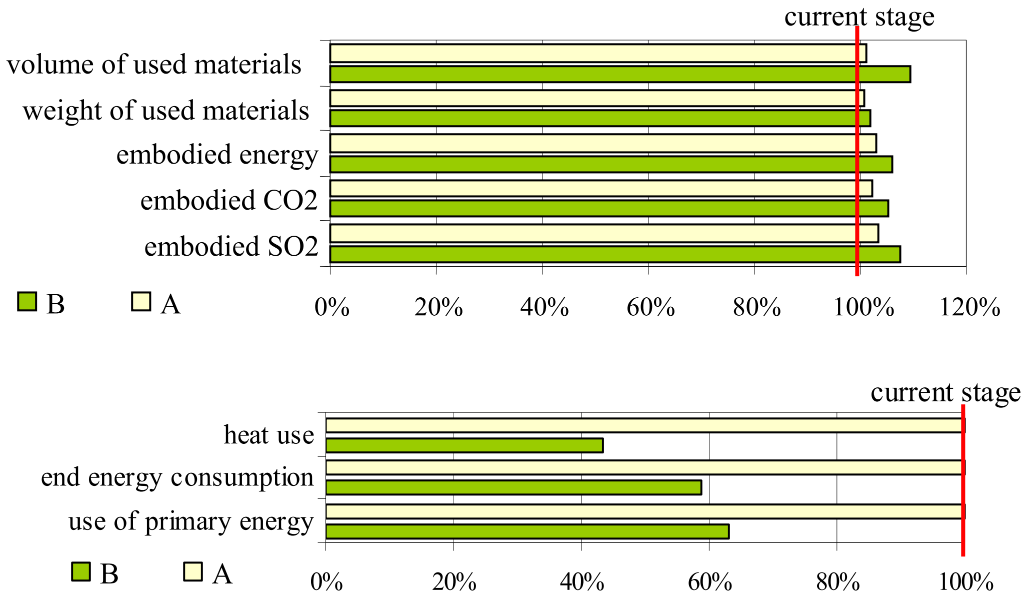


Fig. 2 Environmental profile of apartment building I from the 30s

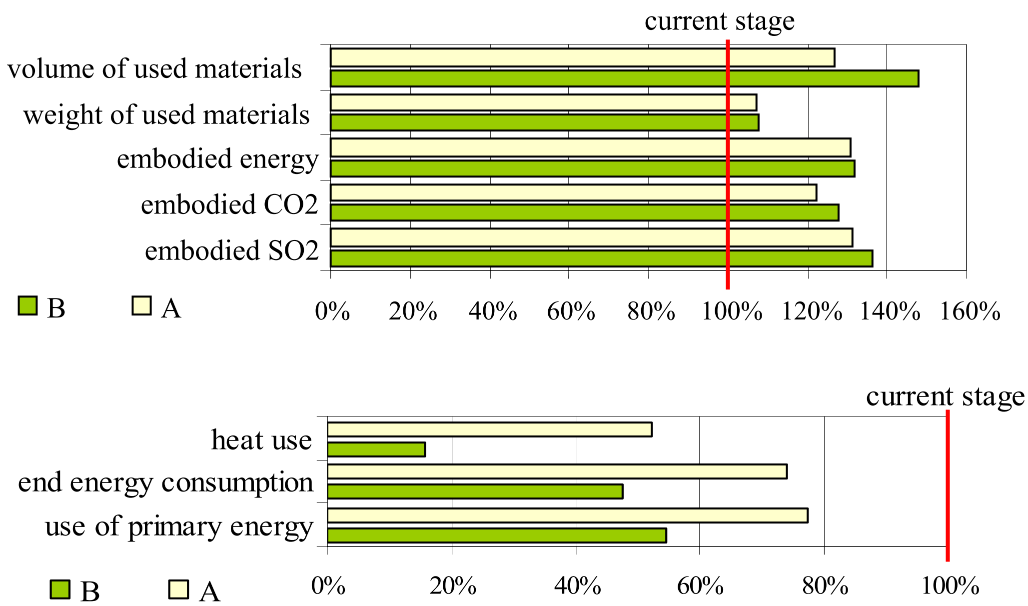


Fig. 3 Environmental profile of apartment building II from the 50s

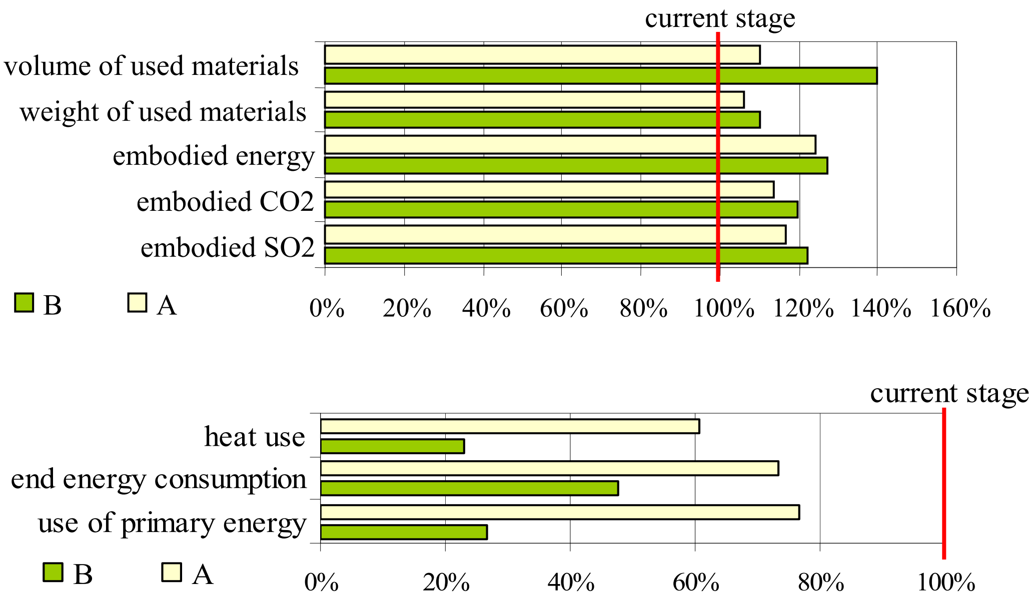


Fig. 4 Environmental profile of panel building III from the 1984

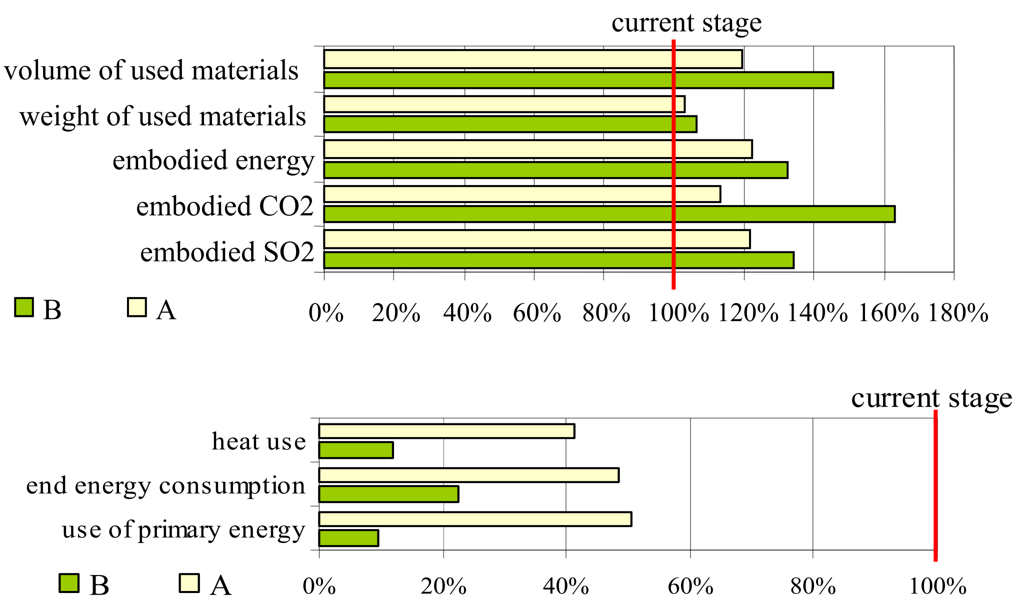
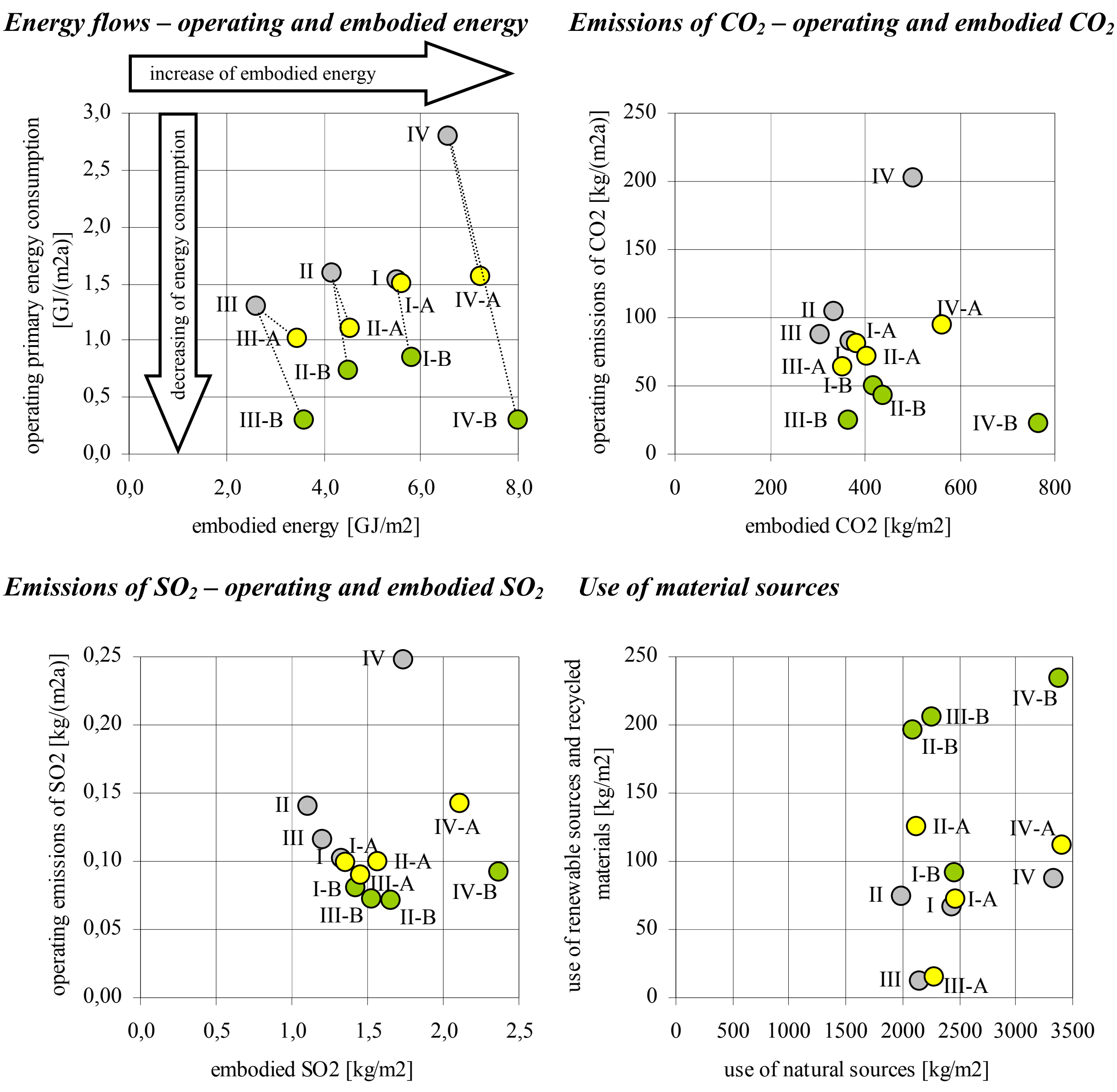


Fig. 5 Environmental profile of family house - brick building IV from the 1957

It is essential that any modernization can not be done without some increase of built in and embodied environmental criterions - see the first graph. However, this increase is significantly very small comparing to environmental impact related to demolition of existing building and construction of the new one. This underlines the importance of refurbishment of existing buildings rather than demolition and construction of the new one. The efficiency of refurbishment process can be expressed by a ratio between improvement of operating environmental criterions (characteristics in the second table) and increase of built in and embodied environmental criterions (characteristics in the first table).

It is obvious that the difference between scenario A and B could be in the case of some criterions very insignificant, for example in the case of embodied energy. The sustainable scenario B has in many cases only a little bit bigger embodied energy, but concerning the operating primary energy the reduction is more significant (see the next figure Fig. 6). Moreover, it is necessary to note that embodied values are the final total value, however operating values are considered per annum.

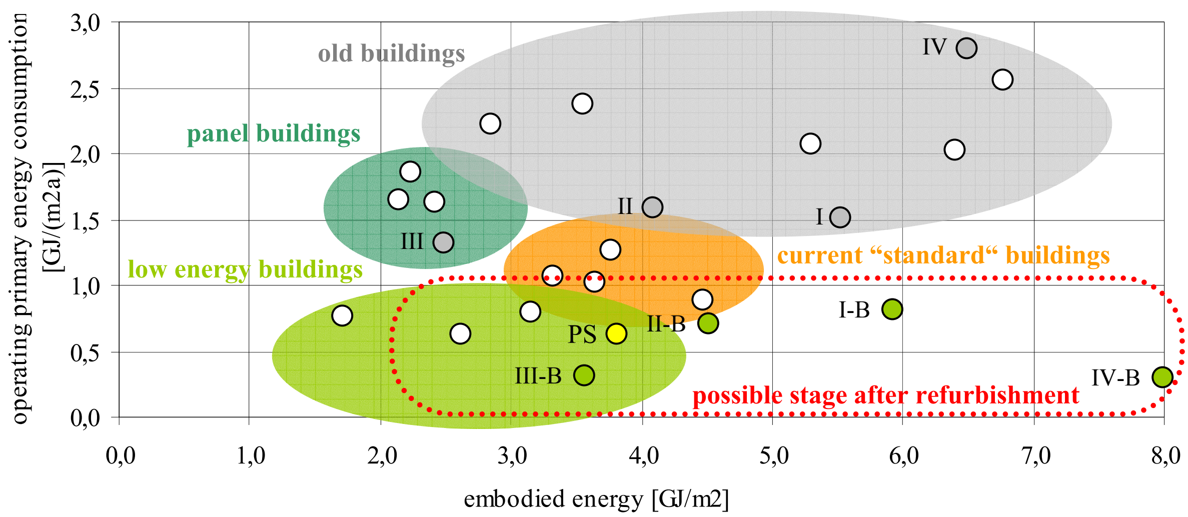


I Five storey apartment house built around 1930
II Two storey apartment house built in Prague around 1950
III Four storey large panel apartment house – structural system T06B – built in 1984
IV Detached two storey single family house in village Babina – built in 1957
All values are related to m^2 of floor area.

Fig. 6 Values of environmental criterions of representative buildings and their refurbishment scenarios A and B

The results presented in graphs in Fig. 6 clearly show the potential for improvement of environmental characteristics in relation to existing stage of evaluated buildings. Even better results could be achieved in the case of refurbishment designed in low energy standard (scenario B).

The next figure Fig. 7 shows complex comparison between assessed representative buildings and other types of buildings evaluated within the Martin Vonka´s thesis “Life Cycle of Assessment of Buildings”. All shown buildings were analyzed using the same evaluation methodology. The graph on the Fig. 7 represents example of assessment from the energy point of view. The yellow point PS means a passive family house built this year near Prague and the green point means the precast panel building after the modernization using the scenario B. It is evident that using BAT approach in refurbishment process (which is considered in scenario B) it is possible to achieve such energy parameters of precast panel building, which could be even better than current realization of passive family house. Also embodied energy within the whole life cycle is in the case of precast panel building lower than in the case of assessed passive family house. To be fair, it is necessary to note, that large compact blocks of flats (like panel buildings) have in general higher potential for decreasing of operational as well as embodied values – especially energy, than detached family houses.



PS a passive family house built this year near Prague

Fig. 7 Energy flows (embodied energy x operating primary energy) of buildings

5. Conclusion

The presented results of performed analysis show potential of possible improvements of design, construction as well as utilization of residential buildings within their entire life. This can be achieved by implementation of sustainable principles in the maintenance and refurbishment phases within following life cycle stages of existing residential buildings.

The high potential for improvement of technical, energy and environmental parameters of existing building stock in the Czech Republic is evident. However, up to present, in the Czech Republic was built only a small amount of buildings in the standard going near to the "sustainable" level. The step by step improvement of the average standard of the CZ building stock (from the sustainability point of view) is possible, but it is conditioned by (1) development of technical basis (know-how, database, product base, technology of production and construction etc), (2) development of legal support for implementation of sustainable principles in building practice and by (3) implementation of economy stimulation.

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ENVIRONMENTAL ASSESSMENT OF MANAGEMENT OPTIONS OF THE URBAN MINERAL BUILDING MATERIAL STOCK

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1. Abstract

The building industry in Europe is causing a large consumption of natural resources and emissions to the environment. Hence, environmental impact assessment of building waste management options is necessary to assess the ecological best options. The paper gives a rough overview of the impacts on the environment caused by building processes and estimates the in- and output of building materials for the City of Vienna in Austria. The stock of building materials which are "stored" in buildings is determined. Concrete is one of the dominant building materials. Therefore, production emissions for concrete and recycling concrete are examined and their impacts on CO_2-equivalents and the consumption of natural resources are investigated.

2. Importance of the building industry

The building industry in Europe is responsible for a large consumption of areas and energy, for production of waste and for growing stocks. In the EU with the borders of 2003 3,200,000 km² of the land area are used by buildings. The daily growth is 10 km². Buildings claim 45 % of the primary energy consumption in the EU. 15 % (7.5 mill. t) of the yearly waste generation in Austria are building wastes. The buildings are responsible for the erection of a huge stock of materials in our society. In Austria the stock of buildings (volumes of existing constructions) is 200 to 500 t per capita. It doubles in 30 to 50 years if the growth of now is extrapolated. The domination of the building industry in the material flow of a state brings the need to deal with the question on how building wastes shall be managed and how environmental impacts can be assessed.

3. Goal and questions

The goal of the paper is to assess the stock of urban mineral building materials and compare the environmental impacts of the production of concrete and recycling concrete. The paper deals with the following questions:

- Of which materials consists the stock of buildings?
- Is scarcity expected for mineral building resources?
- Which potential for secondary resources represents the building stock?
- How much "nature" is consumed in production of secondary resources compared to primary resources?

4. The observed system and the stock of buildings

The city of Vienna serves as an example to calculate the urban stock of buildings. The observed system is shown in Figure 1. The examined processes are buildings of the structural engineering such as buildings for housing or office buildings and buildings for civil engineering (here only road buildings are investigated), landfills and the processing of building waste for recycling of building material. The system border in space is the buildings in Vienna, in time it is the year 2001. The arrows mark the yearly in- and output flows of goods like building materials or construction waste. Only mineral construction materials are investigated (no metal, wood etc.).

The stock of buildings is calculated using statistical data [1]: the number of existing buildings in Vienna, their age, the use (housing, office, industrial building) and the method of construction (main building material). Indicators (t material per m²) [2] are used for the calculation of the material input into buildings dependent on the construction method. Statistical data of the road areas and their construction is used for the calculation of road building masses.

The yearly in- and output calculation is based on statistical data as well [1] [3]. For the processes "buildings SE" and "buildings CE" together 12 mill. t of mineral construction materials are the input into the city of Vienna in the year 2001. The output is 1 mill. t (concrete waste, rumble, road building waste).

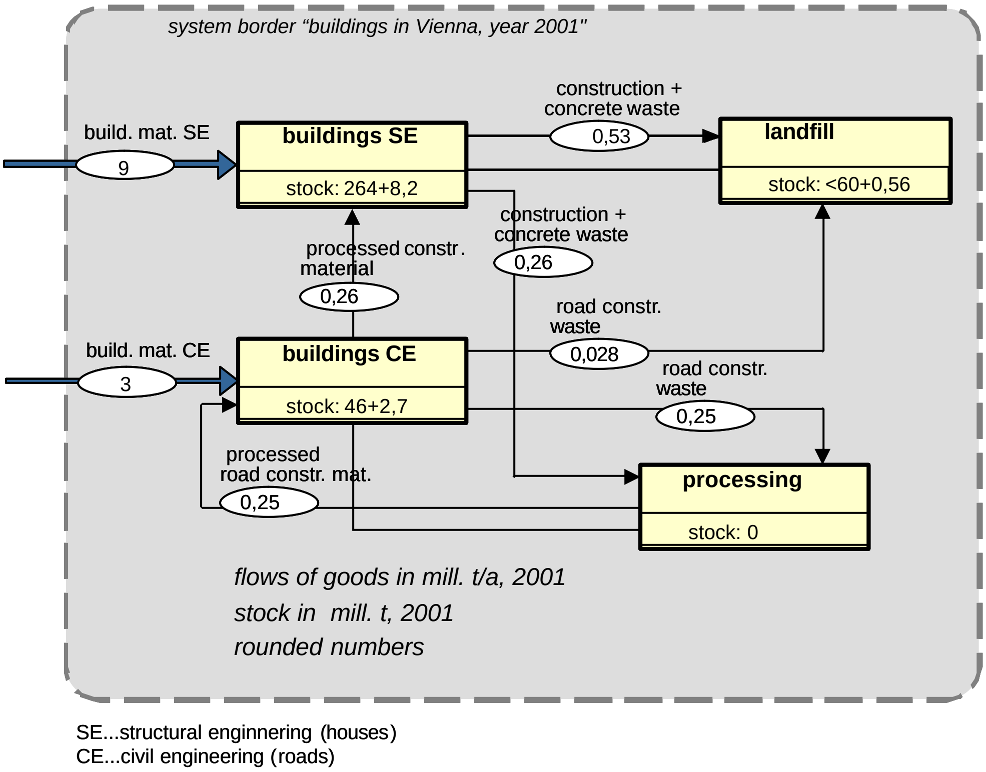

Figure 1: System „buildings in Vienna, year 2001"

The stock of mineral building materials in Vienna has a mass of 311 mill. t: 77 mill. t of concrete and 104 mill. t of brick. The rest is plaster, floor pavement, mortar, gravel, cement, granite, roofing and others (Figure 2).

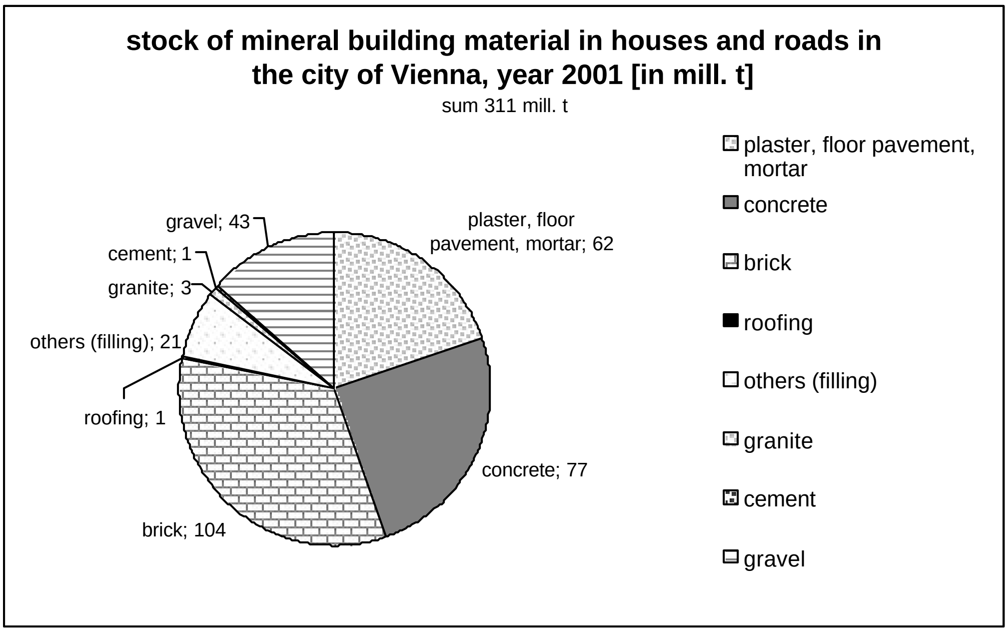

Figure 2: Stock of mineral building materials in houses and roads in the City of Vienna, year 2001. The stock defines the existing buildings which will become waste in the future.

The dominant building material before the 1940s used to be brick and stone (Figure 3). Nowadays concrete becomes the mainly used material. Therefore, the following investigations concerning the ecological impacts of processes will be performed for concrete.

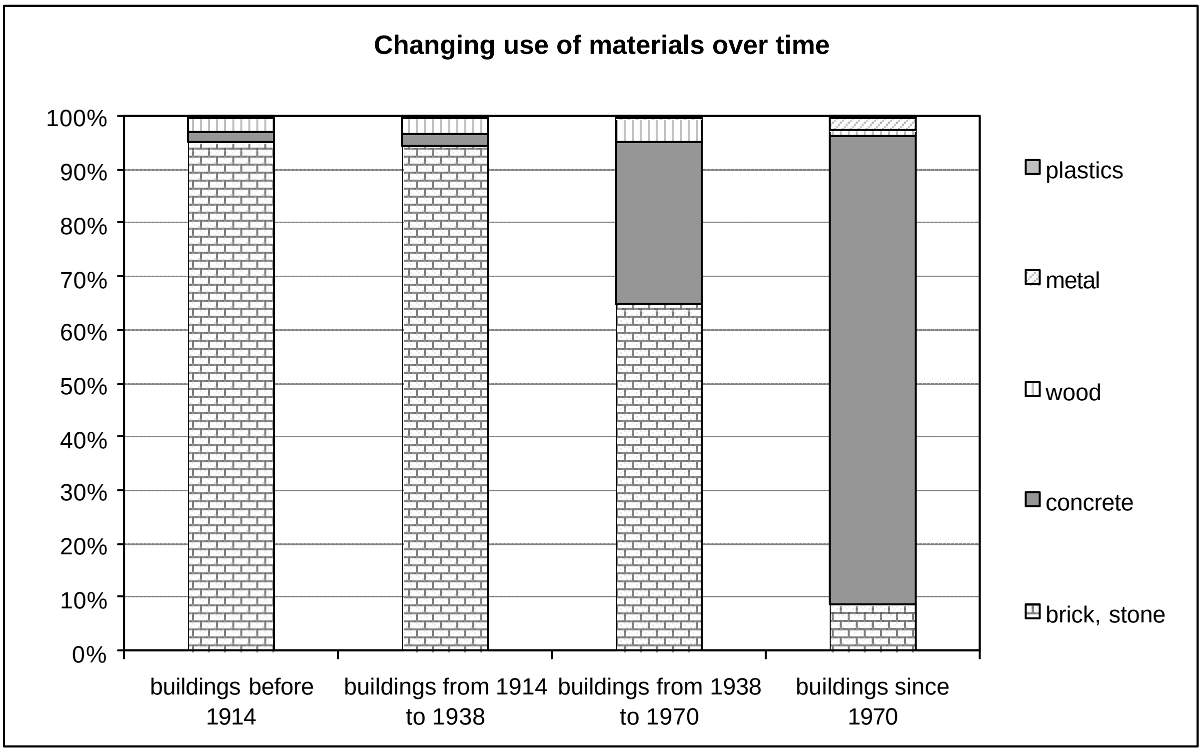

Figure 3: Changing use of materials over time [4].

5. Assessment of ecological impacts

Different building options and building waste management options have different impacts on the environment. Ecological assessment methods allow the estimation of environmental impacts. Environmental categories that can be observed are:

- the consumption of resources
- emissions to air, water and soil
- generation of waste (landfill volume)

Two of the mentioned categories will be discussed here. The focus of this paper is the emissions of CO_2 to air and the consumption of the resources gravel and sand.

<u>Emissions to air</u>

Selected impacts are presented here. The comparison of the yearly concrete production with recycling concrete (RC) production serves as an example. It was assumed that the concrete buildings which are built in one year in Vienna are made of concrete on one hand and of RC on the other hand. The environmental impacts of the concrete production per year for Vienna are calculated. For RC it was assumed that old concrete was crushed and used for aggregate. The fraction < 4 mm was exchanged by primary sand. The cement rate was assumed to be a little higher for RC (concrete: 16 kg cement /kg concrete; RC: 17 kg cement /kg). This higher cement rate does not have to be necessary in RC production but was applied to see the effects of increased cement on the impact categories.

The CO_2-equivalents are calculated to estimate greenhouse effect relevant emissions into air. The GWP coefficients from [5] were applied to calculate the CO_2-equivalents. Cement is the dominant factor for CO_2-emissions (Figure 4). This results from the high energy demand for cement production. The use of crushed concrete as aggregate in RC does not significantly reduce the emissions. The comparison of concrete with RC showed no significant difference. When RC is produced with little increased cement the CO_2-emissions of RC even overtop those of concrete. In the next step it was investigated if CO_2-emissions of concrete production are a relevant category to look at. The yearly CO_2-emissions of cars in Vienna amount about 1 bill. kg CO_2. The Viennese waste incineration plant Spittelau produces 1 mill. kg CO_2 per year. Hence, the emissions of the yearly concrete production (500 mill. kg) can not be neglected.

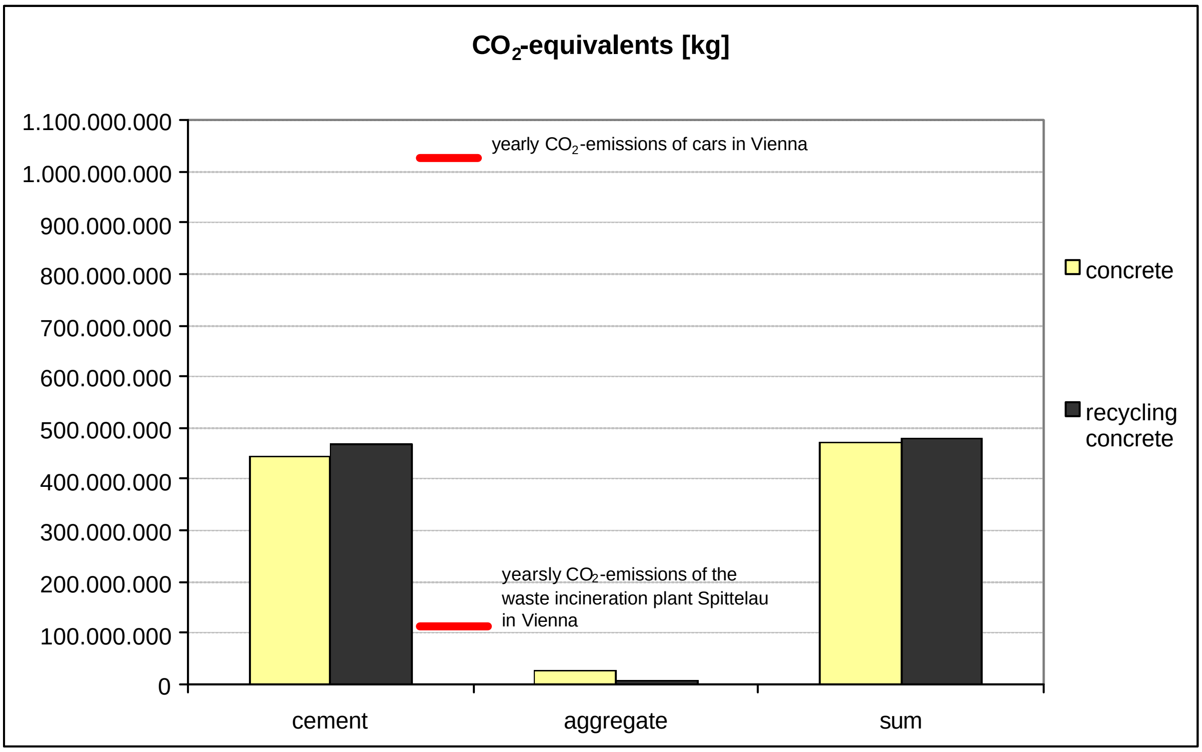

Figure 4: Comparison of the CO_2-equivalents of the yearly concrete production and recycling concrete production to CO_2-emissions by cars and a Viennese waste incineration plant.

Consumption of resources

To find out whether the use of a resource is critical it has to be assessed if it is scarce. The scarcity of the resources gravel and sand can be only made regionally. Gravel and sand are not limited by the volume of their occurrence in nature but by conflicts of interests of the regional policy (waterproofing areas, building land etc. [6]). Figure 5 shows a map of an important gravel deposit outside of Vienna. The authorized deposits around Vienna contain 310 mill. m³ of gravel. As the yearly need of gravel and sand for buildings in Vienna is 1.4 mill. m³ the deposits would last for 220 years if it is assumed that no other city consumes these resources.

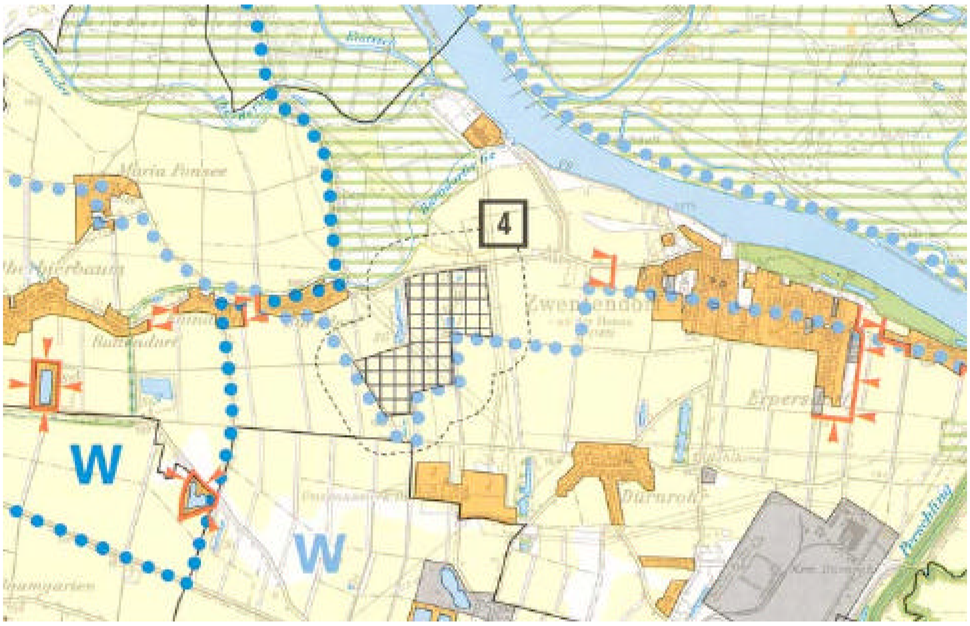

Figure 5: Map of an important gravel deposit (Tullnerfeld No. 4) near Vienna [7]

In case of the use of crushed concrete as aggregate for concrete the deposits would last for 250 years. The small difference of 30 years derives from the following conditions: The output "concrete waste" is only one tenth of the yearly needed concrete material (input into the system in Figure 1). From concrete waste only 50 % can be used for RC. Fractions < 4 mm are excluded. This is why only a small part of the needed gravel could be replaced by recycling aggregate and the natural deposits can be conserved just to a certain amount. Here it is assumed that crushed concrete is not used for road building but for RC in structural engineering.

6. Conclusions and outlook

Of which materials consists the stock of buildings?
The stock of mineral building materials in Vienna has a mass of 311 mill. t: 77 mill. t of concrete and 104 mill. t of brick. The rest consists of plaster, floor pavement, mortar, gravel, cement, granite, roofing and others. Brick and concrete are the dominant materials in the stock of buildings. The output of the process "buildings" is one tenth of the input. The data for the calculation of the stock is based on statistical data which is still not satisfying. Accountancy for the input materials into buildings should be established in Austria as the building industry is responsible for a large volume of goods.

When results of different studies concerning the ecological impact of processes are compared the different system borders have to be taken into account.

How much "nature" is consumed in production of secondary resources compared to primary resources?
The main factor to reduce CO_2 production emissions is cement. If a higher cement ratio is needed for the production of recycling concrete (RC) the impact on the environment of RC is even a little higher compared to normal concrete.

Is scarcity expected for mineral building resources? Which potential for secondary resources represents the building stock?

Gravel and sand can not be declared as scarce. They are not limited by the volume of their occurrence in nature but by conflicts of interests of the regional policy (waterproofing areas, building land etc.). The use of recycling aggregate in RC conserves the natural resources gravel and sand. The conservation is limited because the yearly production of concrete waste is only one tenth of the needed concrete for new buildings on one hand. In case of RC only 50 % of the concrete waste could be used on the other hand. Hence, the potential for concrete waste as a secondary resource is limited. The production of RC can help to reduce landfill areas for concrete waste.

The here presented assessment method will be expanded to other environmental impact categories to make a comprehensive assessment of concrete and RC possible.

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METHODS OF UNSTABLE HEAT TRANSFER REGIME ANALYSIS AND OF POWER ESTIMATION

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1. Introduction

When making practical calculations of heat losses and energetic evaluation of buildings we presume that the heat exchange in the buildings is performed in the settled regime [1]. The desired temperature in the premises is reached when not only the heating devices heat up, but also building constructions and all other objects that are in the premises, i.e. a certain amount of heat is accumulated by the building itself. In such a way in the case of steady-state heat exchange, the heat losses of the building depend just on the coefficient of heat transfer. However, in reality the outdoor air temperature is changing – rising or falling – therefore the temperatures of building constructions and inside objects are changing too, i.e. the heat exchange process is not steady. The lack of universal calculating methodology for unstable heat exchange regimes does not let analyze deeper and evaluate the solidity of bodies (buildings), the possibilities to regulate the temperature of premises, and the power of heating system.

2. Method

It is quite difficult to analyze unstable heat exchange between separate bodies that make a certain limited system, and to adopt classical methods to calculate heat regime.
The heat that gets into any element of the body (system) is used for rise the temperature of the same element and is given to other elements of the same body (system):

$$Q_1=Q_2+Q_3, \tag{1}$$

where:
Q_1- is heat getting into the body element being analyzed;
Q_2 - is heat being accumulated in the element itself;
Q_3 - is heat that is given to other elements of the same body.
In the differential form the balanced equation is expressed in the following way:

$$\frac{\delta\vartheta}{\delta\tau} = a(\nabla^2\vartheta + \frac{N}{\lambda}), \quad (2)$$

where:

$\nabla^2\vartheta = \frac{\delta_2\vartheta}{\delta x^2} + \frac{\delta^2\vartheta}{\delta y^2} + \frac{\delta^2\vartheta}{\delta z^2}$ is a Laplace operator.

N=(x, y, z, τ) – the power of the heat flow that gets into the element being analyzed.

Having in mind the fact that there are a lot of different body forms, moreover one variant may have different boundary conditions, and the answers of this equation are very complicated. The classical methods let us find the answers of this equation only when the bodies of ordinary shape are at certain boundary conditions.
When such problems are being solved, usually a certain model of heat exchange is being used and the formulation of problem is neared to concrete cases of heat transfer, i.e. Fourier equation of heat transfer is expressed in another form, and consistent patterns of heat transfer inside the body are left unanalyzed.
The analysis of thermal interaction of the system made of several bodies may be based on F.M. Kamja theory of impulse heat conductance. [2] This theory is based on the method of heat source – when the body receives certain heat impulse. G.M.Kondratyev theory of regular heat regime [3] is based on Newton law of body heating-cooling; this theory can be used for heterogeneous bodies of difficult shape, which ∞>Bi>0.
During the unstable process of heat transfer the temperature changes in each point of body. However, at any moment it is possible to find out the general body temperature:

$$\theta_a = \sum \frac{V_i \rho_i c_i \theta_i}{V_i \rho_i c_i}, \quad (3)$$

The sum of points of general temperatures creates isothermal surfaces (EMIS) which temperature at the given moment corresponds to the general body temperature.
If the term of equivalent material isothermal surface is introduced to the body participating in heat exchange, the balanced equations of heat exchange can be made according to Newton law of heat removal:

$$\frac{\delta\vartheta}{\delta\tau} + m(\vartheta - \theta) = 0$$

or

$$\vartheta - \theta = \Delta \exp(-m\tau), \quad (4)$$

where

$m = \frac{hF}{V\rho c}$; is rate of body's self-cooling; $m\tau = BiFo$.

Each body, in which a regular heat transfer process is performed, can be imagined as a material surface where the mass of analyzed body is concentrated gradually on the whole surface.
To formulate the problem, the following conditions have to be taken into account:
1. Boundary conditions of the III type are accepted for heat exchange between bodies and environment.
2. The sum of the surface heat transfer coefficients (emission and convection) is constant.
3. Heat flows between bodies are proportional to the temperature difference. Heat exchange is regular.
4. Each body is treated as a material surface.
The main variant of this problem is a general heated building. The purpose of problem solution is to determine the regime of indoor air temperature when the constructive building solutions, fluctuations of outdoor air temperature are known and when you have heat source of determined power.
The equation of building heat balance may be expressed in the following differential form:

$$\frac{dT}{d\tau}+\mu\frac{d\theta_i}{d\tau}+\mu_1\frac{d\theta_1}{d\tau}+...\mu_n\frac{d\theta_n}{d\tau}+m_a\theta_a+m_1\theta_1+...m_n\theta_n=k \quad , \tag{5}$$

where
μ-is the value that expresses the part of the accumulated heat attributed to each body (the building element) in respect of the heat delivering body, when the difference between the temperatures is one degree. It is the thermal inertia index of the body (undimensional massiveness;
m_a -is the specific cooling rate of the body;
m_i – is the cooling rate the body, if the intensity of delivery is equal to the intensity of heat delivery of the body studied;
k - is the heating intensity of the body;
T- is the generalizing temperature of the heat source;
τ - is time.
The components of the heterogeneous body made of finite number of elements can be divided into three groups: heat source (heating system), inside constructions and equipment, building envelope constructions.

In this case the transformed equation system of building heat balance for any heat exchange regime may be expressed in such a way:

$$\begin{cases}\frac{dT_a}{d\tau}=k-m_a(T_a-\theta_i),\\ \frac{d\theta_i}{d\tau}=\frac{1}{\mu_a}\left[m_a(T_a-\theta_i)-\mu_1 m_1(\theta_i-\theta_1)\right]\\ \frac{d\theta_1}{d\tau}=m_1(\theta_i-\theta_1)-m_{il}(\theta_1-\theta_e)\\ \theta_e=f(\tau).\end{cases} \tag{6}$$

In the balanced equation system of building unstable heat exchange the following factors are evaluated:
- power of heat source, its heat capacity, intensiveness of heat transfer;
- heat capacity of the inside constructions of building (inside equipment and partitions) and air, intensiveness of heat exchange;
- thermal resistance of building’s envelope, heat capacity, intensiveness of heat exchange with outdoor air.

The building is analyzed as a heterogeneous body, where the heat migrates from one body elements to others under the influence of constantly changing outdoor and indoor air temperatures, therefore there is a possibility to high lighten the influence of some factor on the thermal behaviour of building and energy input for heating. When the equation system is solved, the following parameters may be determined:
- which heating system is the most suitable in the energetic view (air, water, accumulative, etc.);
- what the possibilities to regulate indoor air temperature of premises are, the optimal power of the heat source and the work regime of the source;
- the influence of the constructional material on building thermal regime and energy input;
- the influence of the layers order in the building envelope, sun radiation or the intensiveness of heat transfer to the environment (influence of wind) to the energetic characteristic of the building.

This equation system connects all the changing rates of the general temperatures of the enlisted components. When analyzing the change (change rate) of general indoor air temperature we can see that there is no direct connection with the change of outdoor air connection. On the contrary, influence of outdoor air temperature on indoor air temperature is expressed through the mediator – building envelope, at the same time the influence of heat source's temperature on indoor air temperature is the direct one. On the basis of the made equation system (6) there is a computer scale of calculation program made [4].

The proposed method of buildings' energetic evaluation let us analyze with expedition many variants of building construction and to choose the most economical energetically. As the solutions of equations are expressed by exponential functions, the laws of body heating and cooling may be adopted to the building. The indexes of exponents are expressed by the criteria Bi, Fo or Kn, Fo. Heating and cooling of building is expressed by the exponential function:

$$\theta_i = \theta_{\lim} \exp(-m\tau), \tag{7}$$

Thus the index of building's thermal stability may be a semi-period of building's cooling

$$\tau_{½} = \frac{0.693}{m}, \tag{8}$$

The semi-period of building's cooling $\tau_{½}$ or $Fo_{½}$ defines the flexibility of regulation of its thermal regime. The more massive the building with its all equipment is, the longer its cooling semi-period is.

3. Transitional Regimes of Buildings Heating

When the parameters of the surroundings are constantly changing, it is necessary to search for some other ways to make the heating systems of the buildings to work according to the real conditions and in such a way to save energy input.

Although outdoor air temperature is constantly changing and the desirable premises' air temperature is kept, some regularities and stages of the process may be observed. During some periods of heating season, outdoor air temperature's change is stable (traditionally is received through sinusoid), however a certain temperature regime is maintained in the premises. Such a stable regime of temperatures change was called pseudo-stable and was analyzed in the earlier stages of the work [5]. Still, during the heating season a sudden (unforeseen) change of climate conditions is quite usual, while we want to keep the set temperature regime in the premises. In this case it is necessary to correct the work of heating system before certain period of time (period of process lag) in order to save energy input.

3.1 Flexibility of Indoor Temperature Control

It is impossible to regulate indoor air temperature by big bounds, therefore the transition from one temperature level to another happens during certain time period. When the work regime of heat source or outdoor air temperature is changed, the change of air temperature in the premise is changed with some lag. The transitional period depends on set diapason of indoor air temperature, constructions of the premise partitions, solidity of equipment and envelope constructions and power of heat source. The most rational way to assert economical temperature regime in the premise is to change the power of heat source at the proper moment. The power of heat source has to be changed before foreseeable changes of outdoor or indoor air temperatures in order to keep with the set schedule of the air temperature in the premise. Outdoor air temperature is not very eager to change, the change of air temperature in the premise happens in 0,2 –2,0 hours after the work regime of heating devices is changed, so it is enough to have a short time prognosis to control wok of heating devices more precisely. In this case a method of probabilities may be used.

The closest to reality diagram of theoretical change of outdoor air temperature is sinusoid. If the temperature change is fixed at the initial moment in the direction of growing or reducing, the derivative according to time $d\Theta/d\tau$ on the diagram of temperature change is determined. It is presumed that this tendency will remain during the set period $\Delta\tau$.

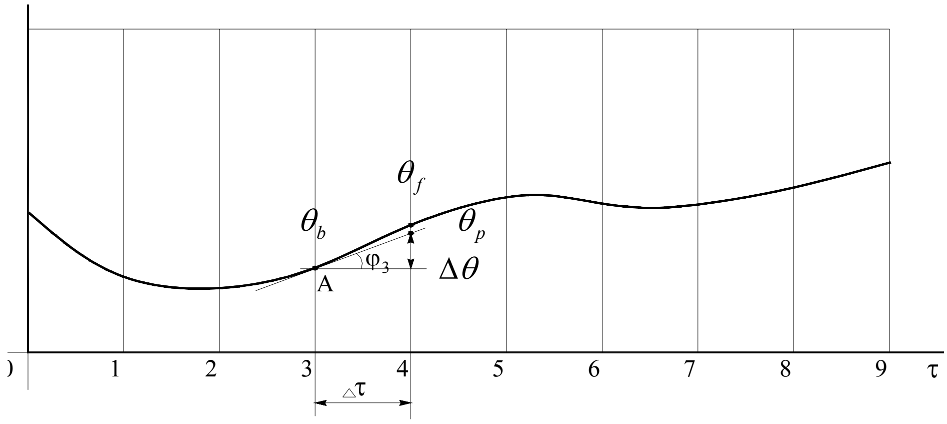

Fig.1. The diagram of short-term prognosis of outdoor temperature

Let us make the first reading point the point A. Then the forecasted outdoor air temperature in the end of $\Delta\tau$ will be:

$$\theta_p = \theta_b + \Delta\theta = \theta_b + \delta\Delta\tau.tg\varphi = \theta_b + \Delta\tau_p \frac{d\theta}{d\tau}, \tag{9}$$

When the forecasted period is finished the factual temperature will be t and divergence from the factual temperature.

$$\theta_f - \theta_p = \theta_f - (\theta_p + \Delta\tau \frac{d\theta}{d\tau}), \tag{10}$$

When the set forecasted time period is over the factual temperature, its change tendency and the forecasted temperature for the next time period are registered once again. After the regulator of indoor air temperature is designed according to the principle mentioned above, the control of premises heating becomes quite flexible. The curve of short-term probable prognosis of temperature change becomes quite close to the curve of factual outdoor air temperature.

When evaluating buildings energetically, it is necessary to keep in mind the initial state of the building, i.e. how the building reacts to the change of air temperature in surroundings. The transition of building from one settled (pseudo-stable) regime to another depends on the type of building: buildings of massive constructions slowly react to the change of environment air temperature; at present more and more buildings of light constructions are built, while the thermal resistance of envelope constructions remain the same as in the case of buildings of massive constructions, but the reaction to the change of outdoor air temperature is much quicker.

3.2 The Influence of the Power of Heat Source on Energy Input Used for Building Heating

The law of general temperature change of heat source is expressed by the first equation of the equation system (6), and

$$k = \frac{N}{V_s \rho_s c_s},$$

characterizes the heating intensity of heat source. The rate of buildings heating and cooling

$$m = \frac{h_{se} F}{\sum V_i \rho_i c_i}$$

does not depend on the power of heat source, if the regime of heat exchange is of regular shape. The quantity $h_{se}F$ determines the building heat losses for one degree of temperature difference, and $\Sigma V_i \rho_i c_i$ is a building enthalpy. Nevertheless, to heat the body (building) up to certain temperature by using heat source of different power, energy input for body heating is different.

As the time of body heating up

$$\tau = \frac{1}{m} \ln \frac{1}{1 - N\left(1 - e^{-m\tau}\right)}$$

is inversely proportional to the power of heat source, when the heating time of body (building) is shortened, the body transfers less energy to the surroundings. Therefore if the regime of heat exchange in the building is unstable, the determination of the optimal power of heat source is a very important factor in order to save energy.

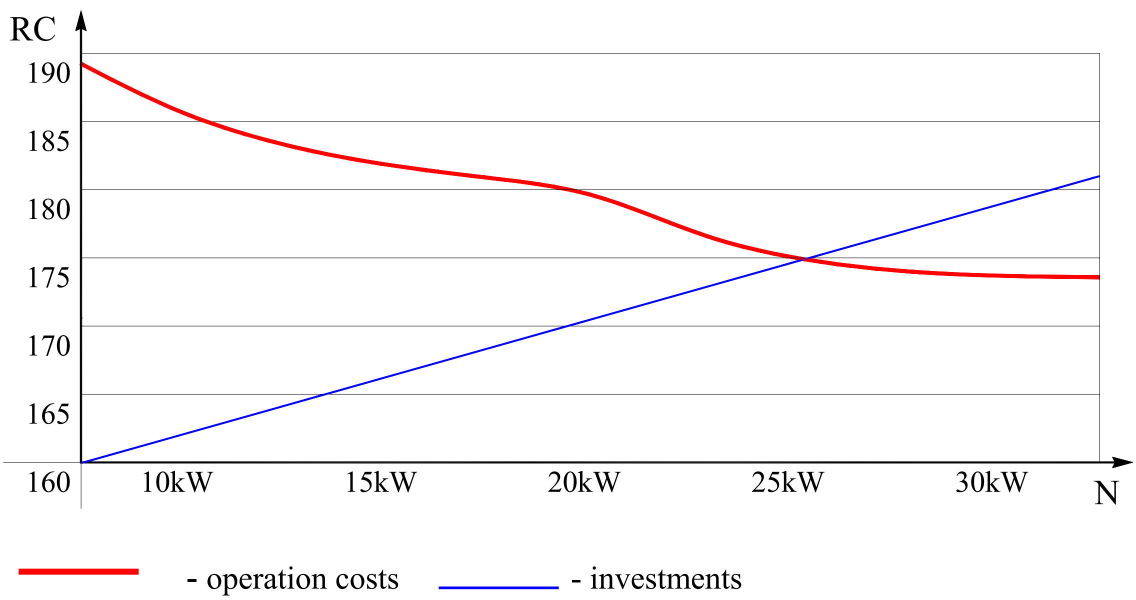

Fig.2. The optimization of power of heat source (1 – operation costs; 2 –investments)

In Fig. 2 there are presented optimization results of the power of heat source of the building, which has 10 kW heat losses. The optimal power of the source is about 25-27 kW. The of investments dependence for heating system due to heat source power is assumed to be linear, as the admissible bias has been observed within the only certain range of the heat source power, up to the 3 times of the nominal value. If power range will be extended, the character of the dependence will become quite another.

3.3 The Influence of Constructive Decisions about Buildings on Energetic Characteristic of the Building

According to the research of changing heat regime of concrete buildings, inside constructions of the building and the mass characteristic of inside equipment is very important in trying to keep flexible temperature regime a day.

The rate of heat source heating up does not depend on the solidity of surroundings (inside constructions of the premises), but the character of the change of indoor air temperature is clear: the less massive inside equipment is, the quicker rising of indoor air temperature in the initial stage of building heating is. The building reaches the pseudo-stable thermal regime quicker when the inside equipment is not very massive, at the same time energy input for the building transition from one regime to another is smaller.

The bigger heat amounts are accumulated inside the building, the slower indoor air temperature changes, thus the economy of energy is smaller when regulating indoor air temperature.

The main criterion of building's thermal characteristic is thermal resistance of envelope constructions. It is too little attention paid for the massive characteristic and layers order in the envelope when buildings are being projected and the material for inside constructions is being chosen. It is often argued where it is better to arrange the insulating layer – outside or inside of the envelope, but there is no difference if we count under the conditions of stable heat transfer. However, having in mind that the heat balance in the buildings is actually changing, the factor of the massive character of the envelope becomes very important [6].

4. Conclusions

1. Under the conditions of unstable thermal regime, the energetic evaluation of buildings may be done only if we treat the building as a heterogeneous body, where the thermal interaction between separate components and environment is being done.
2. The theoretical analysis of the transitional periods to heating season of the buildings has high lightened the possibilities to save energy by regulating the heating regime of buildings and the impact of solidity proportions of separate components of the building in an adequate way.
3. The proposed calculation methodology of unstable heat exchange regimes should be used for complex energetic evaluation of newly projected and renovated buildings.
4. The evaluation of transitional thermal regimes of the buildings has a critical meaning not just in case of energy effectiveness, but is related to the durability of the buildings as well (maintenance of moisture regime, erosion of used material, etc.)
5. According to the proposed methodology, it is possible to decide which variant is the best for construction and renovation of the building due to complex estimation of the effectiveness of the indoor air regulation equipment and the envelope structure.
6. The thermal regimes in the buildings depend on the compatibility of the constructive decisions, the used material and equipment, the maintenance of the comfortable conditions. All the factors that influence the process are reduced to the constants of differential equations [k, m, μ and $t_0 = (\tau)$]. Therefore there is a possibility to classify the buildings into certain groups according to the meanings of the constants mentioned above.
7. When the massive building is insulated from outside, the effectiveness of indoor air temperature regulation in the premises is reduced, as well the energetic effectiveness of the buildings at the same heat losses level.
8. The power and type of heat source have to be determined by optimizing the proportion of the investments and operational costs.

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POTENTIAL OF ENERGY CONSUMPTION DECREASE IN HISTORICAL BUILDINGS

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1. Introduction

Almost the ¼ of buildings in Lithuania are built from 50 years to centuries ago and are of some historical importance. Energy consumption in them is high to keep indoor climate on satisfactorily level, some building elements are worn out and need for replacement. Renovation of such buildings is related with certain restrains, when external view, and in some cases interior spaces as well can not be changed. The energy savings estimated by percents are not big, in average up to 20-30 %, but in real figures they are significant.

2. Estimation of Energy Saving Potential

2.1 Basic Characteristics of Historical Building Envelope

The walls of the old buildings in Lithuania, as a rule, are of ceramic brick masonry approximately by thickness from 0,7 m to 1,2 m. Later, walls in the buildings of 1920-1940 period were of masonry with thickness of 0,52 m. The thermal resistance of the such walls is between the values of 0,5 and 1,6 (m^2K)/W.

The ceilings in attics are usually insulated only by sand layer of 0,2 m on wooden board in buildings of 19-th century and older, and slag insulation of 0,1 m on concrete slab is met in buildings of 20-th century. The thermal resistance is about 0,6 (m^2K)/W. The attics were not often used for continuous living.

Small windows with two frames are settled in the buildings of 17-th century and older. The area of windows is about 10 % from floor area. Later the residential buildings of the nobility were equipped by larger windows, and the height in rooms was significantly higher. Thermal resistance of them is estimated to be 0,37 -0,39 (m^2K)/W, including the air infiltration effect.

The ground floor is erected on basement in the most of cases and any insulation there is met. In rich residences wooden floor were laid on the stone or brickwork coves. In poorer ones the floor is of ceramic bricks. So, the thermal resistance value could be evaluated by 0,5 -0,7 (m^2K)/W.

Almost all the buildings have been reconstructed in the years of 1960-1980. The worn timber ceilings have been changed into ones of reinforced concrete, the worn windows changed by new. The centralized heating systems, domestic water supply have been installed instead of the stoves etc. But the thermal properties of building envelopes have not been changed a lot, even the energy demand has been increased a little, as at that time interest for energy saving was minimal.

At present the energy demand for heating of the considered buildings is varying from 200 up to 400 kWh/m^2 for average heating season. It is also depending on the former reconstruction volumes carried out. The values are higher by 25- 30 % than in the ordinary multifamily apartment houses [1].

The historical buildings possess by big thermal inertia, time constant t is equal 100 or more.

2.2 Possible Recommended Energy Saving Measures

For first, as Lithuania is situated in the zone of cold and wet climate, and the thermal resistance values of the envelope of the considered buildings are quite low, the additional insulation seems to be one of the best recommendations. The inside surface temperatures then would satisfy the recent hygienic requirements at the lower energy consumption level. The walls could be insulated in two ways, from outside and inside. From the view of point of thermal physics [2], outside additional insulation is preferable, as then the temperature-moisture behaviour of the wall structure is more sufficient, it is possible to avoid the cracks because of the freezing and thawing of the moisture content in the pores in the wall masonry volume.

Thin layer of outer finish on additional insulation is predetermined by varying stresses as temperature alteration difference during the climatic year on the external surface of a wall is about (70-80) K [3], (Fig. 1, a). In another hand, the temperature alteration in the wall volume is quite small (8-25) K, in comparison with the temperature changes on outer surface. Moisture content in wall with outer insulation is less, drying processes are more intensive. At the same time the old wall defects are hidden, and façades are renewed. But the technical problems of outer insulation and it's finish layer proper installation and weather durability are significant. Also it is 3-5 times higher in cost in comparison with the inside insulation. Regarding historical buildings this insulation method can be applied only for side façades or wall parts, which are of the simple design. Usually historical buildings have rich decorative details in the main façades, and application restrictions reduce benefits of the outside insulation.

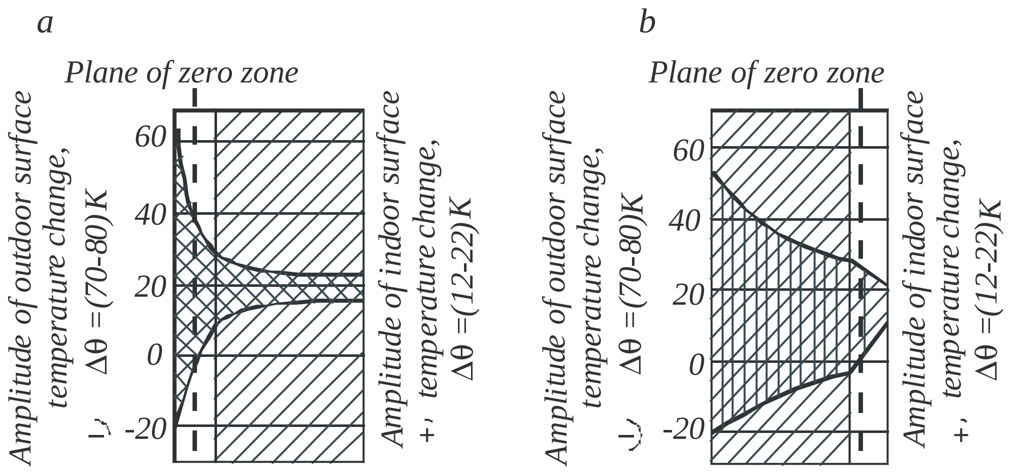

Fig.1. Scheme of the temperature alteration distribution in the wall structure with the additional insulation (a - outside insulation, b – inside insulation);

Additional inside insulation is related with such limitations: the damaged façades are not renewed, and all the defects are left; the plane of zero temperature can move into the inside direction, the vapour condensation can occur then in the wall volume and the big part of the wall structure is at the side of negative winter temperature (Fig.1, b); the floor area is reduced; the insulation of the joints to the partitions and ceilings is complicated.

Application of inside insulation is preferred if façades can not be changed. The possibility to carry out the works despite the season and use of the cheaper and less durable materials is an advantage. The application of the additional inside insulation is considered in each particular case with regard to thermal-moisture behaviour of the certain structure. Block of the vapour movement from indoor space to the wall structure becomes the main provision at the installation of the additional inside insulation. Also the application of considered insulation method is restricted by the presence of decorative details in the interior of the historical buildings often used in 17-19 centuries.

In practice additional insulation of the walls of historical buildings can be proposed only in certain cases and it is applied in small extent. Insulation of the ground floor also is complicated and rare. Most often, the attic ceiling is insulated in full correspondence to present requirements, as well as the windows and doors are to be changed into modern ones, as they are of 30 – 40 years old and of poor quality. The effect of the new windows and door installation is not big as in the buildings of recent mass construction, because of smaller volumes in change.

The modernization of the engineering systems, which have been installed about 30 years ago, also can be suggested as very effective energy saving measure. Inspection of the engineering systems at some historical buildings has demonstrated the failures in the same extent as for the multifamily apartment building stock of the 1960-1990 years. Thermo-valves are not installed on heating devices, almost no control system for heat supply, bad insulation of the pipelines etc.

As an example, the possible energy savings according to the energy audit provided in the Art Academy Department building of 19-th century, located in Kaunas, are presented in Fig.2. The total value of energy savings are considered to exceed 50%, including the installation of ventilation system with the heat recovery. Only constructional measures proposed would save up to 20 %, and control in the heating system – about 20 %.

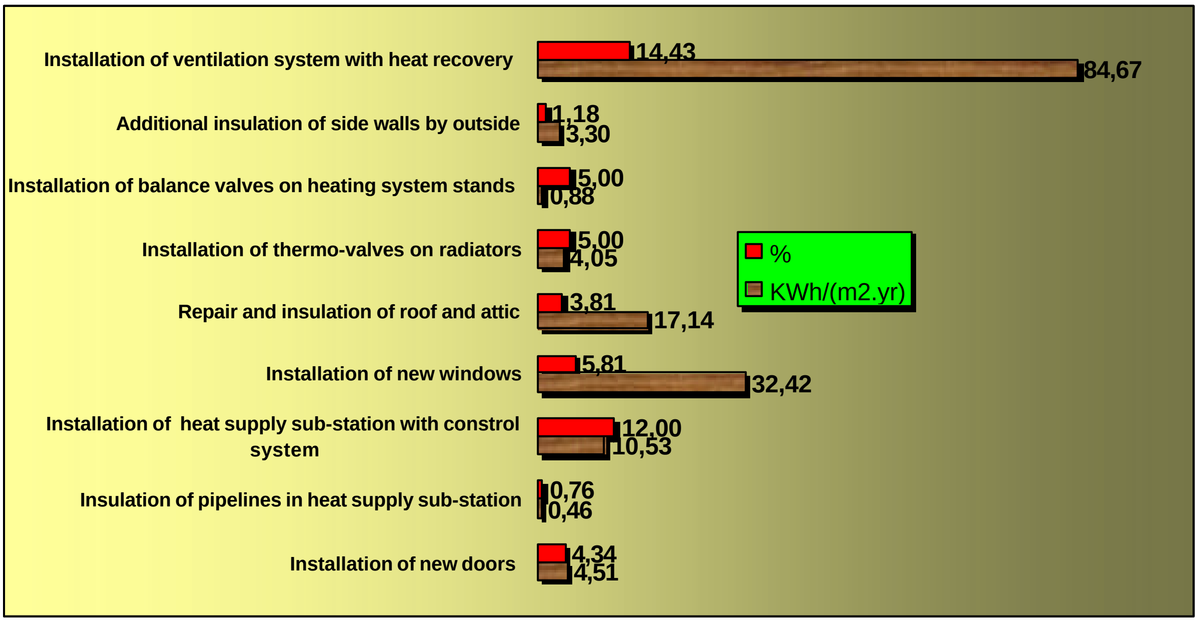

Fig.2. Effectiveness of the energy saving measures (Department of Art Academy, building of 19-th century, in Kaunas, heated area 2375 m², 2 stories, heated basement and attic spaces)

According to the equations of utilization factor estimation in heating system of a building, presented in the [4], the possible energy savings due to only heating system control can reach 15- 25 % from total building energy consumption for heating. The values are predetermined by high thermal inertia of building structures, thus programmable control devices of the heating system due to predicted outdoor temperature changes are of big interest. The thermal behavior equations necessary for controlling also must be determined. Various simulation models are applied successfully in the investigations of thermal and moisture behavior [5, 6].

The effectiveness of energy saving by pay-back period at the renovation according to the audits provided for historical buildings is presented in Table 1. The economical effectiveness is less in comparison with results of the energy audits for buildings constructed in 1960-1990. It is explained by the necessity of the fulfillment of the obligatory requirements held by the historical heritage authorities. For example, only wooden windows frames, the ceramic tiles in the roofs ought to be used. The investments are increased then, while the energetic effectiveness is on the same level or a little less.

As it seen from the Table, the most effective energy saving measures are related to the modernization of the heating system, the pay-back of them is less 5 years in most of the considered cases. The effectiveness of them is alike for the all the post-war buildings, as the heating systems in the historical buildings have been installed with regard to the same background principles, as in ordinary buildings and almost at the same time during the reconstructions.

The installation of ventilation systems with heat recovery also is profitable, such systems could be applied in the bigger part of buildings of public destination.
The pay-back period of the constructional suggestions is bigger because of expensive materials and quality of the labor as well and in every building can have the certain values and must be carefully proved. Also bigger investments are allocated for the finish of the interior spaces of the historical buildings. Totally the renovation suggestions are approximately higher in cost by 1/3. The renovation of the historical buildings must include modernization of engineering systems, as most profitable measures and the constructional improvements in one complex suggestion. The drawn inferences, based on profit of

engineering systems renovation or installation of it in a new in historical buildings, could be applied for the countries in neighborhood of Lithuania. The pay-back time of them could be different, of course, but the ranking of energy saving measures will be similar as well.

Table 1. Comparison of energy saving measures pay-back period in historical buildings and of mass construction

Recommended measure	Pay-back, in years	Pay-back in mass construction, in years
Installation of new doors	**3,2 – 4,5**	**1,8 – 5,6**
Insulation of pipelines in heat supply sub-station	**1,5 - 1,9**	**1,2 – 2,0**
Installation of new heat supply sub-station with control system	**2,2 - 2,7**	**1,5 – 2,8**
Change of windows by new	**12,5 - 17,2**	**6,8 – 8,8**
Insulation and repair of roof and attic	**13,8 - 19,8**	**12,1 -15,5**
Installation of thermo-valves on radiators	**2,5 – 4,5**	**3,5 - 5,5**
Installation of balance vents on stands in heating system	**0,5 – 1,5**	**0,6 – 1,8**
Installation of additional wall outside insulation	**8,6 – 10,2**	**7,5 – 9,6**
Installation of additional wall inside insulation	**6,3 – 7,2**	**4,5 – 6,5**
Installation of ventilation system with heat recovery	**10,5 - 14,5**	**-**

3. Conclusions

1. Suggestions on energy saving measures for historical buildings are related with higher investments in comparison with the buildings of the 1960-1990 mass construction.

2. The ranking of energy saving measures is similar in most of Eastern Europe countries at renovation of historical buildings, though effectiveness of them could vary.

3. The renovation of the historical buildings must include modernization of engineering systems, as most profitable measures and constructional improvements in one complex suggestion.

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ASSESSMENT OF BUILDING MAINTENANCE EFFECTIVENESS ON ENERGY CONSUMPTION AND ENVIRONMENT POLLUTION DECREASE

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1. Introduction

Analysis of present environment pollution level in Lithuania with other European countries shows satisfactorily results. Low CO_2 emission volume is related mainly to Ignalina nuclear power plant [1]. The changes in CO_2 emission, shown in Fig. 1 in 1992-1995, are caused by the economy decline after failure of the Soviet Union, while big amounts of the energy in heat and electricity were supplied to industry. When nuclear power plant will be closed, the fossil fuel shall be used for electricity and heat production and pollution will be higher than it is agreed under the Kioto protocol. The up-today development in industry will request for energy in lesser amounts as it was used ten years ago in big factories with old technological cycles, so the impact into environmental pollution would be at the same level as in other countries and it does not causes special considerations. Great attention must be paid to effectiveness of the energy use in buildings, in regard to requirements of the last Directives of the European parliament and European Council [2, 3]. It seems to be evident, that the biggest part in environment pollution is formed by heating of buildings, especially buildings of 1960-1990 mass construction. The average value of energy consumption for heating is at the top of European countries now. It is determined by the severe climate conditions of winter period and low former requirements for building envelope thermal resistance.

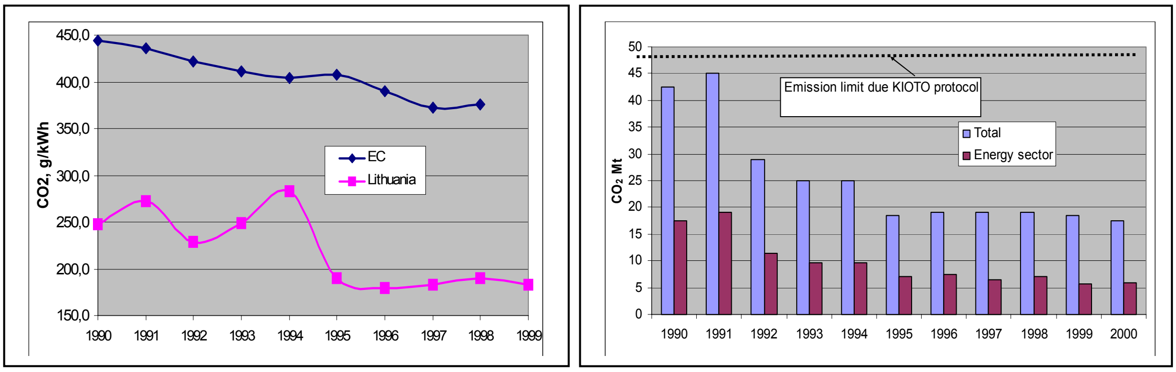

Fig.1. Comparison of the CO_2 emission in Lithuania and European Community

Reduction of energy consumption in buildings shall be performed by renovation of building envelope with especially emphasis on management, maintenance and control improvement of heating and ventilation systems. At present the mentioned improvements are of big interest in Lithuania because of economical and environmental effectiveness.

2. Estimation of Energy Consumption in Lithuanian Building Stock

The heat losses in buildings which must be compensated by heating system form significant amounts of energy. It must be explained that almost all the buildings constructed till 1992 are built according to the minimal hygienic requirements to avoid moisture condensation on inside surfaces. As it seen in Fig.2 [4], the buildings of 1960-1990 of mass construction are prevailing in the building stock. Then improvement of the thermal quality of them become an actual problem of nowadays. The same could be said about the heating equipment.

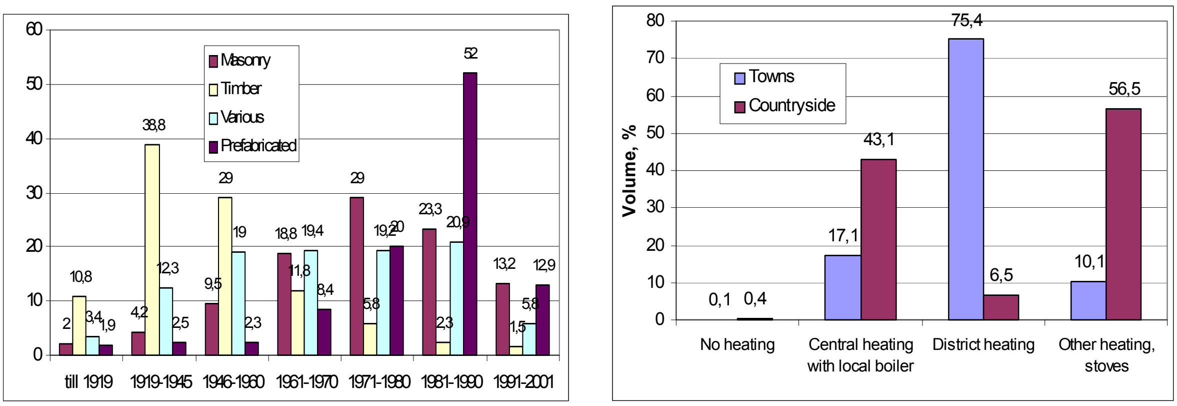

Fig.2 Distribution of the building stock of Lithuania according to construction year, materials and heating systems

According to the investigations provided by Institute of Architecture and Construction at Kaunas district heating enterprise [5, 6], the energy consumption for heating during the recent 1997-2001 has been decreased by 15 - 20 % (fig.3). The study results show the obviously bigger energy consumption in small buildings as well as the bigger dispersion of the values. In big apartment buildings mean energy consumption value can be assumed as 20 - 25 kWh/m^2 per standard month. It is equal to the 145 -240 kWh/m^2 if heating season is estimated by 3790 degree days at indoor air temperature of 18 °C. Energy consumption in a big part, about 30 % of them, is significantly lower, as well as other 30 % are consuming more than mean value.

In small buildings (heated area up to 1000 m^2) the most of buildings could declare energy consumption for heating from 20 up to 40 kWh/m^2 for standard month, respectively it is 150 - 290 kWh/m^2 for heating season. This part is covering about 25-35 % of the considered buildings. Correspondingly about 25 % of the whole volume is consuming more the mean value, 30 % less than the mean value.

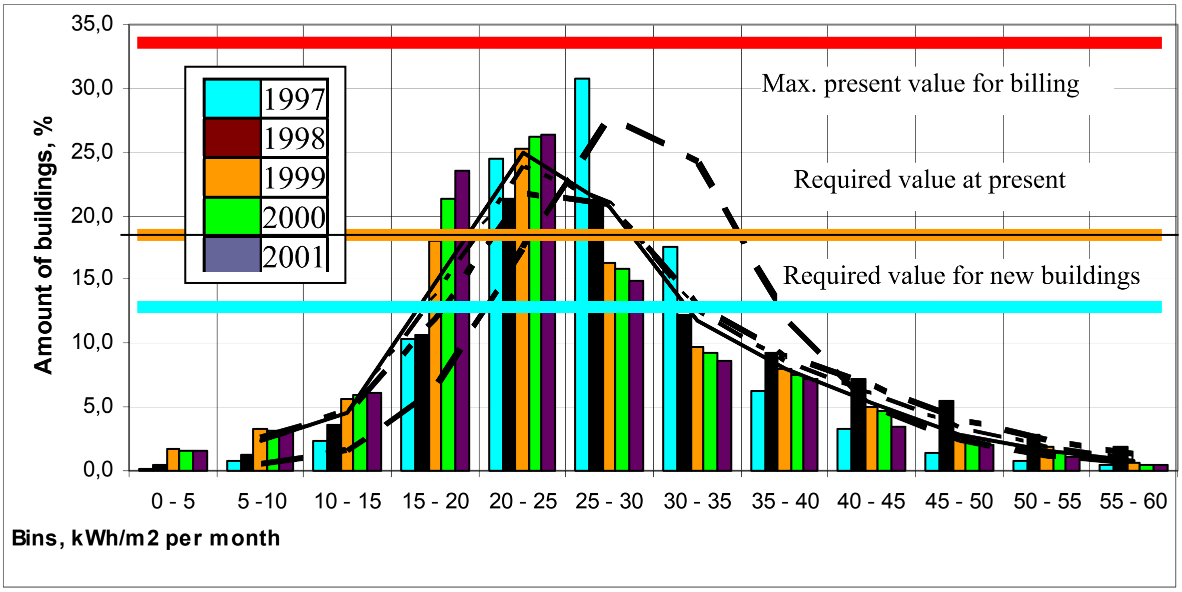

Fig. 3. Energy consumption trends in apartment buildings, 1997-2001 district heating data , Kaunas, heated area 1000 -6000 m^2.

In average it is can be stated that energy volume of 23400.10^6 kWh in a year is necessary for heating of dwellings. The approximate energy consumption distribution according to the construction year in the building stock of Lithuania is shown in Fig.4.

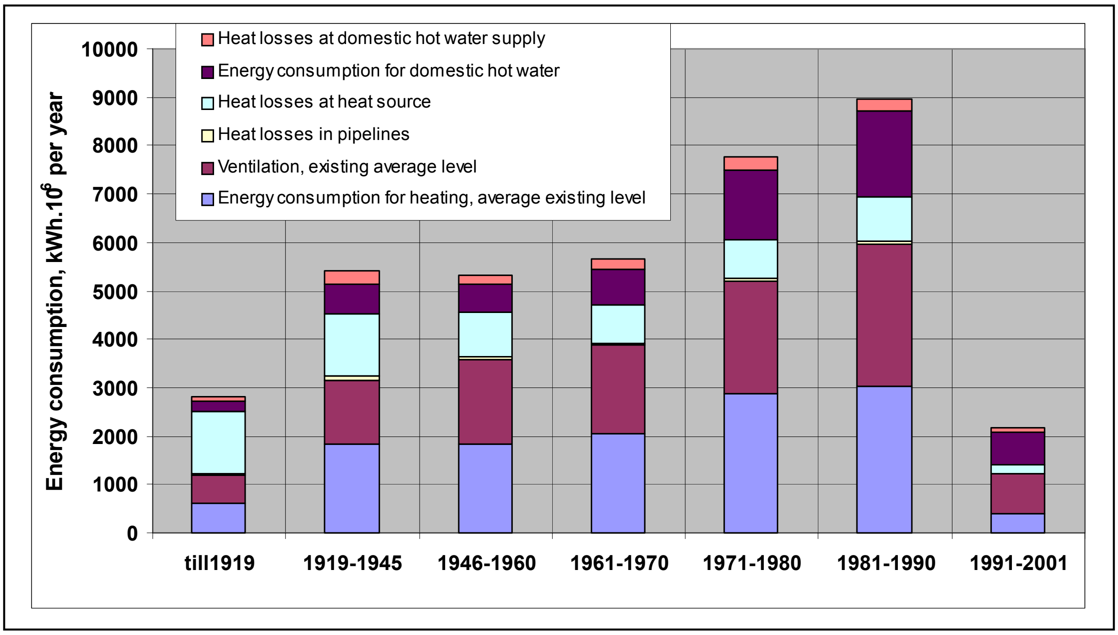

Fig. 4. The approximate energy consumption distribution due to construction year.

In older buildings the heat losses of the pipelines are more and could exceed the 10-15 % of the building heat demand. The effectiveness of the heat sources is also less, as the devices in the heating systems are old [7]. It often could be met the small boilers on wood or coal and ovens with effectiveness by 55 % and stoves in older family houses by 45 %, especially in countryside. Also the big energy amounts are destined to the domestic hot water preparation [8] as well as for ventilated air heating. Natural ventilation is characterized by high air change values because of poor window quality, mainly of sealing.

The heat losses in district heating pipelines are significant, from 20 to 30 % of the heat production [9], the values are predetermined by the long pipelines with insufficient insulation level. Especially it is met at analysis of primary energy consumption estimation for buildings mostly of the 1960-1990 construction period. Almost all buildings of this period were joined to the district heating systems.

3. Estimation of Energy Consumption Trends in Lithuanian Building Stock and Environment Pollution Decrease

Environment pollution in respect to building policy and energy consumption in buildings could be reduced by implementing the projects in such main directions:

- Rise of the thermal protection level in buildings (Arctic dress);
- Development of solar energy use in buildings;
- Improvement of the management of building maintenance with application of new advanced technologies;
- Effectiveness improvement in heating and ventilating systems of the buildings.

In regard to data presented above, the attention must be paid to the improvement of the thermal protection level in the buildings, existing and projected, and of effectiveness for engineering systems.

The present requirements for thermal insulation of new buildings are corresponding to practice of northern countries (Table 1) [10], The Lithuanian requirements are based on estimation of envelope heat loss optimal value. The values in nearest future ought to be revised in regard to changes in technology of insulating materials and new construction technologies with respect to building destination and service life period [11]. In such a way specified required U-values of building elements shall match closer to the state interests.

Table 1. The U-values in European countries, in 2002

Country	U-value, W/(m^{2}K) :																						
	Roofs						External walls						Floor						Windows				
	0,15	0,25	0,35	0,45	0,55	0,65	0,15	0,25	0,35	0,45	0,55	0,65	0,15	0,25	0,35	0,45	0,55	0,65	1,25	1,75	2,25	2,75	3,25
Sweden	■						■						■						■				
Norway	■							■					■						■				
Finland	■							■						■						■			
Danmark	■							■					■						■	■			
Lithuania	■							■						■						■	■		
Ireland	■							■						■						■	■		
Russia	■	■	■				■						■	■	■					■	■	■	■
Great Britain	■								■					■						■	■		
Netherlands		■	■					■	■					■						■	■		
Austria		■							■							■			■				
Germany		■									■					■			■				
Switzerland			■						■									■	■				
France		■								■					■					■	■		
Belgium				■							■							■		■	■		
Italy			■							■						■						■	■
Portugal						■						■						■			■	■	
Spain						■						■						■				■	■

The requirements for the thermal protection of the buildings are a little worse as in Scandinavian countries since 1998 and Estonia since 1999, if to adjust to the climate conditions.

Arctic dress trend. At present the limits of thermal insulation thickness and effectiveness of insulation apply is widely discussed. Some researchers [12] involved into the investigations of insulating materials have drown a conclusion that limit of the thermal insulation level for external walls and roof is 8 m^2K/W. The effective U-value of windows is reached $1m^2K/W$. Then the potential of energy consumption in buildings due to insulation level can be described in Fig. 5.

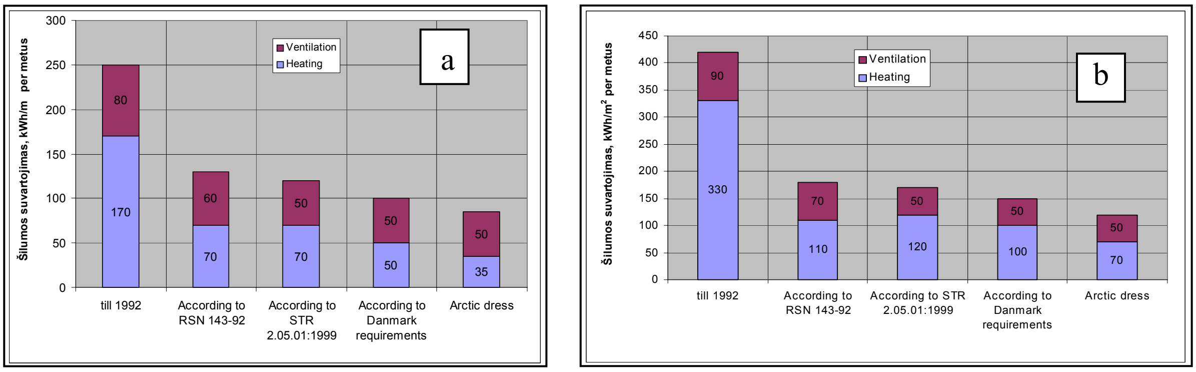

Fig.5. Comparison of energy consumption with future trends of insulation level (a – in big buildings, b – in small buildings)

As it is seen, only thermal protection increase could save more than half of the present consumption in big apartment buildings and 2/3 in small buildings, thus insulation being more effective in small buildings. At the same time the impact of the ventilation heat loss will take more in percentage, and heat gains in summer will require the air conditioning (Fig. 6) for comfort indoor climate maintenance.

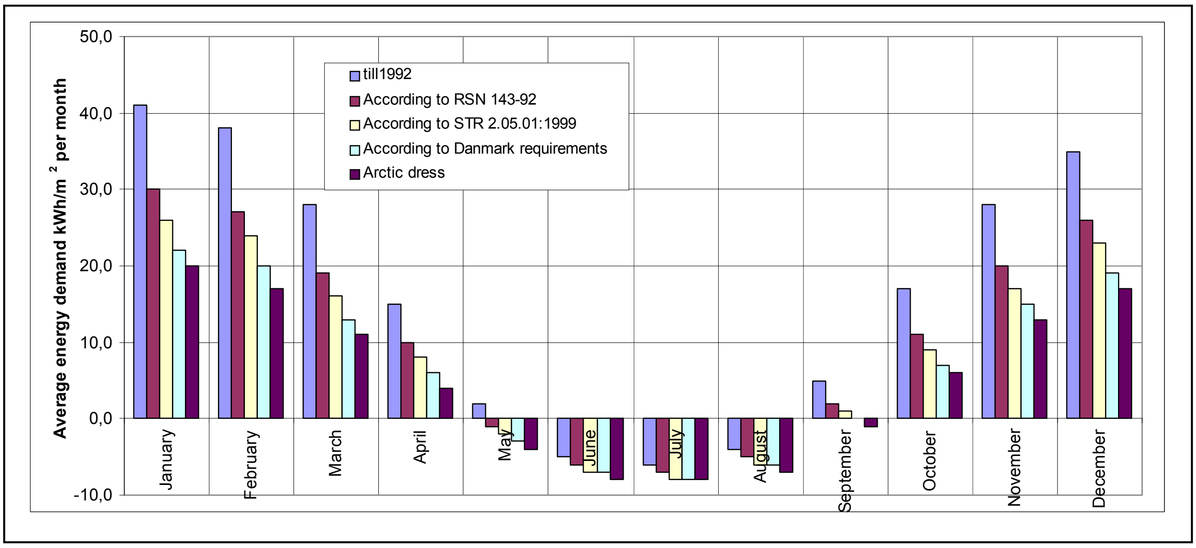

Fig.6. Comparison of energy consumption with future trends of insulation level and heat gains in big apartment buildings

Thus, the increase of the only thermal insulation level is not especially effective in regard of the annual energy balance of the buildings. As it is described in the Fig.6, the monthly summer energy demand for cooling will achieve about the 1/3 of the energy in January. The insulation requirements ought to be combined with the other measures of sustainable development.

Restriction of energy consumption in buildings. Other type of energy consumption decrease is obtained by installation of the various technical innovations, directed to the minimization of the energy use by the control means and energy recovery. The effectiveness of a building is outlined by total annual energy consumption for 1 m^2 of heated area or 1 m^3 of the indoor space,[13], in oil or gas equivalent. For example, if building is at 3 liter oil level, it is equivalent to the value of 30 kWh/m^2 per year. This expression is easily transformed into the CO_2 emission, also the other pollution products in the energy production cycle can be determined, at least approximately.
At the comparison of the energy consumption, presented in Fig.7, with the respect to climate conditions, a conclusion could be done that for Lithuanian climate conditions the energy consumption level of Scandinavian countries is achieved. Then the next step - following energy consumption decrease by combination of effective engineering systems. Application of the renewable energy sources also must be foreseen.

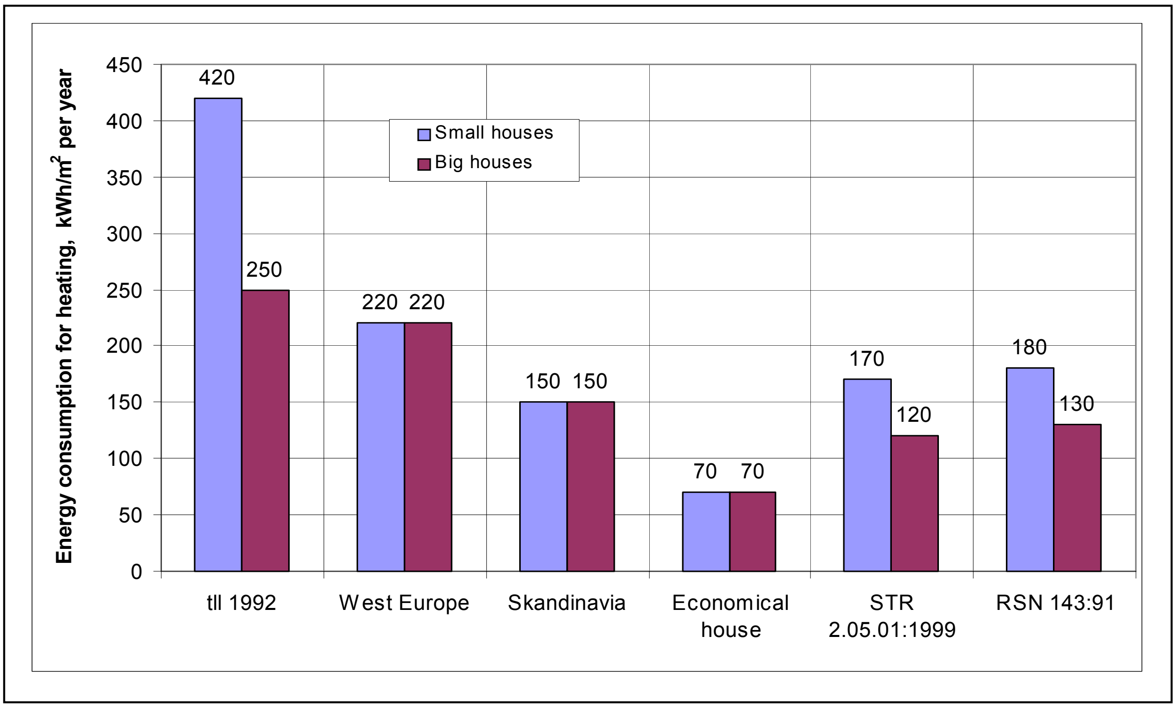

Fig.7. Comparison of energy consumption in Lithuania building stock with the European trends

At present energy supply in Lithuania is adjusted at minimal level, district heat supply being controlled according to the change of outdoor temperature under a special chart with certain and significant lag in time. Control or adjustment of the equipment in heat supply systems of many buildings is not installed at all or it is disabled. Extensive application of adaptive maintenance and control systems of internal engineering systems in buildings could significantly decrease energy consumption in the buildings at reasonable investment level. The saved energy volumes in existing buildings could obtain considerable value because of initial stage of energy consumption. This will effect the environmental pollution from buildings as well.

As the building consists of big number of separate premises or apartments in which indoor climate could be maintained in their own way, the continuously controlled management of building engineering systems become necessary. Maintenance and control systems with the response to owner wishes and outdoor climate changes could save about 10 to 20 % of energy, with simultaneous billing for energy, electricity and water. The management then becomes a multi-criteria task, as the control of the indoor parameters is combined with the maintenance of whole building. The task can be successfully solved only by computational means.

4. Conclusions

1. The energy pollution by the buildings in Lithuania is significant both in heat consumption values and environment pollution emission. Despite the modern requirements for the thermal protection of new buildings the energy demand is rather big, if the other energy saving means are not in favor.
2. Extensive application of adaptive maintenance and control systems of internal engineering systems in buildings could significantly decrease energy consumption especially in older buildings, giving as a result the decrease of environmental pollution at reasonable investment level.
3. The modernization of the engineering systems is most effective in family houses and for whole apartment buildings at present with the following future extension to the apartments control.

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THE PROBLEMS OF SUSTAINABILITY OF REGIONAL SETTLEMENT SPACE IN NORTH-EASTERN POLAND

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1. Introduction

In the 50's, 60's and 70's, Poland showed the highest increase in population among the European countries. A high birth rate was accompanied by the strong internal migrations (especially from villages to towns and to cities). Consequently the rural population in Poland has dropped from 66 percent in 1946 to about 30 percent at present. This illustrates the strength of demographic processes which shaped the spatial and economic situation in Poland. The long-lasting strong migrations from villages to towns and especially to cities were previously a typical and common feature in socialist countries. These processes were initially balanced by a high birth rate but they have led to a depopulation of rural areas and they have caused serious deformation in demographic and social structures in age and sex structures, for example.

The distribution and dynamics of rural population in Poland is a problem itself, but it also forces rapid changes in economics, infrastructure, culture and architectural space, especially on some peripheral territories. These problems are also common to other post-socialist countries [1]. The strongest decline of rural population can be observed in North-Eastern Poland. This paper deals with its dynamics and consequences in relation to sustainability issues.

2. Demographic Context

About 19.400.000 people (60,6% of population) lived in rural territories in Poland in 1939. After the 2nd World War in 1946 a rural population was about 16.000.000 (70% of post-war population) [2]. Finally, 14.753.000 people lived in rural territories in 2000. It was 5,4% less than in 1946, but during this period the population of cities in Poland increased by 65% [3]. Similar trends have been observed in other post-socialist countries. For example, the rural population in Russia decreased by 1% over the decade 1979-1989 while the urban population increased by 15% although significant differences existed between the European and Asian republics [4]. Rural population trends in Central Eastern Europe (in Estonia, Latvia, Lithuania, the Kaliningrad District, Belarus, Ukraine, Poland, Czechoslovakia, Hungary, Rumania, Moldavia, Bulgaria and Yugoslavia) during the 20th century have been investigated by Piotr Eberhardt [1][5]. His analyses revealed moderate depopulation of rural areas in most of these countries and extreme depopulation of Byelorussian rural territories. This means that depopulation processes can act not only on a local level, but they influence wider territories. They can be regarded as inter-regional or even international problems.

In the 80's and 90's a few researchers in Poland (Andrzej Stasiak, Ryszard Horodenski, Wlodzimierz Mirowski, Miroslaw Serwin, Izaslaw Frenkel, Andrzej Rosner, Piotr Eberhardt and others) investigated demographic phenomena in relation to spatial development and rural and urban planning. Their research resulted in describing the rural depopulation dynamics in Poland based on census data (1965, 1970, 1978 and 1988 censuses). The researchers have also studied the consequences of depopulation. Here are their findings [6][7]:

- despite the general increase of population in Poland in the early post-war period, the whole post-war period in Poland was characterized by the stabilization of rural areas and a small decrease in rural population could be observed periodically
- moderate rural depopulation have been common since 60's, accelerating in the 70's. Consequently rural population is declining while population in urban areas continues to grow
- depopulation processes occurred on even bigger rural territories and increased in Sudety Mountains (S-W Poland) and Bialystok region (N-E Poland)
- depopulation has destabilised the rural settlement system on many peripheral territories
- depopulation processes have lowered the population potential in peripheral rural areas and
- fertility/mortality rate has been playing secondary role recently and the main causes of a depopulation were selective migrations, implying serious deformation in demographic structures: ageing of rural population, imbalances between the sexes (loss of women of marriageable age), population stagnation and weakening of the intellectual pool

Spatial heterogeneity of demographic trends in Poland made researchers to focus on territories with highest dynamics of a depopulation [8]. Bialystok region (part of Podlaskie Voivodeship in N-E Poland) was found to be the most influenced by rural depopulation [9][10]:

- average population density in Poland is about 122 people / sq km, but it is only about 61 people / sq km in Podlaskie Province (and it decreases to 10 people /sq km locally)
- rural population in Bialystok region reached its maximum in the 17th century, then it decreased rapidly and before the 1st World War it reached its peak. It has been depopulating continuously since the turn of the 60's and 70's. On the other hand, population of towns and cities decreased during the 2nd World War then it has been increasing rapidly in the 70's. For example, Bialystok had 40.000 inhabitants in 1944 and it has 280.000 at present.

- rural population at peripheral territories of Bialystok region (especially in the very southern part of Podlaskie Voivodeship) declined rapidly after 1970 (*the demographic crash*)
- the long-lasted, continuous flow of inhabitants from the surrounded villages to a few cities in Eastern Poland resulted in a very fast growth of these cities, especially Bialystok (N-E) and Lublin (S-E Poland) multiplied their population during the period 1950-1990.

Three factors characterise methodology of these investigations in the past. First, the subject matter was analysed in relation to the socio-economical phenomena, missing the demography impact on architectural space. Second, the main attention was paid rather to geographical patterns of rural population distribution, resulting in comparison populations by voivodeships (provinces) or communes rather than by villages. So this granularity of their investigations was insufficient to reveal many important aspects of demographic processes. Third, the problem of how depopulation stimulates interrelations between the city and the region, was analysed rather sparsely (except of more detailed analyses of people's motivations for migrations from villages to cities, undertaken by W. Mirowski).

For these reasons, spatial consequences of depopulation of rural areas in north-eastern Poland were re-investigated at Studio of Rural Architecture, the Department of Urban Planning, Faculty of Architecture, Bialystok Polytechnic) in 2000-2003. This research was supported by rector's grants #W/WA/4/00 and then dean's grant #S/WA/2/01. The following were used: the population in 1970 and 1978 (census data in Bialystok Provincial Archive), the population in 1988 (census data, according to Bialystok Provincial Census Bureau), the population at present (according to local authorities).

3. The Analysis of Depopulation Dynamics in Bialystok Region

The accessible data allowed to compare the population of 1500 villages separately in 1970, 1978, 1988 and 2002 in order to get the geographically dispersed dynamics of depopulation processes in Podlaskie Voivodeship. As a result the detailed maps of depopulation magnitudes during the periods 1970-88, 1978-88 and 1978-2002 have been generated (*Fig.1* and *Fig.2*). The maps allowed to analyse the depopulation processes in Podlaskie Voivodeship in Poland with emphasis on how they affect the spatial development of rural areas.

The following facts have been revealed: over 300 villages wasted more than 25% of their population during the decade 1978-88. More than two hundreds villages wasted over 50% of their population between 1970 and 1988; 390 villages wasted over 50% of their population between 1978 and 2002. A depopulation between 1970 and 2002 has not been found because of data incompatibility. The tight territory with the strongest depopulation could be highlighted: it was a wide strip spreading across the province from north to south (generally in S-E directions from Bialystok, towards and along the Byelorussian border). Generally, the depopulation intensity increases horizontally towards the eastern direction, producing a 'demographic vacuum' at some rural territories in communes Michalowo [11][12] and Krynki [13].

Finally, the correlation between the size of villages and their depopulation, have been found. Namely, the 1232 villages and towns (i.e. the ones for which the full demographical information was provided) were classified into nine categories according to their population, as shown on *Table 1*. It reveals that the strength of depopulation processes depends on the size of villages/towns: the smallest units have been wasting their inhabitants very fast during the period 1978-2002. On the other hand, the largest units (towns) have arisen, attracting population from surrounding villages. This observed correlation between the size of villages and their depopulation confirms similar results obtained by other researchers [10].

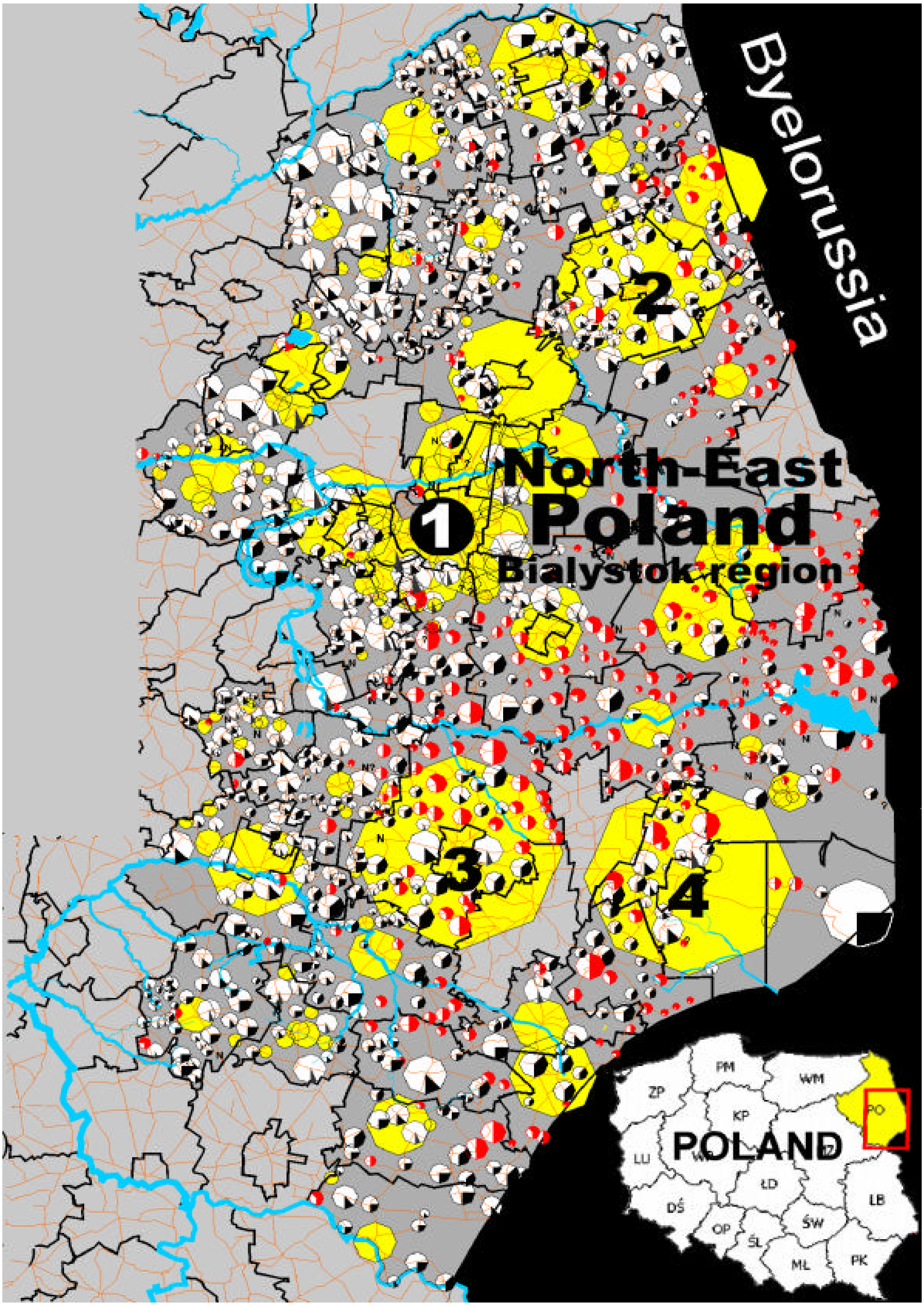

Figure 1. The map is showing the dynamics of depopulation of rural areas in Bialystok region between 1978 and 2002. Settlement units (villages, towns, cities) are represented by various circular symbols dependently of their number of inhabitants and depopulation. Black parts of symbols represent the rate of a depopulation. The largest units arose and the smallest were vanishing. Source: J.Szewczyk

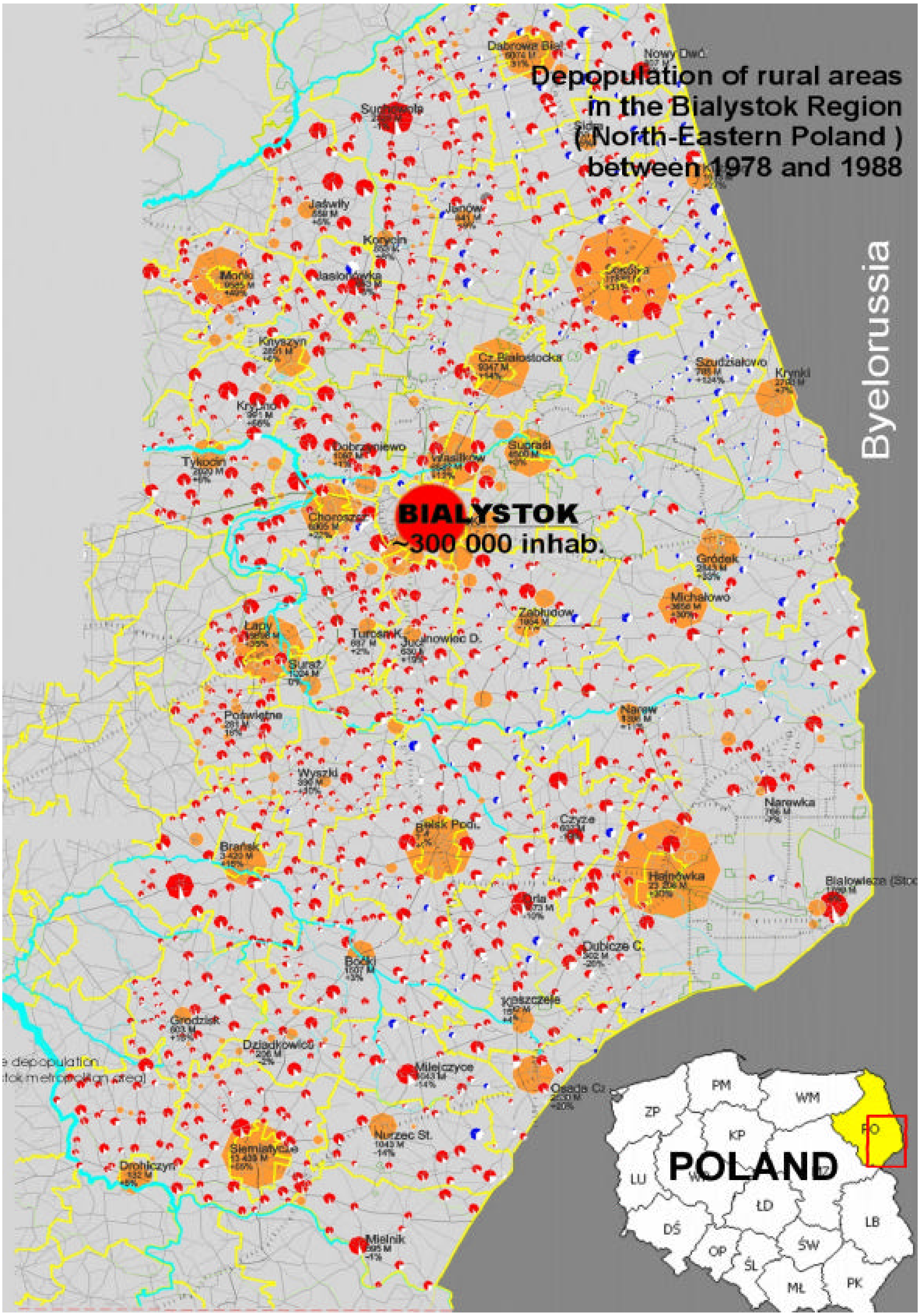

Figure 2. The map is showing the dynamics of depopulation of rural areas in Bialystok region between 1978 and 1988. Settlement units (villages, towns, cities) are represented by various circular symbols dependently of their number of inhabitants and depopulation. Black parts of symbols represent the rate of a depopulation. The largest units arose and the smallest were vanishing. Source: J.Szewczyk

Table 1. The correlation between the size of villages and their depopulation

Population of a village or a town in 2002 [inhabitants]	Number of villages or towns in each group	The average increase or depopulation between 1978 and 2002 [%]
0 — 50	208	— 42,35 (*a depopulation*)
51 — 100	377	— 26,66 (*a depopulation*)
101 — 200	358	— 19,70 (*a depopulation*)
201 — 300	139	— 15,25 (*a depopulation*)
301 — 400	65	— 2,67 (*a depopulation*)
401 — 600	32	+ 1,32 (*an increase*)
601 — 1 000	25	+ 4,41 (*an increase*)
1 001 — 5 000	23	+ 26,44 (*an increase*)
5 001 — 30 000	5	+ 50,55 (*an increase*)
Bialystok = 40.000 inhabitants in 1944; 280.000 in 2002		+ 33 % (+ 600% *since 1944*)

We expected that suburbs and villages which belong to the urban metropolitan system had considerably higher growth rates than peripheral rural areas. But, in fact, a territory of urbanization around the city was surprisingly tight. Bialystok (which has about 300 000 inhabitants) influenced directly an area up to 10 km from the city. Otherwise the city did not prevent from depopulation and degradation of a settlement structure, especially in remote territories. We hardly found a small transition zone around the city and we could observe rather polarisation of villages instead. Suburb villages either gained or wasted their population, i.e. surprisingly, there were not 'stable' and only a small number of moderately decreasing ones.

4. Depopulation, Theories and "Poland B" Factors

In 60's, 70's and early 80's, Michal Chilczuk, Tadeusz Kachniarz and few other researchers in Poland tried to apply social and demographic knowledge to urban and rural planning. In their works [14], [15] they refer to the earlier socio-economical theories, such as the Central Place Theory by Christaller and Lösch (based on a hierarchical arrangement of settlements). It had been stated that Christaller's theory could be a very good approximation of structure of settlement units in socialist Poland, so it was then utilised in spatial planning. Unfortunately the application of this theory presumed two unattainable determinants:

– the stability of spatial arrangements of settlement structure and
– an existence of a dense spatial arrangement of hierarchical settlement units.

But firstly, the settlement structure were really characterised by a quite high dynamics. Secondly, this spatial arrangement had not been appropriate enough even before and, in fact, its dense structure started to decline in peripheral regions because of depopulation of rural areas. In spite of these shortcomings, the Central Place Theory by Christaller and Lösch, was an important theoretical background for urban, rural and regional planning in Poland in 70's and 80's. A few detailed, working theories were based upon it. But in late 80's and 90's, researchers focused their attention on so called "problem territories" that were defined in order to recognise the increasing socio-demographic and spatial problems [16]. The Central Place Theory was not directly applicable for these areas. Some territories have been called "problem" mostly because of the demographic situation (*demographic crash*) on rural areas and because of their economic underdevelopment. Podlaskie Voivodeship was among them. But also all Eastern Poland territory (including Podlaskie Voivodeship) was in some sense a problem area. It was often pejoratively called *sciana wschodnia* ("the Eastern periphery" or exactly "the Eastern wall") or "Poland B" because of the following factors [17]:

– its peripheral location
– its cultural, ethnic and religious differentiation (which potentially can generate conflicts)
– low education and low cultural infrastructure
– low social infrastructure and poor economy
– low population density and very low urbanisation
– the specific settlement structure of a metropolitan type, i.e. with one big city (Bialystok in N-E, and Lublin in S-E Poland) surrounded by very small towns and villages
– various social consequences of depopulation of rural areas

In Bialystok region the above factors feature extremely intensively. For example, the biggest city Bialystok has more than 280.000 inhabitants (350.000 with its satellites), and on the other hand, the average number of inhabitants in surrounded peripheral rural areas differs locally from 150 to 200. Almost 50% of villages (i.e. 585 of the 1232 villages analysed in detail by the authors) have less than 100 inhabitants, 18% (i.e. 217 ones) have up to 50 inhabitants. The population density is small and it is 10 people / sq km locally on peripheral rural territories. This very specific feature of a settlement structure, which is typical to the whole Polish territory, was commented by M. Andor [18] as follows: 'Polish settlement patterns in particular do not correspond to the image conjured up by the term 'village'. Nucleated villages coexist with tiny hamlets of two of three households and 'street villages' with no discernible centre.'

The dynamics of negative demographic, social and spatial processes at the *Podlasie problem territory* disables the prospects of an appliance of old *static theories* in rural spatial planning. New contemporary concepts of development of rural areas seem to be too general and too optimistic. They utilise concepts of *multi-functionality* [19], *eco-* and *agrotourism* [20], which are magic keywords rather than real solutions. At present, some foreign experiences in rural revival, such as Irish or Scandinavian ones [21], are focusing researchers' attention in Poland.

Effective revitalisation concepts that meet the demands of demographic problems are still to be discovered. But, in our opinion, a precise analyses of consequences of a depopulation should be performed first in order to direct revitalisation activities correctly.

5. Disintegrative Consequences of a Depopulation

In Bialystok region, the most intensive depopulation affects the most valuable territories for their multi-cultural heritage, with the unique vernacular architecture and old, historic, spatial and settlement structure, for example, villages near the towns Bielsk Podlaski and Hajnowka. In other words, depopulation directly disintegrates spaces that are the most valuable architecturally, culturally and socially and indirectly leads to the total destruction of its social, cultural and architectural heritage. For example, a few communes (districts) were composed of 20-30 villages around the small central town in the past, but in the near future they are going to be composed of one central town only in a 'demographic vacuum' (examples are Krynki, Szudzialowo and Michalowo). Many of these vanishing villages have their unique architecture which falls into ruins gradually. Examples are a Tartar village Kruszyniany in Krynki commune, hundreds of Byelorussian villages such as Janowo and Waski in Narew commune, a number of Ukrainian villages on the west borderland of Bialowieza forests.

Demographic processes also affect society and environment. It is evident in abandoned fields and forgotten sites, in ruined huts and gentrified 'second homes' indirectly it sometimes stimulates the return of forests and increases biodiversity. In north-eastern Poland, the growing depopulation started to affect space, economy, landscape and even culture at 60's, and since 70's until now it has been influencing disruptively on the spatial development processes. The following disintegrative results of a depopulation can be noticed [22][23] (see *Table 2*):

Table 2. The typology of a disintegrative impacts of a depopulation into the space and society

THE DIRECT IMPACT ON A SETTLEMENT STRUCTURE	
transformation of settlement cells: – fall of villages in general – a decline of small villages (about 100 to 200 villages is going to disappear) – transformation of significance and roles that settlement units play (for example transformation of farming villages towards tourist colonies)	**destabilisation of settlement systems:** – disintegration of settlement units hierarchy – isolation resulting in disintegration of reciprocal dependencies between small settlement units **other problems** (social, architectural) concerning the co-existence of formally interrelating settlement units, that become isolated
THE IMPACT ON A BUILDING AND ARCHITECTURE	
the neglect: – abandoned heritage-significant vernacular building – degradation of farm building, abandoned or owned by retired old people – degradation of other building, especially those being not in usage	
THE IMPACT ON AN ECONOMY	
– a recession at rural territories – decreasing productivity – asset deflation – fall of farming and abandoned farmland	– impact on real estate market – decline of agriculture related activities – the closure of shops and other services
THE IMPACT ON AN INFRASTRUCTURE	
degradation of infrastructure: – low social infrastructure – weakness of transportation systems – weakness of infrastructure media	**lack of new investments** **difficult access** to shops, services, education and to sophisticated entertainment
THE IMPACT ON A SOCIETY	
migrations are selective, so that they imply serious deformations in age and sex distribution and in other demographic structures: – ageing of the rural population – strong imbalances between the sexes: loss of women of marriageable age (the rate of men/women up to 100:141 locally in Bialystok region) – low average educational status and deficiency of well educated and qualified people	**transformations of job structures:** – a rapid deterioration of a job structure, in relation to local needs – an extinction of local crafts – an observed deterioration or retaining of low educational status of the farm work force **lack of a proper support for the elderly** **social isolation**
THE IMPACT ON A CULTURE	
an extinction of traditional culture: – degradation and disappearance of artefacts and places that create local identity and values – vanishing of village public life, resulting in a decline of people's spiritual culture – discontinuity of traditional jobs, crafts, ways of life, habits and folk art – lack of heritage-based cultural significance of space and lack of aesthetical values **discontinuity of the natural development**	

6. Rural Depopulation and Urban Growth

Towns and especially cities attracted people from peripheries. Migrations from villages to towns and then to cities caused the growth of cities in Eastern Poland in the past and supplied some peripheral ones (such as Bialystok) with a great number of new inhabitants. Rural depopulation has slowed down this process. Cities and towns that were integrally bound with their surroundings and empowered by a vanishing net of villages and other towns, are going to waste the power of their "demographic background". As a result the previous rapid spatial development of Bialystok and local towns is going to be retarded.

But in fact, even this model of reciprocal interrelations between cities and rural areas is excessively simplified, if based on direct migrations only. Konrad and Szelenyi [24] defined one of the shortcomings related to the urban and economy space in socialist countries and called it *underurbanisatio*n. This term defines the theory with a main thesis that "low levels of urbanisation [in socialist countries] depend on the system's failure to provide an urban infrastructure that is sufficient to support the industrial output necessary to fulfil the requirements of the five-year economic plan" [25]. According to Murray and Szelényi [26], socialist cities tended to develop rings of proletarian, "pre-urban", suburban villages around them, the inhabitants of which commuted to work every day. The inhabitants of these suburbs have never abandoned agriculture and they "could be classified as worker-peasants" [18, p.4].

A kind of locally-specific *underurbanisation* of Bialystok agglomeration could be observed. It manifested itself spatially as a phenomenon of "worker-peasants" (both inhabitants of satellite villages who work in Bialystok, and inhabitants of Bialystok who still have their farms in villages) and in "sleepy towns" (towns-satellites, such as Suprasl, Choroszcz and Wasilkow, which inhabitants commute to work to Bialystok everyday). It still manifests in the spatial structure of cities, with broad areas of old and destroyed, *rural-like* residential housing even at the very city centre. Surprisingly, rural-urban migrations enlarged *underurbanisation* in the past, and the resulted demographic situation solidify *underurbanisation* now.

The further investigation into how depopulation affects urban growth, show two different models of migration phenomena. The traditional, past model of migrations, is as follows: The city attracts country folks. Country acts as a source of migrants. Towns act as buffers. The other, more actual model of migrations can be described as follows: Generally, the city entices people, but especially **suburb areas** attract people that migrate from outer territories. Towns distribute migrants but depopulated peripheral villages (inhabited mostly by older people) cannot serve as a source of migrants. For this model "suburb area" is highlighted on basis of a demographic criterion. It is defined here as a continuous area with growing population that surrounds the city and is surrounded by depopulating peripheral country areas. Surprisingly, but fortunately for the investigation process, we could observe a very clear sharp border limiting city-like suburban areas and isolating them from outer depopulating territories. As a result we could observe the rapid growth of suburban villages accompanying by the lightning depopulation of outer village even if very neighbouring to the suburban territory.

Both these models imply other, non-demographical problems (social, architectural) concerning the co-existence of interrelating settlement units. Many problems touch sustainability and heritage preservation issues, especially in relation to suburb territories, because the suburbs are usually being shaped regardless to their heritage roots. The main "suburb problems" are: (a) discontinuity of the sustainable natural development; (b) lack of heritage-based cultural importance of space (often enlarged by lack of aesthetical values); (c) unsolved collisions with natural spatial barriers and with existing infrastructure, resulting with general spatial chaos. For example, residential building zones surround the city, grow and generate conflicts with city infrastructure and with industrial and agricultural areas; (d) reverting of social hierarchies that were formerly based on the ties of kinship or on neighbourhood ties; (e) sometimes, an isolation of suburban zones.

In general, rural population decline, *underurbanisation* and urban sprawl (which has not been very extreme yet) around the Bialystok, can act against sustainable development of the region.

7. Conclusions

The following conclusions can be drawn from the above given facts:

1. Recent demographic phenomena influence population distribution patterns and human living space. These processes play especially significant role at some peripheral territories. Bialystok region is the most typical example in Poland. Other post-socialist European countries are also affected by these problems. The phenomena reflects the general trend of increasing concentration of the population in *(sub)urban* areas.
2. The migration processes disturb traditional spatial, social and economical interrelations in the hierarchy of settlement units. As compared to the previous long-term historic development of these areas, these processes at suburban and rural territories are relatively new. Thus we are facing some new, unknown problems and challenges, especially related to the territories overlapped by the most intensive migration processes.
3. Depopulation of rural areas directly disintegrates the most valuable architectural, cultural and social spaces and indirectly leads to the destruction of its social and architectural heritage. As a result village life, people's spiritual culture, folk art and customs vanish, and the neglect, degradation and disappearance of artefacts that carry local identity and cultural values takes place.
4. Depopulation on rural areas indirectly leads to the destruction of social and architectural heritage of towns and suburban surroundings of cities
5. We have no appropriate methods for a regional and urban governance relevant to the new demographic challenges. The traditional methods have been well evaluated for a long time but they are ineffective now. On the other hand, the new challenges result in new "on demand" but untested methods for a regional and urban governance. New approaches rely on sociological, commercial and governmental predictions.
6. The following are the challenges for the urban planning and design (with regard to suburbanization and depopulation of peripheral rural areas):
    A. Preservation (neutralization of degradation and disappearance) of artefacts and places that create and maintain local identity and cultural values
    B. Preservation of traditional model of social life through shaping urban space hierarchically according to the natural social hierarchies
    C. Preservation of continuity of space and avoiding collisions
    D. Enriching the heritage-based cultural importance of space in relation to local aesthetical and cultural values and
    E. Preventing the isolation of suburban zones.
7. These models of the demographic interrelations between the city and the region, imply other, non-demographical problems (social, architectural) concerning the co-existence of interrelating settlement units.
8. These reciprocal economic, environmental, social and population effects should be monitored and for this reason we still need to do further integrative investigation into the range of depopulation processes and their consequences on the larger scale.

Keywords

Depopulation, Migrations, Settlement processes, Settlement landscape, Regional development, Rural planning, Rural architecture,

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COMPUTER-AIDED HERITAGE MANAGEMENT FOR A SUSTAINABLE AND HERITAGE-RESPONSIBLE ARCHITECTURE

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1. Introduction

At the Faculty of Architecture of the Technical University of Bialystok we have over 600 kg of documents that describe rural areas in North-Eastern Poland. There are plans, elevations and sections of buildings, street sections, panoramas, 30 detailed large plans of villages, thousands of questionnaires about buildings and sites, bibliography, relative texts, citations and 5000 photos. The number of these documents keeps increasing and valuable information which those materials contain cannot be used because of its volume and the lack of proper classification and storage methods. Other Polish tertiary institutions also experience a similar problem. In Poland nine Faculties and Institutes of Architecture have archived very rich collections of drawings, photographs and other documents that describe the past and present state of Polish regional architecture. The data contains ethnological data, architectural drawings, maps, filled-in questionnaires, interviews and photographs. Warsaw Polytechnic and Cracow Polytechnic especially have the oldest and the largest sets of documents related to the regional architecture of the past which have been collected since the beginning of the 20th century. It is believed that these collections are of a great scientific value because of their richness, uniqueness and importance to historians, ethnologists, sociologists and architects but data are temporarily unusable because they were neither catalogued nor organised. Thus there is a need to work out methods and tools that could highly increase the worth of such data collections.

To utilise collected data in full we started to analyse the potential of computer tools for archiving such documents. We appreciate digital technology for both, cataloguing and accessing data because contemporary database technologies enable an efficient storage and management of large amount of such data. In the first stage of our investigations we analysed computer tools for the digital representing of local cultural values in order to describe and manage architectural cultural heritage [1]. Then we investigated existing digital notations of architectural spatial data focusing on their usefulness for *culturally significant data* storage [2]. We paid our attention to databases controlled by XML definitions [3] with the intention of utilising them to manage information about local regional architecture for scientific investigations on architectural, rural and spatial planning fields. Various reciprocal dependencies between technology and local heritage values were also investigated [4], [5].

The objectives of the investigations were:

- to digitalise the existing architectural data
- to create methods for the storage of information about data context and about its value
- to create a new methodology to enable efficient dealing with the digital representations of the cultural heritage and utilising the potential of an advanced technology
- to develop a software tool with an efficient graphical interface that could enable an efficient access to open, not fixed metadata and their context
- to develop methods that utilise existing CAD data so that the local values, spatial and cultural context and other data that relate to cultural heritage could be represented.

In this paper we present the final results of our research on how information technology provides a scientist with tools needed to handle local architectural heritage. Also, this paper is to inspire a discussion on software for a sustainable architecture with emphasis on computer support heritage values.

2. General Expectations

We appreciate digital technology for cataloguing and managing large amount of hybrid data and, in our opinion, it could prevent the destruction of the existing collections that are fixed on paper media. We believe that a digital database of regional architecture can enrich scientific investigation into architectural heritage and can be an inspiration for design. We also believe that computer technology can add a new value to the design process based on local inspiration. Premises for such statements are presented below:

¦ Computers can be a powerful tool for scientific data management

  - database software items can process data effectively when performing the following elementary actions: collecting, comparing, sorting, counting, optimising, correcting and visualising data, detecting statistical relations and dependencies
  - database software offers powerful tools for selective data extraction such as searching for information by keys or keywords, by attributes, by data types, data sorting or searching by filters or by queries defined in query languages (such as SQL), browsing and surfing on data structures (horizontal, vertical or free surfing) etc.

    - software enables clear visualisation of both, elementary data and final results of scientific analyses. That is why many pieces of software offer a variety of tools for extracting and publishing tables, graphs, charts, diagrams, reports, maps and figures
    - very few computer data notations are expected to became *lingua franca* in science for their terseness and flexibility (for instance XML)

- Computers add ‘new dimensions’ when processing spatial data

    - the digital technology is expected to supply a design process making it locally-sensitive and oriented towards context by means of employing digitally archived architectural data. For example, database software can help a designer to compare elements of architecture, to extract types and exceptions, to analyse forms, etc. All these activities are common for scientific and designing work. CAD, graphic and database software that perform these activities are expected to enrich and speed up data processing in a creative manner. This capability is especially valuable when processing a large amount of semi-structured graphical and non-graphical data (hybrid data)
    - information technology can add a new ‘dimension’ to a designing process through derivation of values from collected data sets, creative processing and development of these values and their applicability into design projects

From these assumptions the conclusion can be drawn that computer databases of regional architecture and software tools related to these databases can equip both, architects and scientists with the same enhancements and methods of dealing with ‘culturally significant’ data.

3. General Technical Problems

Local values build the global cultural heritage and they generate the worth of architecture but, despite IT development, neither existing architectural software nor networked services supply an architect with tools for representing local or cultural values.

3.1. Lack of Architectural Meaning

Although the commercial vendors of CAD software supply architects with tools for long-turm management of engineering data, these data notations in A/E/C are too atomised, ‘software-oriented’ and they lack consistency in defining architectural content. Neither the developers of the largest notations (like *aecXML* and *IFC*) have focused on architecture itself nor on the strictly architectural notations and they have paid most attention to the data interoperability between application fields through a product lifecycle. That is why neither these standards have simple nor intuitive object definitions. They have poor ‘architectural semantics’, they contain a large number of fixed, ‘technical’ information and they do not carry much important information that can be called ‘conceptual’, that is, aesthetic or architectural meaning. Consequently, nowadays architects are forced to work with semi-architectural notations, that lack essence and method to describe elements of cultural heritage connected to geometric forms. Instead of the language of architecture they deal with virtual *cost-working slang* [2].

The examples of data with architectural meaning are intellectual property value, aesthetical classifications of spatial forms and architectural object types. Architectural meaning also refers to aesthetical, cultural and heritage values because architecture itself is not only geometry of shapes but it has its roots in cultural heritage which *should be represented* in CAD data notations *but, in fact, it is not*. In contrast to real architecture, digital representations of architectural objects have no cultural identities and miss all important semiotic dependencies!

3.2. 'Heritage-Conscious' Data Formats

A/E/C notations are either too simple or excessively redundant. In practice their information structures do not meet architects' expectations enough although for the last five years many commercial software vendors have been rapidly developing architectural CAD software. The software supplied architects with tools for long-term management of engineering data but did not give them any tools for management of cultural context. We suggest that management of cultural context is essential when dealing with cultural heritage and local values. This is the reason why much architectural software lacks architectural tools and most architectural notations lack architectural meaning [2]. Unfortunately the lack of tools for management of local values for dealing with aesthetical and cultural information and for representing 'the-worth-of-context' is a typical and common deficiency in commercial graphical software and CAD (see *Table 1*). This seems to be strange because CAD systems and other tools for graphics have been regularly used for many years by historians, archaeologists and many professionals dealing with cultural values.

Table 1. The taxonomy of the existing architectural notations in CAD. Source: J.Szewczyk [2]

ARCHITECTURAL CAD NOTATIONS		**Primary** notations	**Notations that have been optimised** ...through XML syntax	...other
EXPRESS-based	Structural	**STEP**	**STEPML**	PDES*
			XMLPlant/STEP*	
	Object-oriented	**IFC**	**IFCXML, BLIS-XML**	**BLIS IFC**
XML-based	AecXML dialects (Bentley initiative)	—	**aecXML** dialects (**LandXML**, etc.)	
	DWG-optimised (Autodesk initiative)	—	**DesignXML, RedlineXML** adpML*, **i-drop**, **e-drop**	
	Independent	—	**gbXML, bcXML**	
Binary	Basic (CAD)	—	**SVG**	DWF*, SVF*
		DGN		**DGN**-based
		DWG	**i-drop**, **e-drop**	**DWG**-based (ADT)
	Object-oriented	**GDL**		
	3D/VR	**VRML**	**X3D**	**VRML 2.0**
		o2c	**o2c**	
Experimental	Based on STEP standard	a few	a few	
	Based on XML syntax	a few	**XML for VR-DIS**	

**- notations not oriented towards architecture and on the margins of architects' interests*

3.3. Lack of Semantics at Conceptual Stage of Design

Lack of the architectural meaning in CAD notations refers to the general problem of collecting and accessing architectural data. This creates the second problem of creative processing the collected architectural data and utilising them in design, especially when redesigning existing spatial artefacts (buildings, urban areas). It was noticed that "80% of architectural work in Europe is done on old buildings. This is undoubtedly also the case in any country with an architectural heritage of buildings made of stone or other durable material of equal or greater importance than any new construction work" [6]. So the question arises how the computed collections of architectural data can be utilised to assist an architect or a scientist with redesigning and reinventing existing architectural space. This issue has not yet been solved.

In fact, there are no standard notations for conceptual design data in early design stages. Some software notations (*GDL, o2c, VRML*) tended to be of such standards in the past but software itself (except of *VRML* interfaces) was not optimised for conceptual architectural modelling. Only a few experimental notations had really an interesting grammar or inspiring solutions which potentially could make them a base for the further development of architectural notations for conceptual modelling stages.

3.4. Flexibility Problem with Architectural Data

Data contents and structure should depend on users' expectations, that is, data should be rewritten, organised and optimised to satisfactorily meet well defined expectations. We have found a number of architectural data layouts designed for educational and scientific purposes, for heritage preservation, for statistical estimations and facility management, for urban and rural planning, architectural design, for administrative and governmental purposes. No one of these discipline-oriented layouts was appropriate for a broad range of users.

To supply multi-discipline investigations with proper data or to satisfy a broad range of users, we need either a huge, complete bank of data (which is almost impossible and surely impractical) or smaller, but flexible data sets. The second solution meets scientists' demands, because their architectural analyses are expressed through a number of abstractions (textual, drawings, models, images, etc.) which reflect specific aspects of the objects (such as function or structure). Abstractions and the relationships between them define the information structure and they present its different aspects. Therefore a richer or more flexible information structure is needed. This can be achieved by expanding data structure, replacing abstraction entities by detailed component substructures and by augmenting the structure's relatedness with content information [7]. Unfortunately in practice the existing 'richer' A/E/C notations (especially IFC- and XML-based ones) suffered from data redundancy (data were redundant in order to achieve compatibility with application-specific data layouts or as a result of a poor synchronicity of developers' efforts).

3.5. 'Open' *vs.* 'Closed' or 'Fixed' Data Notations

Excepting databases for educational purposes, there are no good standards for scientific architectural notation. Architectural databases for scientific investigations should have very specific data layout which is needed to be structured in many ways, especially if including a very large amount of heterogeneous information [1][5]. Besides, it is often impossible to fix the structure of information and all the pieces if information belongs to many data structures and can be accessed for many different purposes. This implies problems with defining 'open' (not fixed) large structures of architectural data optimized for scientific needs. Some aspects of these problems were mentioned by Korolczuk and Szewczyk [3].

In fact, except for a few very specific ones for educational purposes, notations of 'open' architectural scientific databases have not been developed yet. The existing 'fixed' data sets are too complex and difficult to use. They are often inconsistent and not really designed for architecture.

3.6. Top 3 Technical Problems

To sum up, the following reciprocally related issues still remain the main challenges when handling culturally-significant architectural data:

1. Despite the complexity of architectural design, digital tools should allow us to handle heritage values. Local values build the global cultural heritage and they generate the worth of architecture. We need efficient tools and methods for dealing with these values. These tools and methods of investigation and management of scientific/art information should be sensitive to these values in their contexts. Architectural software has not been supplying tools for the representation and management of local values yet.
2. Architectural software and networked services still need to be developed in order to provide an architect tools for representing and controlling the cultural heritage in architecture and it will be possible only if the applications can intuitively act with local cultural values. This shows the need for 'context-friendly' architectural tools which enable users to digitally store both, local and global values as well as digital representations of their contexts.
3. In contrast to real architecture, digital representations of architectural objects still cannot carry their cultural identities. But we claim that, similarly to the real architecture, digital representations of architectural objects must have their cultural identities.

4. Technical Solutions: Data Repositories for Architectural Heritage Management

The above-mentioned discrepancy between the expectations and real problems concerning computer-assisted heritage management still exists in spite of many scientific works and theories. Few such theories are worth our attention. Attempts to reshape architectural data in order to get a consistent database for designing, educational or scientific purposes were made by Gu and Xie [8], for example. He introduced and analysed three database modules: *specification library, case library* and *"generative mode" library*. The problems of the data repositories and the hybrid metadata management in general were partially recognized by Kahn and Wilensky [9], Arms et al. [10] and Loudon [11]. For example, Arms et al. introduced the concept of data repositories with four main modules: (a) a user's interface, (b) a repository, (c) a handle system used to identify resources and (d) an independent search system based on a query language and keyword search capabilities. This modular approach seemed to be applicable for the architectural databases for scientific and educational purposes and conditionally for designing [3] but we suggest adding a fifth module. Namely, (e) a processor of graphical data, that is, the CAD engine. Problems and advances in the development of these five modules are outlined below.

4.1. Data Processors and User Interfaces

There are many types of data processors. We have focused on the CAD engines because of their ability to effectively manage complex data not limited to a graphical shell.

The second challenge is to provide an intuitive and visual access to the data. This implies that a need for 'context-friendly' interfaces which extract and show heritage data when user asks for them (a querying or browsing model with an option of *heritage access*) or display them automatically while browsing. These interface tools are still to be developed. Common interface problems related to the CAD systems were recognized in detail and divided into 24 groups by Jakimowicz and Szewczyk [12]. Integration of the CAD data and user interface was recognized as an important aspect of engineering systems by Anumba [13]. Arms et al.

[10] suggested the necessity of dual interface for digital libraries, i.e. one interface for users (for data extraction) and the second one for managers (for data processing). This duality can make sense in scientific and educational databases linked to the CAD systems. A few interesting interface concepts were also developed for the systems assisting conceptual design [14].

4.2. Data Repositories

Szykman et al. [15] described a web-based repository system for dealing with the corporate design data emphasizing the differences between databases and data repositories. Gu and Xie [8] discussed the implementation of the dynamic engineering component database focusing on the data organisation and access. Arms et al. [10] recognised problem of restructuring data classifying them into: (a) digital materials, (b) key metadata and (c) structural metadata describing the types, versions, relationships and other characteristics of digital materials. Others suggested a multi-levelled architectural data organisation which uses the XML syntax. But there are also sceptics such as Fisher et al. [16] who insist that XML specifications suffer from a conceptual deficit and that XML was not primarily intended to provide containers for the data storage but to enable the data transfer between domains.

4.3. Search Systems and Handles

Search systems of two types are essential for large hybrid data repositories: query-based search engines for extracting data records from databases with known structure (by attributes or by data types) and keyword search engines for searching unstructured data (by data values, keys or keywords). Data extracting capabilities can also be extended by including sorting tools.

When dealing with graphical and CAD data this first group includes filtering capabilities, that is, the selective data extraction based on a layered and visual data structure. When dealing with heterogeneous, complex, unclear architectural metadata, search systems must be well integrated with handle systems and indexing services. Handles identify resources over long periods of time. Identifiers indirectly reduce the data redundancy and increase flexibility of data structures. Another tools are surfers/browsers which allow surfing on hyperstructured sets of data (horizontal, vertical, free or random surfing). These are essential for large, graphical data sets when it is not so important to process all the data but rather to find out a representative or an exemplary subset of specific data or to discover interrelations between heterogeneous data items.

Recently the XML-based notation focused scientists' attention. It is expected that XML syntax can represent both structured and unstructured data. XML-based searching tools were developed or analysed by Badard and Richard [17], Deutsch et al. [18], Florescu et al. [19], and Houlding [20]. Those search methods and tools are to be implemented in the future.

4.4. Reworking Data Notations

As it was noted A/E/C notations are either too simple or excessively redundant. For this reason Tunçer and Stouffs [7] suggested non-redundant richer information structures. They proposed the adoption of the XML syntax for representing data abstractions to be interpreted and broken up into components and relationships to be added. These resulted in richer information structures of components and relationships which provide new and not inherent to the original structure views of abstractions and offer new ways of interpreting a data model.

In spite of such theoretical models, there are no applications of these models. For instance archaeologists who lack proper tools for management of cultural values often try to work in AutoCAD and apply complicated layer structures which pretend to substitute the non-existing representations of local values, context information and other ‘cultural data’. In 1993 Harrison Eiteljorg, the Director of the *Center for the Study of Architecture/Archaeology* (CSA), worked out the AutoCAD model of the older Athenian propylon containing data defined by 153 drawing layers and by the three DBF files. These digital representations of the archaeological artefacts have been segmented, classified and stored according to their date, material, and a variety of other criteria [21][22]. Unfortunately the 153 drawing layers seemed to be far too small for representing cultural data. After that Mr. Eiteljorg developed an extended *CSA Layer Naming Convention* which enables users to define over 1200.000.000 abstract layers, each containing archaeological data and named separately (for example, 2002NT10045_PTPCWFXA-0489-0478). The *CSA Layer Naming Convention* is regarded to be the best, the most flexible and exhaustive notation of data containing the archaeological meaning that is also similar to the data representing architectural meaning and containing cultural values. But this example poses the question: Can the 1200.000.000 abstract layers such as 2002NT10045_PTPCWFXA-0489-0478 effectively and easily carry rich cultural meaning? Can they satisfy us?

4.5. Sharing the Data

Problems with the access to the application-specific data are also taken into consideration. Besides, we can foresee possible problems with public sharing the CAD data because the CAD technology remains unfamiliar to the public. That is why in practice we apply partially redundant data structures with the CAD data doubled by appropriate raster files or by the popular vector graphics formats such as SVF or SVG. But unfortunately, this enlarges the data redundancy problems.

5. Back to Conceptual Problems: The Present, Real Applicability of Technology to Heritage-Conscious Sustainable Building

It should be expected that the technology enables architectural digital data to be context-sensitive and heritage-sensitive. Here is an exemplary opinion: “Reconstitution is not a recent science but the CAD applications do offer nowadays an easier possibility of recreating damaged, transformed or disappeared sites. In fields such as archaeology, history and architecture those technologies are of particular importance” [23]. In fact, this technology facilitates the abandonment of human values in architecture instead. The discrepancy between the expectations and a real applicability of technology to the heritage preservation and sustainable buildings has been reflected in theories, software tools, scientific analyses and working design methods even at a very conceptual stage.

5.1. Terms, Notions and Classifications

Classifying, organising and mapping heritage values represented by digital identifiers might be a preliminary stage for the development of methods and tools for further advanced computer-assisted storage and maintenance of cultural heritage data. For this reason Maver and Petric [24] introduced the term *Virtual Heritage* (*VH*) when they reported on the usage of the VR systems for the digital restoring of the cultural heritage. Heritage values have also been classified by Szewczyk [5] on the basis of a variety of earlier works done by Torre and Mason [25], Mason [26], Reigl [27], Lipe [28] and Frey [29] as well as official documents such as *Heritage Asset Management Guideline* [30], *ICOMOS Burra Charter* [31] and the *English Heritage* document [32]. But the existing classifications and notion systems have not been reflected in any software tools yet. They are rather randomly and amateurishly used to assist the heritage management.

5.2. Borrowing Tools from Other Fields

Generic architectural systems have surprisingly limited usage and they are perceived as robots for generating standard documentation of standard architectural models. The relatively small but interesting group of applications is a software for an early stage design but the most popular pieces of software (Autodesk Architectural Studio, D-Board from Nemetschek and SketchUp from @Last Software), found as *architectural software,* do not contain architectural data at all. In fact, this applications are conceptual solid modellers only (Architectural Studio, SketchUp) or digital sketching boards (D-Board, Architectural Studio) but they are not oriented towards the 'cultural identity of data' nor even 'architectural identity of data'.

The lack of architectural tools for representing the 'cultural identity' compels architects to use non-architectural tools in their work. Architects and scientists deal with architectural information using modelling software, the VR environments and the GIS systems (for example, VR-GIS for urban analyses). For instance, Maver and Petric [24] reports the usage of the VR systems for digital restoring of the cultural heritage. In fact, many more researchers investigate the usage of GIS and visualisation software rather than CAD for gathering the heritage information (compare Boehler et al [33]). A very specific group is the archaeological software developed in order to represent chosen cultural values. For example, the ArchEd Program is a tool for drawing Harris matrices which are used in archaeology. Harris matrices are defined to be 'a new type of calendar' which allows archaeologists to see stratigraphic sequences of complex sites in a diagram. That is, they represent relative time parameters of complex graphical data converting data to a simple diagram [34]. We can perceive Harris matrices as computational methods for representing the *time aspect* of *historical values*. Using Harris matrices for describing the time aspect of historical values suggests that similar tools and methods can also be used for describing other values but such tools and methods have not been developed yet.

6. Conclusions

As mentioned, that this paper is to inspire a discussion on software for a sustainable architecture, on how information technology can provide a scientist with tools to handle local architectural heritage. The investigation has resulted with the following conclusions:

1. Generally, scientists and architects lack methods and tools for digital representing of information about heritage values, architectural data and its context (local values). Such methods and tools are missing, especially ones that could utilise the existing CAD data so that local values, spatial and cultural context and other data that relate to cultural heritage, could be clearly represented.
2. The discrepancy between expectations and real problems concerning computer-assisted heritage management, has resulted with a number of theories and technical solutions related to the following 'technical' issues:
    A. General problems with architectural CAD notations
    B. General problems with computer notations that can become standards in science ('*lingua franca'* problems and a focus on XML-based notations)

C. Attempts to reshape architectural data in order to get a consistent database for designing and for educational or scientific purposes
D. Problems with public access to application-specific or discipline-specific data
E. Other ‘semantics problems’ (discipline-specific or software-specific)
F. An intuitive and visual access to databases and to architectural CAD data
G. A number of interface problems

3. Classifying, organising and mapping heritage values with their digital identifiers might be a preliminary stage for a development of methods and tools, for advanced computer-assisted storage and maintenance of cultural heritage data. Unfortunately, the existing classifications of values have not been reflected in any software tools yet.
4. In practice, the lack of architectural software tools for representing the ‘cultural identity’, compels architects to borrow non-architectural tools from other disciplines. Especially modelling software, archaeological software, the VR environments and the GIS systems can focus architects’ attention.
5. Similarly, tools and methods for architectural heritage management can be applied to some other disciplines based on cultural heritage data.

Finally, we claim that firstly, the present impact of technology on heritage preservation and on sustainable design, should be monitored and secondly, the future place of computer technology in cultural heritage research, should be explored.

Keywords

Cultural heritage, Cultural identity, Architectural data, Heritage values, Heritage management

Acknowledgement

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DIRECT PASSIVE SOLAR USE

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1. INTRODUCTION

The passive solar systems still appear to be the most promising and simplest way to absorb, accumulate and utilize solar energy in contemporary low energy building. This kind of energy source, utilized in the most natural and simplest way could be a proper symbol of the building sustainability.

Passive systems have been broadly described and discussed during the last decades. Unfortunately, there is not much reliable evidence documenting the thermal efficiency and designing rules of these systems, especially in the climate of Central Europe.

The most common passive system is direct gain, that in fact is applied in every building with glazed openings. But the available, in the local climate, solar energy can be used in the most efficient way only when the building design is based from the very begining on the solar architecture rules of thumb. To the main factors influencing the solar building performance belong [1,2]:

- local climate
- thermal properties of the envelope
- glazing orientation, size and type
- thermal storage capacity.

Designers do not usually think about building technology in terms of its accumulating abilities, but rather in terms of structural decisions. Window size is often a result of aesthetic considerations or old lighting procedures. In a passive building these decisions should based on quite different assumptions. Some of the relations existing between those factors have been already investigated and reported in [3], further results are presented in this paper.

The main goal is to formulate the simple rules of thumb for solar designers in Poland. The results obtained are limited now to the relatively narrow data range used in simulations. The broader solution field demands further research.

2. BUILDING SIMULATION

Computer simulation is a valuable research tool, allowing to develop and investigate the design rules for engineers, called "rules of thumb". One of the largest and newest simulation tools is, nowadays, an American program called Energy Plus. Version 1.2 was released by the American Department of Energy, its agencies and the other cooperating institutions in April 2004, version 1.0 was used in described simulations. The general overview of this program was shortly presented in [2]. Weather data for Kraków, Poland, in the special Energy Plus EPW format of hourly data, have been imported from the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) website.

2.1. Main assumptions

The simulated building consists of the nine thermal zones. All of them were considered during the very simulation run, but only one zone was a subject of numerous modifications and analysis.

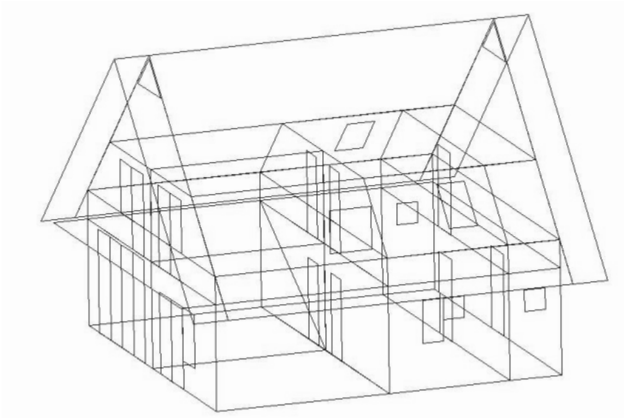

Fig.1 The general outline of the simulated building

It was assumed that:

- the whole opaque envelope of the lightweight building structure is well insulated, thermal conductance of the wall is 0.249W/(m^{2}K), roof 0.165 W/(m^{2}K) and floor 0.245 W/(m^{2}K)
- high density structural layers are in good thermal contact with the space
- continuous heating and cooling systems are considered
- the minimum internal air temperature is set to 20^{0}C and the maximum to 25^{0}C
- the amount of the purchased heating and cooling energy is the measure of the passive system's thermal efficiency
- heating simulation period: 15.IX – 15.VI, four timesteps in an hour
- ventilation rate is constant and equal to: ca. 2/3 ac/h in the investigated south-west zone
- building is not ocuupied i.e. there are no internal heat gains other than sun radiation and the purchased air heating system
- one-dimension heat flow through building envelope is considered.

2.2. Glazing properties

Glazing properties, regarding the thermal conductance and radiation transmission, are very important factors of the passive solar use. In simulated building a highly efficient glazing type has been designed. All windows are double glazed, glass covered with low-emissivity spectrally selective coating and xenon filled. Glazing conductance is 0.912 W/(m^{2}K). Some other features of the window glazing have been gathered in Table 1.

Table 1 South window glazing properties

Energy Efficient Glazing double glazing with spectrally selective low emissivity coating	
thermal conductance [W/(m²K)]	0.912
SHGC*	0.331
solar transmittance ⊥**	0.213
visible transmittance ⊥**	0.601
IR hemispherical emissivity: front side	0.84
IR hemispherical emissivity: back side	0.03

* *SHGC - solar heat gain coefficient, in Energy Plus program it is calculated according to the ASHRAE procedure*

** *symbol „^" means "at normal incidence "*

2.3. Thermal storage

Thermal capacity of the building space was modified by means of the altered internal massive layers of the walls and the floor. The properties of the material layers used in simulations are given in Table I.

Table I: Internal accumulating layers used in simulations

material	density [kg/m³]	thickness [m]	areal density [kg/m²]	areal thermal capacity [kJ/(m²·K)]	material admittance* [W/(m²·K)]
1	2	3	4	5	6
concrete	2500	0.2	500	420	16.13
brickwork	1800	0.25	450	396	9.43
concrete	2500	0.10	250	210	16.13
brickwork	1800	0.12	216	190	9.43
plaster	1850	0.02	37	31	9.64
styrofoam**	20	0.13	2.6	2.2	0.29

* *Material admittance is calculated for 24 hour harmonic variations and semi-infinite layer*

** *Styrofoam is not considered as a heat accumulating material, but it is the only internal layer in the theoretical case of extremely low capacity space*

The following cases of the thermal storage distribution have been considered:

- Walls and floor (except ceiling) with thick internal massive layers + extra internal massive wall made of concrete, 20 cm thick, both surfaces are in thermal contact with the zone air
- Walls and floor with thick internal massive layers, no extra mass
- Floor made of 10 cm concrete plate, the other walls with internal plaster only
- Internal partitions with 10 cm concrete layer, the other walls with plaster
- External walls with 20 cm concrete inside, the other walls with plaster
- As above but 10 cm concrete inside
- External walls with 25 cm ceramic brick inside, the other walls with plaster
- As above but 12 cm ceramic brick
- All the walls with internal plaster only
- External walls without any massive layer, the others walls with plaster
- No accumulating mass inside of the space, in this theoretical case styrofoam is the inner layer of the walls and of the floor

In spite of the introduced changes, total heat transmission through the outer walls was in each case kept at the same level, due to the adjusted insulation thickness.
In all cases the light structure of the ceiling is covered with the gypsum plaster only. In first two cases external walls inner layer is made of 20cm concrete, internal walls of 10cm concrete, floor of 4cm concrete.

3. HEATING DEMAND REDUCTION

The impact of the window orientation on the building energy balance was discussed in various sources, among them in author's papers [3,4]. According to them, in moderate climatic zone as in Central Europe, only the south oriented, well insulated windows may achieve the positive energy balance during the heating period. That is why, only the south facing, energy efficient glazing has been considered in the simulated building.
Window area is the fundamental factor influencing building demand on conventional energy. Increased glazing area provides increased solar flux, that must be efficiently stored and used to heat the space or may result in acute overheating and increased demand on cooling. High efficiency of the passive solar system, in specified local climate and building envelope thermal features, demands proper combination of the south window area and the space thermal storage.

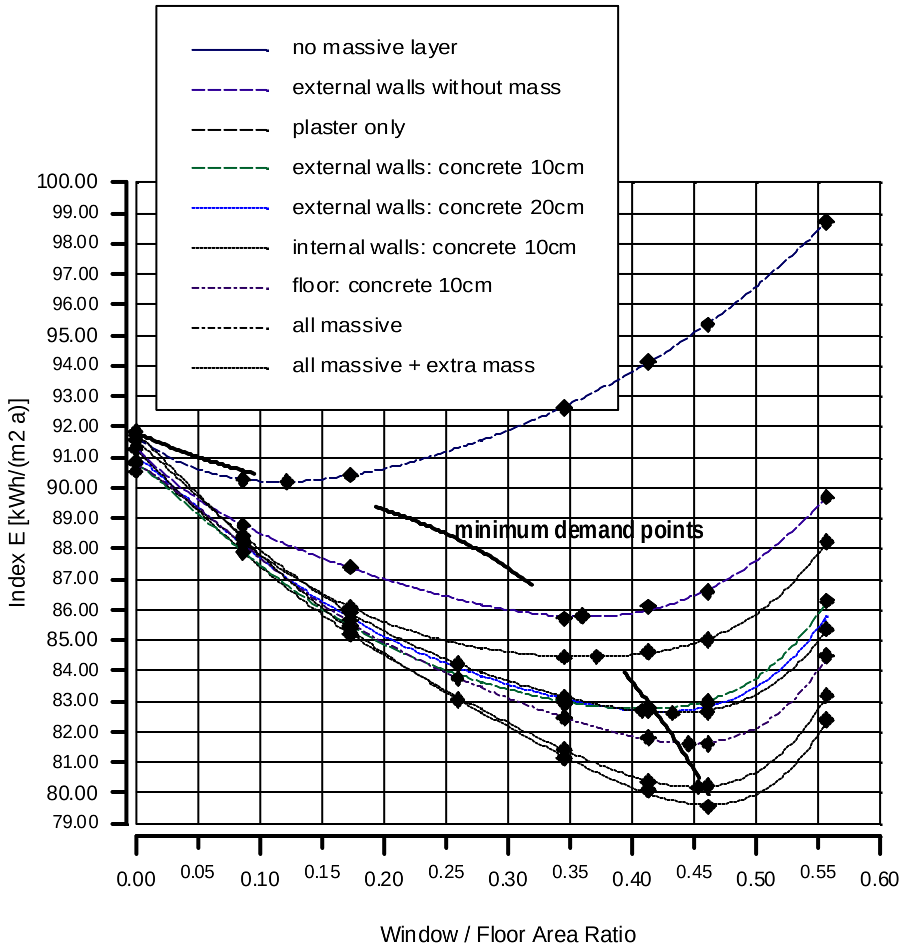

Fig. 2 Heating energy demand versus window/floor area ratio and space thermal capacity

Non linear relations between variables, big amount of parameters and stochastic character of meteorological data prevent from finding an analytic solution of this problem. So the multiple simulation data have been used to search for optimum designing rules.
For the all thermal capacity locations, as in the cases described above, the whole sequences of the simulations with modified each time window/floor ratio have been conducted. Due to the polynomial regression analysis of the simulation data, the data points and curves have been plotted in diagram, Fig. 2.
Because of the very close or even the same values obtained in case of concrete and brickwork, diagrams displayed in Fig. 2 have been reduced to the concrete layers only.
Simulation results presented in Fig. 2 allow to precise a few important, for the efficient passive solar use in Poland, observations and principles. Some of them confirm the general relations of the solar architecture, the others are new and valid for the local climate and introduced assumptions:

- space thermal capacity is necessary to store solar energy and decrease demand on the conventional heating energy
- in spite of the positive total energy balance of the energy efficient glazing, lack of the thermal capacity is leading to the increased heating demand, when the window area is increasing
- even a low thermal capacity of the space allows to reduce heating demand due to the absorbed and stored solar radiation, increased south window area decreases heating energy demand
- south window area must be strictly combined with the space thermal capacity, it should not exceed the optimum value, otherwise investment costs, heating energy demand (and overheating) would be increased again
- for the given window to floor ratio, increased thermal capacity allows to reduce heating energy demand, but observed improvement is relatively small when compared with huge growth of the capacity (E-value differences in the diagram are significantly emphasized due to the narrow range of the vertical axis)
- there is no point in increasing the thickness of the massive material layer, like concrete or ceramic brick, beyond 10cm, heating demand is practically the same for the layers of 10 and 20cm thickness
- further increase of the space thermal stability may be achieved only by means of extra free standing accumulating mass (internal walls, fire place etc.) in good thermal contact with the space air
- massive floor is a little bit more effective heat storage than the vertical walls, due to the direct solar radiation reaching its surface
- in case of the low thermal capacity of the space (plaster only), the optimum south window area is close to 1/3 of the floor and significantly bigger than the area needed for the expected daylighting level
- optimum area of the energy efficient window in the building with very high thermal stability and extra storage is equal to 46% of the space floor
- but taking into consideration: relatively small differences between the curves, high risk of overheating and high investment costs of the window, south window area equal to 1/3 of the floor may be considered as the simplest rule of the thumb for this climate.

4. WINDOW AREA VERSUS THERMAL STORAGE

The curves plotted in Fig. 2. have been obtained due to polynomial regression analysis of the simulation data. One sample function of window/floor area ratio and heating index: E in form of 5-th degree polynomial is given below, equation (1). This function was obtained for the space with all masive walls.

$$E(R_{w/f})=90.4414-20.9712\,R_{w/f}-170.532\,R_{w/f}^{2}+1017.28\,R_{w/f}^{3}-2313.51R_{w/f}^{4}+1944.36\,R_{w/f}^{5} \quad (1)$$

where:

E - yearly demand on heating energy per square meter of heated building floor, kWh

$R_{w/f}$ - window/floor area ratio

The similar equations have been determined for the all considered cases of the internal thermal mass distribution.

For a given internal thermal capacity there is a value of the window/floor ratio for which the seasonal space heating demand is minimum. The approximate value of the minimum can be found in diagram, but the exact value should be calculated as a minimum of the function. It may be obtained after solving derived equation (2):

$$-20.9712 - 341.064\,R_{w/f} + 3051.84\,R_{w/f}^{2} - 9254.04\,R_{w/f}^{3} + 9721.50\,R_{w/f}^{4} = 0 \quad (2)$$

The optimum value of $R_{w/f}$ for the analyzed case is equal to 0.453. So such a big glazed area would minimize in a massive space the demand on conventional heating energy due to absorbed and efficiently accumulated solar energy. Window area of this size is four times bigger than the one needed for daylighting. According to traditional designing rules, window area should be in the range of 1/8 to 1/10 of the floor area.

The same procedure as above was performed for the all considered mass distribution cases. Minimum points in the diagram have been connected by the dashed line after regression analysis, Fig.1. Another regression analysis has been conducted for window/floor area ratio and the space internal capacity, equation (3) and Fig. 3.

$$R_{w/f}\,(C_a) = 0.0650379 \cdot \log C_a + 0.141839 \quad (3)$$

where:

C_a - mean, weighted, areal heat capacity of the inner layer of the building envelope

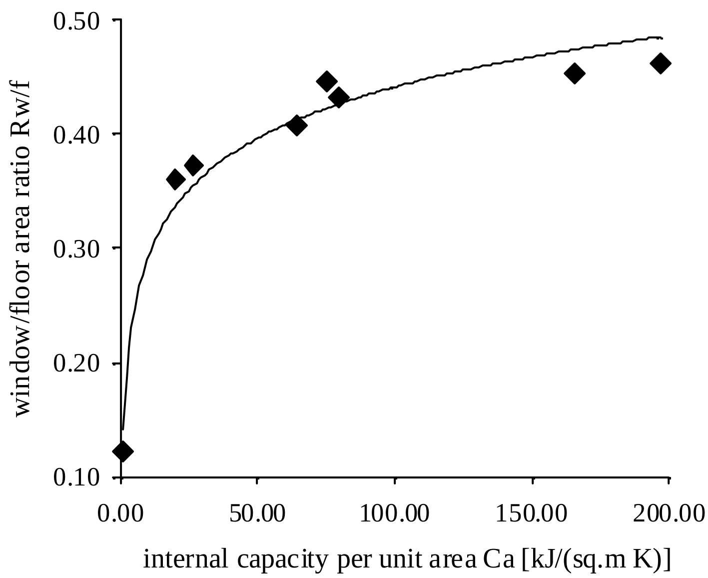

Figure 3 Relation between space thermal capacity and window to floor area ratio according to equation 3

Function presented in Fig. 3 or equation (3) can be used by architect to design optimum combination of thermal storage and window area with a view to energy demand reduction.

5. OVERHEATING RISK

South glazing is usually associated with the greatest overheating risk. This opinion is false but nevertheless large areas of glazing may cause overheating in warm periods of the heating season and summer of course. Efficient protection against overheating should be in every case an important part of the design. Direct solar gains can be reduced by external or internal shading components. Large thermal capacity of the building space may help to decrease daily temperature rise and to transfer at least a part of energy absorbed during the day to the night period [2,4,5]. The great significance of the heat storage for overheating reduction may be proved with the following example. For window area close to 1/3 of the floor area, amount of the energy that should be removed from the space to keep air temperature below +25°C was for:

- all massive walls: 5 kWh
- 10cm concrete in external walls: 23 kWh
- plaster only: 39 kWh
- no massive layer inside: 228 kWh.

In case of the larger window area (Rw/f = 46%), overheating rises to:

- all massive walls: 25 kWh
- 10cm concrete in external walls: 73 kWh
- plaster only: 106 kWh
- no massive layer inside: 356 kWh.

Thermal stability of the building is of a great importance to protect space against overheating. Low thermal capacity increases overheating load for many times comparing to the massive structures. As it was shown in chapter 2, very large window does not reduce heating demand in significant way, so, especially in case of the lightweight structures it would be reasonable to confine its area to 1/3 of the floor to decrease overheating risk.
The other temperature moderating effects of the thermal storage have been illustrated in Fig. 4. For the summer chilly period, with the lowest ambient temperature +7°C, free run of the internal temperature (heating and cooling systems switched off) is displayed.

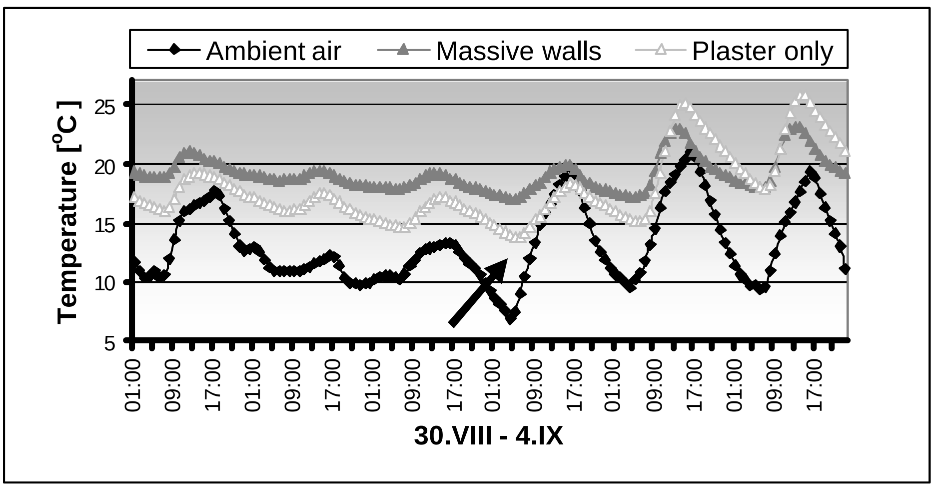

Fig. 4 Internal air temperature in the space with massive internal layers and internal plaster only (chilly summer period)

In a space with the low thermal capacity (internal plaster only), air temperature dropped down below 13.70^{o}C after a few cloudy days and raised rapidly above 26^{o}C on the following sunny days. In the same period, the lowest temperature in the heavyweight building was 16.23^{o}C and the highest 23^{o}C. So the temperature variation range was significantly reduced due to the space thermal stability.

6. CONCLUSION

Demand on conventional heating energy can be reduced by means of absorbed solar radiation, but it is possible only in the buildings with sufficient thermal capacity. Solar heating fraction depends of course on amount of the solar energy that is transmitted through glazed opening and can be increased to some extent with increased window area. Function (3) allows solar architecture designer to combine in optimal way window area and the space thermal capacity. This simple rule of thumb could be very useful for designers, who understand the complexity of dynamic interactions within the building space. Of course, use of this function is strictly limited to the features of the building envelope, glazing properties and local climate as assumed in simulations. If any of these factors are modified the rule of thumb should be modified as well. Author is now working on enlargement of the result field due to multifactor analysis.

Thermal stability of the building is of a great importance to protect space against overheating and to reduce the temperature variation range.

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CANADIAN BEST PRACTICES IN SUSTAINABLE RETROFIT DESIGN

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1. Emerging issues in sustainable architecture.

Introductory questions to problems of today:

- What will we, contemporary architects, face in our profession because of unstoppable world development?
- Should we all operate in a global / world context?
- The design of cities and buildings – destruction or improvement of our environment?
- Do we have reasons for fear or anxiety and can we honestly fight the statement: "architecture is the art of how to waste space"?

Besides regular definition of a sustainability building and common understanding that such a building should contribute to social and economic development and be environmentally-friendly with its design open to alternatives, it has also to help communities and societies move towards sustainability.

When we consider today's construction, we observe clear results of years of our negligence, greed of developers, lack of professional "honesty" between architects and a very significant lack of proper education towards sustainability. Additionally, there is a wrong perception that it would be easier to build a new building than to "repair" the old one. It happens very often on a new site, or on an old one with demolished building in both cases leading to depletion of land or resources or both of them.

Some people still consider our cities as sources of unlimited new construction possibilities: it is enough to simply demolish the old building, be it an office, an old factory or a school, or just enlarge the urban buildable area by pushing politicians to re-zoning, or "bribing" or blackmailing communities for favorable decisions giving them unrealistic promises while never thinking about fulfilling them later. And then, to build a new building, designed with a dictate of those who pay for the design and construction and sell or lease it. However, that situation is changing rapidly because we are already facing a crisis.

New versus Retrofit as the reality and necessity in today's construction.

Existing building stock of today require major retrofit / renovation due to either very high operational cost related to energy inefficiency or to costly "regular" maintenance (the older building, the costlier maintenance) due to the fact that each building has to be remodeled or reconfigured several times over its life span, with changes to interior partitions and possibly the addition of new products or systems. The ratio of buildings requiring renovation to a number of all existing buildings is currently so high that the "replacement construction" is virtually

impossible and for many reasons, financial and environmental including. In that context ideas of combining the reuse of the existing stock with good energy and environmental solutions could result in interesting sustainable developments. It seems to be logical but how often we seem to forget that logic with its solutions?
When considering major sustainability issues for a building, we always must consider three factors: Ecological, Economical and Societal (= social, cultural, ethical etc).
The first two, although basic, are easier to achieve, especially with good financial backing, the third one is the culprit in many failures, as a matter of fact, too many. It encompasses history of the place, cultural heritage and very often decides about the perception of the place by providing employment, entertainment, basic amenities etc. So, when revitalizing or retrofitting the urban area we should take into an immediate consideration social / neighborhood connection. Such a small scale approach is needed to achieve better sustainable goals.

Analysis of three designs across Canada with the overview of the case study assessments based on Green Building Challenge 2000 and 2002:
Angus Technopole in Montreal and Red River College in Winnipeg are the examples of successful, community created and supervised projects and Telus Building in Vancouver is a corporate project in the centre of Vancouver.

Recent years brought a lot of fresh air into the sustainable architecture's approach to retrofit. Three presented here Canadian buildings represent new trends in this just starting development and are known as "no-frills", solid designs with no cost overruns and with their performance verified over last few years of operation. They are neither the very best energy achievers, nor the architectural wonders and yet two of them are outstanding for the simple reason of being totally co-designed by local communities and the third serves as the showcase for corporate acceptance of the new rules of renovation versus demolishing in a prime and expensive spot downtown..

Two case studies responded to the challenge being almost perfect examples of a co-operation between a willing developer, design team and all interested parties from the unemployed factory workers through to students, community activists and office clerks and business people.
Both buildings provide examples of large urban developments on previously designated sites: industrial and commercial. They reflect the collective will of the local populace and aim at providing employment opportunities in what became, in the case of Montreal, a depressed area with more than 20% unemployment [1].

Case studies

	***Angus Technopole, Montreal, Quebec,*** **Architect**: Guy Favreau, Aedifica, Montreal **Building Type:** Office/ Other **Approximate gross area:** 12,500 m2 **Number of floors above ground**: 1-2 **Year of completion**: 2000

General Description: Renovation, converted locomotive factory to industrial mall, major deconstruction effort. After Canadian Pacific closed the locomotive factory in 1992 and threatened to demolish building or convert it to the shopping mall, a local grassroots organization, SDA, was formed to save the historic building.

Building Form and Orientation

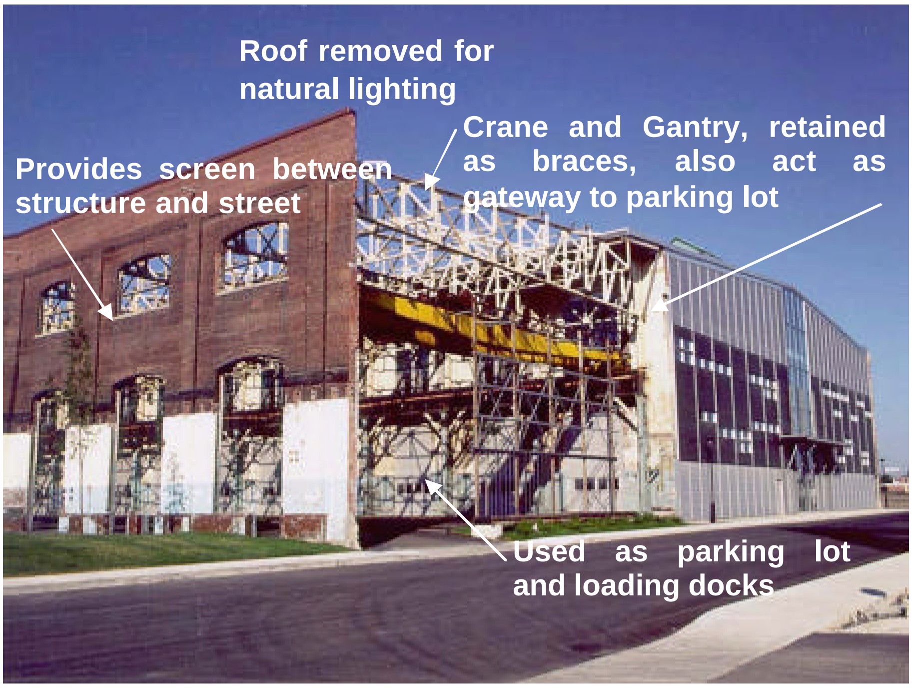
The fundamental issue of this project was the integration of different functions, not only within the Locoshop, but also integration of the industrial mall and the Technopole within the neighbouring urban fabric.

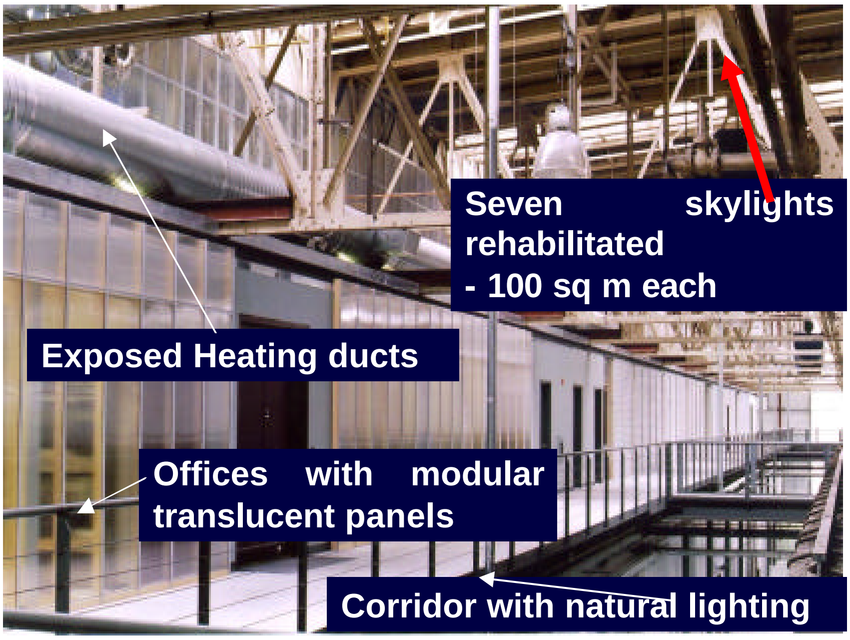
The scale and character of the building was preserved and reinforced. Particular attention was given in planning the Technopole to the linking of the existing street grid system and streetscapes, the diversified land uses, the relatively high density, and the proximity of existing and new amenities.

The site has remained a working space, reflecting both its history and responding to local working community needs. By increasing building and site density, the ratio of built area to land area was maximized, offsetting the relatively high land cost. Green building criteria enabled costs to be offset and defined a marketing key. Interior spaces provide three-dimensional flexibility to meet a large diversity of tenant needs.[2]

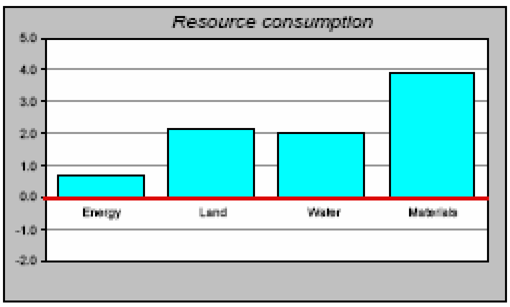
Main Green Features

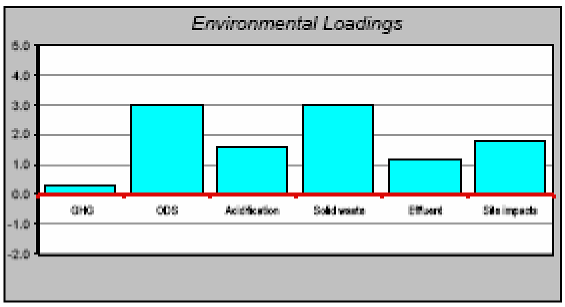
- The envelope was significantly upgraded by roof insulation and superior insulation for all new outside walls.
- Free summer night cooling by integration of louvered windows and air extractors with skylights - reduction of air conditioning (see section).
- The building features natural ventilation, natural daylighting, and operable windows.
- Existing heavy steel structural framing is fully retained
- “Deconstruction” practices were emphasized instead of “Demolition”
- Entire building was de-contanimated prior to deconstruction
- Roof timber - partially reused in interior stairs and surplus retained for future use
- Brick veneer - partially reused and the rest crushed for use in landscaping and pedestrian walkways
- The building uses existing, refurbished brick walls as "screen "walls.
- Fenestration with low emissivity glass.
- The building demonstrated excellent repeatability [3]





Levels of Performance for Design at Category Level





Red River College, Winnipeg, Manitoba,
Building Type: Office/ Educational – Partial retrofit
Approximate gross area: 20,500 m2
Number of floors above ground: 1-5
Year of completion: 2003

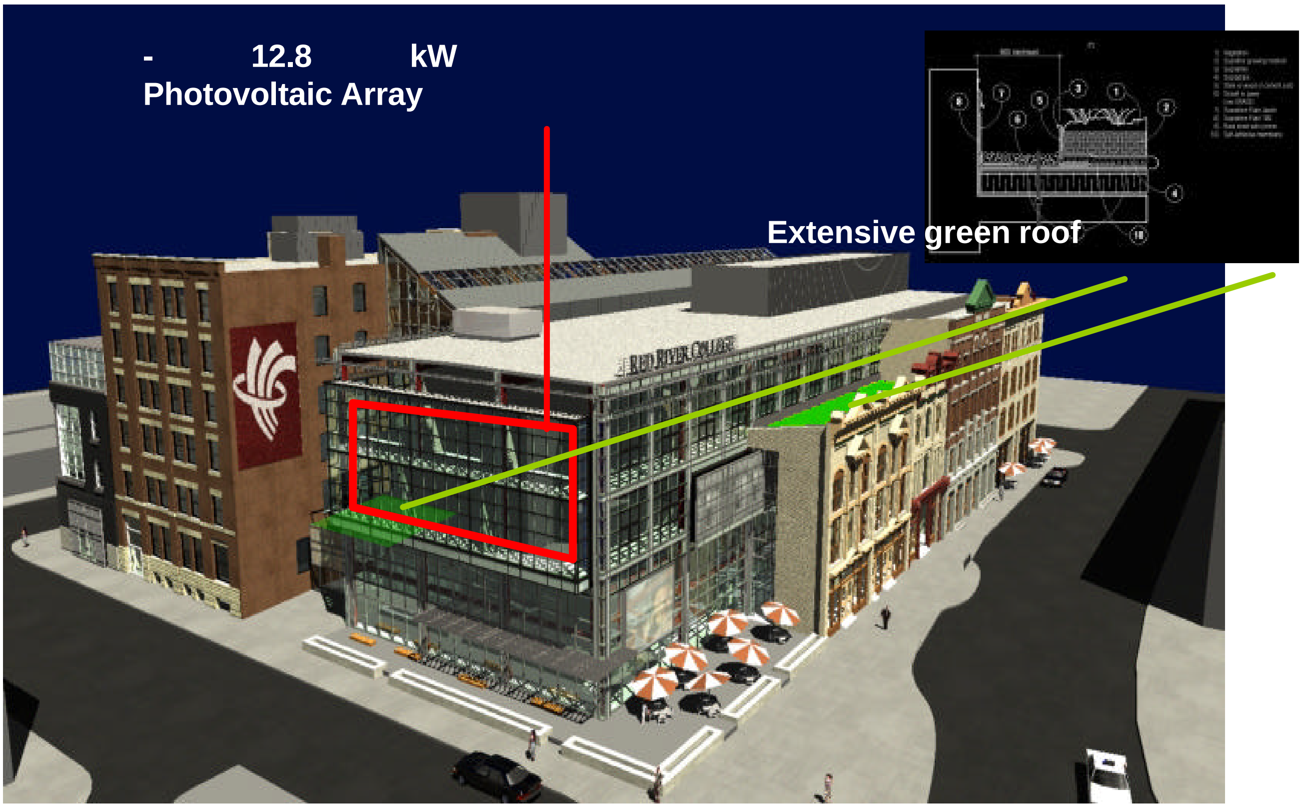
General Description: This project, a $31.5 million satellite campus for Red River College in Downtown Winnipeg is a partly historic reconstruction, partly adaptive reconstruction of existing buildings with substantial new construction.

All major building systems are affected in all cases. Renovation /construction for approximately 2,200 students and staff seen as a catalyst in the revitalization of the centre of Winnipeg - probably the largest intact collection of turn-of-the-century and terracota architecture in North America.
The main goal was to revitalize the so called Exchange District, run down part centre once the flourishing part of the of the City

Existing site circa 1905

Main Green Features

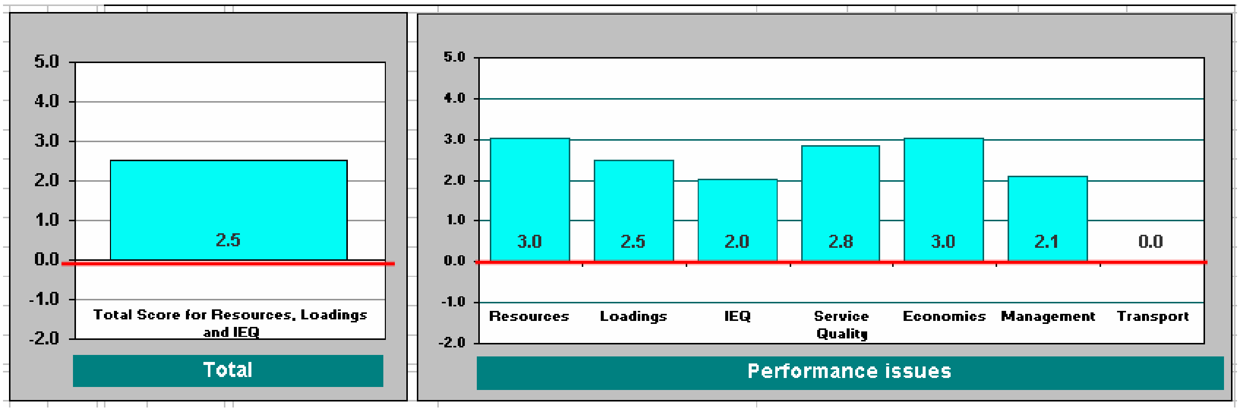
- Site development - The site was previously almost 100% buildings and hard surfaces. The new project is similar but with a green roof and some new landscaping to mitigate habitat, groundwater and micro-climate effects.
- Water consumption - The campus is being fitted with water-conserving fixtures and controls. The vegetated roof will be irrigated exclusively with precipitation once established.
- Re-use of existing structures and materials - Phase One is primarily an adaptation of a 4600 m^2 existing bldg. with a new roof and an addition. Subsequent phases incorporate the reconstructed heritage facades along Princess Street. All heritage millwork suitable/or salvageable was removed for reuse, as were some windows and doors and interior tile and glass. A high rate of brick and stone recovery for reuse from demolition was achieved through hand methods. Timber trusses, cast iron columns and reusable lumber were salvaged as well as many other miscellaneous items. Records have been kept of materials recovered.
- Use of local and recycled materials - Purchasing from local and Canadian sources has been emphasized where possible, using Manitoba's Sustainable Development Procurement Guidelines. Further recycled content is found in materials such as steel, copper and ceiling tiles. Records of materials specified and purchased are being kept for assessment.
- Emissions of Greenhouse Gases - The aggressive energy consumption targets demanded by the C-2000 program ensure reduced environmental loading from operating energy. 20 kW Photovoltaics curtain wall on South wall. Building materials have been selected with low effective environmental loading as a criterion.



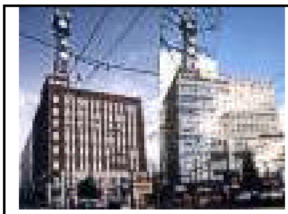
- Emissions of ozone-depleting substances - Major refrigeration compressors employ 134A refrigerant. Smaller units use the lowest ozone depletion rated commercially-available refrigerant. Non-HCFC rigid insulation materials are being researched.
- Emission leading to acidification from building operations - This is expected to be minimal. Natural gas flue venting from condensing-efficiency burners will be the only emissions.
- Construction and demolition wastes - The contractor has initiated a site waste recovery program. Demolition waste records are available for buildings removed and for construction.
- Indoor air quality - The HVAC design has a high ventilation effectiveness and excellent air distribution. Operable windows are used throughout to promote natural ventilation. Dedicated exhausts are provided in equipment areas where pollutants may develop. Low toxicity interior materials are emphasized to reduce pollutant loads.
- Thermal comfort - Solar control to reduce overheating is achieved by spectrally-selective glazing and window and shading device design. The high performance glazing eliminates the need for perimeter radiation in most glazed areas. A four-pipe fan coil HVAC system provides tight zoning as well as stable temperature control.
- Building demonstrates excellent repeatability [4]

When assessing the RRC, the Team had to take into consideration several aspects such as:

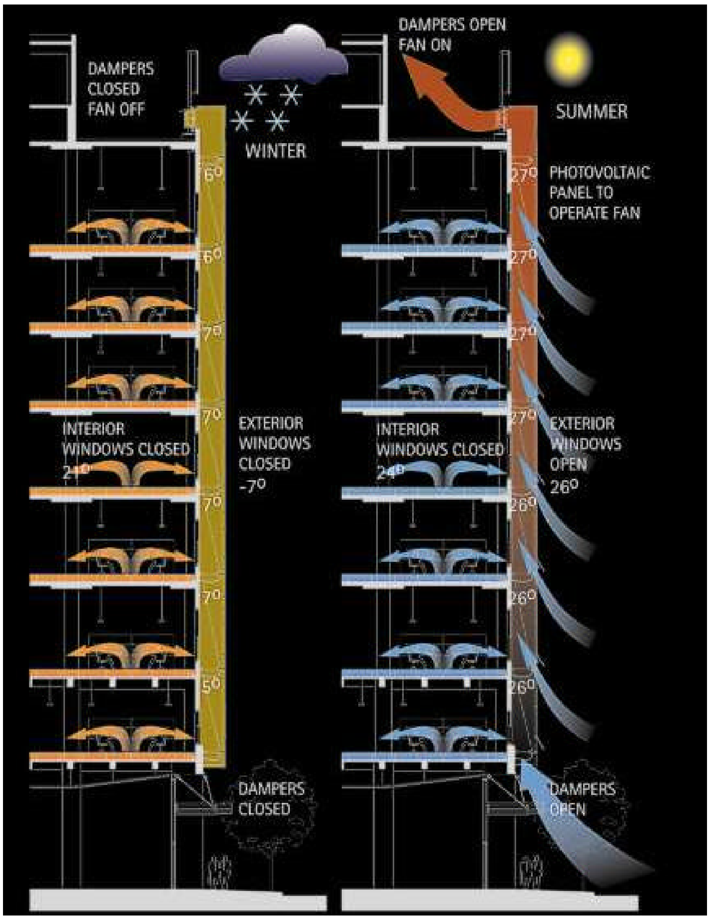
- **The location of the project - not the leading edge of sustainability thinking or practice within Canada when the project started.**
- Winnipeg's energy prices - **the second lowest** in North America
- New material availability - **not an issue**
- Waste management **not seen as a problem** and **no tradition** of conservation in the area.
- **… still the project has achieved a great deal**



More information on:
http://www.rrc-pscampus.com/index.html
http://www.rrc.mb.ca/environmentalmanagement/princess.htm

	***Telus Building, Vancouver, British Columbia*** corporate project in the heart of Vancouver **Building Type:** Office / Retrofit **Approximate gross area:** 12,075 m^2 **Number of floors above ground**: 8 **Year of completion**: 2000

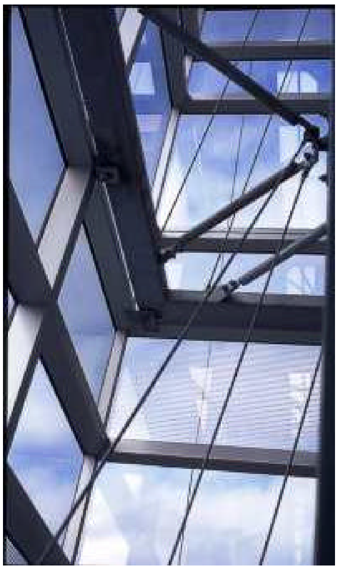
General Description: The William Farrell Project was conceived to satisfy a number of internal business needs and revitalize a high profile location to create a strong Telus, a major Canadian telephone company, presence in downtown Vancouver. The project scope included extensive interior and exterior renovations to the 1940's section of the building, Telus mandated that the existing building should be recycled and re-used, and that green strategies should be incorporated.
This is one of the few cases where a double facade is clearly logical, since it prevented demolition, allowed the re-use of existing systems and also provides a measure of pre-heating of make-up air during winter conditions.



Sketches showing intended air flows through the exterior double skin

Building Form and Orientation

Preservation of the existing building determined the basic configuration of the building. A new double glazed, fritted and frameless glazing system with operable windows is suspended from the existing building face, and thus creates the first triple-skinned green building solution in Canada.



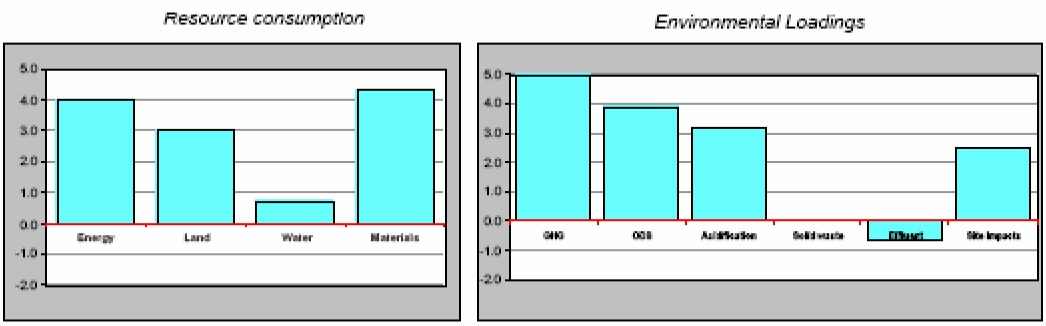
Triple skin

Typical floor plan

Main Green Features

- The envelope was designed as a refurbishment of an older office tower. The building has a new second layer of fritted double glazing added to the existing envelope suspended 900 mm from the existing building, resulting in the first triple skin building in Canada. This allows opportunities for natural ventilation in summer and acts as a warm buffer zone in winter. The energy target is 55% of ASHRAE 90.1.
- The client (Telus) and the architects developed a strategic green option to recycle/reuse the entire building,
- The building features natural ventilation, natural daylighting, operable windows, and individual user-controller diffusers at each station.
- The building has retained the entire structure. The interior furnishing and fitting were reused.
- Raised access floor provides flexibility for upgrading mechanical and electrical systems.
- The building has bicycle storage; change rooms and showers.
- The building uses PV powered fans to assist the natural ventilation.
- Interior light shelves extend the natural daylight into the interior spaces.
- The primary heating is to reuse waste heat from the existing refrigeration plant within the same complex.
- Building demonstrates excellent repeatability [5]

Levels of Performance for Design at Category Level



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SCIENTIFIC ASSURANCE OF WORKS ON ASSESSMENT OF TECHNICAL STATE AND OVERHAUL PERIOD RENEWAL OF THE IMPORTANT CONSTRUCTION OBJECTS

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Investigation actuality. The procedure of initial information formation concerning building structures dynamics depends not only on properties and features, but also on climatic, hydrogeological and other conditions. Landslides, the generation and impact effect of which on building structures cause significant damage in many regions of Ukraine, relate to the most complex exogenous geological processes. The following regularity groups, caused by the rhythm of natural phenomena and vicissitude of exogenous geological processes are known [1]: daily, monthly, yearly and different by continuance longstanding cycles. The scientists came out with the suggestion about relation of landslide process increasing with 11 years period of solar activity, based on the fact, that the quantity of atmospheric precipitations increases during periods of increasing of sun spot quantity. Data of investigations, performed in city areas of Nizhniy Novgorod, Volgograd, Kyiv, Odessa, Sochi, and on the Southern coast of the Crimea and Odessa shore, confirmed this hypothesis [1]. These data processing allowed ?.I. Sheyko to make conclusion about the largest activity of landslide processes in the first quarter of 11 years cycle in minimums and on branches of its increasing. V.V. Kyuntcel and G.P. Postoev determined one and two years rhythms in distribution of landslides in time for the coastal strip of the Black Sea and in interfluves Mamayka-Kudepsta with the help of time series analysis according to the correlation functions. Mutual correlative function of a number of landslides with solar activity index (Volf's number) gave comparatively high value of correlation factor at time shift of 3-4 years [2, 3].

The requirements to measurement for periodicity and precision of different indices and factors of lithodynamic process can considerably vary. The most high measurement rates are necessary for quickly varying factors, that determines the necessity of computerization for receiving, forming and preliminary processing of the initial data.

Hardware-in-the-loop realization of high-precision measurement system.

The computerized systems of gathering and accumulation of initial static information are applied for analysis of quickly varying factors of exogenous geological processes and their impacts on building structures. The following is measured:

- deviation angles of the separated elements of building structures (determined by experts) inside of the investigated landslide slope (angle deformations of building structures or measurement boreholes drilled in the slope);

- groundwater levels in boreholes determined by geologists;

- other parameters, which characterize stress and strain condition and lithodynamics of the investigated object [7-9].

Continuous control of exogenous geological processes in real time regime is carried out with the help of a new program "Sensor", which process data, incoming from high-precision electric inclinometer sensors, installed on certain building structures of the Livadiya palace and in distinguished regions and areas of the central Livadiya landslide system (CLLS). Program "Sensor" provides a continuous regime of the analogous signal transformation with the help of ADC (analog-digital converter) to the numerical code and data input to personal computer in real time regime, primary processing of statistical measurement data and their storage regime.

One of the main elements for the monitoring system of exogenous geological processes are the recording sensors, the precision of which first of all depends on the type of the selected sensing elements, their sensitivity and errors, both chance and systematical. We selected the inclinometer sensors among many types of sensing elements, with the help of which exogenous geological processes can be studied. This type of sensors allows to perform independent measurements by each sensing elements, does not have rigid linking to reference points on the investigated territory, but records the angle deviations from the vertical line of that sensing element regarding to the Earth Center. This property of inclinometer sensors allows installing them as directly on building structures as on the investigated territory (in specially drilled boreholes, or on the surface [4, 5, 8, 9]). Electrolytic angle sensor allows to measure the angles with high precision ($s = \pm 1$ angle second) over the range ± 30 angles minute, ? potentiometric one – with precision ($s = \pm 2$ angles per second) over the range $\pm 10^?$. During changeover of the electronic blocks the range of measurement angles can be increased up to the required value. Appliance of two sensors – electrolytic and potentiometric in one block is caused by two reasons: potentiometric angle sensor allows to receive horizon plate owing to air bubble, i.e. set the direction of reference plane; electrolytic angle sensor allows to increase the sensitivity of measurement equipment at small angles and by that promote the increase of measurement precision.

Basic technical data and operation conditions of electrolytic and potentiometric sensors [4,5]:

1. The range of deviation angle measurement from the vertical line $\pm 10^?$;

2. Error (s) of angle measurement: in range $\pm 30' - 1''$; in range $\pm 10^{?} - 2'$;

3. Power supply by voltage of alternating current.......... $220V$,50 Hertz;

4. Consumption current..*not more than 0,5 ampere;*

5. Time of readiness for operation ....*not more than 30 s;*

6. Guarantee service life during 3 years.....………*2000 h;*

7. Mass...*not more than 0,8 kg.*

8. Temperature range of the surrounding air........*from - $10^{?}$?? $+40^{?}$? ;*

9. Relative humidity of the surrounding air *98 %* at temperature *$+35^{?}$?* .

Requirement to the sensors:

1. reliability;
2. possibility of operation in water, for example on CLLS, considering of sinking of the Livadiya palace, water in measuring boreholes starts from elevations 1,5 - 2 meter (depending on season);
3. hermetic fulfillment;
4. pressure input;
5. precision;
6. operating time for failure not less than the determined time.

Data from inclinometer sensors by parallel channels enter the analog-digital transformer, management of which is realized in "ADT" block of program "SENSOR", Fig. 1.

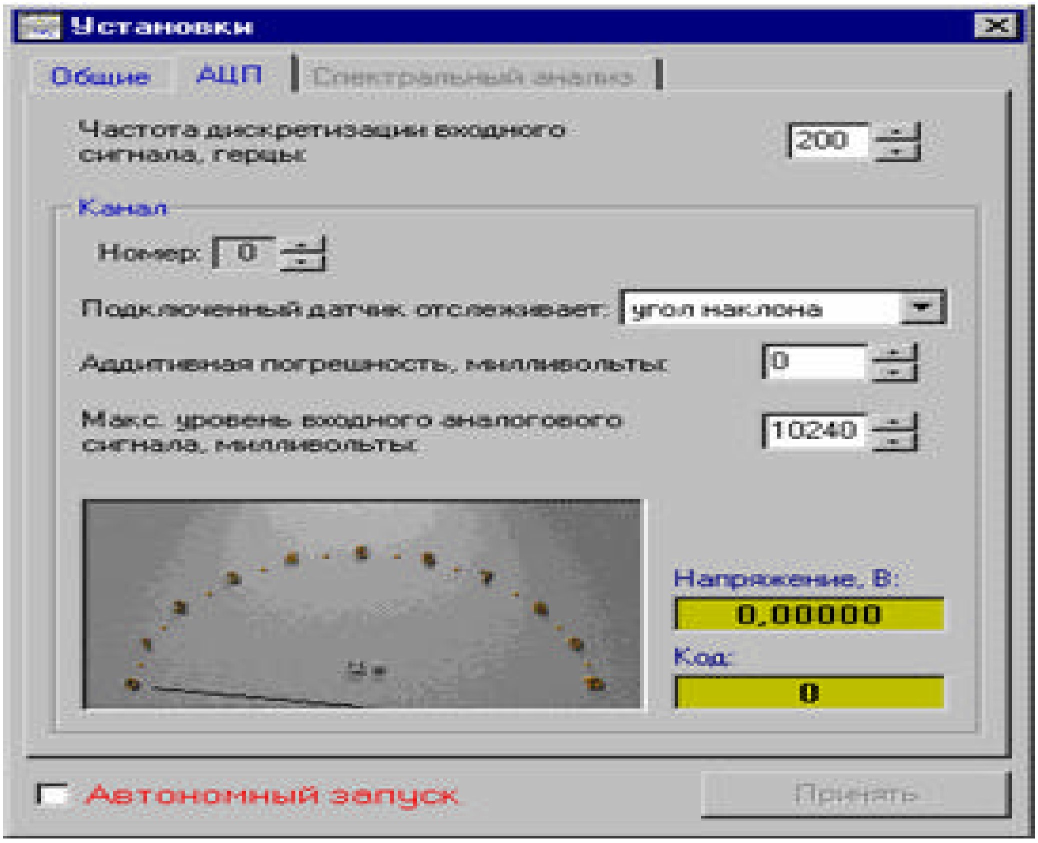

Fig. 1. "ADT" Block

Explanation to some parameters of "ADT" block (Fig.1):

1. *Sampling frequency of the input signal, Hz* – for experimental study of the exogenous geological processes, in which the dynamic regimes are possible with frequency **N** *Hz,* it is necessary in control panel of analog-digital transformer to establish frequency of signals recording **2N** *Hz* according to Kotelnikov-Naykvist theorem.
2. *Channel, number* – number of the channel of the analogous-digital transformer, to which the I-inclinometric sensor is switched.
3. *The switched sensor traces* – type of the measured physical value.
4. *Additive error, mV* – measurement additive error according to the given channel (sensor).
5. *Maximal level of the input analogous signal, mV* – maximal range of voltage changing, coming from inclinometric sensitive element by the given measurement channel.
6. *Voltage, V* - instantaneous value of voltage by the given measurement channel.

Other block "General" of program "SENSOR" manages the regime of initial processing of statistical information and regime of data storage (Fig.2.).

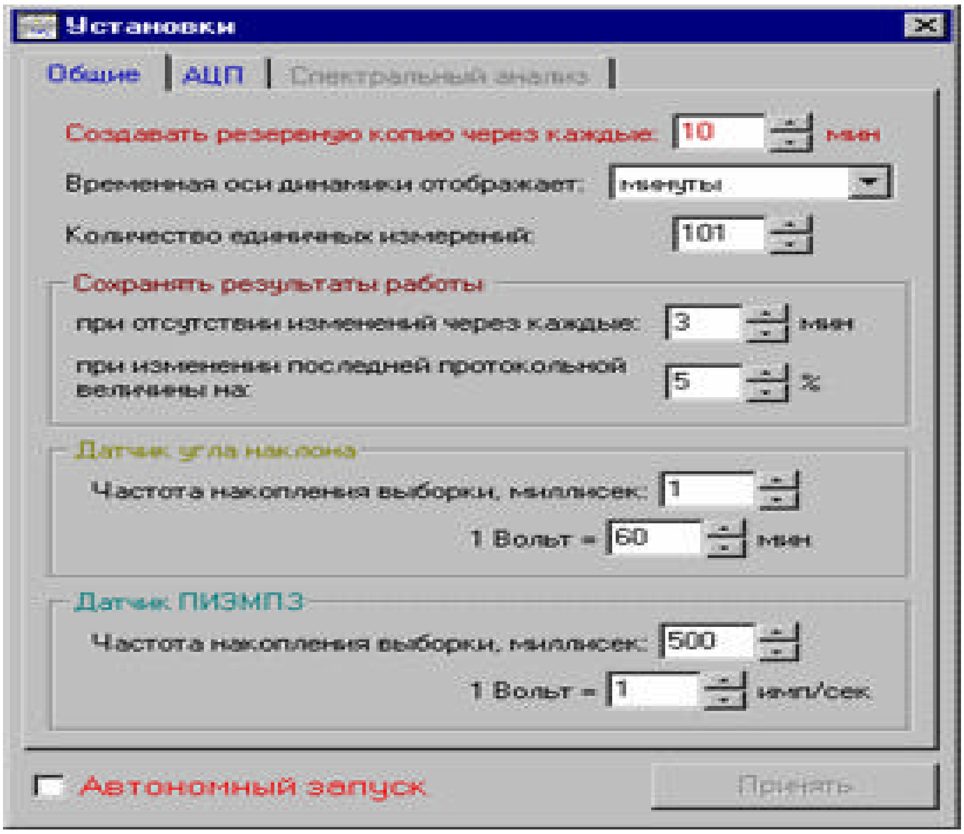

Fig.2. Block "General"

Explanation to some parameters of block "General" (Fig.2):

1. *To create a backup copy in every* – a back-up copy is created by archiving all files, which correspond to pattern Snsr#*.* using an archiver (pkzip.exe). The archive is located into sub-directory BUCKUPALL.

2. *Sensor of deviation angle. Frequency of selection accumulation, ms* – selection frequency of ADT selected channel, to which a certain inclinometer sensor is switched (sensors selection is performed in sequential regime).
3. *Dynamics time base reflects* – scale of time base.
4. *To save the results of work:*
5. *At absence of changings in every*
6. *At changing of the last protocol value on* - storage regime of initial statistical processing data.
7. *Sensor of deviation angle. 1 Volt* – establishes scale between voltage, coming from inclinometric sensors and angle deviations.
8. *Autonomous start* – with established target immediately after ? S loading completion the program starts automatically.

At cursor pointing on text field one can change the parameters of settings. At cursor staying on a certain field of blocks "ADT" and "General" a prompt appears in a certain time with the range of permissible values of the changed parameter. Work of program "SENSOR" (data accumulation, correction, processing, etc) stops at active window of blocks "ADT" and "General". All made changes come into effect only at the next starting of the program "SENSOR".

Initial statistical processing. The transformed analogous signals using ADT from each inclinometric sensor pass the initial statistical processing. The initial statistical processing, realized in program "SENSOR", corresponds to Code 8.011-72 (Indices of measurement accuracy and form of presenting the measurement results) and consists of the following:

- minimization of scope of random values selection (many-times measurements) at set confidence probability;
- description of its statistical parameters at unknown law of distribution of density function of random value;
- calculation of the interval of angle deviation uncertainty with set confidence probability;
- accumulation of statistical parameters about deviation angles in time;
- detection of changing of deviation angle with quick informing of duty operator;
- spectral analysis of selection of repeated measurements data;
- regression analysis of measurement results and prognosis of the registered process development;
- graphic expression of the results of data initial processing of repeated measurements on display;
- creation of the protocol archive of the repeated measurements results processing with storing it on the personal computer hard disk.

The mathematical model of the initial statistical processing of measurement information of the exogenous geological processes has been developed according to the requirements to control and program complex on data registration and is designed for solution of the following tasks:

- detailed presentation of the measurement results according to Code 8.11-72;
- generation of precise confidence intervals of data scattering taking into account errors of the measurement system;
- detection of even insignificant but statically authentic changings of exogenous geological processes data using a checking method of statistical hypotheses;
- prognosis of the processes development by changing of a number of parameters:

1. prognosis by changing of form of the distribution law of isolated measurements selection;
2. prognosis using measurement information results obtained over final period of time (monitoring time).

In this program of the initial processing of measurement information the calculation algorithm of the confidence interval with probability ? = 0,90 is realized:

1. Firstly on the basis of numerical simulation on the personal computer it has been ascertained that there is dependence between error distribution law and necessary selection scope (quantity of isolated measurements) for obtaining the corresponding statistical assessment with set relative average quadratic errors.
2. Secondly changing of the type of error distribution law often can be the sigh of any changing of the experiment performance.

This circumstance can be used at building structures monitoring and prognosis of their development. As long as on the one side changing of selection excess and asymmetry can occur without changing of selection center and dispersion, and in the other side changing of the lower statistical moments (selection center and dispersion) cannot happen without changing of higher statistical moments (excess and asymmetry). Thus they can be the signals to further changing of selection center that can play an important role at early prognosis.

The mathematical model of initial statistical processing and the algorithm developed on its basis represent an open system. It can be adjusted to a certain type of the measurement angle that will give the possibility to increase the measurements authenticity (for example to change the selection scope of the isolated measurements for certain distribution laws of density function of the measurement data, to perform digital signal filtration at presence of noises, to perform signal correction at presence of considerable dynamic error).

Database. Database concerning heliumgenic and lithogenic parameters is being performed for analysis of the correlation dependence between solar and landslide activity on the central Livadiya landslide system. As there is no necessity to use the automated system of the initial information collecting and accumulation to study these processes (periodicity of increasing and decreasing of the solar activity makes 11 years [1]), at this data are introduced in manual regime into personal computer using program "ZSUV" (Fig. 3).

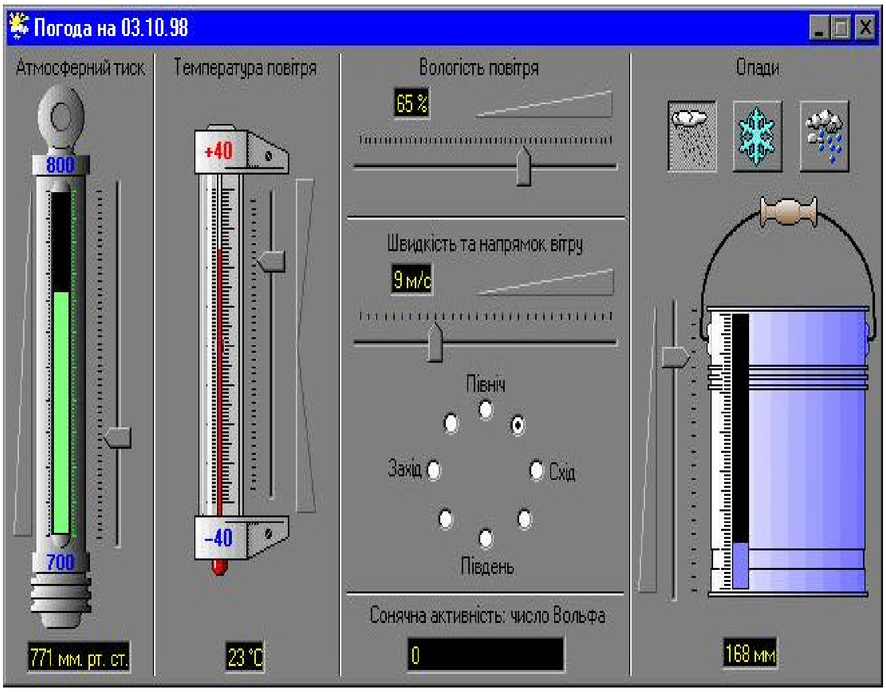

Fig. 3. Program "ZSUV"

Heliumgenic parameters include solar activity, changing of temperature and moisture regimes, character and intensity of precipitation, wind activity and so on. Lithogenic parameters are the totality of conditions and factors characterizing the mechanism and dynamics of changing of the balanced state of CLLS slopes.

Management of control points displacement CLLS is performed using visual observations of the landslide surface and further manual introducing of the information into personal computer using a specially realized analogue for geoinformational system of the program "ZSUV".

Conclusions.

1. Specificity of the initial information formation concerning dynamics of the building structures on the real example of the landslide process dynamics of the central Livadiya landslide system has been studied.
2. Combined with high-accuracy measurement sensors and ADT the program “Sensor” in real time regime allows the following :

- to trace seismic activity CLLS and reaction to it of the building structures of the Livadiya Palace (dynamic characteristics);

- to trace deviation angles of the separated elements of the Livadiya Palace and CLLS (static characteristics);
- to trace level of groundwater and precipitation CLLS;
- to trace parameters of the landslide-hazard territory CLLS and to warn in advance about hazardous development of events;
- to perform initial statistical processing of the obtained data;
- to perform archiving of the obtained data and results of the initial statistical processing.

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OBJECTS AND PROCESS INTEGRATION FOR SUSTAINABLE CONSTRUCTION

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1. Abstract

Within the built environment, the increasing use of IT as an enabling agent to integrate design with construction is challenging historical product and process management models which are associated with traditional protocols for information generatio n and exchange. Invariably these traditions and their associated professional role definitions and working practices rely on paper based methods for recording and distributing information between disciplines within design teams and between building designers constructors and managers through abstracted representations of construction elements based on orthographic projection using diverse information sources such as drawings, specifications and bills of quantities. Increasingly, IT offers a fresh dynamic for information exchange through the facility to define virtual building components and assemblies during detail design and embed them with information which can be carried through construction and service life, providing virtual databases to inform the processes of assembly, use, maintenance and recycling phases serving whole life use. This paper will discuss aspects of collaboration, integration and co-ordination through the built environment supply chain. Particular reference will be made to pedagogic issues associated with teaching and learning for sustainable design, construction and deconstruction. The paper will articulate theoretical methodologies and practical applications of the concept of design for deconstruction and recycling using the context of IT based experimental work, [1] including undergraduate student projects developed around the provision of recyclable housing for urban communities.

2. Paradigms for sustainable construction

2.1 The United Nations position: a global strategy

The current United Nations Energy and Environment Programme (UNEP) [2] places a premium on raising awareness among built environment design and construction professionals to consider and respond to the medium to long term effects of their decision making and consequent interventions on local and global physical environments. This initiative has been described as "sustainable building and construction" [3] and suggests an holistic and whole life approach to the design, construction, management and, where necessary safe disposal of buildings and infrastructures at the end of useful service life. Although its strategic objectives are clearly stated, the UNEP acknowledges that it is difficult to formulate a language to articulate universal principles and practice for sustainable construction. Primarily this is because concepts of sustainability tend to be diverse, evolving, lack precise definition and could include a range of wide ranging and sometimes mutually exclusive imperatives such as:

- dealing with finite resources particularly in relation to energy issues
- embodied energy of building materials, components and systems
- energy consumption of buildings in use
- energy related design concepts
- economic and social stability
- aspects of cultural heritage in relation to physical environments [4]

2.2 Contextual and regional issues

An added difficulty in establishing a universality of definition is that, taking a global view, the contexts for application of sustainable building and construction theory are broad. These may range from developed market economies where priorities for energy saving suggest a focus on technical solutions [5] (see Figure 1) to developing countries where, at this point in time, the meaning of sustainability may primarily be bound into the application of strategies for physical survival, social equality and economic stability [6]. In consequence, not only does sustainability raise substantive issues for consideration and action, but also in terms of allocating resources the question of the relative balance in prioritising between these issues depends on context.

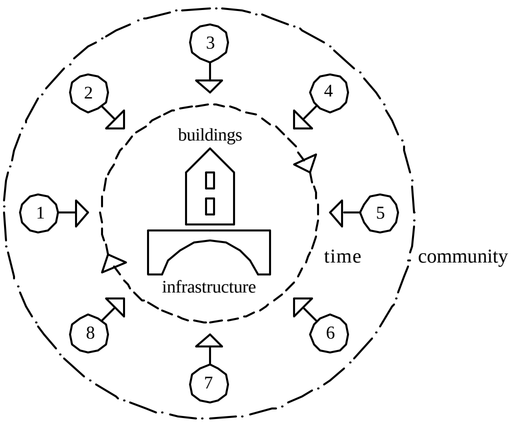
2.3 The European position

At a regional level where developed economies are prevalent, the European Union (EU) defines sustainable construction as "the use and/or promotion of a) environmentally friendly materials, b) energy efficiency in buildings, and c) management of construction and demolition waste" [7]. At face value, in terms of contemporary thinking, this definition seems rather narrow and devoid of context, particularly in the situation where current EU membership may include a range of socio-economic circumstances among participant states.

Figure 1. Photo-voltaic pergola at Barcelona's Universal Forum of Cultures produces 1.3 megawatts of electricity; "roughly the consumption of 1,000 Spanish homes" [8]. *Metamorphosis of the technical solution into an art form and an exemplar of the enduring temptation to customise built artifacts around new technologies* [9]

2.4 The closed loop model

One development from the broad raft of UNEP imperatives offered to stimulate thinking and actions on sustainable construction proposes a closed loop approach [10] (see Figure 2) which prompts building designers and their co-professionals to be proactive in ensuring that "building materials, structures, industrial systems and settlements no longer deplete the resource base but rather operate in continual cycles of production, recovery and manufacture"[11]. In developing design propositions and *sustainable* solutions, the closed loop approach seeks to link primarily technical issues with the context in which they will be applied. In this sense, the paradigm is generic, not context specific.



1 materials extraction and re-use
2 component manufacture
3 formation of assemblies
4 construction
5 use/adaption/re-use
6 deconstruction
7 assembly/component re-use
8 material recycling

Figure 2. Closed loop paradigm for sustainable construction

3. Education, knowledge transfer and communication

3.1 Overview

The education of the next generation of built environment professionals holds a key position in transferring strategic policy and evolving ideas for sustainable design and construction into meaningful actions, not so much in terms of developing the precipitate and short term, for example technical solutions, but more so in shaping attitudes and establishing a dialogue through enquiry, analysis and synthesis of which will ensure an holistic and consequential approach to sustainable building across a range of countries and their communities over the next 25 years. The structure and mechanisms for knowledge transfer are also important in ensuring that strategic policy as discussed and promulgated at an international level is translated into meaningful actions at regional and local levels. In this respect, undergraduate education is seen as a mechanism or transposing strategic thinking into best practice and IT as the most appropriate means for facilitating knowledge transfer and dissemination (see Figure 3).

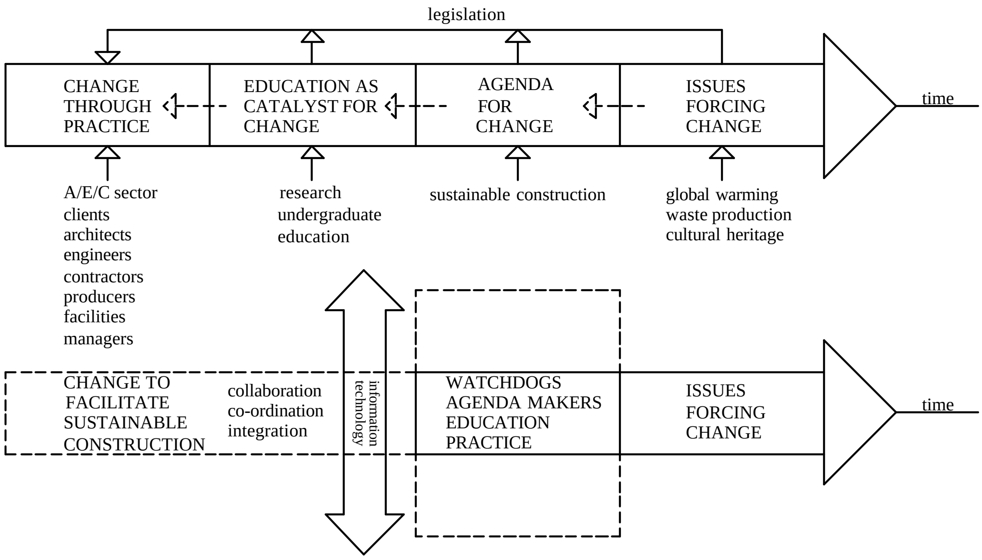


Figure 3. Sustainable construction: theoretical process models for change

3.2 Research aims and methodologies

Through investigation, observation and case study analysis, the ongoing research aims to generate inclusive strategies for the teaching and learning of sustainable construction. These strategies focus on issues of collaboration and integration of information over the whole life of buildings using a theoretical closed loop model which links product (the building and its immediate environment) with context (local, regional and global environments). The research methodology uses current mainstream industry practice as a starting point and data is collected using the observation-participation method [12] in which the researchers are not merely passive observers, but assume a range of roles within case study structuring and development [13]. The use of IT is central to the development of the pedagogic methodology both as a medium for product/process development and as a portal to facilitate the sharing and dissemination of information in digital formats. In this respect, the academic model is seen as a possible precursor for change in a real-world context. Formation and development of case studies is through student projects written as instruments of assessment within The Robert Gordon University's undergraduate programme in architectural technology. In the UK, the architectural technologist (elsewhere may be known as technical architect or constructing architect) is deemed to fulfill a key role in ensuring integration of product and process development across professional disciplines. Undergraduate students are active participants both in case study development and through contributing to output through research papers. Although the model was devised primarily as a vehicle to develop knowledge and understanding at advanced levels of undergraduate study in a discipline specific context, it has also been applied to entry level built environment teaching and learning projects for groups working in cross-discipline teams. The EU SOCRATES scheme which encourages student and tutor mobility across geographical boundaries brings a pan-European dimension to the work and the current programme aims to contribute linked and evolving output to the regional dialogue on sustainable construction in 2004 and the world summit in Japan in 2005.

4.0 Teaching and learning concepts and strategies

4.1 A performance based rationale for teaching sustainable construction

The undergraduate programme in architectural technology is not specifically about sustainable design. Rather it aims to introduce concepts of good design which, of course should be sustainable [14]. The challenge is formulating a strategy for "good design", taking account of a range of imperatives for sustainability. The primary aim is to introduce students to and develop an understanding of the integrated nature of building design in terms of realising a symbiosis between the a building's component parts or systems and their aggregation or separation during the phases of design, construction, use/adaptation and deconstruction as relates to the wider ranging issues of building performance on a whole life basis. Taking a whole life view is a necessary precursor for a closed loop approach to teaching and learning for built environment development. This rationale is not exclusive to building designers, may be applied across conventional professional discipline boundaries, takes account of the needs of clients and building users and could equally pertain to the development of infrastructure. In fact, it could be argued that buildings and infrastructure are inevitably linked. The key issue is mutual inter-dependence, whether applied to elements of product or process and linkage to local, regional and global environments. Performance based design focuses specifically on the relationship between design decisions made, invariably across discipline boundaries, and the impact of these decisions in respect of whole life issues relating to building performance. For example, a simple performance based model for sustainable construction is offered by Canada's federal housing agency the Canada Mortgage and Housing Corporation (CMHC) in respect of healthy housing [15] which should be:

- resource efficient
- energy efficient
- affordable
- environmentally responsible
- built to maximize occupant health

Each of the performance criteria may develop into sub-sets of imperatives for building performance which could range across discipline boundaries and the model is conducive to audit at any stage of design, construction and whole life use. In addition to issues which could be read as being building specific and explicit, for example occupant health in relation to indoor air quality, the performance framework also suggests issues which are more strategic, eg resource efficiency suggests waste minimization, one of the underpinning principles of a closed loop approach to sustainable construction.

4.2 Object oriented design: real-world and virtual models

The case study reviewed later in this paper has been developed using object oriented design (OOD) techniques within the context of a closed loop model for sustainable construction. Unlike conventional methods for abstracting buildings and their component parts through two dimensional orthographic drawing, object oriented design uses the powerful medium of IT to generate 3D CAD models which are constructed to represent components, assemblies and whole buildings in a virtual environment [16]. In effect, this means that because the mode of representation is transposed from 2D into 3D, the ensuing visualization looks like the *real thing*. This paradigm shift adds value by extending the domain for knowledge and understanding of the representation beyond building professionals [17] and into a new field which includes clients and building users. In this respect, and in the wider context of the current research, the use of object oriented design extends the performance concept. If a temporal element is added to the visualization, the concept of 4D CAD emerges. This provides linkage between 3D visualization and elapsed time. It is pertinent to note that adding a fourth dimension to the object oriented model offers huge potential for developing process tools associated with sustainable construction. In respect of the closed loop approach, ongoing and future research will use 4D CAD tools to define processes of sustainable construction and deconstruction.

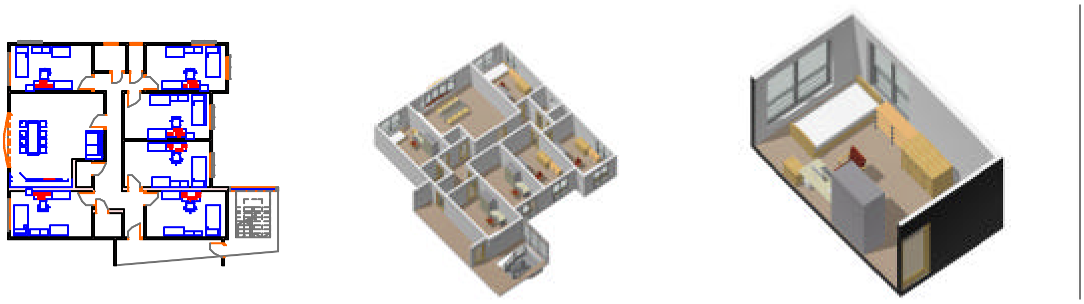


Figure 4. Conventional (left hand view) and object oriented modes (centre and right hand views) of representing the same area from a case study student project under design

Object oriented design is not limited to the construction of virtual objects as solely graphic representations of buildings and their component parts. Effectively, the object oriented approach is a sub-set of the broader paradigm [18] of building information modelling (BIM). The building information model is based on the generation of a structured alphanumeric database which can be initiated and continuously updated for a building or infrastructure under design [19] and developed as the building evolves through the whole life cycle implicit in a closed loop approach to sustainable construction. The model is accessible to a range of participants including clients, professional disciplines, contractors, facilities managers and building users. In this respect, the power of IT is manifest not as a (passive) means to an end, but as an (active) catalyst facilitating the process of attaining goals for sustainable construction through collaboration, co-ordination and integration of information. This is the message that we encourage our undergraduates to engage with in developing and projecting their ideas beyond attaining project specific goals towards consideration of the longer ranging impact of their design decisions on local, regional and global environments.

4.3 Design for disassembly

Within a closed loop approach to whole life building performance and consequently sustainable construction, it is essential to consider the impact of design decisions made at concept and detail design stages on the future potential for buildings and infrastructure to be adapted for partial or complete change of use [20] and disposal at the end of useful service life [21]. This premise applies particularly to the safe and productive disposal/reuse of materials within the supply chain while minimizing impacts on associated environments (see Figure 5). This approach has been called Design for Disassembly (DFD) [22] and forms a key part of both the structuring of the case study reviewed later and in forming a focus for continuing research. The latter is concerned with linking protocols [23] which could impact on design decisions with the labelling of building assemblies/components. Labelling leads to consideration of the exchange of information between real and virtual objects (within building information models) using radio frequency identification (RFID) [24]. In this context it is interesting to consider the potential relationship and dialogue between *hard* (IT) and *soft* (green building) approaches [25] in pursuing the common objective of articulating definitions and practices for sustainable construction. In developing ideas as a precursor to actions, it has been suggested, [26] for example, that housing designers should consider the application of DFD as a function for facilitating whole life change through *strategic actions* to be incorporated into the design process, inter alia

- designing for versatility to allow components, assemblies or systems to accommodate change of function
- utilising simplicity of design to reduce the complexity of assembling materials, thus facilitating disassembly
- favouring independence of materials within assemblies to allow for minimum damage during maintenance, disassembly and removal
- making significant labeling information explicit on each component or material of an assembly to assist with reuse or disposal after disassembly

- exposure of mechanical connections where possible to facilitate disassembly
- making materials or components with the shortest anticipated life most accessible

and *design drivers* applicable to the proposition and application of construction technologies for housing to facilitate layers of whole life change for maintenance, replacement, alteration or complete disassembly for relocation or disposal through

- the principal structure transferring dead and live loads to the foundation system to be demountable
- internal partitions to be designed as independent of the principal structure
- external and internal finishes to be removable using hand or non-specialist power tools without significant component or material degradation
- push fit or mechanical connectors for all services
- an assembly or disassembly rationale which facilitates progressive disassembly in sequence of roof, internal partitions, floors, external walls and foundations

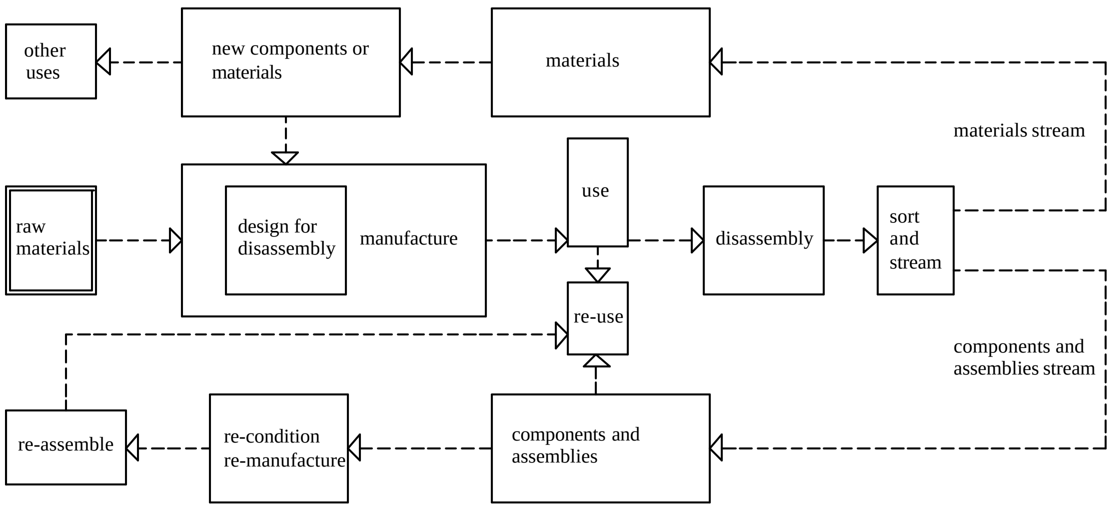


Figure 5. Design for disassembly model based on a theoretical closed loop for reuse and recycling of materials, components and assemblies. After Young & Wright [27]

5.0 Case study structure: performance based brief for sustainable construction

The case study for review was based an undergraduate project which was required to generate a design and procurement strategy for a mixed development comprising student housing and infrastructure on a post-industrial site inner city site on the east coast of Scotland. The project brief was devised taking account of a closed loop approach and drafted on a performance basis. While not being wholly prescriptive, the brief set out a range of implicit design criteria. In terms of relationship between design proposition and local context, the project was required to comply with the city council's published design guidance for promoting "sustainable development" [28] which identified a number of key areas:

- the aim is to build on local character not to copy it
- development should respect the constraints of the site and the detailing should draw strength from local identity
- an attractive and well detailed landscape plan should be developed in conjunction with the built form design
- the existing site and surrounding infrastructures must be enhanced to provide a valid network of permeable streets and attractive open amenity spaces to strengthen the local community facilities

Beyond local context, the brief set out a number of performance criteria framed as client imperatives. Each of these criteria was deemed to have an impact on sustainable construction:

- the importance of consulting with potential building users during the design process
- affordability for building users
- use of off-site prefabrication where such techniques could offer gains in terms of time, cost and quality
- maximizing passive energy sources and bioclimatic design
- flexibility of building layout in use to facilitate adaption for given and future occupancy types
- design for disassembly and recycling

The given performance criteria were not intended to constrain design, rather to provide a framework within which students could develop a more personal but disciplined approach to sustainable construction on a whole life basis [29].

6.0 Case study review

The case study development was progressed in two stages. A formative phase which was conducted as group work. This comprised students carrying out analytical research on the given site, its context and the needs of building users and the formulation of a design strategy. The latter was intended to propose a range of design imperatives which developed from the performance based brief. Typically, a design strategy included:

- results of a user needs consultation through questionnaire review including design requirements to meet the needs of physically challenged building users
- social infrastructure requirements based on observation and analysis of local facilities
- conceptual proposals for building design based on considerations relating to local, regional and global environmental issues

- indicative proposals for physical infrastructure, building services, and external spaces including hard and soft landscaping
- proposals for the minimisation and disposal of waste

This phase also included the preparation of a 3D CAD model of the site and its environs to form the basis for observational and analytical environmental analysis using IT software. It was the intention that the 3D CAD model would form the basis for a building information model but this proved to be too ambitious based on time constraints set for the project and CAD hardware/software limitations. The group phase was followed by project development by individual students and the evolution of performance based design strategies into scheme and detail design propositions. These were audited against the performance criteria set for the project by cross-discipline tutor review and critique. In terms of achieving sustainable construction, tutors sought to determine that student projects achieved some synergy of purpose and representation. Although such a synergy is difficult to define, where achieved, it was usually explicit in the student work presented.

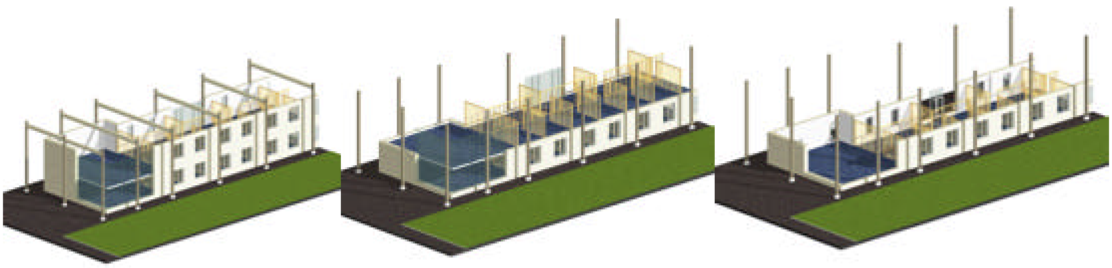


Figure 6. Sequential views from a building information model of a student project showing the *progressive sequence of disassembly at the end of service life following Catalli's* [30] *principles*

7.0 Conclusions

The research efforts presented in this paper have embraced issues associated with the implementation of sustainable construction in an academic context and using object based IT to facilitate collaboration, co-ordination and integration of design propositions. There are deemed benefits of projecting this academic effort into a real-world domain of construction practice.

- In framing and developing a universal view of sustainable construction, it is essential to link technical solutions with context. This may be applied in a generic way using a closed loop model for whole life building and infrastructure review

- The whole life closed loop paradigm presents a useful model for developing undergraduate teaching and learning strategies as a vision which reaches beyond contemporary AEC practice. This pedagogic approach lends itself to accelerating evolution and change for sustainable construction over the next 25 years

- The use of IT, in particular to develop object oriented design and building information modelling suggests a powerful tool for the integration and dissemination of information among a range of actors including clients, professional disciplines, contractors, facilities managers and building users over the whole life of buildings and infrastructure. It is suggested that this integration is a key component of achieving sustainable construction.

8.0 Further research

Ongoing research is focusing on development of the building information model as a database of graphical and alphanumeric information in respect of sustainable construction. In particular the work will develop frameworks for the tagging of building components/assemblies [31] and the use of RFID technologies to link real buildings with virtual models. The purpose of this work is to develop protocols for the safe disassembly of buildings, either partially to facilitate adaption/reuse or in respect of recycling at the end of useful service life. It is intended that this development from the current paper will evolve to a stage where the ongoing research can be presented at the world summit on sustainable construction in Japan in 2005.

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BUILDING-PLANT COMPLEX PERFORMANCE ANALYSIS STRATEGIES AIMED AT THE ENVIRONMENTAL SUSTAINABILITY

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1. ABSTRACT

Recent black-outs highlighted how critical the energy system is at present, from production to end-uses. A way to face such an issue, considering both the growing energy demand trend and the consequent environmental impact, in industrialised and developing countries, is to encourage the improvement of end-uses efficiency.

In particular, with regard to the construction sector, the European Directive 2002/91/CE stimulates the definition of energy diagnosis strategies aimed at increasing the knowledge of the building-plant complex characteristics, to optimise its energy performances. Besides that, the promotion of cost effective building solutions helps to raise the buildings' environmental sustainability level.

In this context, ITC-CNR carried out specific activities, that foresaw the use of building-plant complex energy simulation tools, defining as outputs, indicators that were to support and guide designer's decisions. To reach this objective a building was chosen as case study; it was analysed both experimentally and through dynamic simulations. The building analysis was completed by verifying the level of the indicators laid down by the national legislation.

The results achieved through the simulation were compared with the experimental results in order to validate the input scheme defined for the building. Having assessed the reliability of such a scheme, it was possible to compare various configurations obtained by interventions on the envelope with specific building technologies and on the plant by the adoption of novel components and a different management.

The performed study allowed to develop a data analysis methodology able to assess the effectiveness of interventions made on the building-plant complex and to quantify the energy saving and the environmental and economic impact also in correlation with the building's activity schedules and with environmental conditions.

2. INTRODUCTION

One of the main aspects to define the building environmental sustainability level is the operative consumptions of primary sources.

The Directive 2002/91/CE application should carry a general improvement of the building-plant complex characteristics, also through the energy performance certification imposition, in order that it will become one of the fundamental items in the property evaluations, both directly having affect on the building value in a sale and indirectly becoming a necessary condition to assign any fiscal discount, that transforms in currency units the produced environmental benefits.

There is the need to harmonise the assessment methodologies to allow also and above all the final user to carry out a main role in every building life phases: design, realisation, maintenance, refurbishment, etc.

In this way a larger use in the analysis procedures of a life-cycle approach is hoped, since a building is the synthesis of design choices, not always aware of the produced environmental consequences in the building itself and setting elements life phases.

The here presented work is a part of this context, analysing the building operative energy performances problematic with the aim to define a methodology and relative performance indicators able to interface with the environmental sustainability assessment tools.

3. OBJECTIVES

More than the environmental policies promoted by the heads states, have to be increased the final user or buyer awareness of the performances that may be required by a building.

In synthesis the specific objectives may be schematised as follows:

- to define performance indicators that allow to have a dialogue among the building stakeholders and that contribute to increase the awareness of the real building value;
- to define understandable benchmarks that refer to standard schedules with regards to the internal gains and activities;
- to define integrated analytical and instrumental methodology, that, through characteristic indicators, allow to identify the real building characteristics;
- to demonstrate the reliability of the simulations results as a useful tool integrated with the designer activities.

This paper deals specifically with energy diagnosis methodologies through simulation tools and with the definition of a methodology aimed to the determination of energy performance indicators that, further than determine the needed parameters for the environmental sustainability assessment tool, allows to increase the building behaviour knowledge of designers, builders, installers, investors, managers, final users.

4. METHODOLOGY

The building environmental sustainability assessment need expertise and skills in several sectors with regards to the building physics, the environmental sciences, the economy, the transport, the civil and building engineer, the chemistry, etc.. In general the necessity to manage in an effective way a problem with a huge number of variables, some dependent of each other and some independent, with linearity and non-linearity, carry to simplifications and to subjective evaluations for example in the weights attribution or in the credits to be assigned to a thematic area rather than another. The implicit uncertainty in the environmental sustainability assessment tools, called of III level [1], and the consequent attribution of qualitative and quantitative score could absolutely be reduced with the standardization of the input parameters calculation methodologies, that are II level assessment tools focused on specific thematic areas and needing the same specific knowledge.

In the context of the building environmental sustainability assessment, the energy analysis, both experimental (in real working conditions) and analytical (with dynamic calculation tools) is one of the most meaningful, particularly if it is together with LCA analysis with regards to the main environmental and economic (LCC) indicators.

These analysis carried out with second level tools determine as output, as stated above, results to use as input by the successive level tools (BREEAM, LEED, GBTool, …), that assign a building determinate environmental sustainability rate.

Having to define a methodological approach that allows to carry out the energy performance diagnosis of new (design) or existent (retrofit) buildings, a series of performance indicators were defined, synthesising the complex building-plant behaviour and allow to comply with the in force legislation and the energy saving principles.

The methodology was applied to a case study that is an experimental building of three floors above ground, 100 m^2 each, built at research aim at ITC-CNR area. The used simulation tool was EnergyPlus with which the building-plant complex was schematised; the results were compared with the experimental ones collected in a previous experimental campaign, carried out by ITC with the aim to validate the defined scheme.

Having verified the reliability of such a scheme, it was possible to compare different building configurations, obtained by intervening on the envelope with specific constructive technologies and on the plant by introducing new components and changing the management modes.

EnergyPlus allows to make energy diagnosis, that is the starting point for a proper design and for a careful energy retrofit and makes it possible to verify and quantify the energy saving, supporting the designers decisions both in the preliminary and in the executive phases, avoiding disadvantageous solutions in terms of overall energy balance.

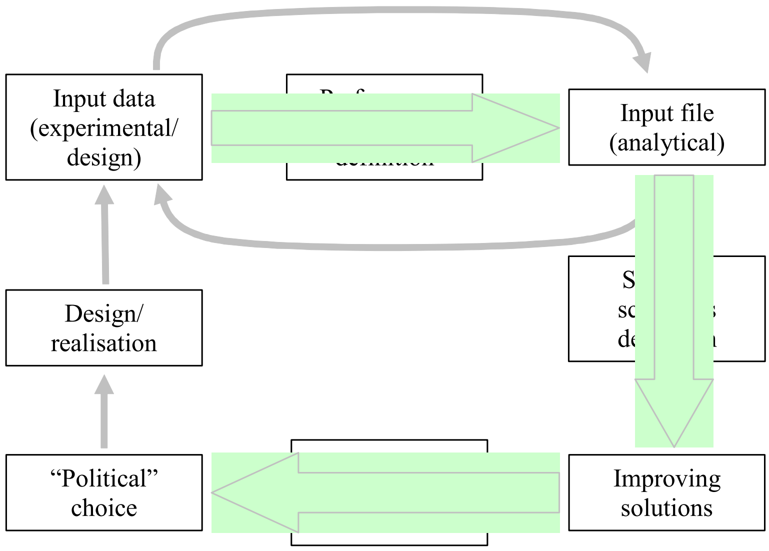


Figure 1. Scheme of the analysed methodological context

A synthesis of methodological frame is shown in Figure 1, where the analysis were carried out, in particular defining simulation tools input schemes validation procedures, standard schedules with regards to the activities (type, intensity, technological plants use) and optimal solutions development procedures.

4.1. Tested building-plant configurations

Four building configurations were tested:

1. experimental: uninhabited building in real conditions;
2. use conditions: obtained by hypothesising a residential destination for the previous configuration;
3. retrofit 1: obtained by hypothesising an envelope thermal insulation improvement and a boiler power reduction;
4. retrofit 2: obtained by hypothesising an envelope thermal insulation improvement and plant components modifications.

The first retrofit solution was focused mainly on the envelope; with this kind of intervention the thermal dispersion highly decreased, as a consequence it was possible to lower both the boiler power and the flow temperature.

The following improving solution, retrofit 2, consisted in replacing the traditional boiler with a condensation one. Besides its high efficiency, the condensation boiler was chosen as a consequence of having selected a low temperature heating system using wall radiant panels.

4.2. Model validation

The method used to validate the developed model was the one making use of degree-days as indicators of the building energy need [2]. This method allows to cancel the differences caused by the different climate conditions between the "weather file" used for the simulations and meteorological conditions during the experimental period. A relationship is defined between the consumptions trend and the degree-hour, evaluated as the difference between a reference temperature and the mean hourly external temperature. The following expression was used:

$$GH = \sum_{i=1}^{4392} \left(T_{bi} - T_{ei}\right) \tag{1}$$

where:
i is the i-th hour,
4392 is the number of hours in the conventional heating period (183 days);
T_{bi} is the reference temperature (°C);
T_{ei} is the mean external temperature (°C).

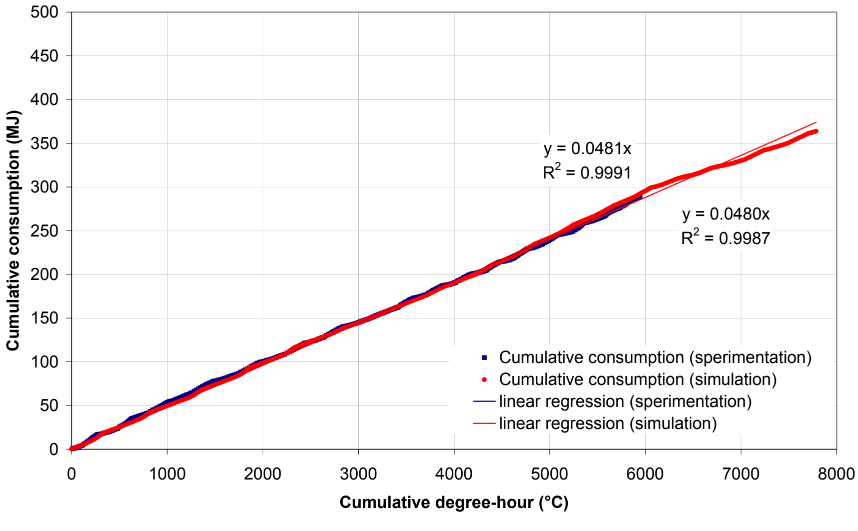


Figure 2. EnergyPlus building model validation

The reference temperature corresponds to the external temperature limit under which the building needs to be heated. In a simplified way, the thermostat set-point temperature was considered as reference temperature.

Then the hourly fuel consumption trend is represented, cumulated over the overall analysis period (4392 hours), as a function of the sum of the corresponding GH values. The two obtained curves (experimentation and simulation) are shown in Figure 2.

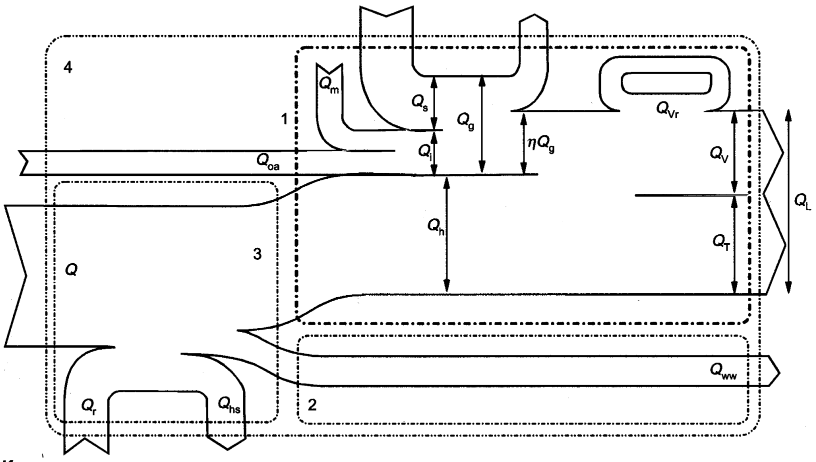
These curves can practically overlap with an error around 0.2 %, calculated by comparing the angular coefficient of the two regression straight lines.

5. RESULTS ANALYSIS

To evaluate the simulation results, specific indicators were defined as graphs and numerical values. These indicators are the outcome of output data processing, which are directly calculated by the simulation tool. They allow the comparison among several design configurations in terms of energy consumptions, that depend on a series of factors such as the thermal dispersion through the envelope, the free gains, the plant components and their regulation and management.

The key factor to analyse the results and in particular to evaluate the energy performances, is expressed by an overall energy balance (Figure 3) like the one in prEN 13790, where the building is assumed as an open system with an internal source, for which the following equation is valid:

$$Q + Q_{oa} + Q_r + Q_s = Q_V + Q_T + Q_{ww} + Q_{hs} + (Q_G - \eta Q_G) \qquad (2)$$



Key

Q	Energy use for heating	Q_h	Heat use
Q_{oa}	Heat from other appliances	Q_V	Ventilation heat loss
Q_r	Recovered energy	Q_{Vr}	Ventilation heat recovery
Q_{hs}	Losses from the heating system	Q_T	Transmission heat loss
Q_m	Metabolic heat	Q_{ww}	Heat for hot water preparation
Q_s	Passive solar gains	Q_L	Total heat loss
Q_i	Internal gains		
Q_g	Total gains	1	Boundary of the heated zone
ηQ_g	Useful gains	2	Boundary of the hot water system
		3	Boundary of the heating plant
		4	Boundary of the building

Figure 3. Energy balance for a building without summer cooling system

5.1. Consumptions

The results obtained with regard to the fuel consumptions are shown in Figure 4 where the energy performances obtained by the several hypothesised configurations are compared. To highlight the performances stated above, the cumulative consumptions are diagrammed as a function of cumulative degrees-hour. The use of degrees-hour allows to compare analyses carried out also with different climatic conditions. Output data interpolating straight lines, obtained by linear regression, were determined; this allows an immediate comparison among the different configurations, because the angular coefficient of these straight lines is an indicator of the building operative modality in terms of energy consumption.

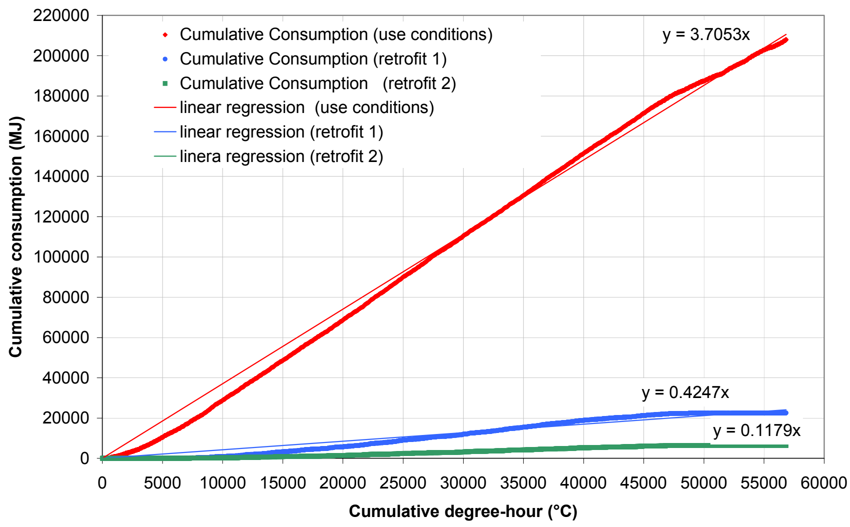


Figure 4. Comparison among consumption of the analysed configurations

Błąd! Nie można odnaleźć źródła odwołania. highlights how the second intervention (retrofit 2) had the best energy performance. This is confirmed by the Table 1 where annual fuel and electricity consumptions are shown.

Table 1. Simulated consumptions in the run period (15.10 – 15.04)

	Thermal consump. [MJ]	**Electric consump. [kWh]**	**Thermal cons. [kWh/m^{2}anno]**	**Base temperature [°C]**
Experimental cond.	273'804	3'696		
Use condition	207'963	4'446	234	14.2
Retrofit 1	22'523	3'655	25	8.9
Retrofit 2	6'332	3'655	7	8.8

Two indicators were defined to immediately evaluate the proposed interventions, from the energy point of view,:

- the kWh/m^2 year;
- the base temperature.

The base temperature by "Building energy signature" graph (Figure 5) put in relationship fuel consumption and degree-days:

$$E = a + b \cdot GG \tag{3}$$

where:
a is the parameter that defines the energy not dependent by meteorological conditions;
b is the angular coefficient of the straight line that defines the building thermal request;
GG are the degree-days.

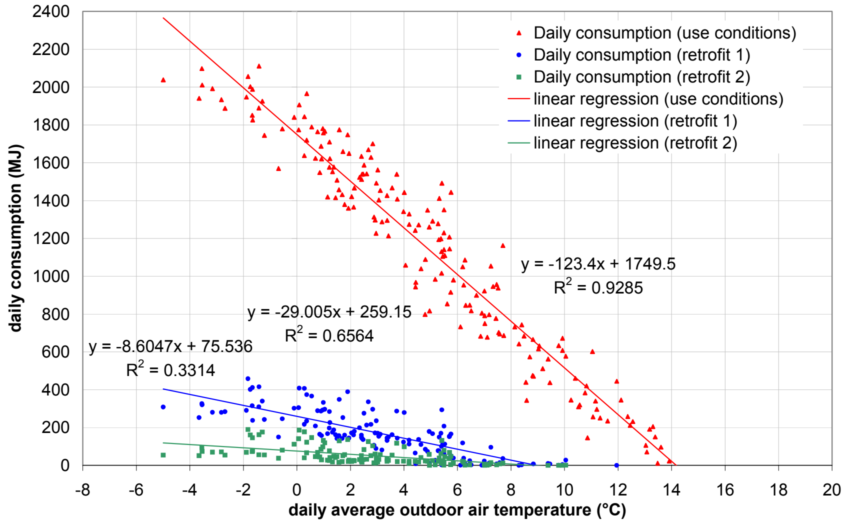


Figure 5. Building energy signature of the analysed configurations

The building is characterised by a straight line whose slope depends on the meteorological conditions and by a horizontal straight line independent from them (in this case coincident with the “x” axe, since only heating consumption was considered). The intersection of these two straight lines determines the reference temperature (T_{ref}) or base temperature. The building needs energy for heating purposes only when the external temperature (T_e) is lower than the reference temperature and the energy use is proportional to the difference (T_{ref}-T_e).

5.2. Losses and free gains

The first intervention consumptions reduction is essentially due to the increased vertical closing insulation. Thanks to this intervention the thermal dispersion was largely reduced (Figure 6). Besides, the further reduction of the losses through the envelope structure for the second improving intervention is due to the natural insulation layer, cork, and to the reflective aluminium sheet, both placed in the counter-wall, behind the radiant modules.

For the second intervention it is noticeable an increase of he energy expenses, because of the dispersion produced by the infiltration, more precisely from $2.86\cdot10^4$ MJ to $3.07\cdot10^4$ MJ; this because EnergyPlus calculates the thermal power depending on the temperature difference between outdoor and indoor, transferred as infiltration, as described in the follow equation:

$$\dot{Q} = \dot{m}_{inf} \cdot c_p \cdot (T_z - T_e) \quad (4)$$

where:

$\dot{m}_{inf}$ is the mass flow rate (kg/s);
c_p is the specific heat at constant pressure (J/kgK);
T_z is the zone temperature (K);
T_e is the external temperature (K).

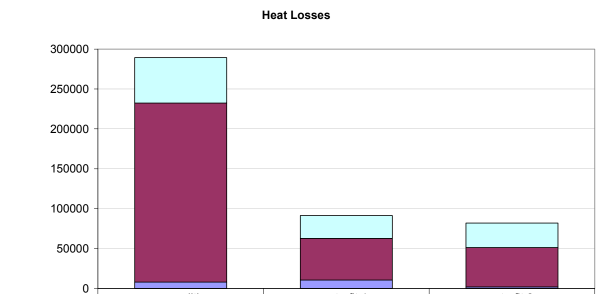
Being increased the mean zone temperature in the second intervention, also the heat loss increases proportionally, since the mass flow rate and the specific heat remain constant.

The same can not be said for the comparison “use conditions – retrofit 1”, since the low permeability windows application in the first intervention has a bigger “weight” with regards to the increase of the mean zone temperature. Then, for the evaluation of a solution against another it has to be taken into account its effect, considering the results in terms of energy balance.

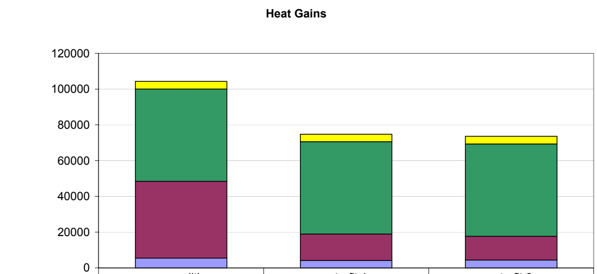
The free gains are progressively decreased in the three analysed cases, since the building was more and more thermal insulated and less and less dependent by the meteorological conditions. Such an aspect is shown in building energy signature graphs (Figure 5). The insulation application, as a matter of fact, modified the function that put in relationship consumptions and external temperature, whose linearity is greatly reduced. Then, the building energy signature is a meaningful analysis only for not insulated or scarcely insulated buildings.

The free gains reduction (solar irradiation) in the three considered configurations depend on the constructive choice of increasing the thermal resistance of the building envelope. This produced a decrease both of the dispersions and the external free gains. On the other hand the internal free gains (people, artificial lighting, electric equipments) remain constant and, as a consequence, they assumed a more and more important weight on the total.

The amount of heat blocked toward the external (losses) is bigger than the toward internal one (external free gains), with a relative energy balance: Q= losses – free gains, smaller and smaller.



	use conditions	retrofit 1	retrofit 2
infiltration [MJ]	56915.2	28616.4	30683.4
structures [MJ]	224319.5	52168.3	49216.4
windows [MJ]	8072.2	10694.4	2165.5



	use conditions	retrofit 1	retrofit 2
lights[MJ]	4289.9	4289.9	4289.9
people [MJ]	51596.4	51596.4	51596.4
structures [MJ]	43058.5	14721.8	13340.8
windows [MJ]	5376.4	4180.5	4353.0

Figure 6. Losses (sx) and free gains (dx) in the different building configurations

5.3. Energy balance through the glasses

The energy balance inside the thermal zone could be analytical schematised by the following equation [3]:

$$q''_{LWX} + q''_{SW} + q''_{LWS} + q''_{ki} + q''_{sol} + q''_{conv} = 0 \qquad (5)$$

where:
q''_{LWX} is the heat transmitted (long wave) by the thermal zone surfaces;
q''_{SW} is the heat transmitted by short wave emitted by the light sources;
q''_{LWS} is the heat transmitted by the long wave emitted by electric equipments;
q''_{ki} is the conductive flow through the wall;
q''_{sol} is the solar radiation absorbed by the surface;
q''_{conv} is the convective flow exchanged with the thermal zone air.

Each term of the energy balance is schematising introduced in Figure 7.

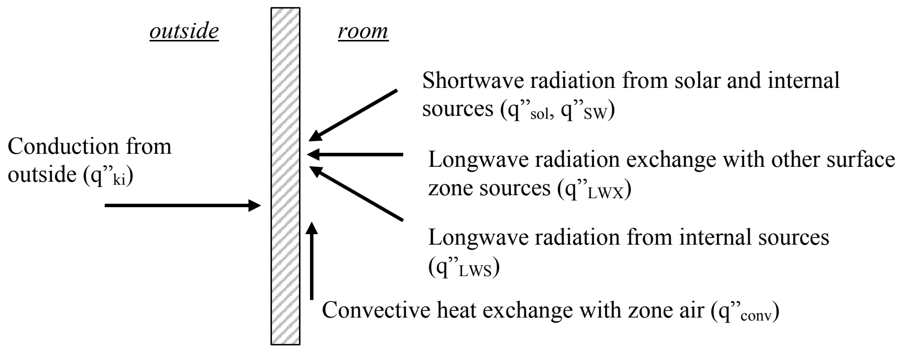


Figure 7. Energy balance inside the thermal zones

In the tested configurations q''_{SW}, q''_{LWS}, q''_{ki}, q''_{sol} are constant, then the (5) becomes:

$$q''_{LWX} + q''_{conv} = 0 \tag{6}$$

where q''_{LWS} is the sum of the flows exchanged among the surfaces and q''_{conv} is the convective flow.

$$\sum_{i,j} A_i F_{i,j} (T_i^4 - T_j^4) + h_c \cdot (T_a - T_s) = 0 \tag{7}$$

where:
A is the i-th surface;
$F_{i,j}$ are the view factors between surface i and j;
h_c is the internal convective coefficient;
T_a is the air temperature;
T_s is the surface temperature.

In the equation (7) the surface temperature increase produces very meaningful variation since that term is raised to the fourth power. In the first intervention the insulation and the counter-wall application produced a consequent increase of the mean surface temperature from 13 °C in the configuration "use conditions" to 19 °C.

The increase of the term q''_{LWX} in equation (6) for the bigger thermal flow emitted by the wall justifies, in the first retrofit intervention, the loss through the glass increase even if a window with a double glass having a thicker gap (12.7 mm against 6 mm) filled with argon gas was used.

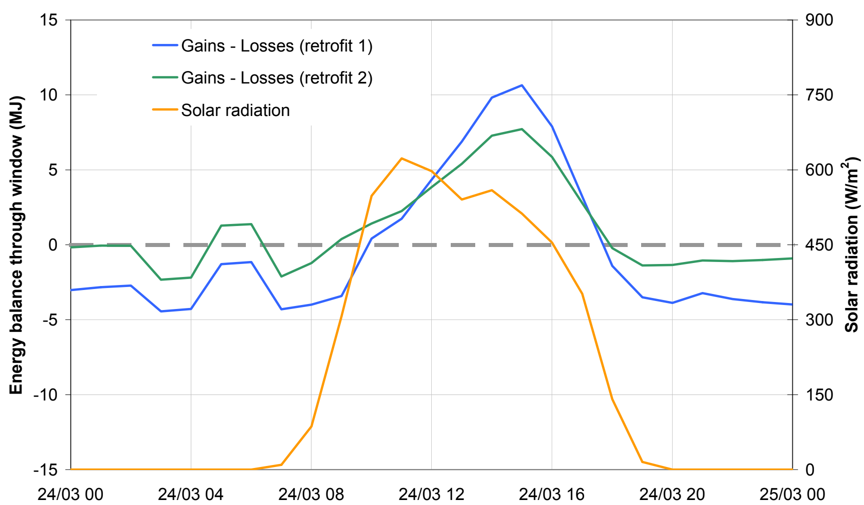


Figure 8. Energy balance through the glasses the 24th of March

As shown in Figure 6 the losses through the glass are decreased in about 80% with the second intervention compared to the first; the reason of such an important decrease is the application of reflective curtains in the internal side. In fact, EnergyPlus considers the re-emitted heat from such curtains as free gain through the windows. Besides, this can explain the increase of the free gains through the glass during the night hours.

The energy balance as difference between heat gain and heat loss with regards to the first and second retrofit intervention is shown for a typical day in Figure 8, whilst the monthly trend for the three configuration (use conditions and the two retrofits) is shown in Figure 9.

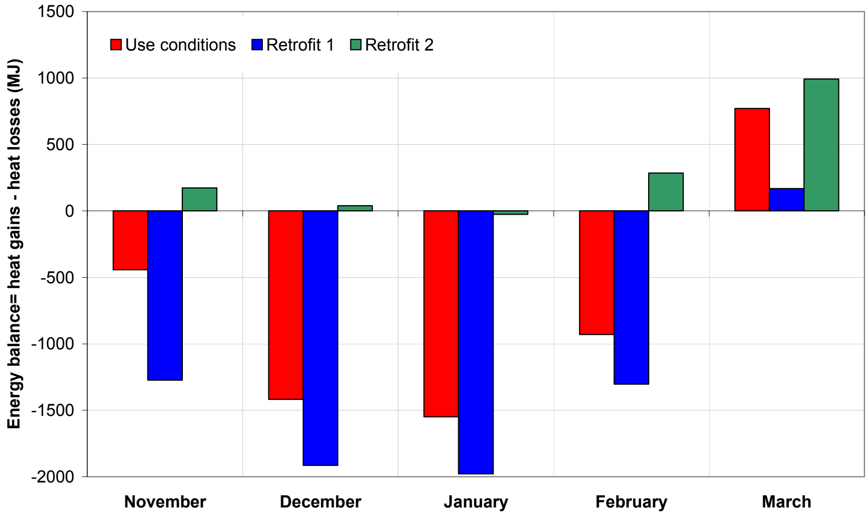


Figure 9. Overall energy balance in MJ through the glasses: gains-losses

Although the boiler power was reduced to 10 kW, the thermostat temperature is reached both in the first and in the second intervention in less than an hour from the switching on (Figure 10).

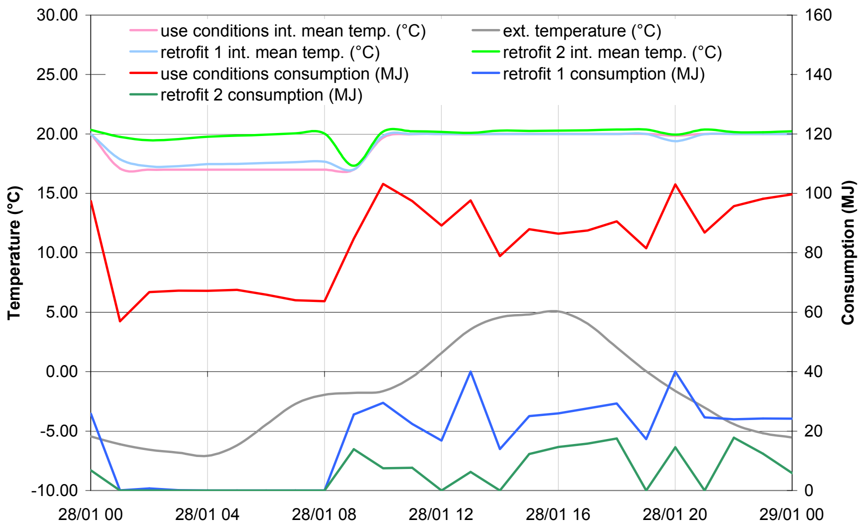


Figure 10. Comfort and consumptions for the tested configurations

Although no summer simulations were carried out, the design choice was conceived for not penalizing the energy performance in the hot season; for example the reflective curtains may be raised to allow the heat loss.

5.4. Influence of plant components on the consumptions

The thermal dispersions decrease in the first intervention allow to hypothesized a less powerful boiler compared to the initial one; similarly, also considering the occupancy and the foreseen heating plant manage methods, the flow temperature was appreciably reduced (Figure 11). With the solution "retrofit 2" condensation boiler and radiant panels were introduced. The two components combination is optimal since the radiant panels for the same level of operative temperature set-point allow to keep a smaller value of air temperature. As a consequence the flow temperature may be further reduced, reaching the operative condensation boiler ideal thermal level.

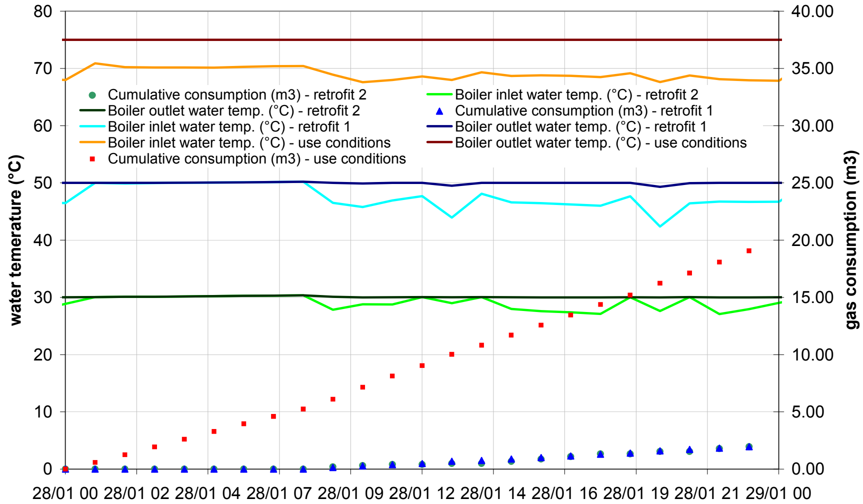


Figure 11. Boiler working conditions and relative consumption the 28th of January

The reflective shield application close to the glass, of the cork layer and of the reflective aluminium sheet behind the radiant modules, reduced the thermal dispersions with a consequent increase of the thermal zones mean air temperature and decrease of the thermal power supplied.

The building thermal inertia influence is highlighted above all in the second intervention, where the indoor temperature also in the morning hours, even if is set at 17 °C, does not never go down under 20 °C, with the boiler switched off and, of course, without any fuel consumption (Figure 11).

5.5. Commissioning

The described results come from simulation carried out by a software that assumes building operative conditions equal to those hypothesised in the design phases. Of course in the real working condition the uncertainty characterising the building phase has to be kept in mind. Such an aspect is fundamental since a plant functional deficit makes vain the carried out analysis.

The commissioning aim to warranty the final product quality, in order that the design prescriptions were really realised and the systems integrated in the building were used in the best way. The commissioning plan is a document describing all the aspects of installation, plant components setting, management and maintenance during the building-plant complex life. It covers from the building conceiving in the design phases until the building enjoyed by the users. It includes time planning, management responsibility and evaluation procedures. These include design revisions, contracts and work validation and control in every process phases to assess the performance level defined in the contractual phase.

To erase plants operative deficit means: higher level of environmental comfort, energy saving, lower maintenance expenses. In fact, recent studies noticed that a building built without any commissioning has a higher management cost of the 8-20% compared to a building where the commissioning process is previously studied (for cost between 0.5 % and 1.5 % of the overall costs) [4].

6. FINAL REMARKS

The study has allowed to develop a data analysis methodology able to assess the effectiveness of interventions on the building-plant complex and to quantify the energy saving.

The simulation tool allows to obtain a great number of parameters, indicators and "reports", making it possible to compare the building-plant complex behaviour with different configurations, by evaluating its effectiveness from the point of view of energy and environmental comfort.

Having knowledge of the relationships existing among the building characteristic parameters allows the definition of a more qualitative building, analysed with an overall systemic approach, starting from the initial design phases up to the achievement of the building.

The retrofit configurations were not conceived considering the summertime performances, being the building context an Italian cold thermal zone; nevertheless, as stated above the solutions choices were defined also thinking, even if in a qualitative way, at the building behaviour in such season. With regards the analysis approach a more holistic one could be chosen, but the objectives of the research and the specific building context were very focused on the carried out analysis.

The energy software application highlights the importance of having a correct size of the plant components on the basis of the real building thermal need; the analyses on the best coupling between heat generator and final heater proved to be meaningful.

As for what concerns the evaluation of comfort, the capacity of the building-plant complex to maintain a constant indoor temperature level was taken into account. Then the stability of the mean temperature of each building floor around the set-point value was observed.

The use of a simulation programme reaching such a high degree of detail entails base skills and time dedicated to the analysis and processing that must be balanced with regard to the desired results and to the building under study typology and "value".

The development of a simplified version, especially for what concerns data acquisition, would allow a huge diffusion of specific calculation models to define reliable input for the environmental sustainability assessment tools.

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INTEGRATING THE CONCEPT OF ‚ENVIRONMENTAL PERFORMANCE' INTO DECISION MAKING PROCESSES ALONG THE LIFE-CYCLE OF BUILDINGS

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Summary

In connection with international and European standardisation activities the basic principles for a description, assessment and interpretation of a building's 'environmental performance' are currently discussed. This paper provides recommendations for an appropriate definition of the 'environmental performance', for a classification into and an integrated concept of building related information and documents and for the application of suitable assessment criteria and indicators. It is argued that the 'environmental performance' – as a part of the assessment of buildings' contribution to sustainable development – is increasingly considered within decision making processes during the planning stage as well as during the further life-cycle. Environmental and health-related characteristics and attributes of buildings are becoming an additional part of the informational decision making basis not only for investors, occupiers and tenants but also for banks, insurance companies, funds and facility managers.
This paper also aims to give research colleagues and other interested parties an understanding of this issue of international and European standardisation, to encourage discussion and to invite for an exchange of ideas and information.

1. Reasons and causes for a sustainability assessment of buildings

The issue of implementing principles of sustainable development has been and still is heavily discussed within the worldwide construction and real estate industry. The ongoing debate covers a broad range of problems and questions; for example: how to supervise, control and manage sustainable development within the national building stock and on a regional, urban and local level; how to bring construction and real estate companies' corporate missions and strategies in line with the concept of sustainability; how to describe and assess the contribution of buildings to sustainable development and how to provide necessary information about building products and materials. However, this paper's subject-matter solely is the single building and the associated plot of land.

Sustainable planning, construction and management of buildings requires both the satisfaction of needs of current and prospective building users as well as the provision of evidence on economic efficiency and on environmental, health and social compatibility during the entire building life-cycle or within the remaining life-span of the building respectively. In this connexion it is important to take into account and to include the specific interests and perspectives of the construction process participants.

In recent years a wide variety of assessment methods, indicators, checklists, computer aided tools, certification systems and databases with building product information have been developed [1] to support the planning and decision making process. Their application, however, is hampered by various aspects, e.g. the users' state of knowledge and education; the inconsistent process of collecting and applying data; the inconsistent development of methods, indicators and reference values; the ambiguous situation concerning the area of legal responsibility of construction process participants for different aspects of sustainability; and in particular the missing demand for and the lack of consequences from a detailed description of a building's sustainability facets and criteria. For this reason the authors argue that it is not only necessary to improve the supply of sustainable planning and construction works as well as of supportive tools and utilities, but there is also the need to clarify how to increase demand for such kind of building related information and certificates and how to integrate them into multifaceted decision making processes. Thereto recent developments on a European and international level exist:

Within the scope of the development of a thematic strategy on the urban environment [2] and in order to achieve an area-wide realization of sustainable construction the Commission of the European Communities suggests incorporating the concept of sustainability into national building codes and regulations. Furthermore, the Commission encourages member states to introduce sustainability requirements in their own tendering procedures and in relation to the use of public funds for buildings and other construction works. The following incentives can be facilitated for sustainable buildings and construction works:

- Grant of lower taxation,
- Development and offerings of favourable banking products and of advantageous interest rates for lending purposes,
- Development and offerings of favourable insurance products and of advantageous insurance rates.

The EU expert working group ‚Sustainable construction methods & techniques' states that „taxes and all other regulatory mechanisms at global, regional and local political levels need to be adapted (transformed into incentives) and used to help motivate the actors in contributing to achieve more sustainable construction." [3] These incitations perfectly correspond and are in conformity with two self commitments [4], [5] which have been issued within the scope of the UNEP-initiative 'Innovative Financing for Sustainability' by members of the international financial services and insurance industry. These self commitments emphasise that identifying and quantifying environmental risks shall be part of conventional risk assessment and risk management procedures within the financial services and insurance industry and that products and services shall be developed which promote environmental protection. Meanwhile, a group of banks developed a system of indicators to assess their environmental-friendliness for internal use. [6]

Assuming that these developments progress and that the degree of a building's sustainability impacts on taxation, insurance and lending conditions as well as on the appraisal of worth and value (corresponding approaches have been discussed in [7], [8] and [9]) there will be a growing demand for the description and proof of a building's contribution to sustainable development on the basis of commonly accepted assessment methods. For example, typical occasions are transactions, planning, appraisal and lending. Also awarding authorities from governmental or municipal administrations will need appropriate instruments in order to demonstrate the consideration of sustainability issues when spending public funds. Related approaches in Germany are available with [10]. Furthermore, there is a growing number of investors, buyers and facility and funds managers who recognise the importance of considering sustainability issues and who expect and require appropriate information, basic principles and tools for an assessment from their own point of view. It remains to be seen if the assessment of the contribution of buildings to sustainable development will be carried out by planners and architects or if specialised valuation professionals, surveyors or certifiers will undertake this extensive task. **Figure 1** exemplarily describes possible flows of information between actors and allocates methods and instruments.

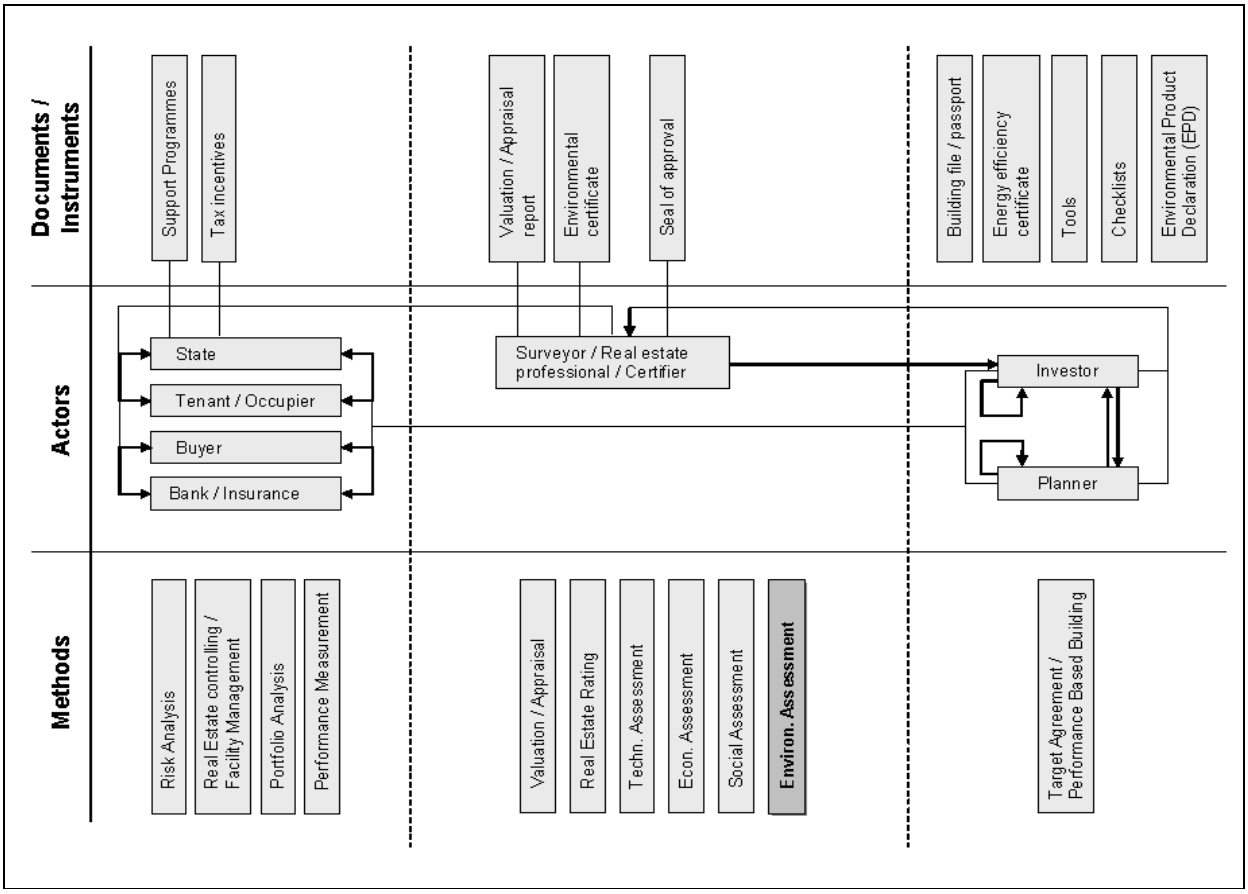

Figure 1: Flows of information between actors concerned with a sustainability assessment.

2. Classification and role of the 'environmental performance'

The assessment of the contribution of single buildings to sustainable development is a very complex exercise which comprises the description and assessment of the current and future serviceability, of the functional and design quality, of the technical solution as well as of economic, environmental and socio-cultural criteria. The assessment requirements which can be deduced form the concept and the principles of sustainable development can only be fulfilled by simultaneously and equally considering the mentioned aspects within the planning stage as well as within the further life-cycle of the building. This advisement also forms the starting point for current international standardisation activities within the scope of ISO TC 59 SC 17 'Sustainability in building construction'.

In cohesion with the effort to operationalise the planning and decision making process it is appropriate to break down the complexity of the subject sustainability into manageable sub-questions. Therefore, various working groups and standardisation activities are currently dealing with questions concerning performance measurement, integrated life-cycle analysis, life-cycle costing and with the development of the methodological framework for the description and assessment of building characteristics and attributes concerning health and the environment, i.e. 'environmental performance'. In the following the authors focus on the discussion of the actual state of affairs of defining and standardising the concept of 'environmental performance'.

In connection with the description and assessment of a building's 'environmental performance' several approaches exist which currently are in discussion [11], [12], [13]. Furthermore, the EU issued a mandate to CEN (the European Committee for Standardization) to develop methods for an 'assessment of the integrated environmental performance of buildings' [14]. Altogether it seems that the discussion about the description and assessment of the 'environmental performance' becomes independent at the moment. It is important to explicitly point out that the 'environmental performance' must be integrated within the overall context because it is only a part of a sustainability assessment. The demonstration of positive building characteristics and attributes concerning health and the environment has been sufficient in order to classify 'green buildings'. However, this is no longer appropriate when it comes down to deal with the far more complex approach of a 'sustainable building'. The integration of the 'environmental performance' into an overall building performance context is shown in **Figure 2** and is discussed in more detail in [15].

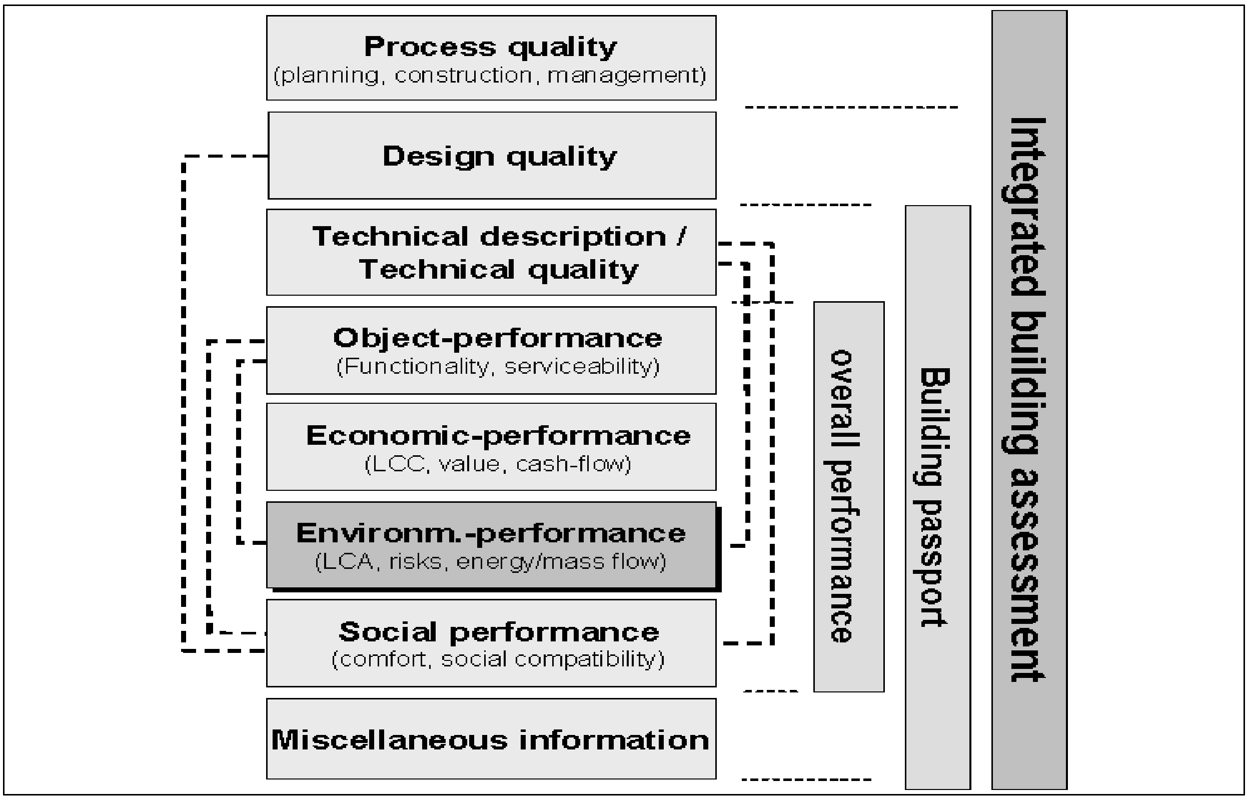

Figure 2: Integration of the ‚environmental performance' into an overall performance context

Without the existence of a detailed description of the functional unit, i.e. a definition of the object to be assessed, it is impossible to interpret the results of an 'environmental performance' assessment. In the present case the object to be assessed is – also in order to assure compliance with the awarding authorities' or building owners' responsibility – the single building as well as the associated plot of land. The impacts on the local and global environment are also taken into consideration within the assessment.

Within the planning stage the functional unit must be described via essential user requirements (e.g. function, required useful life). After completion or regarding existing buildings respectively the degree of compliance between user requirements and corresponding building characteristics and attributes can be examined by conducting an assessment of the 'functional building performance', i.e. 'object performance'.

Characteristics and attributes like maintainability and reusability, longevity and adaptability have an influence on the environmental building quality. However, this information is part of the description of the functional unit or of the 'object performance' respectively. For this reason it not necessary to mention these characteristics and attributes over again when describing and assessing the 'environmental performance'. The same applies to questions concerning the description of the technical solution. Information about the type and quality of the heating and ventilation system or about other technical building equipment can be gathered from the object documentation. The authors explicitly disapprove the approach of using information which actually should be part of the 'object performance' in combination with extracts from the object documentation as the sole basis for an assessment of the environmental building quality; also the use of checklists for a pure qualitative assessment is not appropriate.

Using the categories of the 'environmental performance' should fulfil another purpose: By focussing on essential statements it can be examined what input in natural resources is necessary in order to realise the desired building and which resulting impacts on the environment can be expected from the compounded technical solution. Furthermore, the disburdening effect of building characteristics and attributes on the environment can be measured along the further life-cycle by using the categories of resource depletion and of impacts on the environment.

3. Basic principles for a description and assessment of the ‚environmental performance'

In connection with an international trend (which can also be observed in standardisation activities) towards performance based building the performance approach is currently discussed in the construction sector. In general 'performance' is understood as the degree of compliance of user requirements (demand side) with the corresponding building characteristics and attributes (supply side). The performance approach has its seeds in the area of describing and assessing the fulfilment of functional requirements (functionality and serviceability). The transference of this concept on questions related to the environment and human well-being is new. Thus, 'environmental performance' would be – assuming a consistent extension of the original performance approach – the degree of compliance of requirements concerning health and the environment formulated by the awarding authority or by building users with the environmental and health-related building characteristics and attributes. Except for very few cases (e.g. requirements concerning energy consumption values) awarding authorities and building users are not yet able to formulate individual requirements concerning the building's environmental and health-related friendliness or the building's 'environmental quality' respectively. In such cases individual requirements can and must be replaced by public/social and legal requirements. In this regard the authors' perception is in compliance with [13].
These individual and social requirements can be available and used for an assessment as project-specific or universal reference values (minimal, boundary or target values). If it is not possible to formulate particular individual or social requirements (which can be justified scientifically or by any other means) the 'environmental performance' will be reduced to the declaration of environmental and health-related building characteristics and attributes. This information can be unvalued (e.g. results of an inventory analysis), valued (e.g. results of an impact assessment) or, as the case may be, qualitative. An assessment is then possible via relative comparison with project alternatives by using baselines, benchmarks or verbal evaluation.

The description and assessment of 'environmental performance' can be established on the basis of the following methodical basics:

- Inventory analysis (part of LCA, described in the ISO 14040 series),
- Benchmarking, based on physical quantities,
- Life cycle impact assessment (part of LCA, described in the ISO 14040 series),
- Hazard and risk assessment (risks and threats to the local environment and human health),
- Quality management,
- Use of qualitative decision-making tools (checklists) on a supplementary or alternative basis.

Thus, it is not possible to reduce the 'environmental performance' to a mere LCA-based approach.

Individual and social requirements concerning the building's environmental and health-related characteristics and attributes can and will be subject to changes over time. On the one hand it is therefore necessary to temporally classify the assessment as well as the chosen reference values. (Regarding the reference values it is recommended to also state the corresponding source, e.g. country, type of association or organisation, individual target agreement, etc.). This classification can exemplarily be conducted as follows: 'environmental performance from 2003 on the basis of reference values for Germany from 2000'. On the other hand it is necessary to regularly update and to adjust the 'environmental performance' in order to keep pace with changing levels of requirements.

The construction and use of buildings always brings out interference into the environment and is associated with both resource depletion and impacts on the local and global environment. Therefore, the construction and use of buildings does not result in any benefits for the environment but it does for society and for human individuals. However, substantially reduced resource depletion and impacts on the environment in comparison to benchmarks, baselines or project alternatives can be interpreted as an 'environmental relief' and described (for marketing purposes) as *good* or *very good* 'environmental performance'.

4. Goals and areas of protection

In order to describe and assess ‚environmental performance' appropriate criteria and indicators must be developed and applied. Criteria can be described as essential characteristics or aspects which form the basis for decision making in connection with an assessment procedure. An indicator is a precisely measurable and assessable circumstance or surrogate which reduces complexity on the one hand and which endues satisfactory significance or explanatory power on the other hand.

Criteria can be deduced from goals and areas of protection which have been agreed upon and which have been commonly accepted by the society. Regarding the environmental dimension of sustainability goals and areas of protection are:

- Protection of the basic natural resources air, water and soil,
- Protection of nature and landscape,
- Protection of flora and fauna and preservation of biodiversity,
- Protection of non-renewable energetic and non-energetic resources,
- Protection of the climate.

Given a simultaneous examination of environmental *and* health-related aspects as proposed in this paper the goal

- Protection of human health and well-being

has to be included additionally. Alternatively, health and human well-being are often assigned to the social dimension of sustainability.
Those general goals and areas of protection mentioned above can be summarised by using the categories 'protection of natural resources' and 'protection of the ecosystem'. However, they must be applied to the object 'single building and associated plot of land'; thus, they need to be adjusted and operationalised in order to form the basis for those aspects that can be described and assessed within the scope of the 'environmental performance' of buildings.

The following aspects provide both a purposive structure for a breakdown of the 'environmental performance' into appropriate partitions and a basis for the development of assessment criteria and indicators:

- Depletion of (non-renewable) energetic resources
- Depletion of (non-renewable) material resources
- Land use; conversion of land and soil conditions

- (Potential) impacts on the global environment through energy and mass flows
- (Potential) impacts on the local environment through energy and mass flows
- Impacts on the local environment aroused by the building (shading, wind damages, etc.)
- (Potential) impacts on indoor environment and climate
- Threats and risks to the local environment

If health-related aspects are to be included in the approach

- Threats and risks to health and well-being of occupants/users/visitors, residents and construction workers

need to be included in the list.

In accordance with [16] the authors suggest regarding and establishing the building's 'energy performance' as an integral part of the 'environmental performance'. Regulations and guidelines which already exist for the 'energy performance' and which are stated in [16] (e.g. the responsibility of the building owner for preserving, updating and providing or publishing of information regarding the building's energetic quality) could and should be devolved to the 'environmental performance'.

5. Details on the application of 'environmental performance' assessment within the life-cycle and on appropriate indicators

Description and assessment of the ‚environmental performance' shall follow the building's life-cycle. Subsequent to an initial assessment during the planning stage on the basis of assumptions and scenarios the 'environmental performance' must be endorsed by collecting and assessing 'actual-values' after commissioning. At every serious alteration or modification of the building, and/or of user requirements or reference values respectively the 'environmental performance needs to be adjusted and updated. Thus, merely putting assessment results on record is not sufficient; i.e. adjusting a past assessment to new reference values requires raw data from the inventory analysis. The basic principles for describing and assessing 'environmental performance' within the life-cycle of single buildings are affected by:

- the cause of assessment *(e.g. support of decision making processes during the planning stage; lending; appraisal; transaction; controlling within the process of continuous improvement)*
- the point in time *(e.g. during the planning stage; within and/or during the building life-cycle; during the planning of refurbishment or revitalisation)*
- the object to be assessed *(e.g. new building in the planning stage; new building after commissioning; existing building which has been regularly assessed during its past life-cycle; existing building without any information and past assessment results available)*

On the one hand those ancillary conditions determine the amount and type of information available. For example, during the planning stage the expected demand for heat energy can only be calculated on the basis of assumptions and scenarios, whereas real energy consumption can be measured during the stage of occupation and use. Consequently, it is likely to happen that data and information from the planning stage can be specified, replaced or amended with completely new information (e.g. results of a post-occupancy evaluation) during the stage of occupation and use. The authors suggest responding to the issues mentioned above by selecting appropriate indicators. An initial approach is introduced in **Table 1**:

Table 1: Proposal for indicators

Criteria	Indicators
Energy use	Primary energy demand (*) or consumption (**)
Raw material depletion	Usage of fossil fuels (embodied energy) (*)
	Share of non-renewable raw materials in the constructed asset's mass (*)
	Share of renewable raw materials in the constructed asset's mass (*)
Waste production	Waste production on site
Land use	Sealing / Covering of the lot, planned (*) and real (**)
Impact on neighbouring lots	Shading, planned (*) and real (**)
Share in greenhouse effect	Global warming potential (GWP 100)
Share in ozone depletion	Ozone depletion potential (ODP)
Share in acidification	Acidification potential (AP)
Share in Eutrophication	Eutrophication potential (EP)
Photo-oxidant formation	Photo-oxidant formation potential
Indoor air quality	Measured concentration of selected substances (e.g. Total Volatile Organic Compounds), (**)
Risks to the environment	Risk of environmentally hazardous emissions into the local environment
Risk to human health	Risk of harmful emissions (related to occupants and/or to the neighbourhood)

(*) applies during the planning stage; (**) applies for already existing buildings

The content of Table 1 is oriented at and influenced by the actual state of affairs in Germany. Within the scope of further work it is necessary to develop rules and guidelines concerning inquiry and assessment of each indicator, including a determination of system boundaries. In order to assure comparability of different assessment approaches and to assure a certain degree of quality and amount of required information it is essential to reach agreement on a 'minimal list' of indicators within an international or European framework respectively. In doing so the specific characteristics of new and already existing building should be taken into account. The authors suggest addressing this task within the scope of international or European standardisation activities.

On the other hand those ancillary conditions mentioned above influence the choice of system boundaries. For example, regarding an old building retrospectively calculating primary energy consumption during the past manufacture of the building products is no more useful.
By illustrating different assessment scenarios, comprised life-cycle stages as well as corresponding flows of information **Figure 3** provides information on the classification of the description and assessment of 'environmental performance' along the different stages of a building's life-cycle.

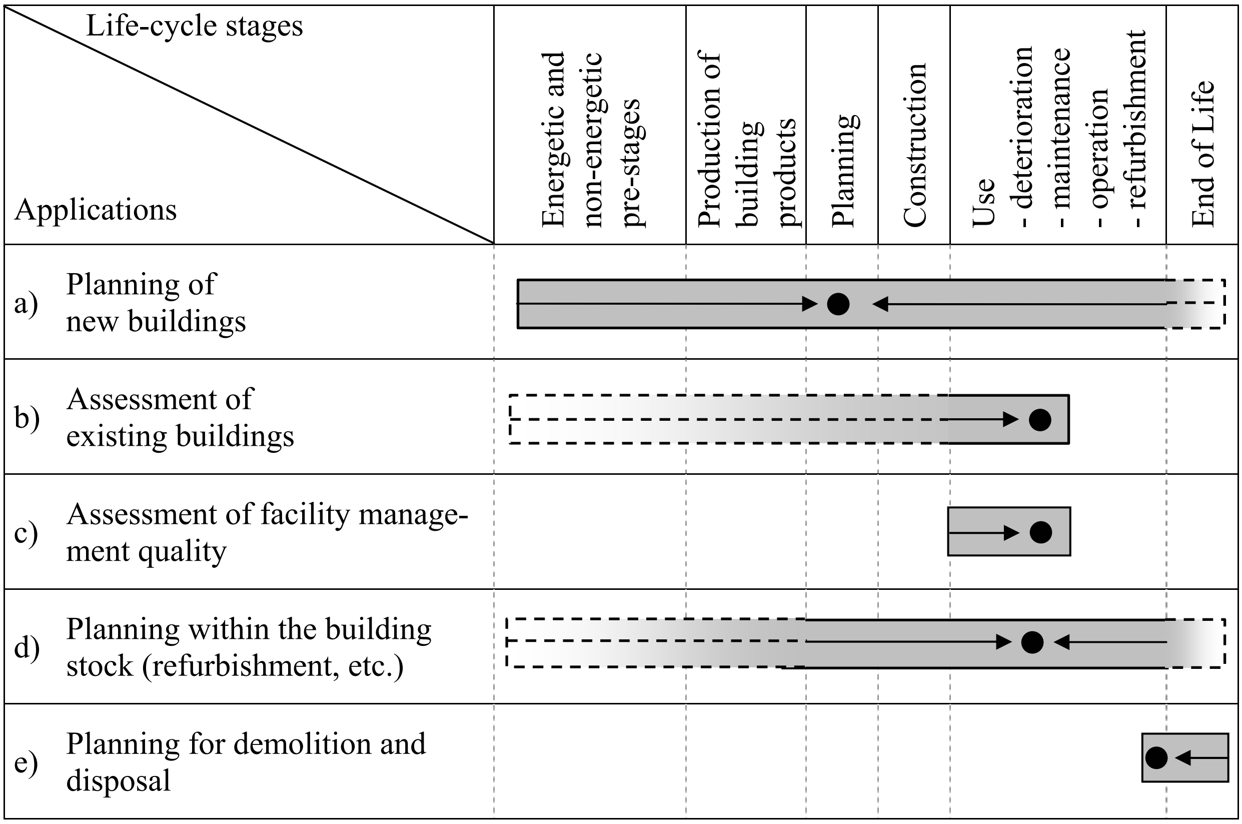

Figure 3: Assessment scenarios and flows of information

Figure 3 shows the different points of time within the life-cycle of buildings (displayed by the black dot) at which assessments can be conducted by using different existing assessment methods and tools. The frames express the phases of the building life-cycle that are usually considered for each analysis. However, depending on the applied assessment method partial modifications can exist regarding the manner and the extent of the comprehension of different phases of the building life-cycle; this circumstance is displayed by the dashed frames. For this reason it is import to declare which phases of the building life-cycle have been actually regarded for the assessment. Otherwise a valid interpretation of the assessment results can not be guaranteed. Additionally, the arrows within the frames provide information on the character or on the nature of the data underlying each assessment; i.e. the arrows declare if the assessment is either based on an analysis of past measurements ('retrospective evaluation'), on current data ('snap-shot evaluation') or on a well-founded prognosis of future developments ('anticipatory evaluation').

6. Options in considering a building's environmental performance within commercial property valuations

Property valuation or appraisal plays a crucial role within the life-cycle of building for various reasons and purposes, e.g. for investment or disinvestment decisions, performance measurement, lending, insurance, accounting and within the context of forced sale auctions. In this context an important distinction can be drawn between the calculation of worth and the assessment of Market Value. The latter is defined in [17] as "the estimated amount for which a property should exchange on the date of valuation between a willing buyer and a willing seller in an arm's-length transaction after proper marketing wherein the parties had each acted knowledgeably, prudently, and without compulsion." In contrast, worth represents a specific investor's (or occupier's) perception of the capital sum that he would be willing to pay (or accept) for the expected benefits (and risks) associated with the ownership of the property. Thus, Market Value can be interpreted as an average figure resulting from the aggregated calculations of worth of all market participants.

Current international property valuation practice completely disregards the environmental as well as the social dimension of sustainability when assessing Market Value. This is because, on the one hand, the majority of market participants has not yet realised the chances and risks associated with these two dimensions of sustainability; therefore, they omit to consider these aspects within their individual calculations of worth. And on the other hand, transforming specific characteristics and attributes of buildings into monetary measures is an extremely difficult and complex task. Unsurprisingly, there are no commonly accepted procedures, tools and/or guidelines available at the moment that allow property professionals to consider all dimensions of sustainability within an assessment of Market Value. However, initial approaches are available with [7] and [8].

In particular, this situation is dissatisfactory for those investors and occupiers who have realised the advantages of a sustainable point of view, who know about the risks and costs associated with increasingly stringent environmental legislation and energy efficiency regulations and who are aware of their social responsibility. Therefore, at present efforts are being made to develop models that allow considering sustainability issues within individual calculations of worth. A promising approach is available with [9] and will shortly be described in the following: The basis of the model (which has been develop within the scope of a research project funded by major UK real estate market participants) forms a method of calculation worth developed by the Royal Institution of Chartered Surveyors (RICS) [18]. For simplifying reasons this method assumes that all the characteristics of a property investment can be reflected through four key variables. The variables are rental growth, depreciation, risk premium and cash flow.
It is now assumed that specific sustainability criteria impact on one or more of these key variables. Selection, classification and weighting of the sustainability criteria was based on consultations with real estate professionals, investors and occupiers who participated in the research project. A total of nine sustainability criteria has been selected and integrated into the appraisal model; three of them are concerned with the building's 'environmental performance', namely energy efficiency, pollutants and waste and water. Table 2 lists the remainder criteria which can partly be described by using the category 'object performance'.

Table 2: Sustainability criteria linking through to worth [9]

Sustainability criteria	**Conduit**
Building Adaptability	Risk premium, cash flow, rental growth, depreciation
Accessibility	Rental growth, depreciation
Building Quality	Rental growth, cash flow, depreciation
Energy Efficiency	Rental growth, risk premium, cash flow, depreciation
Pollutants	Rental growth, risk premium, cash flow, depreciation
Contextual Fit	Rental growth
Waste and Water	Rental growth, cash flow, depreciation
Occupier Satisfaction	Risk premium
Occupier Impact	Risk premium

In the next stage of the research project appraisals of selected properties have been carried out; once on the basis of the RICS standard appraisal and once as a weighted sustainability appraisal with adjusted figures for the key variables risk premium, cash flow, rental growth and depreciation. As expected the application of the standard appraisal to ‘average’ properties resulted (compared to the results of the sustainability appraisal) in an over-valuation; whereas the application of the sustainability appraisal to a building performing particularly well under the sustainability criteria lead to an under-valuation. In this context the concluding remark of this study is of major interest: “What is clear, however, is that a deeper analysis of property characteristics is necessary if appraisals are to keep pace with the investment risk implications of changing occupier demands.” [9]

Without further specification the nine sustainability criteria mentioned above are not sufficient in order to appropriately consider all three dimensions of sustainability. What is needed is a multidimensional system of criteria and indicators which allow for a description, measurement and assessment of the overall building performance which can then form the basis for the appraisal of worth. Regarding the determination of Market Value it can be argued that it is first of all important to provide investors and occupiers with instruments, methods and tools that allow for a comprehensible sustainability appraisal of worth. If market participants then change their approach of assessing and evaluating real estate in favour of a sustainable perception property valuation practice must also change or accommodate accordingly. From the authors’ point of view such a change in market participants’ perception is likely to happen due to the developments on an international and European level which have been described above. In sum, an integrated valuation and appraisal approach which accounts for overall building performance does not only lead to better and more profound valuation results but also substantially improves the informational basis for further decisions within the life-cycle of buildings. In this regard, the standardisation of a building’s ‘environmental performance’ (see [14]) plays an important role.

7. Conclusion

Describing and assessing a building’s ‘environmental performance’ is a sub-area in assessing the contribution of buildings to sustainable development. The ‘environmental performance’ is no longer mere subject of scientific discussion and research but develops to an additional source of information that supports decision making processes within the life-cycle of buildings. This information is now increasingly requested by investors, banks, insurance companies, surveyors and funds-managers, etc. But in order to achieve transparent and commonly acceptable assessment results it is pivotal to standardise criteria, indicators and assessment procedures by simultaneously maintaining and allowing for national and local peculiarities. Therefore, participation in and supporting of international (ISO) and European (CEN) standardisation activities is of great importance.

Within the scope of a research project funded by the German Federal Office for Building and Regional Planning the authors will examine if and how the ‘environmental performance’ can be integrated into real estate assessment procedures for lending purposes (so called real estate ratings) which are in accordance with the property related guidelines formulated in the New Basel Capital Accord [19]. Also within the scope of this research project it will be examined to what extent good environmental building quality can be reflected in lending conditions. Research colleagues and all other interested parties dealing with similar questions and problems are invited to make contact and to exchange ideas.

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LUMINOUS ENVIRONMENT IN SCHOOL BUILDINGS

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Abstract

The requirements to indoor luminous environment should take into account both, the user needs and the energy saving.

There are three routes by which lighting conditions influence health, well-being and performance of individuals: through the visual system, through the circadian system and through the perceptual system. The capabilities of the visual system are determined by the lighting- and daylighting conditions. The visual comfort during all operation hours should be an important objective. The state of the circadian system is influenced by a light-dark cycle. To stimulate the circadian system very high illuminance levels are needed, much higher than the ordinary lighting system usually delivers. The message delivered by the perceptual system is influenced by many factors, lighting is just one of them. Since light has a strong influence on perception of shape and form, the visual information delivered by the perceptual system can be considerably manipulated by lighting/daylighting. Windows enable also the visual contact with the outside environment. The outside environment is an additional source of visual information and makes the visual perception richer and more varied.

The interior lighting/daylighting designed entirely to save energy may result in the windowless rooms equipped with roads and columns of luminaries for fluorescent tubes giving as low illuminance as the actual building code requires, pure colour rendering and very even and boring luminance distribution.

To satisfy human needs for visual comfort, well-being and health large windows with daylighting- and/or shading systems as well as advanced control system are to be used. The electric lighting system should be flexible enough to deliver both; varied lighting that meets the respective functional needs and a very high illuminance to stimulate the circadian system in periods of daylight shortage.

How those contradictory aims may be combined in school buildings?

Introduction

In most buildings people prefer interiors to have daylight appearance. It should be noted, that interiors might have daylight appearance even if there is a significant amount of electric light during daytime.

The following values should be adopted where the daylight appearance is required [2]:

> *If electric lighting is not normally to be used during daytime hours, the average daylight factor should be not less than 5 %.*

> *If electric lighting is to be used during daytime, the average daylight factor should be not less than 2 %.*

The required minimum average daylight factor values do not necessarily provide the minimum illumination needed for a visual task, especially at the beginning and at the end of a day and/or in areas lying away from windows. From that reason nowadays standards specify requirements for lighting for most interior work places in terms of quantity and partly quality of illumination. Daylighting, artificial lighting or a combination of both can provide the illumination [3]. Unfortunately, it gives opportunity to apply electric lighting alone, something that disables utilization of the daylight benefits.

Requirements given in standards

Lighting requirements for indoor work places are specified in the European Standard EN 12464-1:2002 "Light and lighting – Lighting of work places – Part 1: Indoor work places". New and redeveloped school interiors in Poland should also meet these requirements as the Polish Committee for Standardization is obliged to follow the European Standard [3].

The main parameters determining the luminous environment that are included in the European Standard are: illuminance and uniformity, glare, colour rendering, reflectances. Values for maintained illuminance E_m, discomfort glare index UGR and colour rendering R_a are given separately for the respective interior types, tasks and activities:

Nursery school, play school	**E_m [lx]**	**UGR -**	**R_a-**	**Remarks**
Play room	300	19	80	
Nursery	300	19	80	
Handicraft room	300	19	80	
Educational buildings	**E_m**	**UGR**	**R_a**	**Remarks**
Classrooms, tutorial rooms	300	19	80	Lighting should be controllable
Classroom for adult education	500	19	80	Lighting should be controllable
Lecture hall	500	19	80	Lighting should be controllable
Black board	500	19	80	Prevent specular reflections
Demonstration table	500	19	80	In lecture halls 750 lx
Art rooms	500	19	80	
Art rooms in art schools	750	19	90	$T_{cp} \geq 5000$ K
Technical drawing rooms	750	16	80	
Practical rooms and laboratories	500	19	80	
Handicraft rooms	500	19	80	
Teaching workshop	500	19	80	
Music practice rooms	300	19	80	
Computer practice rooms Language	300	19	80	DSE-work: see more detailed
laboratory	300	19	80	requirements
Preparation rooms and workshops	500	22	80	
Entrance halls	200	22	80	
Circulation areas, corridors	100	25	80	
Stairs	150	25	80	
Student common and assembly rooms	200	22	80	
Teachers rooms	300	19	80	
Library: bookshelves	200	19	80	
Library: reading areas	500	19	80	
Stock rooms for teaching materials	100	25	80	
Sport halls, swimming pools	300	22	80	
School canteens	200	22	80	For more specific activities, see
Kitchen	500	22	80	another requirements

The illuminance of the immediate surrounding areas may be lower than the task illuminance but shall not be less than the values given in the table below.

Task illuminance [lx]	Illuminance of immediate surrounding areas [lx]
≥ 750	500
500	300
300	200
≤ 200	E_{task}

The uniformity (minimum to average illuminance) of the task area shall not be less than 0,7. The uniformity of the immediate surrounding areas shall not be less than 0,5.

Ranges of useful reflectances for the major interior surfaces are:
- ceiling: 0,6 to 0,9
- walls: 0,3 to 0,8
- working planes: 0,2 to 0,6
- floor: 0,1 to 0,5

To avoid bright light sources a suitable shielding of lamps is recommended.

Lamp luminance [kcd/m^2]	Minimum shielding angle
20 to <50	15°
50 to < 500	20°
≥ 500	30°

For luminaries that may be reflected in DSE screens the limits of the average luminaire luminance at elevation angles of 65° and above from the downward vertical are recommended.

Screen classes in accordance with ISO 9241-7	I	II	III
Screen quality	Good	Medium	Poor
Average luminance of luminaires which are reflected in the screen	≤ 1000 cd/m^2		≤ 200 cd/m^2

For certain special places, e.g. were very sensitive screens are used, the above luminance limits should be applied for lower elevation angles (e.g. 55°) of the luminaire.

Following parameters that should also be taken into consideration when designing the luminous environment, not mentioned in the requirements, are:

modelling, i.e. ability to reveal three-dimensional forms by light;

colour discrimination i.e. the possibility for discrimination between very similar colours;

flicker from luminaries.

Generally, the requirements are formulated for electric light; there are no requirements or recommendations that would ensure e.g. visual comfort in day-lighted interiors.

The impact of daylighting on human health, well-being and productivity: short review of newest research results and consequences for daylight and electric light design,

<u>View to the outside</u>:

William M.C. Lam [9] describes the human perception as an active, information-seeking process. “We direct our voluntary attention to elements of the visual environment which provide information we need to perform our conscious activities.” He lists the following biological needs for environmental information:

- *Location*, with regard to water, heat, food, sunlight, escape routes, destination
- *Time*, and environmental conditions which relate to our innate biological clocks
- *Weather*, as it relates to the need for clothing and heating and cooling, the need for shelter, opportunities to bask in the beneficial rays of the sun
- *Enclosure*, the safety of the structure, protection from could, heat, rain
- *The presence of other living things*, people, animals, plants

- *Territory*, its boundaries
- *Opportunities for relaxation* and stimulation of the mind, body and senses
- *Places of refuge*, shelter in time of perceived danger

The biological needs for visual information listed above are of such importance, that it is difficult to fully concentrate on a demanding task if they are not met. Generally, good lighting is necessary for any visual perception. The first three needs are not possible to satisfy without any daylighting opening in walls or roof enabling visual contact with the outside.

Psychologists Steven Kaplan and Ulrich Roger found a very interesting correlation between the quality of the outside view and the changes in human mood. A view of nature may generate very positive feelings, as sympathy and love. An urban view may generate opposite feelings [14].

Another interesting founding is that the view to nature may help to restore the ability to concentrate. This should be utilised in any educational institution [7].

Ulrich Roger [13] found that a nice nature view can even accelerate the recovery from surgery.

Author's recommendations:

To fully utilize the advantages of the view through the window, an outside view with as many elements of nature as possible should be ensured from all workplaces. If a sun-shading device is necessary, efforts should be made to ensure a maximum of the view to the outside, even in a semi-closed and closed position.

<u>Healthy lighting:</u>

Until late 1990s, lighting recommendations were based primarily on lighting for visibility. Latterly, the lighting community has embraced a more broad definition of lighting quality, encompassing human needs, architectural integration and economic constrains [15,16,17]. These human needs incorporate vision but also demand attention to lighting for maintenance of good health, task performance, interpersonal communication and aesthetic appreciation. This definition incorporates the evidence that there are non-visual, systemic effects of light in humans. Light processed through the eye can influence human physiology, mood and behaviour.

The Technical Committee 6-11 of the International Commission on Illumination (CIE) are preparing the technical report summarizing the state of knowledge regarding the health aspect of lighting and proposing the principles for healthy lighting. We repeat here only the main points relevant for visual environment in schools.

1. The daily light dose received by people in Western countries might be too low. Exposure to bright light, either in light boxes or architecturally, might improve mood and health in people with very low daily light exposure. It is especially important in the periods of short day length.
2. Light for biological action should be rich in the regions of the spectrum to which the non-visual system is most sensitive. Although the exact action spectrum is under debate, there is good evidence that it peaks in the blue-green region of the spectrum.
3. The important consideration in determining light dose is the light received at the eye, both directly from the light source and reflected off surrounding surfaces. There is ample evidence that the non-visual neuroendocrine effects of light are mediated by retinal photoreceptors.
4. The timing of light exposure influences the effects of the dose. Sensitivity of the circadian system to light exposure varies significantly over the 24-hour day. Generally: exposure to bright light at the morning will speed up the circadian cycle, exposure to bright light at the evening will delay it.

Author's recommendations:

Provide opportunities for high light exposure by propper use of daylight because it delivers bright light rich in the blue region, just what humans need. Especially the areas with working places should primarily utilize daylight i.e. have daylight appearance. It means that the mean daylight factor should be minimum 5% and the minimum daylight factor not less than 2%.

Provide biologically-active light where the eye is, not through the space. Increase light exposure by providing areas of higher illuminance where they will be frequently viewed. In a traditional classroom the blackboard as well as the teacher should be especially richly lighted. Has the blackboard to be dark? Choose a presentation method on a surface having as high reflectance as possible.

If the sun-shading system is necessary, it should consist of elements that can be removed from the glazing to avoid shading of the room in periods with low daylight level, e.g. overcast sky.

The sun-shading of a room should be possible only to a certain degree. Even if the sun-shading system is in a closed position the penetration of daylight should be secured to avoid usage of electric light during sun-hours.

A local control of sunshading device and electric light is preferable. Higher illuminances all day are unlikely to be necessary to the biological effect given the low sensitivity of the circadian system at certain points in the rhythm, e.g. at midday.

Electric light system should help to maintain the proper functioning of circadian cycle in periods of short day length: it should deliver bright light, giving illuminances higher then 2000 lux and rich in blue-green region in short time periods at the morning in winter.

Daylight and productivity

The actual scientific results concerning the impact of daylight on human performance are still unsure [4,8]. The studies curried out by Heschong [4] point in the direction of a positive impact of daylight on the students performance. Students attending extensively daylit schools scored higher in English and mathmetical tests than the "average" student in the district. Each classroom in those buildings has a large, south oriented skylight that delivers huge amount of sunlight and skylight. This positive effect is most probably due more to sunlight than to skylight. It is also not sure if this positive effect is due to daylighting alone.

Since human beings are biologically outside animals, it is reasonably to belive that we need both daylight components in interior rooms: strong and warm sunlight as well as cold and weak skylight.

Author's recommendations:

Affords should be made to deliver both components of daylight to the interior rooms: sunlight and skylight. The sunlight could be diffusely transmitted or reflected inside the room in order to avoid solar glare and/or specular reflections as well as overheating.

Visual comfort

The visual comfort is often defined in literature as the absence of discomfort, i.e. glare. Recommendations are given to the maximum discomfort glare index. But visual comfort is more than the absence of discomfort; other parameters as illuminance level, colour rendering, modelling, luminance distribution in the visual felt are also important for our impression of comfortable-uncomfortable visual conditions. Therefore the recommendations are given to the minimum illuminance level and to colour rendering depending on the type of interior or type of task. The recommendations regarding the luminance distribution in the visual felt were established for a traditional reading- and writing work place (1:3:10) and extended for work places with computer screens [2, 3, 6].

It should be mentioned that daylight has a perfect colour rendering that the producers of electric light sources try to imitate.

Author's recommendations:

Because of all its benefits, daylight should be the primary source of light. Electric light should supply daylight only in places where it is difficult to deliver or in periods when it is absent.

The minimum lighting level necessary for reading/writing should be about 300 lx in classrooms at the students working places and minimum 500, preferably 750 lx, at the blackboard. In offices the minimum of 500 lx should be delivered on working places, in gym hall 300 lx.

The interior design should prevent users to have a primary view direction toward light sources: windows, skylights or luminaries. In classrooms the mirror reflections on specular surfaces, especially on the blackboard should be totally avoided.

The luminance distribution in users visual felt ought to follow the 1:3:10 recommendation.

To obtain a good modelling in a room, a balance between the direct light and the ambient light is necessary. A good modelling can be obtained in rooms with the primarily light falling from one direction, e.g. direct daylight from large windows, supplemented by a secondary light from other direction, e.g. small windows in the opposite wall. The secondary light reduces the contrast between strong light and deep shadow and makes small forms in the shadow clearly visible. On the other hand, the perfectly uniform light makes a good modelling impossible.

The aesthetic appreciation of the visual environment by users should be taken as one of the objectives for architects and lighting designers. Especially the impression of room dimensions, feeling of spaciousness, openness and clearness can be changed by lighting.

Designing luminous environment for energy conservation

One of the fundamental design objectives of sustainable architecture is energy conservation. From energy-efficiency perspective, daylight offsets the need for electric lighting by providing adequate levels of task or ambient illuminance. At the simplest level of evaluation, task locations, solar conditions and illuminance data at given depths from the window wall can be presented as 1) percentage of time when the building is occupied that interior daylight illuminance levels equal or exceed the desired design illuminance level or 2) binned absolute illuminance data over the course of a year.

To minimize energy consumption for lighting in the periods of daylight shortage the control system is necessary. For manual or automatic on/off switching, the first method of presenting data yields what is known as “daylight autonomy” or the yearly relative “time of utilization”. For dimming systems, the second method of presenting the data can allow the user to roughly estimate the number of hours during which the lights can be dimmed to a particular power and light output level.

Regarding space-conditioning energy, window and lighting heat gains are beneficial for heating-load-dominated buildings and are detrimental for cooling-load-dominated buildings. The school buildings in Poland belong to the first group.

The extended utilization of daylight contributes also to reduction of peak demand. This has positive environmental consequences, because the local utility company must often use expensive, non-environmental energy sources to accommodate this non-recurring load.

Considering the design of luminous environment for energy conservation the following elements should be regarded [6]:

- daylighting;
- task illuminance
- room characteristics
- electric light sources and ballasts;
- luminaries and their arrangement;
- lighting control;
- maintenance.

The highest energy use savings are possible when daylight is fully utilised for interior illumination. The energy savings are dependant on the availability of daylight at the place including orientation of the building and outside obstruction, usage pattern during the day, size and location of fenestration and the utilization of lighting controls. In daylighting dominated rooms the electric lighting should be a supplement – aesthetically and functionally complementing daylight and providing required illumination where or when daylight is insufficient.

The basic lighting requirement of a lighting installation is the task illuminance. Required illuminance level influences installed power of the electric lighting. To make the lighting installation energy-efficient, moderate illuminance levels should be chosen.

Room characteristics influence the utilization factor. The higher the reflectances of room surfaces, the higher the utilization factor and the lower energy use is.

The luminous efficacy of a light source and a ballast influences the installed power of the electric lighting. The higher the luminous efficacy of a light source, the lower energy use is. Nowadays, T-8 and T-5 fluorescent tubes and compact fluorescent luminaries are most energy efficient. It is their high luminous efficacy, long lifetime, good colour rendering properties and relatively low price that ensure them unquestionable position in interior lighting. In applications where colour discrimination is the most important criterion, e.g. art rooms and laboratories with colour inspection, T-8 and compact fluorescent luminaries with colour rendering index CRI > 90 could be applied. Their higher cost and lower efficacy limit their application in other teaching areas.

T-8 and compact fluorescent lamps can operate on both: old traditional and electronic ballasts; T-5 lamps can operate on electronic ballasts only. Electronic ballasts increase the lamp efficacy and the lamp lifetime. They also provide a light output regulation that is unavailable in passive, magnetic ballasts.

Efficient luminaires of high light output ratio, low dirt accumulation ratio and efficient light distribution influence utilization factor and energy use. As fluorescent lamps are preferable, the luminaires for fluorescent lamps are an obvious choice. They are manufactured in variety of types: recessed, surface mounted, wall mounted, pendant and portable.

The general lighting is still the main method for illumination of school interiors. Though ceiling mounted (recessed or surface mounted) louvre luminaires dominate nowadays, high quality pendant luminaires seems to be the most promising choice for school interiors in the future. The most modern pendant luminaires provide opportunity for controlling light distribution in an interior through the use of electronic dimming ballasts. It has not only light intensity control but also opportunity to change the light distribution in upper and lower hemisphere of the interior depending on the users need. Such new systems provide opportunity of mounting different optical devices for the same housing of a lamp.

To minimise the installed power of the electric lighting, an optimal arrangements of luminaries should be proposed. Generally, for low illuminances the task lighting and for high illuminances combination of general and task lighting are most energy-efficient choices.

Off all control systems at the marked, the dimming control system is the best one for the energy conservation purpose. A central system controlling both, the shading device and the electric light installation is the best option. Also integration with other energy-consuming systems in the building is preferable. One of the main advantages of lighting control system is the possibility for automatic adjustment of illuminance to desired level.

Lighting systems require maintenance during operation. A well-planned maintenance schedule may save both: the energy and the operating costs. It is advisable to work out the maintenance schedule at the initial stage of lighting design process. The maintenance schedule should include lamp inspection and replacement, luminaries inspection and cleaning, room cleaning and repainting.

Authors' recommendations:

Designing luminous environment of school interiors for energy conservation an integration of electric lighting and daylighting should be applied. Control systems of electric light and shading system (providing flexibility and considerable energy savings) should be used. Energy efficient electric lighting systems (lamps, ballasts and luminaires) and effective luminaires arrangements should be applied. Room characteristics, maintenance procedures and lighting requirements should be considered in detail to contribute to energy savings, too.

Lighting system may be also coordinated with the other energy–consuming systems in the building.

Proposal for luminous environment design in a typical classroom in polish schools.

Tremendously many school buildings in Poland need renovation or redevelopment. There is a common political agreement that it should be done in accordance with the principles for sustainability. In this chapter we present ideas for design of the luminous environment for a typical classroom. Many of the principles and ideas presented here may be also used in other room categories, e.g. offices for teachers and the administrative personnel and in gym halls.

Description of a typical classroom

A typical classroom in Polish schools has an area of 50-55 m^2, an orthogonal shape in plan 6.0 x 9.0 m (sometimes 7.0 x 7.0 m) and is 3.0–4.0 m high. It has large windows in one of the longer walls giving much daylight from one side, figure 1. The glazing area is often about 20% of the floor area. There are no other daylight openings in the room. The mean daylight level in classrooms is rather high (5.5%) but the distribution of daylight is very uneven with very high level in the window zone (19%) and rather low level in the rear zone (1,5%), figure 2.

Figure 1. Photos of a typical classroom, at the morning to the left, at the evening to the right.

The teaching method is most often of the blackboard type; blackboard is fixed on one of the sidewalls. Students are normally sitting by two-mans tables with the main view direction toward the blackboard. They receive daylight from the left side. The teacher's workplace is situated before the blackboard with her/his view direction toward students.

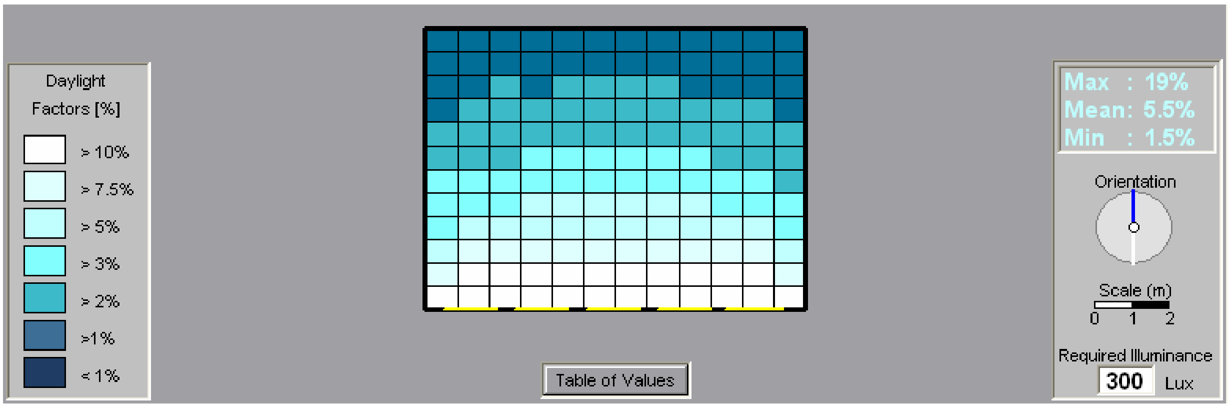

Figure 2. Daylight factor at the working plane in a typical classroom simulated with the LESO-DIAL program.

Recommendations for interior design: colours and finishes of room surfaces and furniture

The interior design of room surfaces and furniture is an important factor in determining the visual impression of the room, the efficiency of the lighting concept, the balance of brightness between the visual tasks and their environment and between the luminaries/windows and their background. Ceilings should be as light as possible (reflectances about 70 %). Wall reflectance's should be within the range 30 – 80 % (40 – 60 % preferably). Window wall reflectance should be at the high end of the range to reduce the luminance contrast between the window and the window wall. Blinds or drapes should have rather high reflectances, too. The floor, the secondary background for horizontal visual tasks, should have high reflectance (up to 40 %), but preferably lower than walls. Student tables and other furniture that occupy a large part of the visual field should have reflectances that create a comfortable brightness balance; preferable reflectances are 30 - 60 %.

Regarding finishes, satin surfaces are reasonable compromise between matte (more difficult to maintain) and glossy (may cause veiling reflections) finishes.

We propose to use whiteboards with a diffuse surface instead of black chalkboards. They should be illuminated as uniformly as possible with at least 500 lx.

Demonstration places should be illuminated taking into mind that both: vertical and horizontal illuminance component are equally important. At least 500 lx should be provided.

Daylighting in classrooms oriented to the east, south and vest

In the classrooms oriented east, south and vest a sun shading system is necessary to avoid solar glare. A sun-shading system is also necessary to avoid overheating in the spring and summer time. If the sun-shading system covers the whole height of the windows, the users sitting near the windows tend to close the system completely during the sun-hours to avoid solar glare. The light level gets to low, especially for users sitting away from windows, additionally light sources are needed i.e. the electric light is switched on. The result is exactly opposite to the principles for sustainability. To avoid this, we propose to divide the windows horizontally into upper and lower part. The upper part should function as a daylight source delivering comfortable light for vision especially during the sun hours. The lower part should primarily give an outside view and supply the upper part in the periods of overcast sky.

To avoid solar glare and overeating, the lower part should be equipped with a shading system that is capable to reduce sunlight transmission to about 10%. Avoiding overheating is very important, because it causes very poor indoor thermal comfort or necessity for local cooling. Therefore the lower part of the window should be as large as possible comparing to the upper part and the sun shading system should be preferably placed on the outside of the window. The sun-shading system should also be operable, i.e. it should be possible to remove it away from the glazing in periods of daylight shortage to ensure highest possible daylight level in periods when it is most desired. To ensure as much outside view as possible, the shading system should give possibility to adjust the grade of openness, such that the users can adjust the opening to avoid sunlight penetration, but to keep as much of outside view as possible. Typically, users response to solar glare quickly by closing down sun shading systems, but they forget to open it when the sunlight is not annoying any more, they tend rather to work with too low lighting level or to switch on electric light. An automatic control of the sun-shading system is preferable.

The upper part of the window should be equipped with a daylighting system that ensures sunlight penetration, but instead of transmit sunlight directly down to the room, redirects it to the ceiling or to upper parts of the walls. The possible solutions are [5]:

Direct light guiding systems:

- louvers or blind systems with highly specular upper blade surfaces,
- specular light shelf on inside or outside of the window,
- laser cut panels or serraglaze film,
- sundirecting glass,

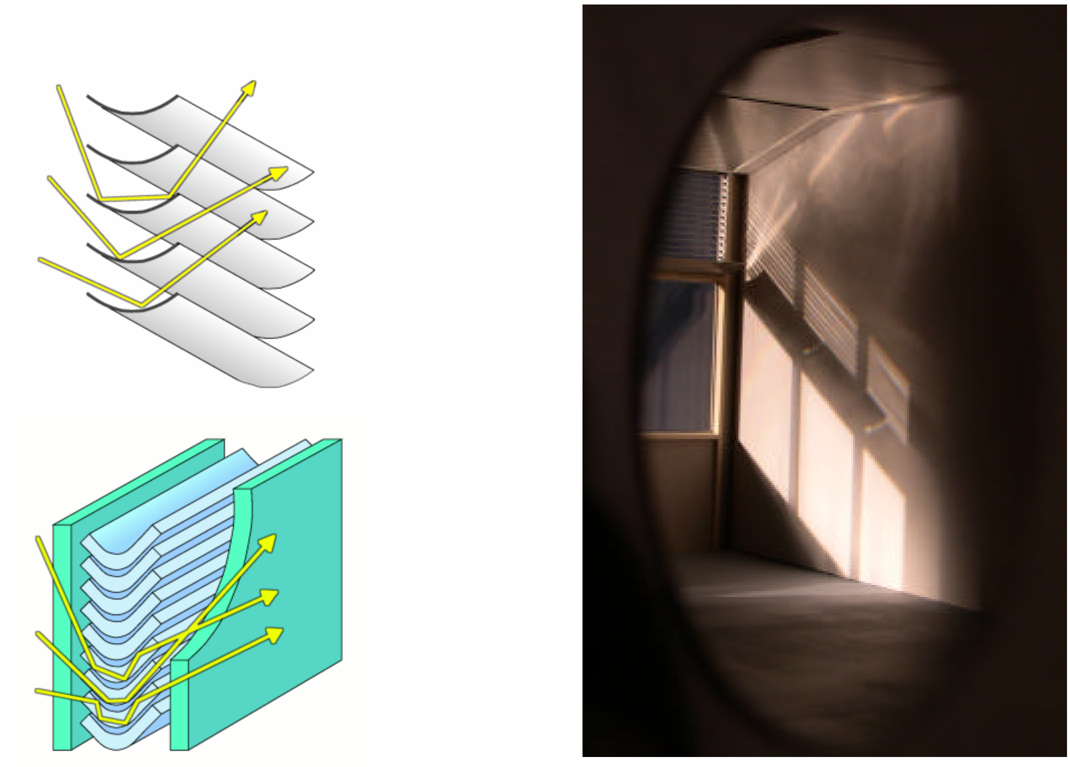

Figure 3. Examples of direct light guiding systems: specular blind system and sundirecting glass to the left, picture of a room with specular blind system and a specular light shelf to the right.

Scattering/diffusing system:

- diffusing screen, or traditional curtain,
- scattering transmissive isolation material e.g. MONIFLEX.

Since the upper part of the window should in principle transmit as much sunlight as possible, it transmits also the infrared part of the spectrum, i.e. it is a source of solar heat. Depending on the chosen system, the minimum size of the upper part of the window ought to be calculated.

Figure 4. The MONIFLEX material.

Daylighting in classrooms oriented to the north

The principle of dividing the windows into upper and lower part could still be an interesting solution for north-oriented classrooms, especially if it could increase the daylighting in the rear part of the room. Since the direct sunlight is not present, a shading system in the lower part is not necessary as long as visual comfort is maintained. In some situations, e.g. in north-oriented rooms were students use computer screens in direct neighbourhood of windows, a reduction of window's luminance may be necessary; in such case the light transmission of the shading system should be between 30-50%. In the upper part of the window the following systems could be used [5]:

Diffuse light guiding system:

- outside light shelf sloped upwards

- anidolic integrated system
- fish system

Daylight control system

Since a classroom is used by a group of people, an automatic control of sunshading system should be optimal, especially if it is coordinated with an automatic control of lighting system. It should be possible to override it by switching to manual modus.

Electric light

The lighting system should be as flexible as possible because different subjects are thought in the same classroom; in the evening classrooms may be used to adult education; different teaching methods may be used too (computer, laptops, audio – video equipment). Lighting system should have a dimming or a switching control so that unneeded luminaires may be turned off or dimmed.

As long as the traditional teaching method is used, the lighting system should be divided to the student zone and the teacher zone. In the student zone the illuminance on the horizontal plane is most important. It may be delivered by uniformly arranged luminaires on the ceiling that provide even illuminance level on the horizontal working plane. The modern pendant luminaires with the T-8, T-5 fluorescent tubes with CRI˃85 seems to be preferable. They provide opportunity for control of light distribution in an interior through the use of electronic dimming ballasts. Dimming may also provide some variability. Peripherally arranged luminaires 0,6 – 1 m from the walls offers some advantages. Due to increased wall illuminance the room appears wider and nicer [10]; wall–mounted objects are emphesized. In the teacher zone the light should emphasize the teacher and the board, the vertical illuminance is most important. Especially the teacher’s face should be perfectly modelled, such that the sliest changes on her/his face should be clearly visible.

During the periods of daylight shortage the circadian system should be stimulated especially in the morning. The traditional teaching method based on the presentation of topic by a teacher on a blackboard with all students looking at it gives a brilliant possibility to use the board as a strong secondary light source stimulating the circadian system through the eyes. The board has to be white; a special wall-washer(s) with additional light sources, giving light in the blue region, could be used. It is not necessary to increase the illuminance in the whole classroom, but the illuminance at the whiteboard (in short time periods) should be minimum 2000 lx.

In classrooms with computer use the care should be taken to create a visual comfort at each working place. The luminance distribution in the field of view should be relatively low and uniform; luminance ratios should not exceed the following: 3 : 1 or 1 : 3 between a paper task and adjacent VDT screen, 3 : 1 or 1 : 3 between the task and adjacent surrounding, 10 :1 or 1 : 10 between the task and non–adjacent remote surrounding. The VDT screens should not be placed in front of the windows. The luminaries should have such lighting properties and arrangement that their reflected images on VDT screens should not disturb the computer image. A general indirect lighting for ambient illumination coupled with task lighting for each work station allows most comfort and flexibility.

A dimming or a turning off the general lighting is necessary for audio–visual presentation (computer images, television and video programmes, slide presentations), but sufficient illuminance level should be provided to enable note – taking.

Because of all advantages mentioned before, the electronic ballasts should be applied in school interiors.

Conclusions

To design a luminous environment i accordance with the principles of sustainable development in school buildings and at the same time to ensure health and well-being for occupants, not only the obligatory requirements but also the newest research results should be considered. The requirements given in standards help to avoid mistakes, but they do not guarantee healthy and comfortable visual environment. They do not guarantee sustainable design either. A close cooperation between architect, lighting designer and the end user as well as exhaustive knowledge about lighting/daylighting is needed to create a successful luminous environment.

Since a school building is a place that students have a strong connection with, both as a place giving room for social behaviour and as a learning place, it should be a good example for sustainable building related solutions. The building itself could be used as a teaching device and presented/discussed during the relevant topics in the respective subjects; this idea is fully utilized in the Kvernhuset Lower Secondary School, Fredrikstad, Norway [11,12].

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ECO-ARCHITECTURAL ISSUES OF SUSTAINABLE BUILDINGS

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1. Introduction

In the modern understanding of this word, the architecture is a discipline comprising the ability of organization and formation of space in a way available in the given epoch in order to meet the material and spiritual needs of men – today and in future.

The approach of the formation of space, respected so far, is not sufficient any more. All fields of knowledge are penetrated by new values. Therefore, a new view on architecture is indispensable, bringing it closer to the user. In the course of many centuries we have receded from our natural environment, changed our surrounding and way of life, as well as the hierarchy of values and ethical standards.

At present architects must also adapt themselves to the existing rules of marketing. A strict cooperation with experts is today a vital requirement. Creative architects are well acquainted with the constantly increasing complex of conditions. A contemporary architect must posses a comprehensive interdisciplinary knowledge, including the ability of managing. Most important, however, is that he can cooperate in teams and convince other of the pertinence of his solutions.

2. Eco-architecture vs. sustainable buildings

In recent years more and more attention has been devoted to the hazards arising from the pollution of the natural environment and our dwellings. If we and our children want to survive, enjoying at least some minimum of our health, our consciousness and habits must necessarily undergo radical changes. As has already been mentioned, an obstacle to the adoption of these obvious ideas is the fact that many people are absolutely unaware of the global character of these problems, exceeding beyond everybody's experience. Hence the philosophy of "here and now", with still deepens the present state of affairs. Following

Lovelok's suggestion that favourable conditions our Earth are kept up by her inhabitants for their own that means, by living organisms, this is after all the result of a global cooperation of organisms, air, water and rocks [1]. And so, from this point of view of creating suitable dwellings, we must look for proper visions, models, methods and concrete applications of new solutions in order to reanimate a healthy and ecologically stable environment [2]. The natural environment predominate all the other systems thanks to its complexity, being a domain of cooperation of all natural factors, including those the source of witch is Man himself.

The Sun and water are the source of life, permitting to keep alive the world around us in its splendour and variety. If man by his activities brutally breaks the chain of ecological bonds, unsettles **the natural equilibrium considerably** [3].

Attempts to realize an ecological development of our planet concern the reduction of an excessive exploitation of the natural environment and protection of the constantly decreasing natural living space. It is imperative, therefore, to set up rules which might contribute to an improvement of the sanitary conditions of the buildings. General principles concerning the requirements of health and safety, the categories classified in the member countries of the European Union as belonging to the range of responsibilities of the governments, have been gathered in the obligatory Directives, the so-called "New Approch", whereas more detailed principles of the realization of the accepted decisions are dealt with in the respective "Interpreting Documents". These latter ones are rather only of an informational character. The Directive 89/106/Eec, concerning buildings products, treats a house as set of components applied for its construction and being merely objects of trading.

It is high time for us to think over our approach to problem of Eco-architecture, connected with technology, power engineering and the environment. What is needed, are alternative assumptions and integrated synergetic actions.

The necessity of satisfying requirements of the consumer for a comfortable internal environment obliges us to aim at providing and sustain accepted level of internal comfort all over the year, by day and by night. Therefore, the designer ought to possess a lot of principal knowledge about the needs of the residents and the fundamental architectural conceptions witch might be applied for the purpose of meeting these requirements as favourably for the environment as possible. The most optimal energy and ecological effects can be achieved when the given problem is solved on a comprehensive way, making use of all the obligatory means, on each stage of designing, keeping in mind all the obligatory tasks that must be realized in course of exploitation. By changing our approach to designing, such buildings may be constructed that not only will meet the expectations of their inhabitants, but also reduce the demand for energy, which in result will also reduce the negative effect on the environment.

3. Issues of sustainable architecture

How should our knowledge be utilized for the purpose of constructing healthy and ecological buildings? Haw can we shape and organize space friendly for man and the environment in order to meet the requirements of o sustainable and stable development?

Setting up a house means to "borrow" from the environment the needed site, to extract material resources for this purpose, to consume energy, water and air for many years to come. If after some given time the house is no state of this environment. The precise deconstruction of the building and careful revitalisation of the site will help to secure the original quality of the landscape. The consumption of energy and water, however, witch is connected with human activities, as well as the pollution of air, contribute to an abiding degradation of natural resources. If we agree that every one living on our Earth shares the equal right to utilize the natural resources, our freedom in this range must necessarily be limited, so that all the resources might be used most rationally.

Sustainable development should, therefore, become more and more important. From the viewpoint of energy saving mainly cumulated energy must be taken into account, comprising its consumption for the getting of raw materials, their transport and processing into components and products, and finally their utilization, and not only the energy used while exploiting the building.

4. Market issues of architectural design

In the creative process there are two participants, the **creator and the material**. The creator, i.e. the architect, knows the assignment of the designed structure, its localization and external environment. He considers the spirit resulting from its assignment, its aesthetics, its form and also the material to be used for this purpose, so that this idea of the building as a whole would be realized ad its best and the material would last for a long time. He takes into consideration various variants to get out the full spirit of the structure, the essence of the designed object [4].

Creative architectural design is a very complex process, requiring a thorough knowledge in various branches and numerous abilities. The architect must be familiar with the art of contemporary designing of structures of various kinds and with the way of securing a healthy and friendly environment. If the designed buildings are to be most functional and aesthetical, their spatial structure and the properties of the material from witch they are, to be constructed must be well know.

As an architectural object, a building on the market is also a product of special importance, being an object of profit for the owner. There operate certain rules and laws as well as the philosophy of marketing. The client who wants to acquire the building is interested in general features of the product, called the core benefit [5].

Four layers may be distinguished in the structure of any product: its core (the architectural object), the actual product, the extended product and potential product. The meaning of the core of the product is easy to understand when we answer the question: “what does the buyer actually expect to by?” The premise of every acquisition is the wish to satisfy some needs, e.g. in the range of getting a flat, a house or some other building.

The quality of the product decides about the extent to which it meets the technical requirements and the requirements of the user. Assuming as a criterion the character of the respective features deciding about the general value of the product, we can separate from among them those features which decide about their material value (e.g. durability, reliability, operational safety) and about their usability, emotional values, determining the effect of the product (building) on the mental life of the user. As we see, quality has its objective as well as subjective aspects.

Both these groups of features deciding about the quality of the product are interdependent. Nowadays the conception of usability is being introduced, as far as buildings are concerned. This conception joins both these aspects of quality – the objective and subjective one, concerning the material and the creative side. This conception can also comprise also other features, as for instance elasticity etc. The essence of an actual product is not something that is fixed. Changes in structure of a product depend on the demand and supply and also on the competition between the vendors. Generally an increase of the usability value of a product (building) involves higher costs of production and maintenance. For this reason we should not aim at achieving the highest level of all the features composing the quality of the object as a whole.

Similarly in the case of buildings the consumption of energy and other costs should be considered for the entire life cycle of the building, not only concerning its erection and exploration in some given period of time.

5. Rules for the architectural design of sustainable buildings

Rules for the modern formation of buildings

Today nobody is able to solve global ecological problems on his own account. Nowadays the protection of the natural environment and the protection of human health is getting more and more important. Hence this kind of architecture and civil engineering, called friendly, ecological and sustainable, has become a required and important discipline and is at present a fundamental challenge for the architecture and civil engineering of the 21st century.

The new sustainable eco-architecture should construct a bridge between architecture and environment in which we live. It ought to deal with those aspects of design that have been up to now neglected giving rise to a new differentiated view and architectural experience concerning the environmental requirements and priorities of the new millennium.

Based on analyses which have been carried out, four fundamental rules of modern architecture are being suggested below:

- **I. The principle of reaching back to the sources – to the roots (durability, expediency and beauty – 3A). This means creative thinking.**
- **II. The principle of synergy between the fundamental elements of creative architectural design. This means synergic thinking.**
- **III. The principle of compact solution in the arrangement Man – Environment – Friendliness. This means environmental thinking.**
- **IV. The principle of effective solutions in the 3E system (Ecology – Energy – Economy) taking into account the complete life cycle of the building. This means thinking from the viewpoint of marketing.**

These fundamental rules indicate the necessity of a complex approach to the formation of building (i.e. designer) assigned mainly the dwelling, including apartment buildings. In our times it is not enough to approach this problem creatively; **we must approach it keeping in mind the synergy, environment and marketing** [6].

Recommendations concerning the formation of contemporary architecture

More than 2000 years ago Plato said that the most difficult task to be faced by man is to recognize oneself. Today another important element should be added – to recognize the environment and its influence on man. According to Plato, between nature and man there exists an inseparable unity. That is why it is so important to spare no pains in order to restore this bond and balance in our activities. Of crucial importance is a full awareness of making decisions concerning building areas.

The principles concerning the formation of modern architecture are rather of a general character and do not comprise many detailed problems. For this reason the most important recommendations for architectural designers have been set up, viz.:

1. Be fully sensitive to historical and cultural values of the given area and their adequate utilization.
2. Don't look only for good technical solutions, but also for architectural solutions enhancing the beauty of the built structures.
3. Give architecture and town planning such a shape that the following issues might always be taken into account:
   - ✓ space and identity
   - ✓ space and widely understood social interests
   - ✓ architecture as a value
   - ✓ modernity and tradition
   - ✓ spatial order in various dimensions
   - ✓ unity in variety.
4. Confide in durable achievements and the values of architecture.
5. Cooperate closely with the future users and with experts representing various branches.
6. Analyse carefully the connections between the aesthetic and material values, and between the ecological and economical ones.
7. Keep in mind that also in architecture the market conditions do not allow for illusion (we have to do not only with an architectural object, but with a market product, as well).
8. Remember, architecture is not merely the past and present time, but mainly reaches into the future (hence the obligatory necessity to scan the evolutionary trends in architecture).
9. Be aware that architectural products involve semantic, artistic and material memories.
10. Do not apply shocking solutions, but suggest sustainable solutions which may be adapted to the existing local conditions.

6. Conclusions and summary

1. Ten recommendations quoted above supplement four principles quoted earlier but do not, of course, address this complex problem entirely.
2. The designing of architectural solutions taking into account up-date ecological, technical and economical requirements, is a very difficult task, because various, sometimes incompatible factors must be brought in harmony in order to attain an optimal sustainability of solutions.
3. It is impossible today to find the best solutions in some given specific situations without applying various complex methods and techniques, as well as auxiliary tools (e.g. computer software). The huge amount of constantly increasing information and knowledge must be segregated and analysed, without which it is extremely difficult to choose the proper "path" of procedure. Otherwise we might get lost in this labyrinth, and therefore an outline of the theory of ecological architecture – eco-architecture has been drawn up, which constitutes on the present stage only a framework of modern buildings.

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NATUREPLUS – CONTROLLING AND ASSESSING THE ENVIRONMENTAL PERFOMANCE OF BUILDING PRODUCTS BY AN INTERNATIONAL LABEL OF QUALITY

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1. Organisation of natureplus

natureplus is an initiative for an international label of quality for building products that are environmentally friendly, do not endanger health and function satisfactorily. The initiative natureplus was conceived by the International Association for Sustainable Building and Living e.V. Members includemanufacturers, traders, consumer and environmental affairs organisations, planners, consultants and laboratories. Its structure is linked to weighted voting rights which assures that none of the groups can dominate the awarding of the label no matter how numerous and well funded they are. Natureplus has national offices in Austria, Belgium, Germany, Hungary, Netherlands, Switzerland.

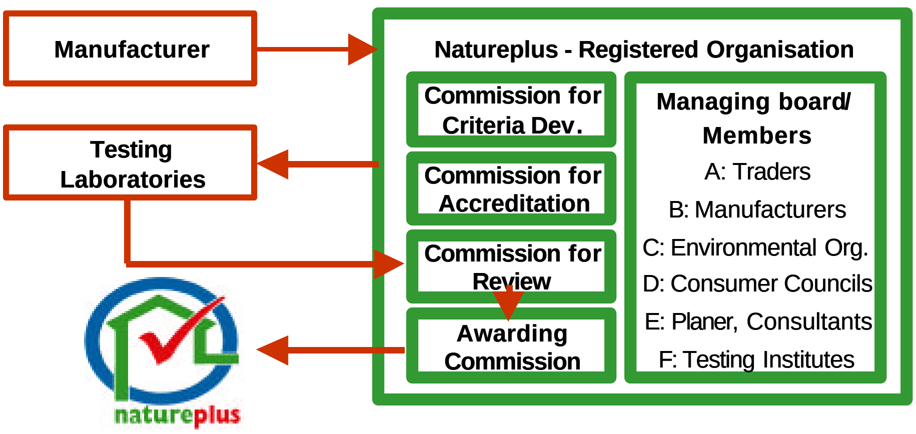

Figure 1: organisation structureof natureplus.

2. What are the aims of natureplus ?

natureplus offers:

- one single and uniform label of quality in which various existing "eco-labels" are incorporated.
- a label of approval that is known and accepted in many European countries.
- straightforward and credible communication of all products that have no adverse effects on the environment or health.
- a step towards ecological product optimisation

The award guidelines can also be used for example, for an environmental declaration or for the technical descriptions of calls for tenders – independent of the fact whether there are natureplus-awarded products or not.

3. What are the qualifying criteria ?

The award guidelines are subdivided into three hierarchies: The basic criterias (for all products), the award guidelines for product-groups and the award guidelines for a specific products. All award guidelines consider the three requirements of health, environmental and functional compatibility. The award guidelines are developed on the basis of scientific perception and data and in a process of discussion with the manufacturers, experts and are finally passed by the managing board. Some of the key criterias are:

- a proportion of renewable and / or mineral raw materials of at least 85 percent
- use of resources that are available in sufficient quantities
- absence of all materials risking damage to the environment and / or to our health
- manufactured with low energy consumption
- low emission of harmful substances during manufacture and during actual use
- ecologically optimized packaging
- detailed information on processing
- a full declaration of all input materials

The criteria of the natureplus ecolabel are very comprehensive and strict but still compliant with the market due to the developing-process with manufacturers.

4. Functional compatibility – precondition for natureplus

The functional compatibility is - beside the compatibility with legal rights - the most important precondition for natureplus.

Expample: Functional suitability for vertically perforated bricks
The product must comply with the requirements of EN 771-1 (or, up until 2004, with German standard DIN 105, Austrian standard ÖN B 3200, or some equivalent standard); and the manufacturer must submit appropriate documentation proving this. Any bricks intended for use in constructing non-load-bearing partition walls must comply with Austrian standard ÖN B 3201 or some equivalent standard; and the manufacturer must submit appropriate documentation proving this.
Any exterior wall construction methods recommended by the manufacturer of this product must ensure a resulting sound reduction index Rw of at least 43 dB.
Ashlar stones intended for use as monolithic exterior walling (i.e. = min. 36.5 cm thick) must ensure thermal conductivity (calculated value) of 0.14 W/(mK) as per EN 1745. This stipulation does not apply to products intended for applications other than the above. This stipulation does not apply to bricks that are marketed and sold exclusively in regions whose heating degree days during the heating period come to less than 2500 Kelvin-days per annum.

5. How does natureplus meet requirements of health?

The requirements of health are met by two principles:

- precautionary principle – limitation of problematic ingredients
- laboratory testing – limitation of indoor air emissions

Expample: precautionary requirements for vanishes

These products must not have any of the following substances added :

- softening agents (as defined in VDL Guideline 01)
- glycol compounds
- alkylphenol ethoxylates (APEO)
- organic halogen compounds
- organotin compounds
- azo pigments that release carcinogenic amines
- biocides not specifically required as pot-life preservative (film preservation agents)
- isothiazolinones
- formaldehyde separators

The product must not contain or be prepared with any pigments or desiccants based on lead, cadmium, chromium VI, or any compounds of these. The product must not contain or be prepared with any pigments that are suspected of being hazardous in ecological and / or toxicological terms, e.g. Naples yellow (lead antimonate).

The proportion of chemical-synthetic additives in total must not exceed 5 mass %; the use of synthetic binding agents (e.g. acrylates) is not permitted. The proportion of organic solvents must not exceed 0.5 mass %. Synthetic preservatives in total must not exceed 0.1 mass %.

Example: laboratory testing requirements for indoor air emissions of varnishes

Emissions: (after drying an conditioning)			Chamber process DIN V ENV 13419-1
Volatile organic compounds (VOC)		**µg/m³**	Preparation: E DIN EN 13419-3 taking samples and evaluation: DIN ISO 16000-6
VOC classified in:	K1, K2; M1, M2; R1, R2 (gem. TRGS 905, RL 67/548 EWG); IARC Gruppe 1 u. 2A; MAK III1, III2	Not determined	24 h after test chamber is loaded
Total volatile organic compounds (TVOC)		≤ 300	28 d after test chamber is loaded
of which	Total alkyl aromats	≤ 50	28 d after test chamber is loaded
	Total terpenes („bicyclische“)	≤ 200	28 d after test chamber is loaded
	Total sensitizing substances, as per MAK IV, BgVV list cat. A, TRGS 907	≤ 100	28 d after test chamber is loaded
	VOC classified in: K3; M3; R3 (per TRGS 905, RL 67/548/EWG); IARC group 2B; MAK III3	≤ 50	28 d after test chamber is loaded
	Total saturted n-aldeyhdes	≤ 180	28 d after test chamber is loaded
	Special individual substances	NPG	28 d after test chamber is loaded
Semi-volatile organic compounds (SVOC) (total)		≤ 100	28 d after test chamber is loaded
Formaldehyde		≤ 24	72 hours after test chamber is loaded
Odor		Odor intensity ≤ 3	Natureplus procedural rules for „Odor test“, 6-level scale

6. How to measure environmental performance?

The environmental performace is measured by both qualitative and quantitative methodes.

Example: Ecological requirements for the production of porous wood-fiber-boards

At least 50 mass % of the raw materials used must come from certifed [(1)] industrial wood or at least 50 mass % from secondary raw materials (e.g. lumber-mill waste, splinters, chips, left-over slabs, and cross-cuts).

(1) For dates and deadlines, see RL 0200, Section 2.4

For the raw materials records must be kept to provide proof of origin. The regulations of natureplus guideline 0200 regarding the use of pesticides must be properly observed and records must be kept to prove that the product complies with these.

If bitumen is used as input material, the manfacturer must provide evidence that in the production and installation of the product no bituminous aerosols or dusts are caused. Production effluent should be managed in a closed circuit. For open circuits the following applies: The specific effluent volumes should not exceed 2 m^3 per tonne of wood-fibre-board produced. If the effluent is discharged into a body of water or into the public drains system, the following emission values must be respected:

	(1)	(2)
General parameters		
Temperature	30 °C	35 °C
Bacterial toxicity GL	4	a)
Fish toxicity GF	2	a)
Precipitable substances	0,3 ml/l	10 ml/l
PH value	6,5-8,5	6,0-9,5
Anorganic parameters		
Ammonia calc. as N	5,0 mg/l b)	-
Sulfate calc. as SO_4	-	200 mg/l
Organic parameters		
CSB calc. as O_2 c)	1 kg/t	-
BSB5 calc. as O_2	25 mg/l	
AOX calc. as Cl c)	0,2 g/t	0,2 g/t
Total hydrocarbons	10 mg/l	20 mg/l
Phenolindex calc. as Phenol c)	0,3 g/t	60 g/t

(1) Requirements for effluent discharged into a body of running water
(2) Requirements of effluent discharged into the public drains system
a) The discharge of effluent must not have any adverse effects on the biological decomposition processes in a public sewage purification system.
b) If effluent is purified by biological means, this emission value only applies so lang as in the biological stage of sewage purification the effluent retains a temperature above 12 °C. The 12 °C minimum temperature is considered not maintained if, from five temperature measurements equally distributed across the test period, more than one measured value lies bellw 12 °C.
c) This emission value refers to the tonne of installed production capacity for wood-fiber-boards (absolutely dry).

If the effluent is discharged into a body of running water, the aluminium content must be less than 2 mg/l. If the effluent is discharged directly into a sewage treatment plant it may be necessary to agree with the plant on certain special regulations to apply per individual case. The recommended values may be exceeded if so permitted or required by special circumstances and if approved or prescribed by the competent authorities.

Plant emissions into the atmosphere must comply with the emission limits specified by the Austrian "Luftreinhalteverordnung für Kesselanlagen" (LRV-K) (clean air ordinance of boiler systems (BGBl. 1989/019 and 1997/324) or equivalent ruling.

The manufacturer of all porous wood-fiber-boards must comply with the following ecological indicators:

Test parameters	Recommended value	Test method
Non renewable energy sources [MJ/m3]	5000	see : Frühwald A, Scharai-Rad M, Hasch J "Ökologische Bewertung von Holzwerkstoffen" (ecological evaluation of timber derivative materials) AIF concluding report, supplemented in the areas chip-board recycling and OSB audits, November 2000
Global warming potential 1994 / 100 years [kg CO2 equivalent / m3]	300	
Over fertilization [kg phosphate equivalent / m3]	0,3	
Photosmog [kg ethylene equivalent / m3]	0,5	
Acidification [kg Sox equivalent / m3]	2,5	

7. Product declaration – an important part of natureplus

It's very important that the consumers are provided with the necessary information about the product. Natureplus meets this requirements by forcing the manufacturers of labeled products to declare some crucial information.

Example: Declaration as per basic criteria
Full declaration of input materials (listed according to declining mass percentage)

- up to 1 mass% - designation of the substance in question
- less than 1 mass % - at least functional designation (e.g. "moth proofing agent")

plus note on the packaging indicating the place and country where the product was manufactured, if ther is no packaging, with the product (in Englisch or in the national language).
If sensitizing input materials as per MAK IV C / TRGS 907 / BgVV-list Kat. A and B are used, there must be a note on the packaging indicating where more detailed information can be obtained (e.g. in the product information /technical data sheet).

8. How can you obtain the natureplus label of quality ?

1. The manufacturer submits an application for product testing to the natureplus e.V. office.
2. He will then receive all the necessary documentation.
3. As and when the manufacturer submits the duly completed documentation natureplus starts the preliminary tests.
4. The manufacturer will be informed in due course whether natureplus considers his product(s) suitable for certification.

5.a) If the product does not prove suitable, testing will be terminated.
b) If the product does prove suitable, natureplus will make an offer for progressing to the principle test phase.

6. The manufacturer then commissions **natureplus** to start the principle test phase. The manufacturing site will be inspected and samples will be taken. natureplus will then conduct various laboratory tests and a full life cycle analysis.

7.a) If the product fails to satisfy the criteria, it may be optimised accordingly and then resubmitted for the principle test phase.
b) If the product does satisfy the criteria, it will be awarded the natureplus e.V. label of quality for three years.

8. During these 3 years there is a yearly follow-up evaluation on a smaller scale

How to get more information?

natureplus is a dynamic project. The abstract on hand describes the stage of discussion at the date of writing (july 2004). You can find all current information like the award guidelines, the assessment methods, the awarded products on the homepage: www.natureplus.org.

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THE ITALIAN NATIONAL STANDARD APPROACH TO ASSESSING ECOCOMPATIBILITY OF BUILDING DESIGN

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1. Introduction

The National Standard Organisation of Italy (UNI) – Building Process Commission, WG on Building Sustainability – has developed a method to evaluate the environmental compatibility of building and urban design as a tool to be used by local government officers in order to assess eligibility of building projects, claiming to be environmentally sustainable, for access to grants or fiscal discounts. This activity has being carried out in connection to the work activated by the ISO TC 59/SC 17 (Sustainability in Building) since September, 2003, with particular reference to WG 4 (Framework for the assessment of environmental performance of buildings) [1]. Guidelines for the assessment method are planned to be published by the end of this year. A partial application of the method has being carried out on projects of the Turin 2006 Winter Olympic Games Programme.

2. General Principles

The evaluation of environmental sustainability (i) of building design is a difficult task due to the complexity of the building process which: involves several actors; deals with building materials, components, and a building as a whole; and encompasses the entire life cycle –from cradle to grave – of all considered elements. The current Life-Cycle Analysis (LCA) approach as applied to management processes (ii) and building products (iii) can play a role on the

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(i) Related to environmental aspects, as defined by ISO 14001:1996; it can also be referred to as “environmental performance”, as in ISO/CD 21931 Sustainability in building construction – Framework for assessment of environmental performance of buildings and constructed assets.

(ii) See: ISO 14040, 14041, and 14042 on Environmental Management – Life cycle assessment.

(iii) See: ISO 14025 Environmental labels and declarations – Type III environmental declarations; ISO/CD 21930 Sustainability in building construction – Environmental declaration of building products.

assessment of environmental performance of buildings and building design. However, a thorough LCA application to all building elements implies a time-consuming and costly process, based, generally, on energy consumption and impact data related to production activities, which cover only a limited part of the building life cycle and exclude the use phase. This phase can be, instead, the far most significant of the life cycle, in terms of environmental loads, and needs to be dealt with using a different approach, based on “scenarios”, i.e., perspective estimates of the environmental effects and impacts related to the types of use, management, and maintenance foreseen by the project.

For these reasons, among others related to the need for simplified tools targeted to non-expert users, the assessment methods of environmental performance of buildings, developed and applied world-wide since the early 1990s [2] [3], are based on approaches that either use lumped LCA indicators ([iv]) or weighted scoring ([v]). These approaches allow for considering both qualitative and quantitative environmental factors and, therefore, can deal with the wide range of issues typical of building design, which include non-LCA related issues such as context relationships, comfort and health. The method presented here is aimed at assessing the design of building and settlement projects and is based on the weighted scoring approach.

3. Methodology

The description of the proposed evaluation method includes the following aspects:

a. data acquisition for assessment and benchmarking;
b. reference classification system for needs/objectives, requirements, and indicators;
c. evaluation procedure, including benchmarking, scoring and weighting;
d. application examples.

3.1. Data acquisition

3.1.1. Data for evaluation

The data sets to be used for evaluating the design of a building/settlement project comprise the following types of information:

a. *context data*, including site and local climate characteristics;
b. *building data*, including dimensions of external and internal spaces as well as types and quantities of materials and building components;
c. *operational data*, including occupancy level, scheduling, and energy consumption prediction;
d. *environmental information*, including LCA-based eco-profiles and ecological labelling of building products as well as possible environmental plans for construction works, maintenance, and end-of-life management.

The main source of the above information is the numerical, graphical, and written documentation provided by the project to be evaluated. Depending on the level of completeness and accuracy of that information, other sources might be needed, such as statistics on local climate and literature references on material environmental characteristics.

([iv]) See, as an example: *Ecoprofile* (Norway), and *Eco-Quantum* (Netherlands).

([v]) See, as an example: *GBTool* (Canada-international), *BREEAM and ENVEST* (UK), *CASBEE-J* (Japan), and *LEED* (U.S.A.).

3.1.2. Data for benchmarking

The proposed method does not foresee explicit benchmarking ([vi]), i.e., does not show, for the various requirements, the level of performance used as a reference for the evaluation. Nevertheless, this level is implicitly set when the classes of values are defined (see § 3.3.1. below). For quantitative requirements, the data needed to set this implicit benchmark level are taken from statistical analysis on local environment-related behaviours – e.,g., energy consumption for dwelling surface unit, water consumption per capita – or drawn from regulatory requirements, e.g., normalised thermal load for space heating as calculated according to the national energy saving law.

3.2. Reference classification system

The reference classification system used for defining sustainability objectives, criteria, and relevant indicators, is based on the standard performance approach set by UNI since 1965 and adapted to the specific evaluation scope. In particular, the performance scheme characterised by "needs" (objectives) ([vii]) and "requirements" ([viii]) was updated to the sustainability evaluation goal, by adding two classes of needs: *reduction of environmental loads* and *rational use of resources*. In addition, the class of needs related to the *comfort and health* was extended to deal with outdoor spaces.

Needs are grouped in *classes of needs*, corresponding to *general objectives* – "items" or "impact categories" in other methods. Differently from the common approach used by the other score-based methods, the general objectives with relevant objectives and requirements are associated to the life cycle phases, as shown in Figure 1 [4].

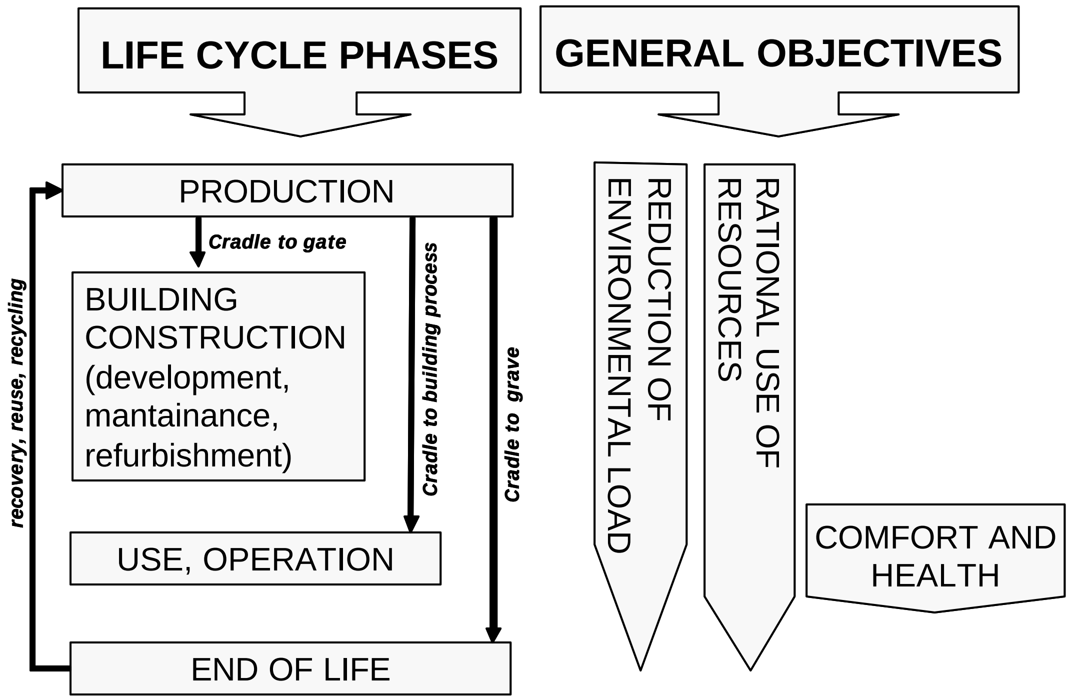

Figure 1 – General objectives associated to life cycle phases

([vi]) As it is done, for example, by GBTool.

([vii]) Needs related to the activities performed by the users of a building/settlement as well as related to the community as a whole.

([viii]) A requirement is the expected "performance" of a building space unit or technical unit to fulfil a need.

3.2.1. Sustainability objectives and requirements

The requirements associated to the production/construction/maintenance/end of life phases [5] are related to the "environmental" general objectives as shown in Tables 1a, while the requirements associated to the use phase are related to both "environmental" and "comfort" general objectives, and relevant specific objectives, as shown in Table 1b [6].

Table 1a – List and classification of sustainability requirements for the production/construction/maintenance/end of life phases

GENERAL OBJECTIVES	REQUIREMENTS	LIFE CYCLE PHASE
Reduction of environmental loads	Use of building products with ecological labelling	Production, construction, maintenance
	Use of environment-conscious systems and techniques in the construction works site	Construction
	Use of environment-conscious systems and techniques for the maintenance operations	Maintenance
	Use of environment-conscious systems and techniques for the end of life management	End of life
Rational use of resources	Use of recycled material and elements	Production, construction
	Use of material and elements highly recyclable	Production, construction
	Use of construction techniques, which facilitate disassembling at the end of life	Construction
	Use of materials and elements, characterised by a long life expectancy as well as high re-usability and maintainability	Maintenance
	Presence and characteristics of an Environmental Management Programme (EMP) for C&D waste recycling	End of life

Table 1b – List and classification of sustainability requirements for the use life cycle phase

GENERAL OBJECTIVES	OBJECTIVES	REQUIREMENTS
Reduction of environmental loads	related to air and climate	Reduction of green-house gasses emission
	related to soil and sub-soil	Limitation of building foot print area
		Limitation in volume of below-grade terrain cutting
	related to water	Maximisation of drainage surface area
	related to natural systems and landscape	Protection of valuable vegetation species and insertion of new autochthon species
		Protection and valorisation of biodiversity
		Preservation of landscape quality, with particular attention to visual features and terrain morphology
Rational use of resources	of waste	Use of a differentiated urban solid waste disposal system
	of water	Reduction of potable water consumption and preservation of water quality
		Recovery of storm water for compatible use
		Recovery of grey water for compatible use
	of climate and energy	Use of winter solar radiation for space heating
		Solar control to avoid overheating
		Use of air movement for natural ventilation
		Use of thermal insulation
		Use of thermal mass
		Substitution of fossil fuel with renewable sources in HVAC and electricity production

to be followed

to be continued

GENERAL OBJECTIVES	OBJECTIVES	REQUIREMENTS
Comfort and health of users	Thermal, visual, and acoustic comfort of open spaces	Control of radiative thermal flux exchange
		Control of convective thermal flux exchange
		Reduction of glaring due to light reflective surfaces
		Protection from noise sources
	Health condition related to the variation of electromagnetic fields (ELF) from artificial sources	Protection of outdoor and indoor spaces from variation of electromagnetic field (ELF) due to high voltage electricity lines
		Provision of electrical systems and location of appliances, to minimise ELF electromagnetic field exposure
		Protection of outdoor and indoor spaces from variation of electromagnetic field due to radiofrequencies
	Health condition related to the exposure to indoor air pollutants	Limitation of exposure to radon in radon-risk zones
		Dilution of indoor air pollutants, if any, by ventilation
		Reduction of fibres and dusts emissions to indoor air

The requirements shown in Tables 1 were selected out of a much larger list of items, set up during the two year-long activity carried out by UNI's WG on building sustainability. This reduction is due to both practical and theoretical reasons. The former are related to the need of developing an easy-to-handle tool which should be based mainly on data available within the project documentation. The latter are related to the lack of sufficient scientific background for requirements belonging to "bio-ecological" aspects ([ix]) as well as the lack of national data base for LCA-based impacts of building products.

As Table 1a shows, the majority of requirements for the non-use life cycle phases are of qualitative nature and refer to programming documents which should include all information needed for the environmental performance assessment of the project. The requirements related to comfort and health of users (Table 1b) are related to issues still non covered by standards and regulations [7].

3.2.2. Indicators

The indicators for the requirements associated to the non-use life cycle phases (see Table 1a) are:

a. presence/absence of environment-conscious systems and techniques in the construction, maintenance, and end of life phases (qualitative assessment);
b. presence/absence of construction techniques which facilitate disassembling at the end of life and their allocation on the building structure for the relevant requirement of the construction phase (qualitative assessment);
c. for all other requirements related to the production, construction, and maintenance phases, ratio (%) of the number of building elements with characteristics fulfilling a requirement, to the total amount of elements of a given type and of the building as a whole ([x]).

The indicators for the requirements associated to the use life cycle phase (see Table 1b) are much more articulated . In relation to the aim and scope of this paper, not all the indicators are presented, but only the ones associated to the requirements belonging to the general objectives "reduction of environmental loads" and "rational use of resources", as shown, in general terms, in Table 2.

([ix]) Such as "protection from changes of energy fields due to alterations of the geo-physical characteristics of the site". However, the complete list of requirements will be published within the final guidelines.

([x]) The number of building elements – defined as a structured set of materials or building products, either pre-fabricated or built on-site – was preferred, as an evaluation unit, to a dimension (mass, volume, or area), in order to speed up the process and considering the level of accuracy typical of a score-based tool.

Table 2 – Indicators of the sustainability requirements for the use life cycle phase

GENERAL OBJECTIVES	REQUIREMENTS	INDICATORS
Reduction of environmental loads	Reduction of green-house gasses emission	Classes of emissions
	Limitation of building foot print area	Ratio (%) of foot print area to lot area
	Limitation in volume of below-grade terrain cutting	Ratio of below-grade built volume (no primary use) to total built volume
	Maximisation of drainage surface area	Ratio (%) of outdoor water-permeable area to total external lot area
	Protection of valuable vegetation species and insertion of new autochthon species	Classes of qualitative assessment
	Protection and valorisation of biodiversity	Classes of qualitative assessment
	Preservation of landscape quality, with particular attention to visual features and terrain morphology	Classes of qualitative assessment
Rational use of resources	Use of a differentiated urban solid waste disposal system	Classes of qualitative assessment
	Reduction of potable water consumption and preservation of water quality	Classes of qualitative assessment
	Recovery of storm water for compatible use	Classes of qualitative assessment
	Recovery of grey water for compatible use	Classes of qualitative assessment
	Use of winter solar radiation for space heating	Ratio of the average length of shadows cast by buildings at noon, winter solstice, to the average meridian distance between buildings
		Weighted average ratio of the area of facades south oriented (± 20°) to the total vertical envelop area of the buildings
	Solar control to avoid overheating	Ratio (%) of number of windows with fixed shaded glazed area grater than 60% of total glazed area between 15h and 17h, summer solstice, to the total number of windows oriented to SE, S, SW, W (sample buildings)
		Area-weighted average shading coefficient of the windows oriented to SE, S, SW, W (all buildings)
	Use of air movement for natural ventilation	Ratio (%) of the number of dwellings with potential wind-driven and/or stack effect-driven cross ventilation to the overall number of dwellings
	Use of thermal insulation	Area-weighted U-value of the envelop of all buildings
	Use of thermal mass	Area-weighted thermal decrement factor for external massive walls and roof of all buildings (winter use)
		Area-weighted thermal decrement factor for external massive walls, roof, and internal slabs of all buildings (summer use)

to be followed

to be continued

GENERAL OBJECTIVES	REQUIREMENTS	INDICATORS
Rational use of resources	Substitution of fossil fuel with renewable sources in HVAC and electricity production	Efficiency Factor for primary (xi) energy loads related to HVAC and electricity production systems, defined as the ratio of the difference between a reference load and the project load to the reference load (range 0-1) (xii)

3.3. Evaluation procedure

The evaluation procedure can be divided by steps, through which various tools and techniques are used for:

a. setting a scale of classes of environmental performance values including different levels of benchmarks;
b. determining, for each requirement, an absolute performance value, based on value/s of the relevant indicator/s;
c. attributing a score to each requirement, by multiply the absolute performance value to a weighting factor;
d. summing up the weighted score of all requirements in order to obtain the overall environmental performance score of the considered project.

3.3.1. Environmental performance values and benchmarking

The evaluation of the environmental performance of a building project is the result of the procedure through which the environmental performance of the project for each of the above listed requirements is evaluated. This evaluation is carried out on the basis of pre-defined classes of performance values to be applied to the indicator/s related to each requirement. The number of classes is 6, ranging from 0 to 5.

These ranges of classes of values, i.e., environmental performance scores, are related to predefined benchmark qualities defined as follows:

a. baseline benchmark (score 0/5) – related to current practice and regulation standards;
b. best practice benchmark – related to the best environment-conscious practice in the local context (score 3/5);
c. optimum target benchmark (score 5/5) – the highest possible target performance values compatible to the local technology state of the art as well as social acceptability and economic conditions.

Regarding the quantitative indicators, the range of variation, within each class, of the relevant evaluation unit (%, dimensionless factor, or physical measure, depending of the requirement) as well as the boundaries between classes are defined on the basis of research results [8], [9], [10], [11], expertise, and literature references [12]. Attention is paid in setting ranges of values and class boundaries in such a way that fit the benchmarking level indicated above. A sensitivity analysis is planned in order to check the effect of the variation of both class boundaries and ranges of values on the final overall score.

3.3.2. Weighting

The relative importance of each requirement for the evaluation of the environmental performance of a project is expressed by a weighting system aimed at addressing local

(xi) Primary energy refers here to the source energy as opposed to the end-use energy. The following coefficients, based on the Italian energy mix, are used to convert end-use energy to primary energy: renewable sources = 0; ibryde renewable sources (cogeneration, district heating,…) = 0,5; methane = 0,75; non-gaseous fossil fuel = 1; electricity = 2,6.

(xii) This ratio can be calculated either for the total building load or separately for each energy system.

contexts conditions and specific building type characteristics. The weighting system which will be applied ([xiii]) to the UNI's evaluation method is based on a hierarchical process through which the final weighting factor of a requirement is determined by multiplying partial weighting factors corresponding to the various level of classification (objectives, general objectives, phases of the life cycle), as shown in the application example below (§ 4).

Different sets of weighting factors will be defined in relation to local-specific and building-specific aspects such as the following:

a. local government policy related to environmental objectives;
b. main function of the building;
c. climate zone of the building location;
d. use and operational scenarios.

4. Example of application of the procedure

Examples of application of the above described procedure for both a qualitative and a quantitative based requirements are shown in Figure 2a and 2b, respectively.

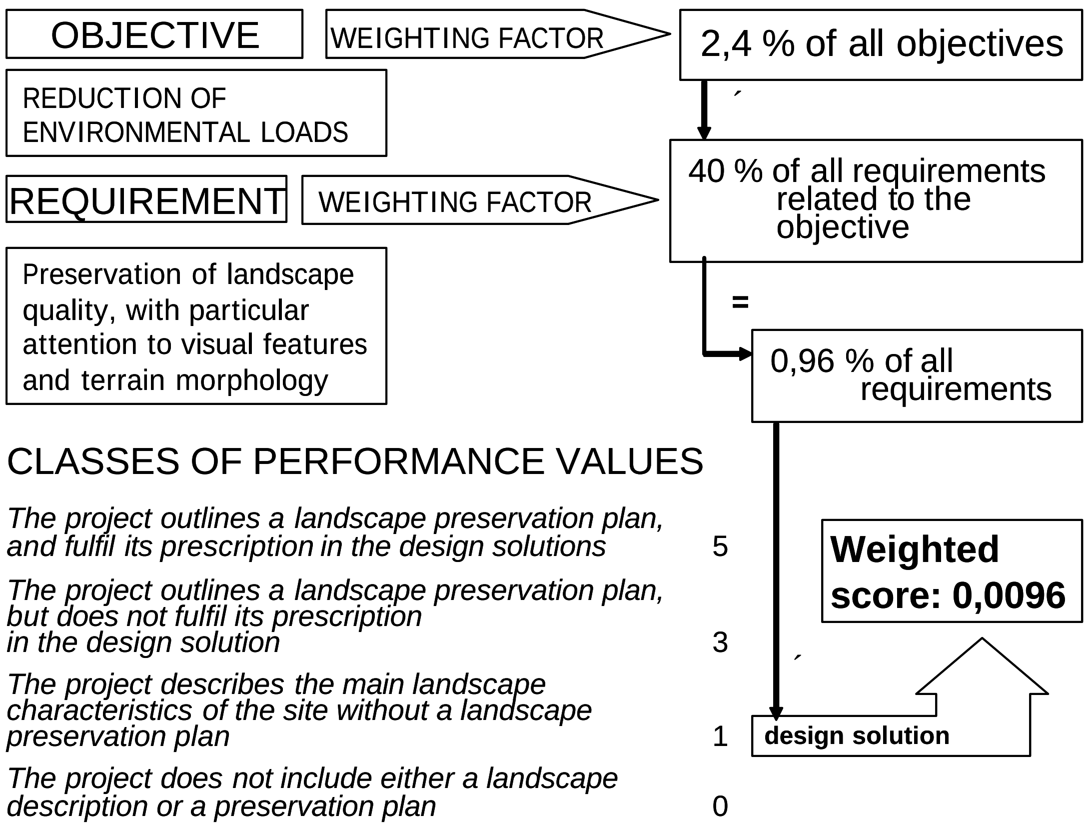

Figure 2a – Example of application of the evaluation procedure to a qualitative requirement

([xiii]) It is not implemented yet at the current state-of-the-art. The decision-making process under way to lead to specific weightings is the one typical of a standardisation body as UNI: within the Working Group on 'Building Sustainability' expertise and stakeholders' interests from various parties of the building sectors are represented.

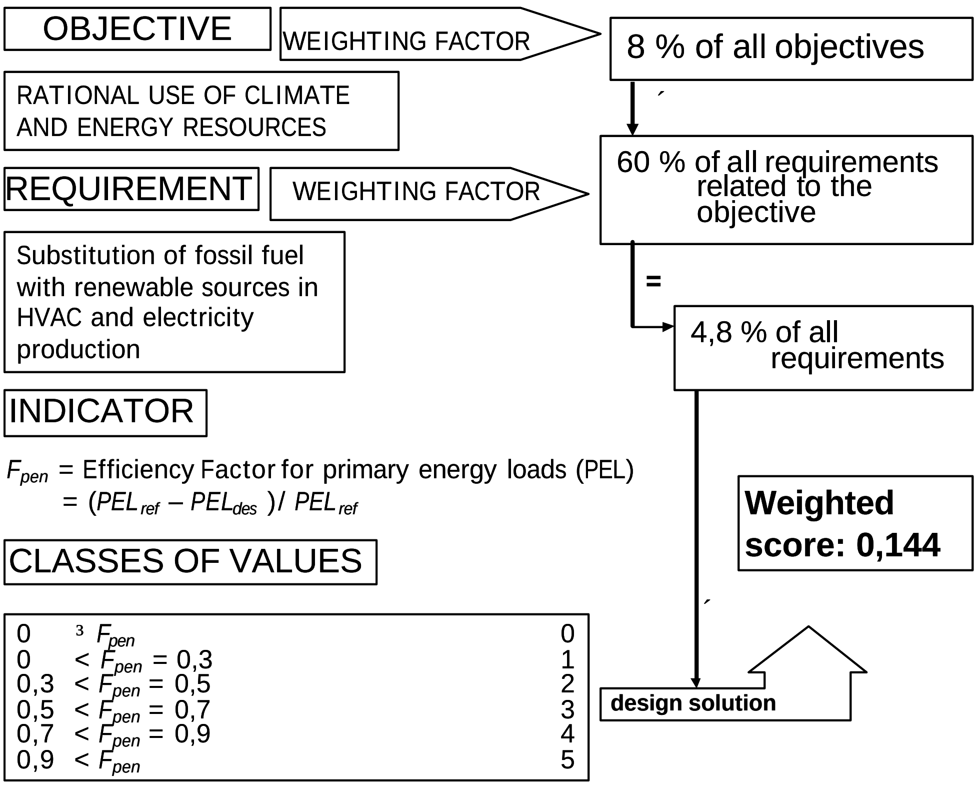

Figure 2b - Example of application of the evaluation procedure to a requirement using a quantitative indicator

With regards to Figure 2b, the indicated class 3 for the design solution, for example, of a residential multi-storey building could correspond to the following design features related to energy systems:

a. space heating system with high efficiency furnace and methane fuel;
b. water heating provided by solar collectors;
c. a buried pipes ductwork supplying part of the cooling load;
d. ventilation load covered by natural ventilation systems;
e. traditional supply for lighting and appliances.

An hypothetical distribution of loads and relevant calculation of the Efficiency Factor (F_{pen}) for primary energy loads are shown in Table 3.

Table 3 – Example of calculation of the Efficiency Factor for primary energy loads

ENERGY LOADS [kWh/m^2]	SYSTEMS					
	SPACE HEATING	WATER HEATING	COOLING	VENTILATION	APPLIANCES	TOTAL
UEL_{ref} (*)	80	40	30	20	30	200
source	oil	electricity	electricity	electricity	electricity	
conv. coeff.	1	2,6	2,6	2,6	2,6	
PEL_{ref} (**)	80	104	78	52	78	392
UEL_{des} ($)	70	40	30	20	30	190
source	methane	renewable	hybrid	renewables	electricity	
conv. coeff.	0,75	0	0,5	0	2,6	
PEL_{des} ($$)	52,5	0	15	0	78	145,5
PEL_{ref} - PEL_{des}	27,5	104	63	52	0	246,5
F_{pen}	0,34	1	0,8	1	0	0,62

(*) Reference end use energy loads (**) Reference primary energy loads ($) Design end use energy loads ($$) Design primary energy loads

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BUILDING SUSTAINABILITY EVALUATION IN THE BUILDING PROCESS: THE CONSTRUCTION PHASE

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1. Introduction

A building is the outcome of a process that starts with the decision to build and continues throughout the production/maintenance/utilisation stages up to demolition and recycling. Such factors as the relatively long life of most constructions, including those referred to as "ephemeral" (compared to other industrial products), and the significance and values that become associated with a building in the course of time enhance the importance of the utilisation and maintenance stages. Over time, a building interacts with the user/buyer/dweller and with its surroundings through a mechanism of "self-adjustment", consisting of maintenance and adaptation works. For these reasons, and in view of the quantities of pollutants released into the air, the water and the soil from most buildings during their serviceability stage, the building "product" should be analysed as a process whose goal is to supply appropriate living conditions during its life cycle, and which entails a huge commitment in terms of resources and the production of considerable quantities of emissions. In buildings, the stages of serviceability, maintenance and adaptation to changing needs account for most of the resources used up and the pollutants emitted. However, this does not amount to saying that the stage of production - of the materials & components and the building as a whole - should be rated as a negligible variable. Moreover, it is at the building stage, and, in particular, at the design stage, that decisions affecting the future impact of a building on the environment are made. Hence, it is important to design and construct buildings that are able to make an efficient use of resources throughout their life cycle.

Eco-compatibility assessments are part of a scenario of increasing awareness of the way the environment is affected by design and construction choices. The goal of the assessment is to evaluate the environmental compatibility of products, processes and actions. Compatibility is defined in general terms, according to a broad, all-comprehensive approach.

The assessment, in fact, must necessarily refer to the entire life cycle of a building and cannot be limited to the stage of off-site production of the materials & components, as is often the case when dealing with an industrial product characterised by a shorter life cycle. Similarly, the assessment cannot be limited to the serviceability stage, focusing solely on the emissions arising from the operation of winter and summer climate control systems.

Yet, the studies conducted so far have been mostly limited to the two aforementioned stages. The reason for this lies in the historical development of research work in the field of architecture. In the wake of the energy crisis of the Seventies, in fact, we witnessed an escalation in the investigations geared to energy saving, culminating in the advent of bio-climate technologies and the use of renewable energy sources for the heating & ventilation plants and the operation of buildings. More recently, we have seen the birth of bio-architecture and the resumption, on new bases, of studies about the relationship between habitats and health. All this has given rise to methodologies and prompted the drafting of specific regulations for the optimisation of building projects or parts thereof. In the industrial field and, above all, in the area of energy production and transport, people have become aware of the need to make sparing use of non renewable resources and to control pollutant emission.

Even the building sector has become involved, albeit to a marginal extent, in the analyses and the efforts geared to the improvement of material and component production processes.

In a different manner, and according to historical dynamics of their own, building management and operation (through the regulations on energy saving in system operation) and building material & component production at the manufacturing plants are also scrutinised nowadays in order to improve their sustainability. The optimisation of material& component production and a reduction in the amount the energy used by a building at the serviceability stage, however, do not exhaust the problems associated with a building's entire life cycle. In fact, this would overlook site preparation, maintenance and demolition processes, whose impact is likely to be highly significant.

The idea behind the research projects that the DINSE Department of the Architectural School of the Politecnico di Torino is conducting on these themes is to extend the analysis to the entire life cycle of the building product/process, so as to be able to start minimising impacts on the environment from the very beginning, i.e., at the design stage, where both the use of non renewable resources and emission control are concerned.

The reference methodology adopted at conceptual level is that of the LCA (Life Cycle Assessment). Accordingly, the first thing to be done is to identify the different stages of the building process and to focus on those that have been investigated less closely so far: the construction stage and maintenance activities.

The various stages of the building process can be summarised as follows:
- off-site production (at the manufacturing plant);
- on-site production;
- use and maintenance;
- demolition and recycling.

The foregoing scheme is based on the latest developments of national and international regulations.

On-site production can be further broken down into construction and maintenance. The maintenance stage can also be associated with the building management processes, in view of the common goal, i.e., maintaining a predetermined quality level. Demolition can be viewed as a separate stage.

The relative incidence of the different stages, in terms of impact on the environment, can be estimated, as a first approximation as: 15% for the construction stage, 15% for maintenance, 10% for demolition. The percentage assigned to the maintenance stage can be deemed reliable, albeit slightly underestimated. Knowing that the costs of maintenance activities exceed by far the initial cost of a building, by analogy, it can be inferred that the incidence of maintenance works on the environment will be at least the same, or greater, than that of the construction stage. The analysis of the building site stage can profit from the development of procedures for the control and management of the specific impacts of building sites, within the framework of the environmental management systems adopted by contractor companies and construction operators. Nonetheless, in the determination of the incidence on the environment of on-site production, the search for local scale environmental improvements should be integrated with the study of site procedures for the improvement of the technological aspects of a building and the organisation of on-site production activities.

From the viewpoint of the designers responsible for architectural and technological choices, it is important to develop reliable assessment tools that will facilitate their task by enabling them to compare different design and technological solutions.

Environmental variables must be taken into account together with quality considerations and economic constraints. In this light, eco-compatibility assessments should be conducted in parallel with the economic evaluation of initial and global costs and with safety and quality assessments.

The general goal of this specific investigation is to identify an approach, compatible with design practices and the tools available, leading to the optimisation of design choices from the environmental standpoint and with reference to the specific conditions of the Italian context. To this end, it is necessary to take into account the design process in its multidisciplinary implications (technological, quality, economic aspects, safety considerations, etc.) and the regulatory framework, with special regard to Public Works legislation.

In the evaluation of the different stages of the building process, two specific aspects must be taken into account: the long-lasting physical life of buildings and the plurality of people and organisations involved in a building's life cycle.

1.2 Environmental accountability: the actors in the building process

The building process is characterised by a considerable fragmentation of the actors involved, making it harder to allocate specific responsibilities. Too many are the steps leading to product definition and too many are the people who can define independently the modalities and goals of their involvement. At present, nobody can be clearly identified as the person accountable for the environmental repercussions of the building process: not the contractor, not the designer, not the material and & component manufacturer and not even the buyer/end user. Surely, in order to achieve a correct environmental management of the different activities it is necessary to identify specific responsibilities so that action can be taken, at the various stages, to ensure a final product that is qualified from the environmental viewpoint.

Within this responsibility scheme, on various accounts, special attention should be devoted to the buyer/end user. The building industry and the designer in particular are motivated by a desire to meet user needs. This gives the final user a possibility to make choices (in terms of materials, assembly techniques, finishes, building size, etc.) that may affect both the design project and the environment. The buyer/end user should become aware of the fact that different choices entail different impacts on the environment.

The construction of a building will have repercussions both on the area directly affected and on a wider area. Some of these effects (emissions into the air, soil and water, waste materials) can be mitigated through careful design & management of the building site. During the design stage, a decisive condition for the evaluation of the potential effects of on-site activities is the selection of materials and the way such materials are installed.

A designer should explain these issues to the final user and guide his/her choices. As mentioned before, the design stage determines all those technological and construction choices that will have a greater or lesser impact on the environment. In his/her position as site manager, the designer must persuade the contractors and the investors to attenuate the negative impact that their building sites will often have. The eco-compatibility strategies that can be adopted from the earliest design stages include:

- defining the durability of the parts that will make up the building;
- adopting technological solutions designed to facilitate the assembly, disassembly and recycling processes;
- adopting technological solutions that will reduce the amounts of waste materials produced;
- adopting building products and processes having a low impact on the environment;
- setting up diversified waste collection systems at the site.

Moreover, careful design should minimise the degree of uncertainty at the assembly stage, since even the most sustainable products can have detrimental effects, both during the building stage and later on, if they are not assembled correctly.

The manufacturer of materials and components plays a decisive role in the production and distribution of goods, in that, depending on the policies adopted by a company, the products marketed will more or less sustainable. Ecology labels (Eco-Label, EPD, etc.) can be a valid tool for an organisation wishing to implement a more sustainable company policy. In Italy, Law Decree no. 22 of 5 February 1997 (Ronchi Decree) has introduced the concept of LCA. In order to foster waste material recycling and salvaging activities (article 4 of the Decree) the relevant authorities and companies are expected to promote product life cycle assessments.

At this point, it becomes important to include in the analysis - in addition to the off-site manufacturing processes - the stages of design and on-site production, which determine choices that will affect the demolition processes. Hence manufacturers might provide useful indications for the designer, regarding the correct utilisation of products in the construction process.

Building contractors, for their part, should adopt a construction system geared to sustainability and the protection of the environment. Depending on the characteristics of a building site (its location, dimensions, morphology of the ground), the materials employed and the objectives defined at the design stage, each building site should adopt regulations designed to ensure a high level of environmental management.

Environmental control by the companies at this stage can take place, with reference to the case of Fiat Engineering (UNI EN ISO 14000 and UNI EN ISO 9002 certified company), through the management of the aspects listed in table 1.

Table 1. Environmental control at the on-site production stage

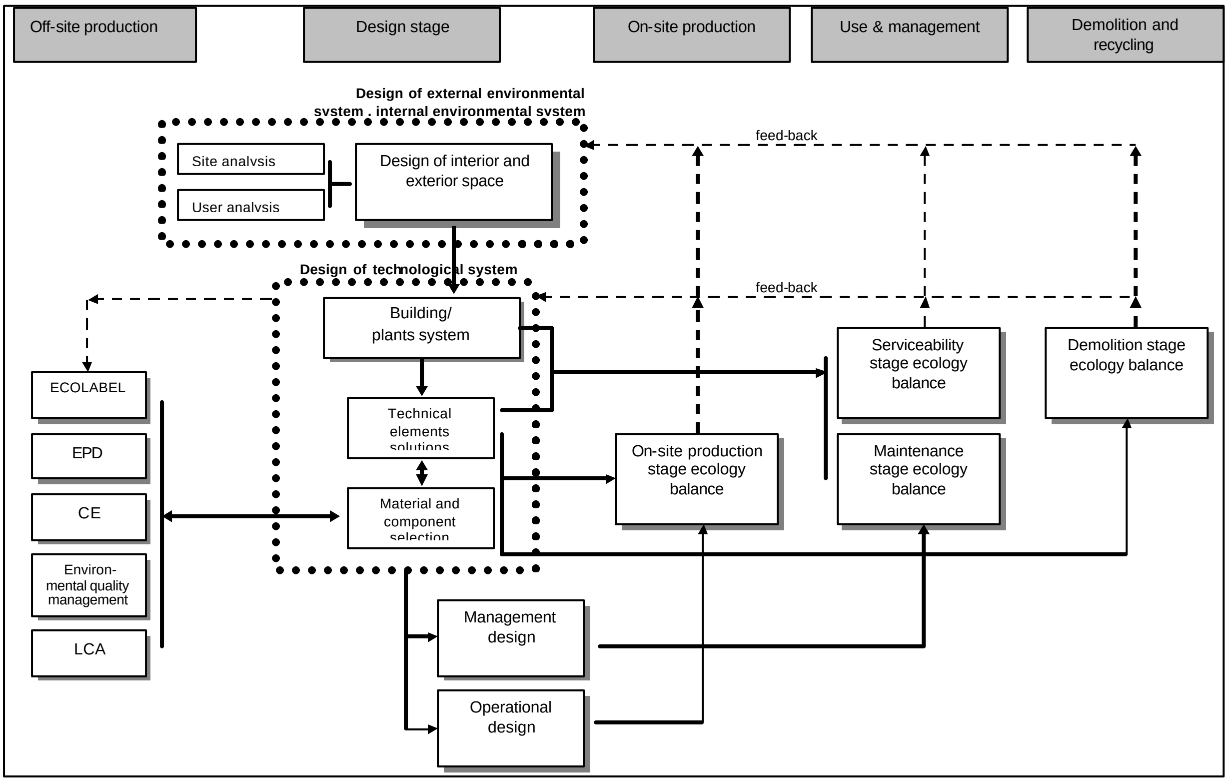
Environmental factors	Impact mitigation activities
Waste materials	- diversified waste collection (wood, metals, glass, plastic, mixed).
Noise	- use of noise-attenuation barriers, if noisy processes are performed in the proximity of a sensitive source - to the extent feasible, moving noisy processes away from the receptors - to the extent feasible, shielding noisy machines and equipment - maintaining the machinery and equipment according to the instructions given in the use and maintenance manuals - equipping the site with every conceivable safety device to safeguard the health of the workers
Dust and emissions into the air	- wetting the ground at variable intervals depending on soil characteristics and climatic zone - maintaining the machinery and equipment according to the instructions given in the use and maintenance manuals - washing the wheels of trucks leaving the site - equipping the site with every conceivable safety device to safeguard the health of the workers
Water consumption	- minimising the use of drinking water - using grey water for all possible processes
Energy consumption	- using low energy consumption lamps - maintaining the machinery and equipment according to the instructions given in the use and maintenance manuals
Hazardous products	- restricting hazardous processes to the factory - disposing separately of hazardous waste materials
Protection of the soil and underground	- periodic checks on the water supply lines - periodic checks on the sewer network, tanks, reservoirs - checking the status of waste materials, hazardous substances, materials, machines and tools

From an analysis of the responsibilities of the people and organisations involved in the building process, we can work out a flow chart of an environmentally sustainable project, as shown in figure 1.

According to the chart, the design stage must include an initial stage geared to the definition of the requirements based on an analysis of the site and the users. Once the needs of the environmental system - inside and outside the building - have been defined, the technological system is designed by defining the technical elements and selecting the relative materials and components. In an environmentally sustainable design process, the designer shall choose certified materials with a recognised ecology label (Eco-Label, EPD, ANAB, etc.) and those for which the manufacturer has performed a life cycle assessment. Technological solutions, material selection and assembly processes have effects at the site stage, the use & maintenance stage and the recycling stage.

The stages that follow the definition of the technology system include management design - whose repercussions mainly affect the use & maintenance stage - and operational design. According to Italian standard UNI 10756, operational design is “the stage during which the indications and provisions needed for a correct execution of the construction phase of the intervention itself are developed, in keeping with the design of the environmental and technological systems. In particular, the building site operational plan is an organised set of indications and provisions for the elementary on-site formation and/or assembly procedures".

Figure 1. Sustainable design flow chart



2. Building site works and maintenance phases

When addressing the various stages of the building process, it is necessary to keep in mind that such a process concerns the long-term physical life of a building a plurality of people involved.

In this context, the Department of Human Settlements Science and Technology of the Architectural School of Politecnico di Torino is conducting a project – within the framework of a larger research project "Strategies for the promotion of eco-compatible public housing" funded by the MIUR and coordinated at national level by Virginia Gangemi – focusing on the evaluation of the eco-compatibility of the technical elements of a building during the on-site production stage, whose main goal is to quantify the energy consumption and emission levels (in terms of C&D waste materials, atmospheric emissions, effluents, etc.) to be ascribed to the on-site construction and demolition stages. On account of the peculiar aspects of the building system, these stages are those for which, to this day, the information collected is particularly scanty and fragmentary. Yet, they consist of a variety of steps involving inputs - use of materials and energy consumption - and outputs - emissions into air/water/soil and waste materials. The scheme given in table 2 shows the inputs and outputs associated with the stages of a typical building site.

Table 2. Building site stages: Inputs & Outputs

Phase	Inputs	Outputs
Transport of the materials	Vehicle used Fuel consumption Vehicle loading/unloading time Man/hours	Energy consumption Raw material consumption Emissions into the air Emissions into the water Emissions into the ground Waste materials produced
On-site handling	Vehicle used Fuel consumption Vehicle loading/unloading time Man/hours	
Installation	Vehicle used Fuel consumption Type & quantities of materials used Man/hours	

The attention devoted to these stages comes from the observation that they originate the main phenomena on which it is possible to intervene through measures and actions designed to prevent negative effects on the environment.

In the course of the research, the activities of several building sites are monitored to formulate a qualitative and quantitative assessment of the resources used up, the pollution and refuse produced during the various stages from the time the site is set up to its closure. Applying the Life Cycle Assessment methodology means to take into account and to quantify the use of resources and energy, the emissions into the air/water/soil, the production of solid waste and other types of refuse - which vary as a function of the size of the building site, its location, the materials and assembling techniques used - in the different sub-stages (see tables 3 and 4).

Table 3. Stages and sub-stages of the on-site production works for the construction of curtain walls

Description of the process	Substage
Transport of the material	Loading the material Transport of the material Unloading the material
Storage of the material	Material handling
Ground plane identification	Material handling Ground plane identification
Material handling on ground plane	Material handling
Assembly processes	Mortar preparation Construction of technical element (curtain walls)

Table 4: Analysis of the impacts corresponding to each substage of the on-site production process

Description	Unit of measure
Energy consumption	Joule
Emissions in the air	Grams
Emissions in the water	Lit./g.
Emissions in the ground	Lit./g.
Solid waste	Kg
Other types of waste	Kg

2.1 Building site works

The impacts associated with technical elements at the building site stage arise from the sum of the effects of all the operations needed for their correct installation, from the transport of the materials to the assembly processes. Thus, we shall have an eco-compatibility evaluation (i.e., an estimate of the energy consumed and the emissions released into the environment) of the installation stage of a given technical element relative to a specific type of building. To this we must add the impact of all the processes associated with building site operations in general, which must necessarily be redistributed proportionally over the technical elements. Table 5 lists some of the preliminary operations performed to set up a building site.

Table 5. Preliminary Building Site Works

Phases	Input	Output
Enclosure		Energy consumption
Roads	Materials	Raw materials needed
Barracks	Machinery Type & Time	Air Emission
Electrical, Hydro, Phone	Fuel	Water Emission
Work areas	Time labour	Soil Emission
Machine layout		Waste materials
Waste Disposal		

Accordingly, every stage of building site preparation will have to be considered, from fencing to the arrangement of the machines, the construction of the internal routes and barracks, the connections to the water supply and the power lines. The stages following site installation, which cannot be associated with any specific process or technical element, such as site management, use and closure, will also have to be taken into account.

2.2 Trial building site

Within the framework of this investigation, a trial building site has been monitored over the last nine months. It is a rather small site, using technologies that make it ideally suited to serve as a case study. The building under construction is a one-storey hotel, of ca 1500 sq.m., entirely assembled dry. (see photos 2 and 3)

Photo 1. Assembling the roof

Photo 2. Preparing the foundations

The data collected (man/hours, machine hours and consumption, transport, materials used) are being evaluated and compared with other widely used construction methods. No quantitative conclusions can be drawn at this early stage of the experiment, however, some qualitative observations can be made on the data collected at the building site, regarding the excavation and backfilling works, as summarised below (tables 6, 7).

Table 6. Man/hours needed for the excavation works

Period	General excavation	Backfill	Trench excavation
[month]	[hours]	[hours]	[hours]
November	110	0	0
December	0	180	35
January	0	140	100
February	0	140	0
March	0	60	0
April	0	90	0

Table 7. Time required for foundation backfilling

Day	Material	Distance from site	Truck	Load	Volume (to and back*)	Time for loading-unloading	Trip no. (**)
[date]	[kind]	[Km]	[brand]	[m^3]	[%]	[min]	[-]
05/04	sand	12	Pellicano	15	100%-0%	10	6
06/04	sand	12	Pellicano	15	100%-0%	10	6
06/04	crushed stone	12	Pellicano	15	100%-0%	12	2
07/04	sand	12	Pellicano	15	100%-0%	10	11
07/04	crushed stone	12	Pellicano	15	100%-0%	12	1
08/04	mixed	4	Pellicano	11	100%-0%	10	7
17/04	mixed	4	Pellicano	11	100%-0%	10	2
23/04	mixed	12	Pellicano	11	100%-0%	15	1

(*) The first value gives the volumes (%) loaded onto the vehicle for transport from the off-site production plant to the building site; the second value is about the trip in the opposite direction.
(**) One unit corresponds to a trip to and from the.

The tables list values measured directly at the building site, which are currently being processed.
From an initial analysis it can be seen that the quantities of energy and machinery required by the technologies employed during the stages already completed at the trial site (foundations and bearing structures) are markedly lower than had been assumed, based on the data available in the literature, for an ordinary type building.

Consumption levels are seen to be very low both for site installation and for the use of site infrastructures, such as barracks, lavatories, lighting, handling the materials on the site. These favourable findings (referring both to the individual processes and to the site as a whole) can be ascribed to the benefits arising from a dry assembly technology which uses an 80% proportion of prefabricated materials, requiring no further processing on site (vs. 50% in wet constructions).

Moreover, the weight of a building assembled dry, with a bearing structure in steel, gypsum board curtain walls insulated with a thick layer of rock wool, and roofing in insulated chequered plate, is ca 1/5 of the weight of a building with a reinforced concrete structure and brick walls.

Considering the technologies employed in the experimental building site as an evolution of traditional ones, it can be stated that buildings tend to become the place of assembly of industrially made products. Such products are rationalised in terms of dimensions, weights and ease of assembly, use of light machinery, shorter assembly times, reduced quantities of waste and rejects.

Adopting a dry technology may entail several benefits from the environmental standpoint, which can be summarised as follows:

- reduced uncertainty in terms of material and components assembly;
- reduced on-site processing times;
- improved overall quality of the finished product.

2.3 Conclusions

From an analysis of the trial site and that of a control case (a traditionally organised building site using the habitual procedures of the Italian building industry), it can be concluded that the analysis of the environmental impact of a building should be extended to the entire life cycle. All stages have to be taken into account, from factory production to the operation and maintenance stages (and hence the durability of the building and its parts) up to and including demolition/recycling.

The early stage of this investigation does not make it possible to draw definitive quantitative conclusions; however, some indications can be obtained. It should be noted that a building created through "dry" assembly processes - because of its conception and construction modalities - entails much smaller energy consumption levels and emissions from the site than a similar building produced through "wet" processes. Such benefits have to be evaluated together with the data regarding component production in the factory and the subsequent maintenance and recycling stages.

The rest of the investigation in the field envisages the collection of data from the site until the completion of the works, which is expected to take place at the end of 2004. The collection of data will be followed by an analysis of maintenance works through direct investigations and based on the data in the literature regarding the frequency and modalities of maintenance/repair and replacement interventions associated with the different technological solutions.

The result sought is the development of a methodology for the identification of the technological solutions and the selection of building components with minimised environmental impacts.

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PROCEDURES, METHODS AND MODELS OF INDIVIDUALIZATION OF MULTISTORY AND APARTMENT HOUSES URBAN STRUCTURE
Case study - Serbia and Montenegro

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Abstract

Serbia is now in the process of essential changes, trying to address the renewal of towns and settlements in accordance with European tendencies and sustainable development.
The inherited situation of the former period is complicated in ownership solution terms, including ownership transformation process and maintenance of the existing residential fund – primarily in multi-story, more-family urban facilities built in the socialist period.
On the other side, in the transition period – that our country is going through right now, we are to change to market economy, accepting its rules, uncertainty and mechanisms required to establish the balance between supply and demand. Market entails introduction of property relations at each space level and establishment of certain relations between parts and a whole.
The work discusses possible responses of the architectural/urban profession to market demand challenges, in terms of searching for new procedures, methods and models, which could answer to plural requests of possession/property relations in the space. Residential assemblies are conceived as complex and their elements are inter-linked by qualitative/valuable relations; they are not simple scores of spatial units belonging to individual owners.
The research methodology develops in several steps. The first part defines the problem and studies possible models of ownership transformations. The second defines individualization methods and models through several methodological steps: decomposition of multi-story residential building assembly, re-affirmation of original family house values, redefinition of possession/property relation individualization degree, de-aggregation of individual and pre-structuring spatial assemblies. The last step comprises testing of procedures, methods and models on concrete examples – multi-story assembly types and conclusion discussions.

0. INTRODUCTION

Serbia is currently in the transition period, and the transition to market economy, which establishes a balance between supply and demand, makes the market uncertain and results in the introduction of property relations on all spatial levels. Such introduction of property relations causes (de-) aggregation of structures to their basic elements conditioned with property relations, at the same time changing their inter-relations.

The question is «what is more important (older) – a part or the whole», i.e. do we get the whole by multiplying parts, or we get parts by dividing the whole. Regardless to attitude taken, the decisive factors are relations and mechanisms established (created, lasting and changing) between the parts (including their inter-relations) and the whole. [1]

Architects and city-planners should react, timely and adequately, to such changes in societies and offer adequate answers to market requirements. At the same time, they should renounce usual canons and turn its action to the quest for new procedures, methods and models that should accommodate all the plural requirements of different property relations in the space.

In residential field, all those changes act in the quality-value plane changing the character of mechanism and the direction, i.e. course of relations, which results in a clearer aggregation of structures to parts (according to property relations) and in the creation of the whole as a complex urban structure made of parts with different owners. The whole is not a simple sum of its parts, but a complex set ruled by plural relations.

Basically, the problem of having such property relations in once socially-owned residential fund (multistory residential buildings in most cases) is reduced to the relation between individual and collective in a residential block, between recognizable parts, separate entities of individual owners in the space and the total spatial-physical and functional-technological urban whole.

1. A CHAIN OF PROGRAM - SUBSTANTIAL OWNERSHIP TRANSFORMATION IN THE RESIDENTAL FIELD (defining the problems and searching for solutions)

Ownership transformation process has three parallel cycles that occur at the same time:

- general-global cycle of market acting
- «collectivization» cycle – getting individual residential objects united into a collective building
- «re-affirmation» cycle – course of re-affirmation of urban individual houses.

1.1. Residential ownership transformation

This transformation has a clear course and takes the following steps:

I step – in the transition period, residential structures inherited from the period of socialism under the influence of the market become goods with certain price (purpose, consumption, location, renting ...);

II step – when such residential structures have become goods they have to have their owners, and this requires privatization of existing and all future residential buildings; [2]

III step – property relations introduce two types of complex sets:

- a set of a big number of owners in the same area, and
- a set of different forms of property rights on residential area;

IV step – every owner of residential area has the right to:

- have its property determined, both horizontally and vertically
- have the identity of hi/her property

V step – a residential structure, in order to satisfy requirements of different owners, has to:

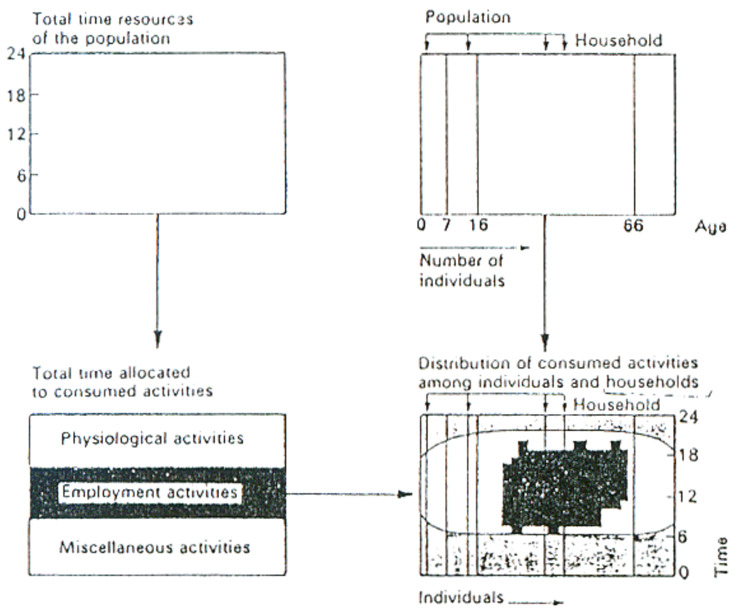
- grow into a complex set of a large number of sub-sets, and

- be of pluralistic form – to include larger number of different structures;

VI step – it is necessary to ensure individuality to each part of the structure, which has to be at the same time independent and complete and co-operative with all other parts and with the whole.

1.2. Collectivization cycle – course of getting houses united into a building

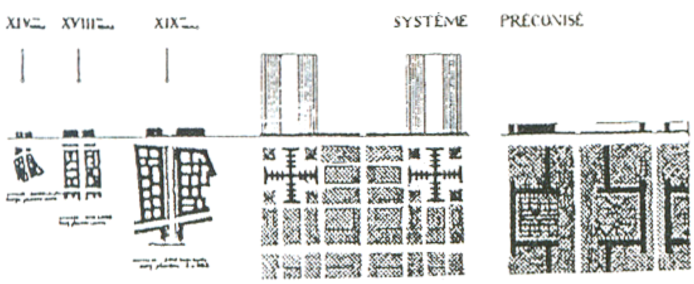
The process of individualization [3] is basically inseparable from and constantly intermingled with the process of collectivization. They merge with each other, complement each other and inter-change in the course of history, especially on the level of activity separation in the space.



Activities in space and time in residential field (B.3. pp. 26) (figure 1.)

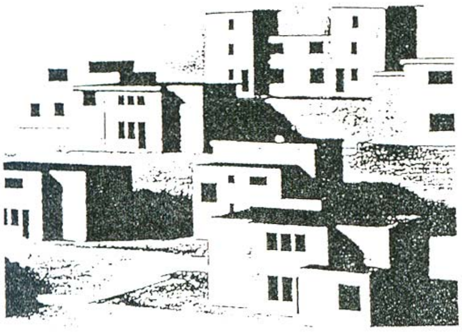
Globally today, the highest level of collectivization [4] has been achieved in residential field. The process of intense collectivization in Europe started in 1920s and was extremely strong in all ex-communist countries after the II World War. The profession was given a task: to have a large number of people economically and functionally placed in joint buildings. According to Le Corbusier [5] the collectivization process in a physical structure has taken several directions: Vertical growth, overall house dimensions growth, reduction of the terrain coverage, increase of inhabitants concentration, etc.

The next stage (Le Corbusier) is formation of a collective object that represents a sum of individual houses (arranged both vertically and horizontally).



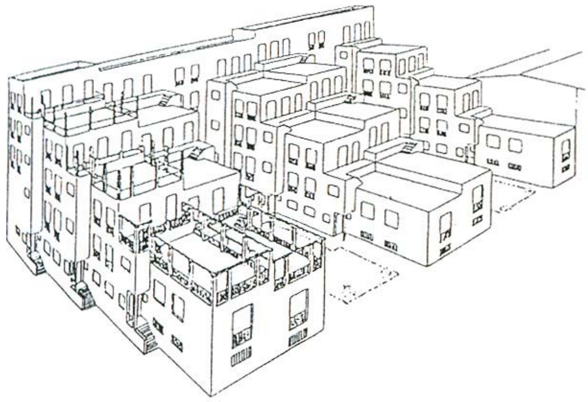
The course of making a physical structure bigger as the function of residential collectivization. Le Courbusieru, (B.3., pp. 3) (figure 2.)

In the beginning, individual houses were built closer to each other, were doubled, got united and transformed into increasingly bigger buildings, which became even faster with serial production – prefabrication of elements.



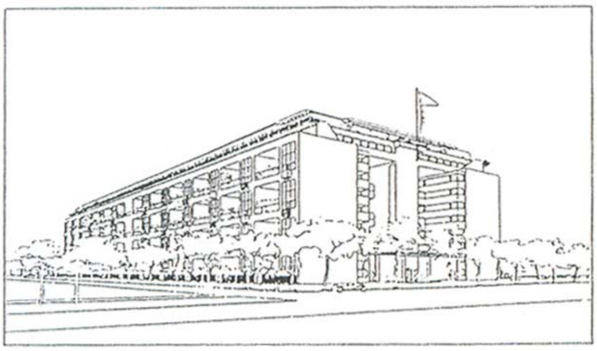
Model of jointing of standardized houses according to Walter Gropius
(figure 3.)

The next development stage is turning into complex systems – the tendency is to ensure individuality to certain entities and, on the other hand, have full collectivity achieved on other entities.



Model of making complex systems from individual houses and collective buildings according to Adolf Loss (B.4., pp. 35)
(figure 4.)

The next stage is when as suggested by Le Corbusier a collective building becomes a sum of individual houses arranged both horizontally and vertically.



Model of collective building as a complex of jointed individual housed according to Le Corbusier, (B.4., pp. 38)
(figure 5.)

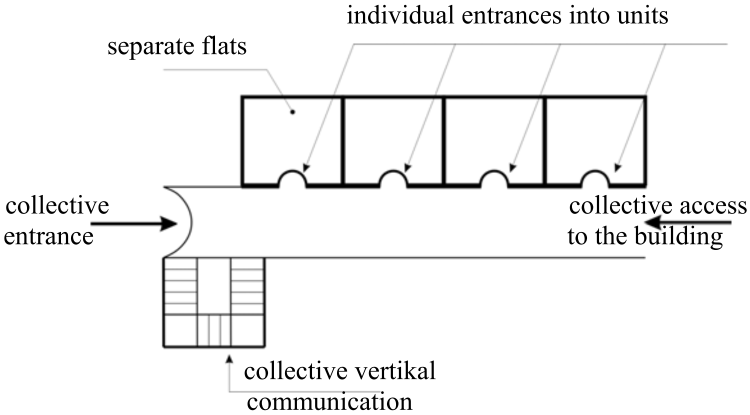
The last traces of residential individuality inside collectivity are the attempts to keep the atmosphere and shape of a joint house on one side, and on the other to create a basic residential unit on a higher level – mostly in the form of a duplex – leaving the impression of complete space – as if living in your own house.
Final result of the collectivization process in the beginning is a variation of a multistory residential building that in time reduces to a smaller number of types. Further development resulted in unification of all building shapes under the motto of universal architecture of international style. [6]

1.3. Course of individualization – re-affirmation of urban individual house structures

Characteristics of a multistory residential building are: [7]

- the whole object represents a closed system ruled by totality in all regards;
- all its element always have an unambiguous function – they cannot function without each other and establish only one-way relation between each other;
- the route through the spaces of the object always have only one direction (and several courses;
- the structure consists of multitude parts, which if taken apart from the whole lose the reason of their existence;
- most of the space is common – all tenants use it (the land lot is common, the approaching lane is common, the entrance, the hall and vertical communication).

Multistory
collective building
(figure 6.)

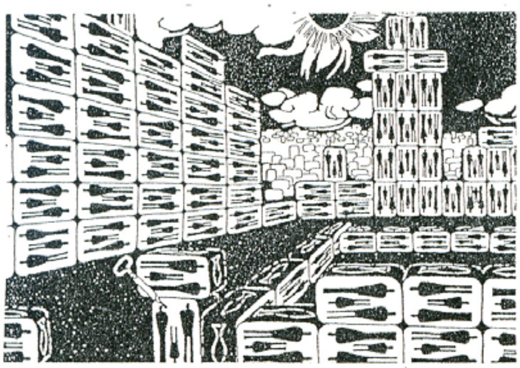


A residential unit inside the building is the only thing with partial level of individuality, but exclusively inside its own self. In all other aspects of individuality, a residential unit is:

- dependent – because it is permanently connected to other common parts;
- inaccessable – because it can be accessed only through common parts;
- incomplete – because it lacks a certain number of functions;
- non-devloping – because it is spatially determined and surrounded with other units.

Structure of a multistory building is based on the principles of multiplying the unified elements on all levels:

- a typical residential unit is a sum of rooms of different purpose;
- a standard story is a row of horizontaly arranged standard residential units;
- a multistory structure is made by piling standard stories vertically, around or along vertical communication;
- an urban structure is made by simple adding multistory buildings, which creates a universal urban block.



The mechanisam of multipliection
 - creating multistory collective buildings
(B.9., pp. 102)
(figure 7.)

Most common in our practice so far has been the situation that there is a single owner of the whole building, namely:

- the state – constructing social apartments;
- socially-owned (the case in ex-socialist countries), when all tenants have the same rights over common space, and
- the property of one owner – when the apartments are rented as residing units.

Introduction of several simultaneous owners and higher number of property forms requires the complexity of the physical structure of a multistory residential building equivalent to the complexity of the property relations in force.

In this regard, contrary to the collectivization process, individualization includes the following procedures:

- detachment of individual elements from a common entity;
- creation of closed residential units fit to function independently;
- specification of such closed entities in accordance with abilities, interests and wishes of the owners;
- integration and inter-connection of units into a complete spatial-physical structure, whose complexity in morphological terms is adequate to the complexity of the given property relations;
- construction of identities for parts and wholes;
- creation of conditions for constant changes (modification, addition, reforming) of elements and the whole;
- re-grouping process is in accordance with market laws and is the function of making profit;
- multistory residential buildings are transformed into complex urban structures that find their justificatin in linking individualization and collectivization into an inseparable entity;
- constructin, furnishing and fixing of such complex urban structures should grow into a unique and complete process of residential space production that will replace mass production of standard buildings with mas production of a larage number of different structures by means of flexible production technologies;
- development of a pluralistic approach will be done through improvment of methods and techniques of action and through creation of a wide range of variant-alternative models of urban residential structures.

2. METHODS AND MODELS OF INDIVIDUALIZATION (instead of the conclusion)

In order to conquer the road from total collectivization to general indivudualization, it is necessary to make several methodical steps:

- (de) composition of a multistory residential building structure
- (re) affirmation of original values of individual houses
- (re) definition of the level of individualization of property relations
- (de) aggregation of individual structures
- (re) structuring of spatial structures according to property relations.

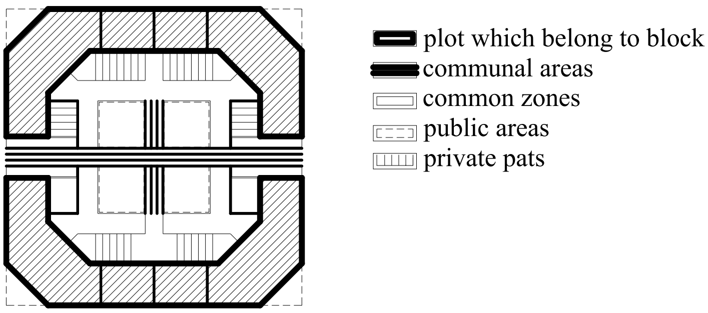
2.1. De-composition of a multistory residential buidling structure

This assumes decomposition of the structure to its basic elements. There are two levels of decomposition:

- external decomposition
- internal decomposition

External decomposition refers to clear recognition of basic property rights to the territory used for placing the structure and its parts, which can be classified into:

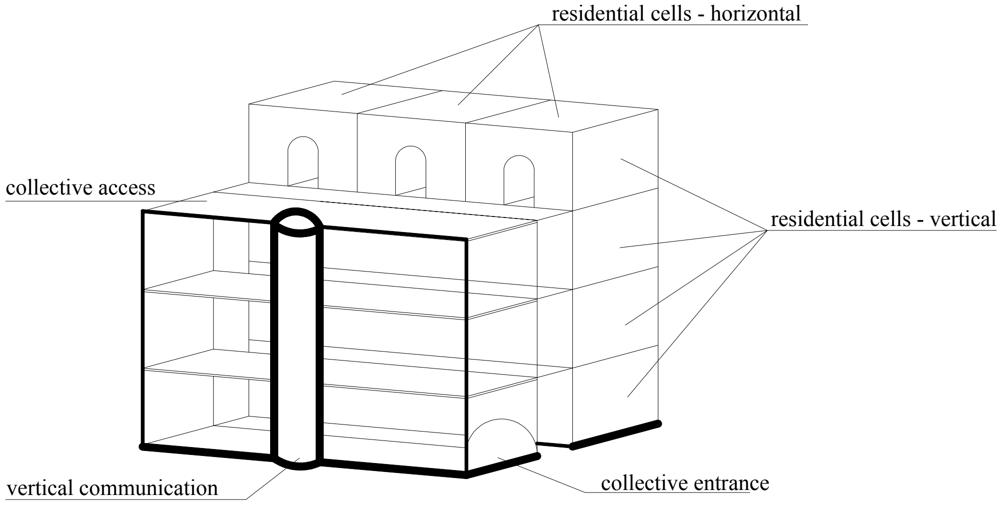
- private lots that should belong to the apartments in the basement and on the ground floor;
- common zones belonging only to the tenants of the given building;
- semi-public zones belonging to the tenants of the block;
- communal areas – belonging to the tenants of the block, but used also by the tenants of other areas for communication purposes (passages, etc...);
- public areas – belonging to the local community (municipality).



(figure 8.)

Internal decomposition consits of the following elements:

- residential cells;
- vertical communication;
- horizontal passage to individual apartments;
- entrance to the building;
- entrance to the residential cells.



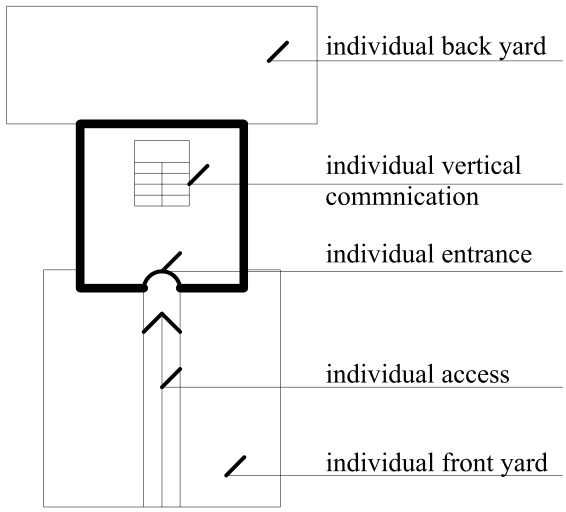
(figure 9.)

2.2. Re-affirmation

Re-affirmation of original values of private individual houses can be seen in their recognition, survey and incorporation into multistory residential units.
Original values consit of:

- estate – front and back yards;
- the entire house with its own vertical connections;
- individual access
- individual entrance to the estate and entrance to the house.

All these values should be a framework for the creation of an individual unit within a plural, urban multistory residential area.



(figure 10.)

2.3. Re-definition of property relations

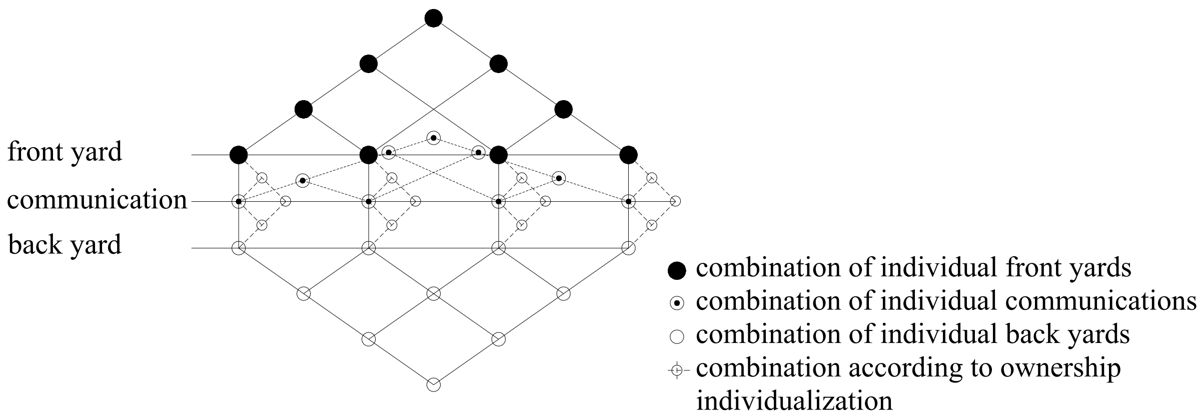
This is the next necessary step in spatial elements of a multistory residential building.
Basic residential unit, regardless the form of property relations, has to be treated as a completely privatized unit. Other areas, depending on desired level of individualization can have one of the characters of ownerships:

- fully private;
- mutual on the level of different groups;
- communal-users
- town-public

Re-definition of the level of ownership individualization

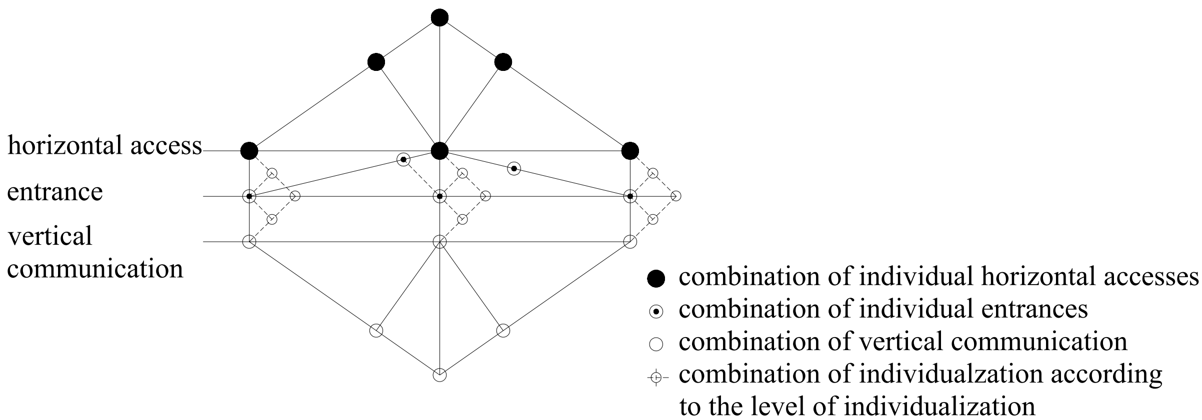
a) external zones

private zones	common zones	communal zones	public zones

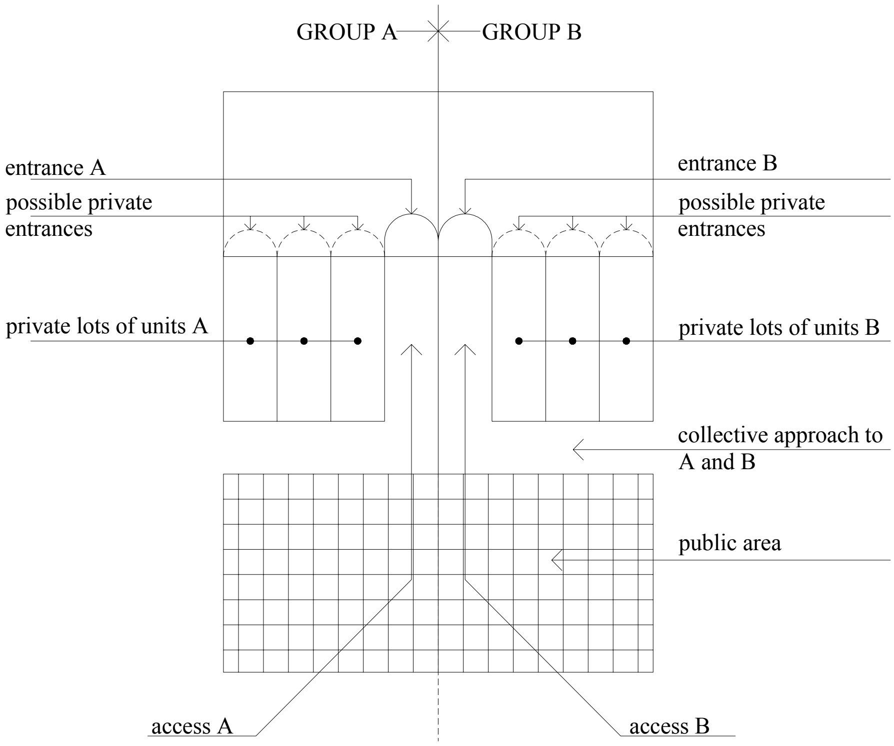


b) internal zones

fully common	grouped	common



c) space and physical
redefinition of individuality



(figure 11.)

2.4. Re-aggregation of individual structures

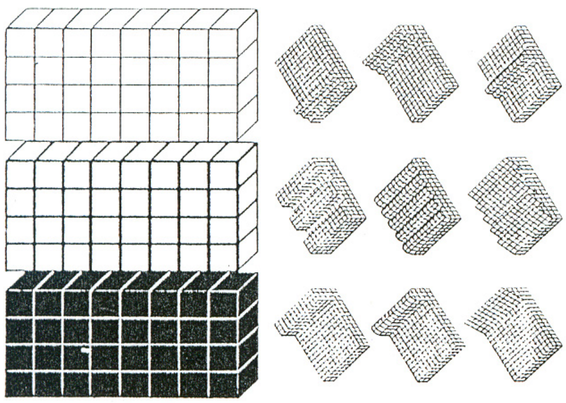
This process of element detachment from the whole has to include complete residential units, which are connected to accompanying space in various ways and which have a different level of ownership individuality.

The following forms of individual structure aggregations are possible:

- concentrated aggregation;
- linear aggregation;
- point aggregation;
- superficial number of combinations is endless, both horizontally and vertically.

2.5. Pre-structuring

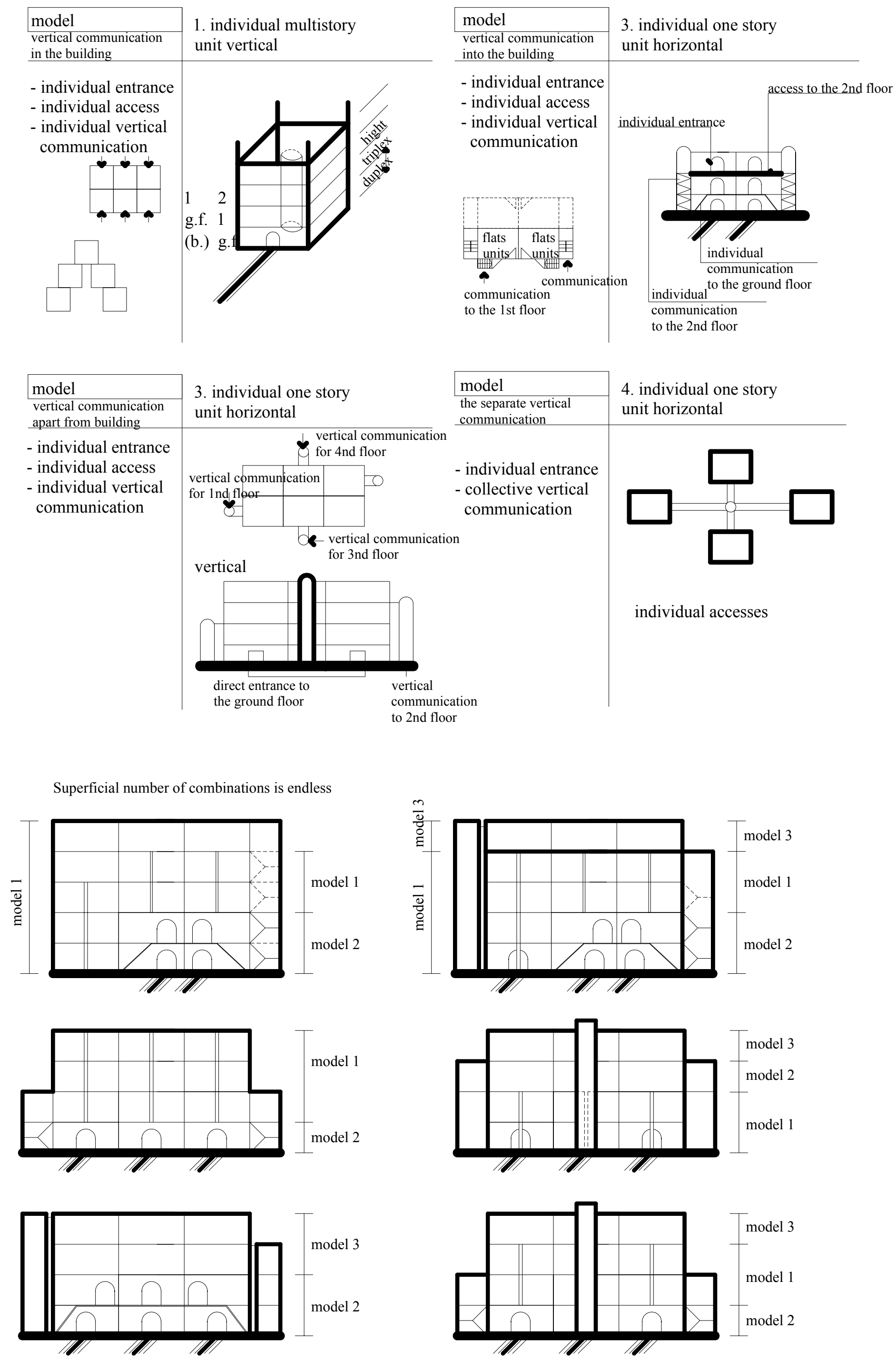
Pre-structuring of multistory urban residential structures based on the principles of pre-drawn methods produces an endless number of models.



The organising of the residential structure model (B.22)
(figure 12.)

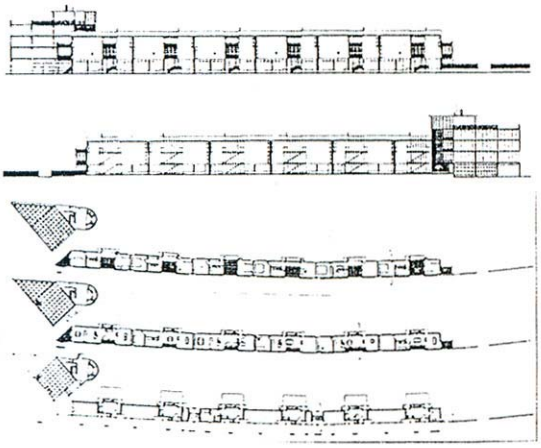
For example, the paper shows the structuring of four basic models of complete individuality in the way which presents a combined position and property character of the following elements:

- verticall connection
- entrance individuality
- way of organizing a residential unit.

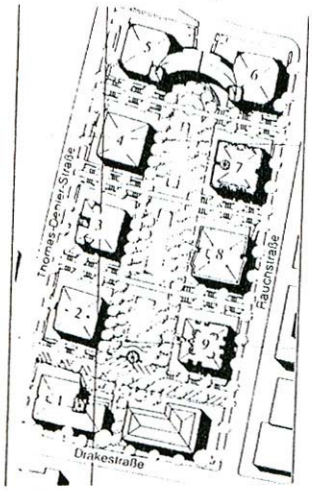


(figure 13.)

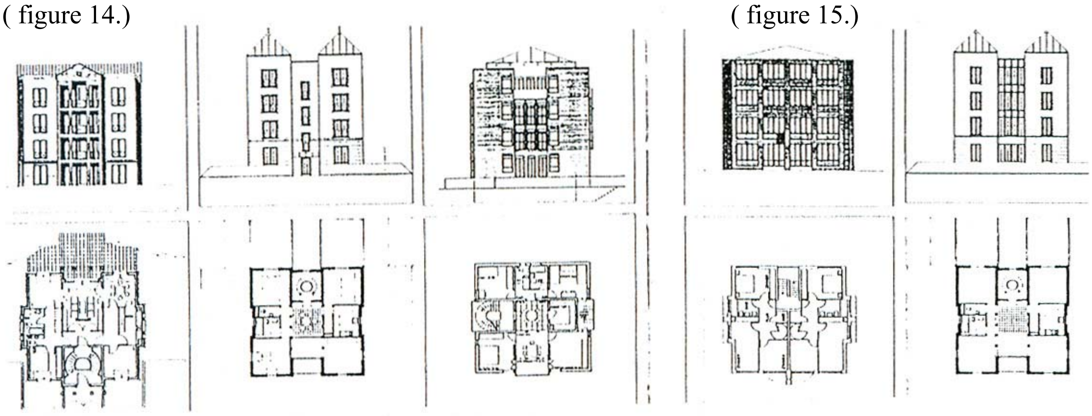
Numerous are the suggestions of individualization that can be found in architectural-city planning theory and practice. An example from Berlin is given as one of the most famous models.



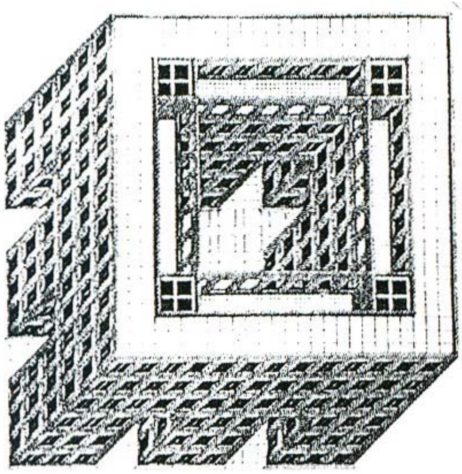
Arh. T. Hercog, (B. 13. pp.19)
(United aggregation)
(figure 14.)



Arh. R. Kriler, (B. 13. pp.31)
("Back home")
(figure 15.)

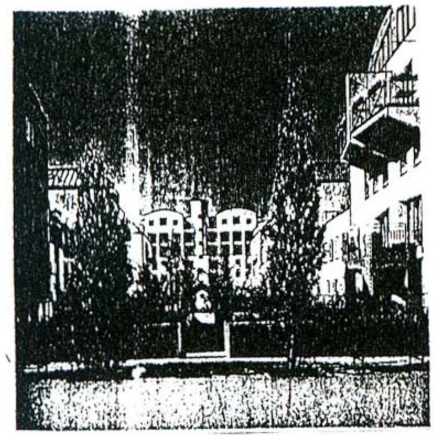


Individual floors of colective buildings B. 13. pp. 54
(figure 16.)

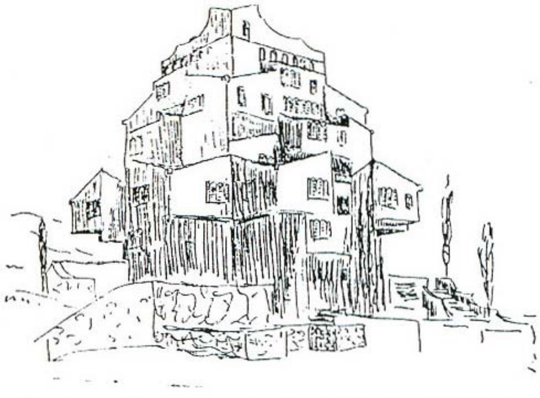


Arch. O.M. Ungers (B. 13. pp. 94)
(figure 17.)

Individual plots (B. 13. pp. 249)
(figure 18.)



Private court yard (B. 21. pp. 181)
(figure 19.)



Tout est permis sur le rocher d'Alicante... (Ricardo Bofill).

R. Bofic, (B. 11. pp. 66)
(figure 20.)

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"DISPLAY"
THE EUROPEAN CAMPAIGN FOR THE DISPLAY OF INFORMATION ON THE CO_2 AND ENERGY PERFORMANCE OF MUNICIPAL BUILDINGS, 2003-2005

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1. Introduction

Display is a European Campaign aimed at encouraging European towns and cities to publicly display the energy, water and carbon performance of their buildings. The campaign is the first of its kind in Europe and is coordinated by Energie-Cités and supported by the European Commission – DG Environment. It will run from January 2003 till summer 2005.

Display is within the scope of the Directive on the Energy Performance of Buildings (adopted in December 2002), which is to be integrated into the national legislation of all member states by January 2006. This directive requires all member states to take measures to encourage, through a consistent system of certification, the public display of information on the energy performance of their buildings. The objective of Display is to anticipate the implementation and to provide European municipalities with an opportunity to be one step ahead of this directive. However, Display does not intend to be a certification scheme, but is an information tool to raise the public awareness of energy consumption.

2. Activities and Actions Undertaken

2.1 Display European working group

Display is the result of networking activities between twenty municipalities from eighteen countries as represented by their Energy Managers. Collectively, they have created the product and all its various components, under de co-ordination of Energie-Cités: poster, calculation parameters, tests, promotion, etc. Of the municipalities involved, some were more experienced than others, some were from the North, whereas others were from the South, the East or the West of Europe. Five experts from five countries contributed their skills and experience to the network of municipal specialists.

2.2. The Display Poster

In the past 12 months, a wide-ranging communication tool has been developed by Energie-Cités. The essential objective, i.e. the design of the Display poster, has been achieved and is now available for all the participating cities. In the foreground of the poster there are pictures showing the classification of the building in the three categories. It features a range of classes from A to G for the overall primary energy consumption, the resulting emissions of greenhouse gases expressed in CO_2 equivalents, and water consumption. Its design is recognisable as comparable to the existing energy label for household appliances. This is one reason for the poster being easily understood and accessible by citizens. The local authority will also record where improvements have been made to the building or are planned within the next twenty four months and this information is included within the certificate making it a very powerful tool.

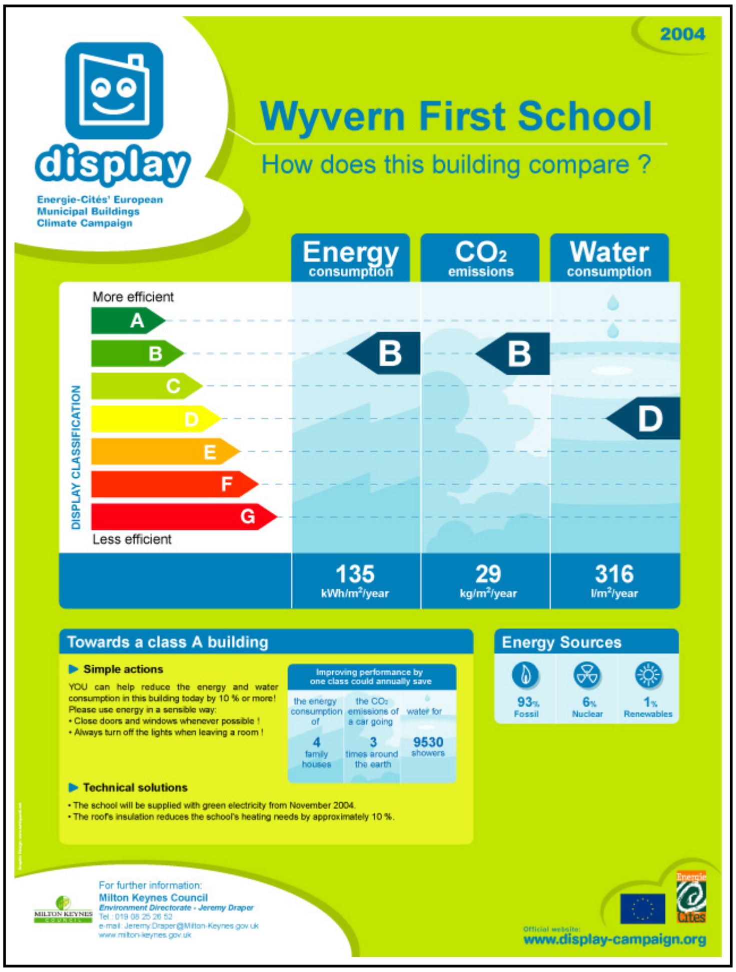

Figure 1: Display Poster

Up to now, the classification scheme existed only for school buildings but will be enlarged to include most kinds of municipal buildings. In addition, by pointing out simple actions, the Display poster enables users of the building to contribute to improving the energy consumption and therefore the classification of the building. For the municipalities, the poster presents their contributions in terms of planned or already realised technical solutions. Finally, the details of a contact person are indicated in order to make it possible for users of the building to contact the responsible department of the city in case of questions and suggestions.

A very successful test phase was organised by the City of Leicester at the beginning of this year. The first version of the poster was hung up in five different buildings during one week and participants were interviewed after having seen the poster. Leicester experience has included testing customer's reaction to the poster and obtaining feed back. 56% of people interviewed said that they were interested in the poster and 27% very interested. Nearly 60% of people interviewed confirmed that they would change the behaviour to reduce energy and water use in the future [1].

Up to now, most cities have already been collecting the necessary information on chosen buildings and the cities of Graz (AT), Almada (PT) and Milton Keynes (GB) have now started hanging up the first posters.

Figure 2: First Display poster hanged up in Milton Keynes

2.2. Display communication tools

A **two-page presentation** of Display is now available in eight languages (en, fr, pt, de, it, fi, sk, nl). It details the main objectives of the campaign, explains its political background and lists the planned activities as well as the cities involved. In addition, a more eye-catching **leaflet** has been produced, principally addressed to representatives of municipalities, aimed at promoting the Display campaign and enlarging it to other willing municipalities. At present it is available in ten languages (bg, cz, el, en, fr, pt, de, it, sk, nl) further languages under translation) [2]. As a complementary tool, **Power Point slides** have been developed and will be used to present the campaign in the future. They target both municipalities and other people interested in Display, contain the basic information on the campaign and show the main results obtained until now. As in the leaflet, the slides have been produced in English and will be translated into further languages shortly.

A in April 2004 inaugurated **website** forms the general communication framework for the campaign. The site, available under www.display-campaign.org, is divided into two sections. The **public part** can be accessed by everybody, but is mainly targeted at municipalities. Everybody interested can read up on the Display campaign itself, the participating cities and those who play a role model within the project. In order to encourage municipalities to improve the energy performance of their buildings the web site presents examples for other cities to follow. At present, the website provides information in English and French. Most of this information is also available for download in printable pdf format.

Municipalities who have signed the Display charter will benefit from the advantages of the **restricted part** of the Display website. The essential component is the Display poster generation tool. It consists of a concise user interface that allows users to easily enter energy consumption and supply data of their buildings. Having completed the data input, the user requests the final Display poster which is created autonomously and immediately by the poster generation tool. Finally, the customised, newly generated Display poster is available for download in pdf format.

2.3 The Display Poster Generation Tool

2.3.1. Features and Structure of the Display Poster Generation Tool

The European Campaign Display was launched in order to anticipate – by a voluntary initiative – the entry into force of the "Energy Performance of Buildings" Directive (EPBD) [3]. The Display project focuses on part of the EPBD, which will, from 2006 on, oblige the Member-States to stimulate public display of information about energy performance in public buildings. Nevertheless, the approach is different: While the EPBD intended the implementation of a building certification scheme – according to its architectural design and technological equipment – the Display label classifies buildings on the basis of their real consumption.

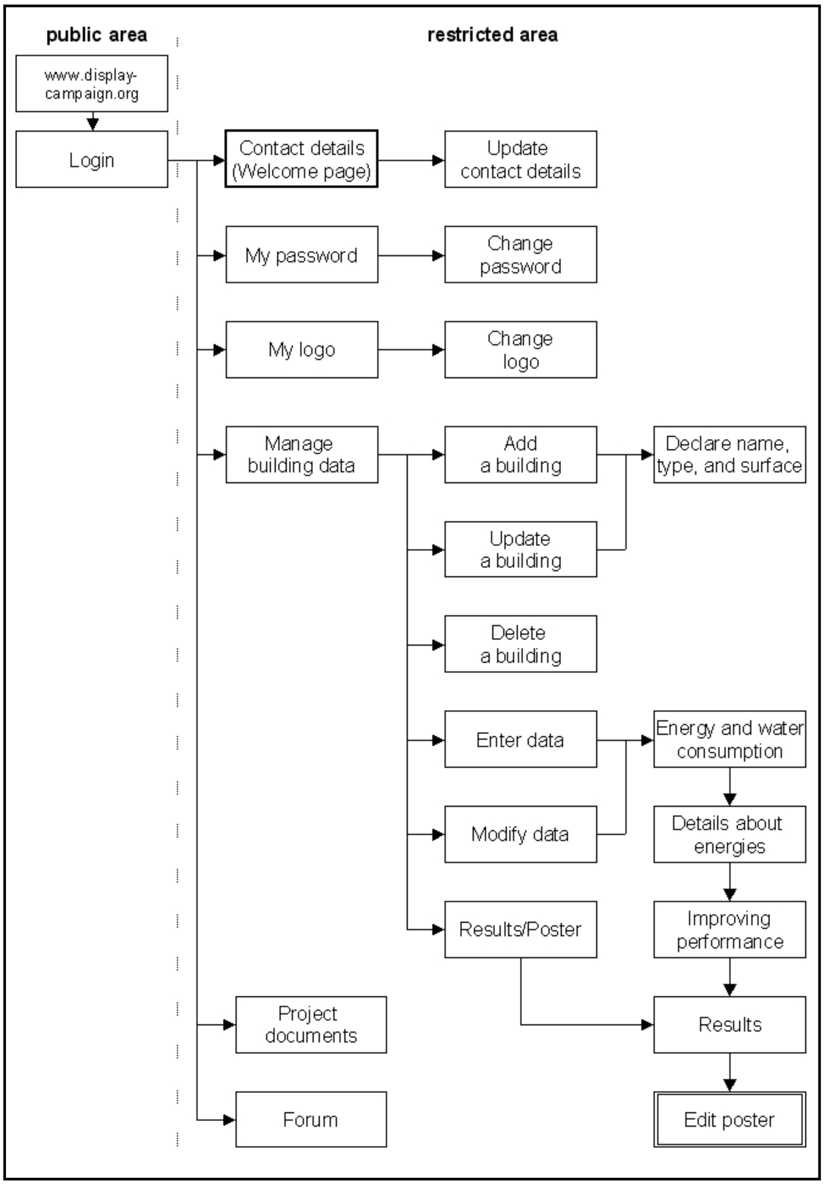

Figure 3: Structure of the Display poster generation tool and further parts of the Display website

The poster generation tool helps to create an individual Display poster. Having entered all demanded information it works autonomously and makes a printable poster available in pdf format immediately. It uses a calculation instrument that determines in a first step the buildings primary energy consumption. Afterwards the instrument generates the primary energy ratio, the consumption of primary energy per square metre of the gross internal floor area of the building. According its type, be it educational, administrative or another kind, the building is graded into a classification scheme of six classes: A to G similar to the well known certification scheme of household appliances. Concerning the $C0_2$ emissions, the instruments follows a nearly identical procedure. The production, transport, and consumption of every unit of whatever fossil energy source entails a certain amount of greenhouse gas emissions, measured in kg of $C0_2$ equivalents. This unit is utilised so as not to neglect the emission of other greenhouse gases. Similar to the primary energy consumption, the tool calculates the C02 ratio, the CO_2 emissions in kg of $C0_2$ equivalents per square metre. Again, this ratio serves as criterion for the grading of the building into a scheme of six classes. The water consumption can be treated in an easier way. The water ratio, the consumption of the building in litres per square metre, is used as performance indicator.

Finally, the tool can fulfil other tasks but this sole calculation. In particular, we want to point out the possibility to experiment with imagined scenarios like a modernisation of the building. For instance, the tool can show the impact – in terms of greenhouse gas emissions and primary energy consumption - of the installation of a wood fuelled boiler or a changeover to 100 % "green" electricity.

2.3.2 Information to be Collected

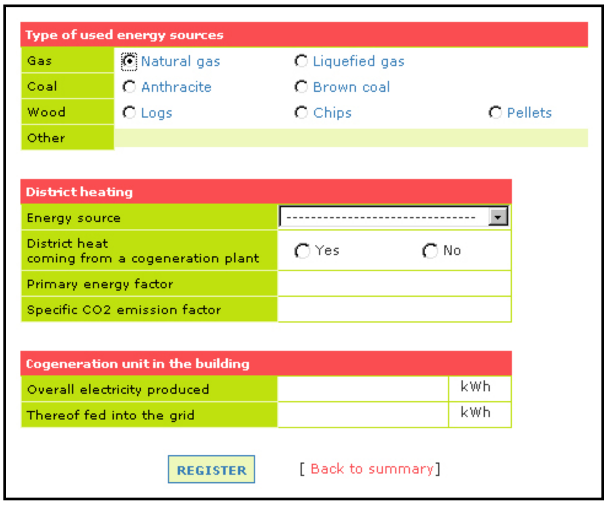

Figure 4: Extract of the website: "Energy and water consumption"

The following list does not include every possibility but should be sufficient for most buildings. Disposing of the data listed in the following will normally enable you to fill in the forms:

- The surface of the building (gross internal floor area)
- The weather correction factor
- The water consumption
- The energy consumption data of the building:
  Separate for every energy source that was used in the building
- More detailed information about the used energy sources:
  - Natural gas or liquefied gas
  - Wood: chips, logs or pellets
  - Purchase of electricity: conventional or certified "green" electricity
- In case of use of district heating the following information:
  - A conversion factor (primary energy factor) informing about how much primary energy is needed for the production of 1 kWh of district heat
  - the CO_2 emission factor (Unit: t of CO_2 equivalents / MWh of district heat)

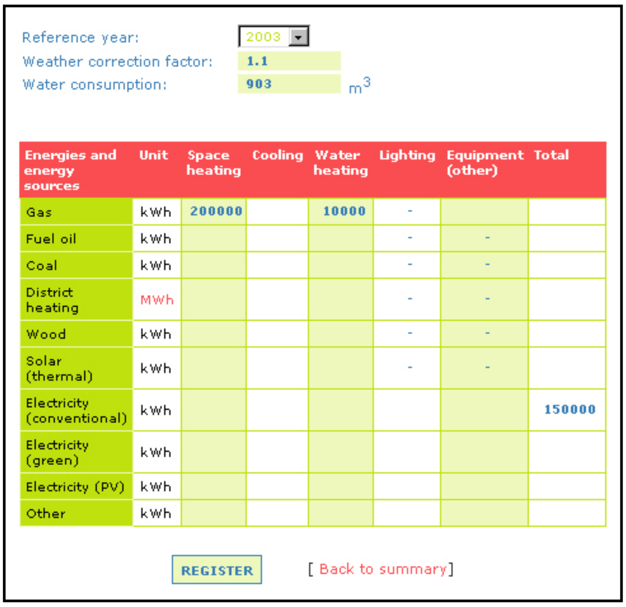

Figure 5: Extract of the website: "Details about energies and energy sources"

2.4. Description of the Calculation and Classification Process

2.4.1. The General Approach

Starting from the input data concerning the final energy consumption of the building the Display calculation instrument uses conversion factors to calculate the primary energy consumption. For this conversion it applies the cumulative energy demand (CED) factors that were developed by the German Association of Engineers (VDI) in co-operation with the German Federal Environmental Agency (Umweltbundesamt) [4]. According to the guideline VDI 4600 the CED is the sum of all the primary energy inputs of a service or a product. This contains its production, usage, and disposal. Contrary to other factors, the CED contains not only the energy demand of the process necessary to provide a service or to produce a product but also the energy that remains in a product, e. g. the calorific value of mineral oil in plastic products.

The German Institute for Applied Ecology (Öko-Institut) has developed the life-cycle analysis program and database GEMIS [5]. This program is capable of calculating the CED factors for a variety of different energy sources and processes. On the basis of the processes linked to a service or a product the program also generates the greenhouse gas emissions related to the production or consumption of a product, given in kg of CO_2 equivalents per kWh of energy. Since the respective conversion factor takes into account the sum of all greenhouse gas emissions on the chain of energy transformation it is cumulative, too.

The Display calculation instrument uses conversion factors based on the GEMIS program, but produced by different sources. The factors concerning the national electricity mixes were calculated directly by the Öko-Institut using version 4.14 of the GEMIS program. The conversion factors for the energy sources gas, fuel, coal, and wood result from a GEMIS version 4.13 calculation made by the Institute for Housing and Environment (IWU) Darmstadt, Germany [5]. They are also used for the certificate of residential buildings developed by the German Energy Agency (dena). The factors for the production of hot water by a solar thermal collector and for the production of photovoltaic electricity in the building were delivered by the GEMIS-based database ProBas which is run by the Umweltbundesamt [4].

Furthermore, experts have verified the mode of calculation. In case of difficulties in the course of the data input, an on-line help and comprehensive user's guide is available to support the user. Additionally, the Display team is contactable via email for questions and suggestions. Finally, a forum, accessible in the restricted part of the website allows members to get into contact with other participating cities and to exchange experiences.

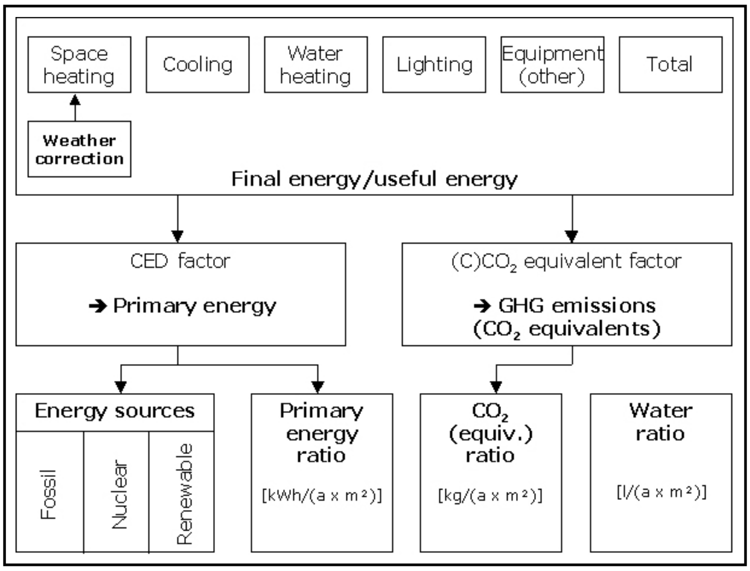

Figure 6: Structure of the mode of calculation

2.4.2 The classification scheme

We only use one single classification scheme per building type for the whole Europe, and this for two reasons:

- First, varying the classification from member state to member state would be a significant limitation of the label. Using common A to G level, of course, it is easier to reach the A level in warmer climate, but on the same side the energy saving potential is lower. This means for example that a lower insulation level is sufficient to reach class A which is very well in line to the economic optimisation: as higher insulation thickness would not be economical if the heating load is low. The Display classification is very close to the Danish classification scheme, the only one so far existing in Europe.
- Second, member states have to develop their implementation scheme for the EBPD till the end of 2005, so probably they will introduce different classification schemes. In this case it is easier to replace on the Display poster the Display classification by the national classification scheme than to replace in two years time a national classification scheme developed under display by the one elaborated by the member state itself.

Table 1: Display classification scheme for school buildings

Display classification School buildings	**Primary Energy**	**CO2**	**Water**
Unit	***kWh / m2***	***kg of CO2 equivalents / m2***	***litres / m2***
A	less than 75	less than 12	less than 100
B	75 - 125	12 - 24	100 - 200
C	125 - 175	24 - 36	200 - 300
D	175 - 225	36 - 48	300 - 400
E	225 - 275	48 - 60	400 - 500
F	275 - 325	60 - 72	500 - 600
G	325 and more	72 and more	600 and more

2.4.3. Visualising energy sources

Display poster is also taking partly into consideration the Directive 2003/54/EC [6] which introduces to electricity supply companies to specify the fuel mix and it's related environmental impact of the electricity they sell to final customers. Each member state should develop a standard list of fuel categories (10-12; including RES) relecting the order of importance within the country. The Display poster provides information on the three main types of fuels: the contribution of fossil, nuclear, and renewable energy sources to the overall primary energy consumption used for the production of electricity that is consumed in a building. Data of the national electricity mix are taken from the Monthly Electricity Survey that is published by the International Energy Agency (IEA, data of 2002) [7].

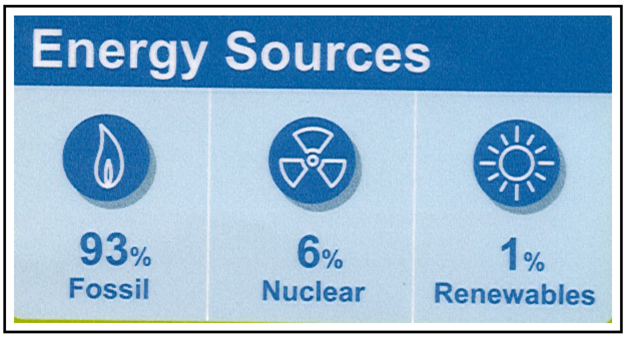

Figure 7: Extract of the Display poster visualising savings achievable by improving the performance of a building

2.4.4 Visualising Savings

In order to visualise possible savings that can be achieved by changing the performance of the building by one class in the corresponding category the Display poster shows three elements of comparison. The first step for depicting possible savings is to calculate the amount of necessary savings in order to achieve the next best class. Afterwards these savings are compared to the annual primary energy consumption per year of an average single family house (basis: PE consumption of one single family house 40,000 kWh/a), the CO_2 emission of a car going once around the earth (basis: 7,37 t CO_2 once around) and the water consumption of a shower (basis: 30 l/shower). Please note that this is based on an improvement of the ratio by one whole class, e. g. not only the next five points that would lift the building into a higher class in a certain category. The only exception is made for buildings that have already achieved class B in a certain category. In this case the calculation of the savings that are achieved by lifting the building from class B to class A is based on the current distance up to the threshold value. If the building has already achieved class A in a certain category the text “Class A already achieved.” is shown on the poster.

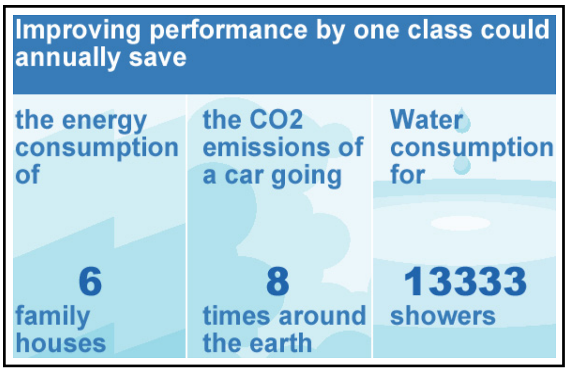

Figure 8: Extract of the Display poster visualising savings achievable by improving the performance of a building

2.4. How to join the Display

All European countries, whether they be Members of the European Union, candidate countries or otherwise, are eligible to join the Campaign. The information package, as well as the Internet interface, are already available in eight languages (September 2004) and should soon be available in at least 12 languages. It is indeed essential to work and communicate in the languages of the countries involved. Display is an ideal tool for those local and regional energy management agencies who wish to develop initiatives in municipalities or at a regional scale. To join the Display campaign, the municipality signs a Members' Charter. In order to ensure the success and common European nature of the European Campaign "Display", the local authority commits itself to comply with the following conditions:

- to display to citizens the performance – in terms of energy consumption, CO_2 emissions and water consumption – and therefore to display the Display posters in each municipal building concerned at locations well used by the public,
- to launch an information and awareness campaign addressing the users of the buildings concerned,

In return, Energie-Cités commits itself:

- to provide the municipality with a web-based calculation tool allowing the production of the Display poster, as well as a handbook for this calculation tool,
- to prepare an information dossier for each municipality by the end of 2004,

Reason why municipalities have joined the European Display Campaign have been:

- undertake a practical and visible campaign to fight climate change,
- raise awareness amongst users and managers of municipal buildings,
- encourage eco-friendly behaviour amongst citizens by setting an example,
- assess local policy using detailed facts and figures,
- be able to simulate the effect of improvement measures,
- compare the performances of its own buildings and be able to compare itself with other towns,
- share experiences with other European towns,
- benefit from targeted and tailored communication tools and media,
- present a positive and dynamic image of one's town.
- make financial savings.

3. Outlook

Several cities are already actively involved in communication activities and the existing experiences are shared between the municipalities. Currently, a single communications strategy is being developed by Energie-Cités, which can be implemented by all the participating cities. In the coming months, we will take advantage of several national events, which provide an ideal opportunity for us to promote Display, and may help recruiting new cities for the project.

Moreover, the existing communication tools will be translated into even more languages in the near future. In this way, we intend especially to attract and integrate the new EU members from the Eastern European countries.

Focussing on the Display poster generation tool it is planned to establish a feature to simulate effects of improvement measures, e.g. the influence of the installation of a CHP unit in the building.

We are currently trying to extend the campaign beyond the fixed period of 30 months as we consider Display a helpful project for awareness-raising in both local policy makers and the general public. This is a unique tool for the dissemination of information on Greenhouse gas effects and CO_2 and helps raise public interest in these issues. The Campaign has a target of promoting the use of Display in more than 1000 European municipalities by 2007.

4. Conclusion: Bringing the gap between Europe and its citizens

At a time when the debate on the relationship between "Europe" and its citizens has very much become a topical issue in all European countries, it is vital to develop a series of initiatives that bring players from different levels together around common objectives that are shared by all. What is at stake is the future of Europe.
Display demonstrates that this is possible, and will provide further evidence of this when more than a thousand municipalities have joined the Campaign. How might this be achieved? It is thanks, essentially, to the networking approach, which provides a new way of thinking, producing, proposing, building and implementing ideas which is at the same time both political and practical, European and local.
The experience acquired by Energie-Cités over the last fifteen years has been used to serve this ambition through a practical project. Compared with what remains to be done in building a sustainable energy society, it is nothing, or almost nothing. One tentative attempt among many others.
But let's just imagine what would be possible – in all areas – if European and national institutions made better use of the strength of networks of players and gave them more encouragement to play their part.

5. References

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SOME PROBLEMS OF STRUCTURAL DESIGN CODES REFERRING TO ATMOSPHERIC ACTIONS AS PROBLEMS PERTINENT TO THE ENVIRONMENTAL FRAMEWORK ASSESSMENT

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1. Introduction

One of the most essential requirements of sustainability for the buildings is that the main structures are to be safe under atmospheric actions such as snow and wind loads.

The assessment of these features is regulated by the relevant design codes – e.g., by Eurocodes such as ENV 1991 [1]). The directions of these codes governing the choice of characteristic and design values of wind and snow loads constitute one of the foundations for structural design and, first of all, for elaboration of various special-purpose normatives. Nevertheless, there are serious methodological problems of interpretation and implementation of these directions formulated somewhat abstractedly and aimed mainly at rather specific conditions of application. Moreover, the problems arising here are essential not only for design codes or other similar practical conclusions – but, first of all and even more substantially, for research providing basis for such practical conclusions.

It is hard to formulate immediately the object of all considerationsions to be presented here – and the presentation of them will take almost all of the remaining part of this paper – but in a very concise exposition main points of discussion may be outlined as follows.

Firstly, we emphasize the necessity of a careful taking into account the proper measure of uncertainty associated with the random parameter that is characterized (e.g., the coefficient of variation of the snow or wind load – or any other similar statistical indicator); and, particularly, the necessity of taking into account the «spatial» («territorial») component of variance alongside the more obvious analysis of the «local temporal» variance is stressed.

Second, we call attention to the possible paramount importance of wind gusts for the total wind loads – a circumstance occurring at least in some quite not unusual cases but being, in all likelihood, underrated rather frequently.

This paper presents a brief overview of these problems based on analysis done by the authors when examinating the normatives recently adopted in Lithuania and analysing the pertinent climatological data. Our main objective here is, however, not a critical revision of these local regulations (although such a revision is actually a necessity) but general methodological remarks following from our analysis and from some unqestionable theoretical considerations. (Nevertheless, some particular quantitative results relating to the local Lithuanian regulations and based on our calculations [1] will be presented in the closing fragments of this paper as an illustration of practical meaning of the considerations put forward here.)

2. Distinction between various components of uncertainty in statistical models of atmospherical actions

If we direct our attention, for the sake of definiteness and clarity of presentation, to the statistical treatment of actions (or loads) in Eurocodes, the following picture may be observed.

The Eurocodes describe the characteristic values of wind and snow loads as the quantiles of annual maxima of corresponding actions with probability 0.02 of excess, – and this definition of a practical normative might appear at first sight as a very clear-cut definition… But in actuality it is not free of problems, mainly in probabilistic interpretation of 'corresponding actions' mentioned above.

First (but not foremost), problems arise when the influence of specific physical circumstances at the given site (such as configuration of the building, possibility of thawing of the snow on the roof caused by heat transfer from within the building, etc.) must be measured quantitatively. However, it seems likely that we may omit such circumstances here since auxiliary formulae appearing in [1] and in other normative literature allow mostly quite agreeable account of these circumstances – perhaps with only not dangerous distortions in the picture of uncertainties and random deviations that is to be considered when reliability requirements are chosen. A question of prominent importance, however, remains latent and calling for more attention in this statistical scheme – namely, a question about a correct probabilistic and statistical definition of the random variable mentioned as '*annual maximum of the load*'. More precisely, the question is: what is the amount of probabilistic uncertainty of such a variable (and, respectively, of its statistical variance as reflected in observations) that must be taken into account when analysing the distribution of such variable and estimating its quantiles?

There are various interesting aspects of this question – but of special note are problems connected with uncertainties in the probabilistic model of the variable under consideration (maximum of the load) resulting not only from variability of actions at a strictly defined location (for which a more or less representative sample of data is presumably available) but also from the fact that the structure being considered is to function in a location which we are not able to characterize so definitely [2]. And we put forth here the assertion that in typical cases the variance of the analysed variable (here – the random level of an annual maximum of the load) must be viewed as including at least two components of variance:

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[1] A corresponding study is now conducted in the Institute of architecture and construction of KTU and applied mainly to the so-called 'Technical Regulations of Construction' [Lith. *Statybos techniniai reglamentai - STR*], including *STR 2.05.04:2003* [2],which deals with snow and wind loads.

[2] In many cases these uncertainties spring up simply because of scantiness of climatological information related to the individual site, – but sometimes even because the localization of the site itself is not determined yet (as it happens when a design is used repeatedly in numerous places).

(1) the *temporal* component – i.e., the component of uncertainties *related with random properties of a chosen time interval* (usually of a chosen annual period and/or a sequence of such periods);

(2) the *spatial* component – i.e., the component of uncertainties *related with random properties of a site* (and/or a subset of sites chosen from the general set of sites).

(Practically, in analysis of data samples, the first component may be observed in comparison of periods surveyed, provided that in any of such confrontations the place of observations is uniformly fixed; and the second may be observed in comparison of all sites treated by official regulations as belonging to the same region – provided that in any of such confrontations the time of observations is uniformly fixed.)

The necessity of considering both these components of uncertainty is, as a matter of principal conviction, rather unquestionable; nevertheless it has not been adequately realized not only in practical decisions and recommendations akin to the Eurocodes but, unfortunately, even in scientific research. In reality, neglection of the «spatial» uncertainties in practical statistical investigations of atmospheric loads may be observed in numerous publications where probability distribution of the load is straightforwardly identified with some empirical distribution obtained at the nearest meteorological station – so that special circumstances and dangerous possibilities which can be specific individually for the targeted site are in such practical application totally ignored. In actuality, this simple-minded assumption is reasonable quite rarely – maybe only if a representative sample of data has been obtained in a rather close proximity to the site for which the design values are to be determined.

It should be realized here that substantial differences of load data (comparable even with the scale of the load variance throughout all the region for which the normative load levels are defined uniformly) can be observed sometimes even under conditions when the comparison refers to a pair of localities separated by a distance of several kilometres in all. Therefore we may not rely upon such simplifications.

3. Considerations relating to the treatment of data describing the wind velocities

We must also notice the problematical character of the fact that in Eurocodes (and as well in numerous other normatives), when the observational data are treated, the characteristic and design values of wind loads are related mainly to measurements of "moving" averages of the wind velocity – with averaging on time intervals as long as 10 minutes. The action of more intensive momentary gusts is to some extent taken into account, but the inclusion of parameters referring to gust velocities is only indirect and so organized that the long-term effects are usually highly prevailing in the end results (at least when the most complicated methods of dynamical calculations are not applied and simplified normative recommendations are followed). Such construction of norms is likely to be sound when rather tall and relatively not very stiff buildings with rather prolonged oscillatory motions are kept in mind – but for relatively simple and stiff structures of low buildings this approach is somewhat misleading since even single gust can make a fatal impact.

The analysis of wind observations conducted by us till now is based mainly on data representing maximal velocities in gusts (and the analysis of the "moving average" data, along with corresponding detailed analysis of effects of the normative prescriptions referring to the gust velocities, has been till now rather provisional). Therefore it is difficult at this point to compare our conclusions quite thoroughly with the recommendations of Eurocodes or the *STR* adopted in our country. Nevertheless the results of statistical analysis of wind velocities obtained so far and briefly presented below seem to indicate definitely that the gust velocities are significantly more dangerous than it is believed to be on the grounds of norms adopted now.

4. Some remarks anticipating the following review of statistical results

The properties of empirical distributions of sample data are such that approximative description of these distributions is, as a rule, quite good when the lognormal model is taken as the «theoretical» model [3].Having adopted this scheme of approximative description, let us recollect briefly some important properties of lognormal variables and characteristics of their distributions. (We hope that these remarks, though not new in their origins, can be interesting for authors of other similar investigations. Furthermore, they are necessary for the following presentation of our statistical illustrations.)

Firstly, if a numerical random variable Z has lognormal distribution, then its logarithm $L := \log_a Z$ is distributed normally – and it is easy to understand that the choice of the base of logarithms (a) results here only in scale transformation of the variable L . It is, moreover, also evident that in efforts to analyse such variable Z and to give its mathematical description it may be advantageous to use such variable L as a convenient auxiliary tool since the properties of normal distributions are very helpful and well explored. To be more specific, in doing so there is good reason to define logarithms mentioned just above as natural logarithms $\ln Z$ (with the base of logarithms equal to e=2.71…) [4]. Hereafter we shall keep in mind just this way of using the auxiliary variable (*logarithmic image*) L , being supposedly normal and associated by logarithmic transformation with a given supposedly lognormal Z (description of which is the main objective).

It is needless to say that for description of lognormal random variable Z all usual parameters of its distribution such as mean value μ_Z , median η_Z , mean square deviation [standard deviation] σ_Z , coefficient of variation υ_Z , etc. (or, perhaps, sample estimates of these parameters for a sample $\mathbf{Z}=(z_1, z_2, \ldots, z_n)$ presenting the observed values of Z – if empirical distributions and statistical estimations are to be considered explicitly rather than a probabilistic model adopted as a result) may be employed in a quite traditional way. Nevertheless there are grounds for use of some other parameters more specific to lognormal model – in particular, some parameters of the normal image L (μ_L, η_L , σ_L ,…) similar to the parameters of Z mentioned above (or some sample characteristics of L from the sample $\mathbf{L}=(\ln z_1, \ln z_2, \ldots, \ln z_n)$). Of special interest here are two such parameters:

the *mean* μ_L of the distribution of L (or an estimate of such a mean if statistical estimations are presented explicitly), value of which obviously corresponds to the median η_Z of the original variable ($\eta_Z = \exp \mu_L$) if the assumption of lognormality is really applicable to Z;

the *mean square deviation* σ_L of the distribution of L (or an estimate of such a parameter).

The interpretation of these parameters is quite traditional and does not require any explanation; but it might be well to point out the practical consequences following from such treatment of the model (when the relation between Z and its normal image L is put to use). One of these consequences is that we arrive at using the median of Z (or, if we are adhered to strictly statistical point of view, – the estimate of this median) in a role closely resembling the usual role of mean values or sample averages (although the difference between the two is worthy of consideration and generally is not negligeable [5]). The second consequence is the wide use of the *mean square deviation of the logarithmic image* [of the variable under

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[3] We do not advocate thereupon that this model has been supposedly established as undoubtedly superior above other possible models. We state only that the approximation works well at least to the level of quantiles covered here – without manifestation of any evident systematic deviations. In addition, this model is very handy by its mathematical features.

[4] Among other motives, it is pertinent to consider here the fact that such description of lognormal variable leads to a situation where the «logarithmical image» L of the original lognormal variable Z is distributed so that mean square deviation σ_L of L is asymptotically equivalent (as its value decreases) to the coefficient of variation υ_L of the original variable Z. This is doubtlessly a great convenience for an easy and clear understanding of the values assigned to the parameters thought of here.

[5] More precisely, for a lognormal variable Z the relation between η_Z and μ_Z is given by formula

$$\mu_Z = \eta_Z (1+\upsilon_Z^2)^{1/2}.$$

consideration, – i.e., use of σ_L for the given Z] – use of a characteristic that is, as it has been indicated before, similar to υ_Z, although not identical to it.

Bearing in mind the importance and frequent use of σ_L we shall abbreviate its denomination ('*mean square deviation of the logarithmic image*') with brief notation '*m.sq.d.l.i.*'.

5. Some preliminary results referring to the Lithuanian statistical data [6] as an illustration of the conceptions presented above

Let us begin, firstly, with the data on snow loads.

When the random variable being analysed is defined as a maximum for a winter season amount of water per unit surface (observed at some site which is, however, not fixed *a priori* and is treated so far as a variable of the model) – let us denote it traditionally as *s* and express its values in kg/m^2 – and the results are concurrently surveyed for all the analysed sites without regional divisions of the country (although grouping of data by individual sites and confrontation of results from various sites is of course a requisite perpetually), the following results are obtained.

The most typical estimates of the median value η_s of *s* are, in a review of data for fixed sites or for single winters, about 45…50 kg/m^2 – however, with substantial variation from one site to another (from approximately 33 to 73 kg/m^2) and in comparing of various winters (from very low values as some winters are almost snowless, and to about 122 kg/m^2 in 1995/96), – and, as a generalized result, the estimate of median for the joined sample of all observations is about 46.0…46.3 kg/m^2. (Slightly different results can be obtained depending on one of possible methods of treating data.) But more interesting from the viewpoint of discussion initiated here are the estimates of the m.sq.d.l.i. $\sigma_{\ln s}$ of *s* – the measures of its variance as observed on variuous grouped samples. These are about 0.56 for the «local» samples (taken at fixed sites and representing the «serial» variation of the variable) – and about 0.35 for the «territorial» samples (gathered in a fixed time period, usually a winter, and representing the «spatial» component of variance). Thus the «local serial» component of variance is distinctly prevailing over the «spatial» («territorial») component; however, both are great (greater than almost all analogous characteristics of variance defined for other factors of reliability essential in stuctural design) so that no one of them may be neglected.

It is necessary to add that quite analogous results are obtained when the territory of the entire country is divided into regions with considerably differing load levels. (It seems likely that in Lithuania two such regions must be distinguished.) For example, for the western hilly region of our country, where the snow loads are definitely greater, the mentioned above estimates of parameters characterizing the distribution of *s* are the following: $\eta_s \cong 46$ kg/m^2 and the values of m.sq.d.l.i. equal, roughly approximately, to 0.62 or even 0.66 for the «local serial» variance and 0.33 or even 0.41 for the «territorial» variance [7]; and for the remaining part of the country – $\eta_s \cong 49$ kg/m^2 and the values of m.sq.d.l.i. equal approximately to 0.51 for the «local serial» variance and 0.26 for the «territorial» variance.

If we turn our attention now to the velocities of wind and, as it has been stated in our introductory remarks, confine the review only within the context of wind gusts velocities (for one year long periods), the following results are to be noted (again with dividing the country into two regions, one of them covering the western belt of territory near the sea).

[6] The data used in this study may be defined briefly as gathered from 19 meteorological stations in 1970-2002. (Minor adjustments of this statement would be appropriate depending on particular tasks of analysis and some gaps in observations; however, such accuracy is not strongly needed here.) This study is not completed yet; nevertheless some primary results seem to be worth of presenting them already now.

[7] Unfortunately, estimates for this region are not exact since the variance is extremely great and the amount of information from the region is rather scant.

For the western (seaside) region: estimates of median about 26 m/s and m.sq.d.l.i., most likely, about 0.16 for the «local serial» variance and about 0.17 for the overall estimate of variance [8]. Thus the characteristic levels of the variable under consideration (wind gust velocity) should rather be for this region about 36 or 37 m/s. For the remaining part of the country: estimates of median about 21 or 22 m/s and m.sq.d.l.i., most likely, about 0.1…0.14 for the «local serial» variance and about 0.14…0.15 for the «territorial» variance – which leads to the overall estimates of m.sq.d.l.i. in a rough approximation near to 0.18 – and estimates of the characteristic level of wind gust velocity near to 32 m/s. From the viewpoint of assessment of wind loads and the considerations presented above we must emphasize here the fact that such characteristic values of wind velocity as just mentioned here (36 or 37 m/s for the seashore region and 32 m/s for the remaining territory) are, in all likelihood, unfeasible as results of analysis when the "moving average" data for Lithuanian territory (or corresponding normatives produced by standard methodology) are taken into account. And still these results point out the possibility of quite regular occurrence of winds with such velocities. (By the way, this is not only theoretical possibility occurring from some lengthy calculations – but also a hard empirical fact of observations.)

Therefore it is highly probable that the methodology of normative regulations and design calculations must be modified in such a way that for relatively stiff structures of low buildings (i.e., for the cases when the load effects arise almost immediately following the wind pressure) the design velocities of wind be somewhat increased.

6. Conclusive remarks

The considerations presented above illustrate the necessity of sufficiently versatile treatment of the scientific statistical information on factors conditioning the sustainability of buildings (and, more generally, of all the environmental framework) – the necessity of analysis giving proper weight to the adequate presentation of the real spatial and temporal structure of detrimental actions such as wind or snow loads. We hope that this illustration, although being rather very specific by its subject matter, may be of interest also in a broader context – just as an example of some general methodological necessities.

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[1] *EN 1991-1-3:2002. Actions on Structures – Snow Loads*. Brussels, CEN General Secretariat.

[2[*STR 2.05.04:2003. Poveikiai ir apkrovos [statybos techninis reglamentas]*. [Actions and loads – technical regulations for construction. (In Lithuanian.)] // Valstybes žinios, Nr. 59 (2003m.).

[8] The paucity of data here is even more acute than in the case of snow loads as there are just three meteorologic stations in this region; however, this shortage is to some extent counterbalanced by the fact that the variance in this case is not so high.

INNOVATIVE MATERIALS

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1. INTRODUCTION

The purpose of this paper is to investigate the practicality and feasibility of certain sustainable and innovative materials, as opposed to traditional building materials. There are mountains of by-products of our civilization which can be reused as building materials. These are the natural resources of the twenty-first century. The paper examines the potential of these materials by considering design issues such as; availability and ease of production, cost, durability/ life span, construction time and aesthetics.

Two materials have been chosen, as case studies, to demonstrate the potential of these materials. They are:
Paper/Cardboard – It examines the use of cardboard tubes and reinforced paper panels called Sonoboard
Bamboo – It examines the use of bamboo as a fast growing materials

2. PAPER AS A BUILDING MATERIAL

The Japanese have always had a special interest in paper as a building material. Paper shoji screens and lanterns define the traditional Japanese house. Shigeru Ban is a pioneer of paper tube structures (PTS). He has come up with a building system based on cardboard tube columns. In the last decade Ban has designed recyclable and easy to mount cardboard houses as well as designing shelters for refugees and disaster victims.

Ban first began experimenting with alternative materials in 1986, when he used paper, instead of wood, to build his Alvar Aalto exhibition display. He was surprised at the strength of the paper and then began to use paper tubes as structural systems. Although Ban has become an icon for advocates of 'green' and 'eco-friendly' architecture, his intention behind his work is slightly different. It's more an ideology against waste. It's about invention, curiosity, discovery, and about tackling problems with a sense of humour. That paper as fragile, flammable and cheap material is also suitable for making real buildings seemed unthinkable, until recently. There are of course a lot of finishing materials in which paper is processed. For example plasterboards, wallpaper and eco-insulation from paper shreddings. When buildings are meant to last for a short time, one should try to use materials that are easily recycled. Reasons to use paper and cardboard, as a construction material are because cardboard is made from recycled paper, and can be recycled too. Using paper as a building material has a number of advantages:

Durability: Paper tubes, made of recycled paper, have stable qualities and are highly durable. In this sense, they can be regarded as "evolved wood."

Weight: Paper tubes as structural materials are much lighter than wood, let alone steel or concrete. This characteristic is one of the great merits of paper tubes, because we can build light weight buildings

Environmental benefits: Paper tubes can be easily manufactured and processed. More importantly, they are recyclable. Therefore, if we use paper tubes, the risk of destroying the environment is quite small when obtaining the materials or disposing of surplus waste.

Aesthetic- Paper tubes are simple, yet powerful and beautiful.

3. CASE STUDIES

In June 1995, Shigeru Ban designed houses which were assembled out of paper tubes for the victims of Kobe earthquake. The simplicity of the structure of these houses made it possible for a house to be assembled in 6 hours by unskilled labours. Teflon-coated tenting was used for the roof and plastic beer crates raised the structure off the damp ground. He established that not only could recycled cardboard be moulded into load-bearing columns, bent into beautiful trusses and quickly assembled, but it could also be made waterproof and fire resistant. In the space between the paper tubes, self-adhesive waterproof sponge tape was applied to both sides. The foundation was made of sand-filled beer cases, the walls of paper tubes and the ceiling and roof of tent material. The roof and the ceiling were kept separate in summer to allow air to circulate and closed in winter to retain warm air.

Figure 1. Paper tube houses for the Kobe earth quake victims

In the church designed for the same victims, Ban used paper as the main building material. The church was constructed in only 5 weeks by 160 church volunteers Although it was originally intended to be a temporary structure, due to its popularity it is still there! (figures2). Tube walls were built up from laminated layers of recycled paper to a thickness of 16mm and wooden stoppers inserted at both ends, resulting to a strong structural column, capable of supporting half the weight supported by a column of wood. The tubes were then sealed and made waterproof by hand, (a process which has to be repeated every year). Each tube was 5 metres in length, 330 mm in diameter, with a thickness of 16 mm.

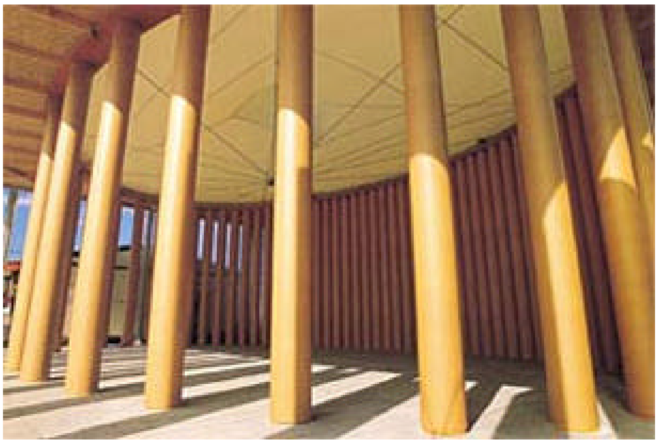

Figure 2. Paper church for the Kobe earth quake victims

'Environment' was the theme of the EXPO 2000 in Hanover and the concept of the Japanese pavilion was to create a structure whose materials could be recycled when it was dismantled. The pavilion designed by Shigeru Ban was a paper tunnel supported by a matrix of recycled paper tubes as structural elements. While paper tube structure was sufficient enough to withstand the loads, a compromise was made by including a supporting wooding structure to satisfy the German building codes. To avoid the use of PVC (a common substance for tent-like structure) that emits dioxin when burned, the pavilion was covered with specially designed water resistant and fire retardant paper roofing which was also light penetrating. After the exhibition, the pavilion was recycled.

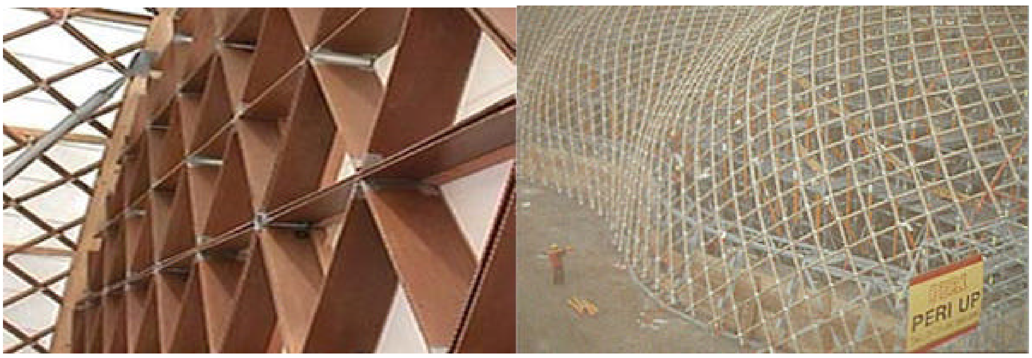

Figure 3. Structural Details of EXPO 2000 Japanese

4. BAMBOO AS A BUILDING MATERIAL

Bamboo is another renewable material with adequate properties to be used in buildings. Building with bamboo looks back on an ancient tradition in the regions in which the plant grows in abundance such as South America, Africa and South East Asia. Bamboo is a high-quality, high-strength material with enormous building potential. It has an amazingly short growth cycle when we compare it with a tree. To grow the bamboo to build a one-family house, there is needed an average of 500 square meters of land for five years. In 5 years, using a space as large as 1/4 of Germany, one could grow enough bamboo to shelter the 100 million homeless people. It is a true alternative to cutting down precious tropic trees in the rain forest. Bamboo is the fastest growing woody plant on earth. It grows one third faster than the fastest growing tree. The project FUNBAMBU in Costa Rica made the construction of about 1000 bamboo houses annually possible. The building material came from bamboo plantations of only 60 hectares. To build the same number of houses an area of 500 hectares of tropical rain forest would have to be felled!

Bamboo has adapted itself world-wide to diverse ecological conditions; The bamboo belt runs through tropical, subtropical and temperate climates around the globe, up to 45° North and South. Bamboo has an amazingly short growth cycle. Some bamboo species constitute the world's fastest growing plants. Some species grow at an incredible rate of 1m per day. Size ranges from miniatures to towering culms of 60m.

Bamboo has unique properties; It is high-strength, stiffened by the nodes, but because of its cavities extremely light and elastic. Its physical qualities are partially far superior to timber. The heartwood is the strongest part of timber, so strength decreases from the centre outwards, whereas the strongest part of the bamboo culm is at the outer edge of the culm wall - a much more stable construction for example for multi-storey buildings.

Another advantage of bamboo is its low weight. It can be transported and worked easily. It can be bent using heat and when growing. Structures made out of bamboo have remarkable flexibility against earthquake and storm forces. They can withstand wind gusts of 100 km/h.

Bamboo is classified, according to the DIN 4102 (Burning behaviour of building materials), as flammable but hardly combustible. The ignition susceptibility depends particularly on the position of the component so horizontal components are less susceptible as diagonal or vertical components. On a horizontal bamboo cane, the flame spreads annularly to the next knot point (node). There the fire dies down because the flame cannot pass easily the hardly combustible node to the next segment. A bamboo tube that is filled with water can stand up to 400°C at the bottom side, while the water cooks in the tube.

One of the problems associated with bamboo is its susceptibility to infestation by insects and fungi once harvested. This problem can be easily overcome by traditional Japanese method of smoking. Burning leftover pieces of harvested bamboo in a large oven, smokes the bamboo poles and extracts the pyrolytic acid from inside the bamboo and evenly applies it to its surface making it resistant to infestation. Treated bamboo may last up to 500 years.

One of the most important disadvantages of bamboo as a building material is it is not possible to use it if it is broken. Broken outer fibres are razor-sharp because of the silicified layer and therefore easily lead to injuries. The bamboo canes differ from each other and cannot be cut like timber - they cannot be standardized. Bamboo shrinks more than wood when it loses water. Moreover, the mechanical qualities of bamboo depend on the botanical species, its habitat and the age of the cane at the date of harvest, the moisture content and of course on diameter and wall thickness. So it is recommended to sort the culms accordingly.

Standards about building with bamboo are still missing, which impedes the application of bamboo in countries with strict technical regulations. But there exists a draft of the ISO about bamboo testing methods. Like timber bamboo can be glued to form slats, boards, arches and I-beams. Tests at the Universidad National de Colombia on glued bamboo products have showed that glued bamboo slats serve very well as source material for high-quality products with good material properties.

5. CASE STUDIES

Colombia pavilion for Expo 2000 in Hanover (figure4), designed by Simón Vélez, demonstrated the potential of bamboo as a building material. The primary building material was 4000 pieces of bamboo (Guadua - with concrete-filled joints) forming a space 14 meters in height and 40 meters in diameter. That pavilion was the only one at the EXPO built twice; once in Colombia for testing and once in Hanover.

Pereira Church (figure 5) and Social Housing project in Armenia (figure 6) by the same architect, are further proof of bamboo as main building material. The 500 homes Simon Velez design as parts of an international challenge to build homes with bamboo for 250,000 people demonstrated the economical and constructional advantages of bamboo structure. The estimated cost for one two-story house is Euro 7,000, favouring it compared with the cost of traditional methods of construction.

Figure 4. Colombia pavilion for Expo 2000 in Hannover

Figure 5. Pereira Church

Joints can be strengthened by injecting concrete into internodes and adding steel reinforcement. Like gluelam timber beams, bamboo can be glued to form slats, boards, arches and I-beams.

Figure6. Social Housing project in Aemenia

6. CONCLUSION

It is necessary to note that some traditional construction methods do more harm than good. They are damaging our planet. Our ability to evolve beyond these systems is becoming increasingly necessary. If we learn to live with alternative production and construction systems, we could radically slow down the destruction of the planet and possibly reverse certain aspects of the deterioration. For centuries, buildings have been built from found materials such as rock, earth, reeds and logs. These finite resources are being exploited and alternatives need to be found. Many of alternative materials have similar properties to those of traditional materials. There is no reason why these materials cannot be used more widespread in the construction industry. In fact some of them had greater strengths and durabilities than traditional materials.

For example, the physical qualities of bamboo are far superior to timber. The heartwood is the strongest part of timber, so strength decreases from the centre outwards, whereas the strongest part of the bamboo is the culm, this is at the outer edge. This provides a much more stable construction. Bamboo is ready for harvesting within three to six years, whereas oak, cherry, maple and exquisite rain forest hardwoods take more than 100 years to grow to maturity.

This paper looked at just two materials, i.e. paper and bamboo as two alternative building materials. There are lots of other similar materials and/or by products which can be used in the building industry to replace traditional materials.

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EFFECT OF WATER VAPUOR CONDUCTIVITY OF EXTERNAL FINISH OF BUILDING ENCLOSURES ON MOISTURE BEHAVIOR OF EXTERNAL THERMAL INSULATION COMPOSITE SYSTEMS BASED ON MINERAL WOOL

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1.Introduction

Nowadays thermal insulation from outside become very popular. Market offers a lot of new materials for the finish of ETICS, although the most popular ones are thin painted renders. For external finish of insulating layer widely the painted thin renders are used. In Lithuania problems related with durability of the finish under consideration often occur in regard to the climate impact. Sometimes the first signs of paint decay appear after 1 - 4 year of exploitation.

A lot of attention has been paid to the weather resistance of external layer of building enclosures before [1; 2], but the influence of moisture characteristics to the durability of thin render in the ETICS has been analyzed only a little. Moisture parameters such as water vapour permeability d_p, water vapour resistance factor µ, water vapour diffusion – equivalent air layer thickness s_d have been evaluated as characteristics of separate materials, compatibility of all layers of the ETICS according to moisture characteristics has not been taken into consideration. If the paint is chosen wrongly, this layer becomes the barrier for the water vapour diffusion and this cause preconditions for the cumulation of moisture in the walls in winter time. Moisture cumulates under the paint layer and becomes the destructive factor in the contact of thin render and paint layer.

While trying to renew these defects, usually the external layer is repainted, leaving the old coat of paint layer because the removal of it is problematic (renders are thin and may be easily damaged mechanically). This is the reason why every repaint of thin render is connected with: enlargement of paint layer: enlargement of external layer vapour resistance: enlargement of the condensation under the paint layer in winter time: durability decrease of a system render – paint.

This impelled to analyze in more detail the genesis of ETICS destructive factors of the external layer, and to define the influence of thin render and paint layers vapour resistance in point of the whole wall.

2. Calculations of the walls moisture condition

For the calculations of the moisture state the wall construction of lightweight concrete blocks with render has been chosen. It has been additionally made thermal insulation with ETICS based on mineral wool for the further calculations. Five construction variants of the wall have been got this way and their schemes are given in the Table1.

Calculations of the moisture state were performed according to the EN ISO 13788 which determines how to count the annual moisture balance and maximum amount of the cumulated moisture (kg/m^2) because of appearance of condensation inside the walls.

Because a movement of the moisture through the material in the shape of water vapour happens very slowly, we used the average monthly temperatures and relative humidity of air values of Kaunas city, accepting the steady state conditions. Such a precision is enough to determine the conditions possible for the condensation of water vapour, its location, amounts of the condensation and evaporation (drying).

In pursuance to designate the influence of indoor air parameters to the appearance of condensation, room temperature and relative humidity of air was chosen:

1) 18^{o}C/50%;

2) 18^{o}C/70%;

3) 22^{o}C/50%;

4) 22^{o}C/70%.

The first two cases when the room temperature is 18^{0}C, matches to the room temperatures of the most block of flats in winter time in Lithuania. Although according to the HN 42: 1999 norms [4] the temperature of living room should be 22^{0}C. That's why we performed the calculations using both temperatures.

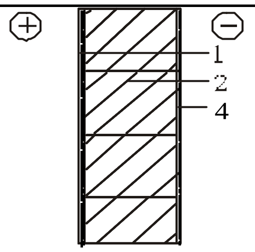
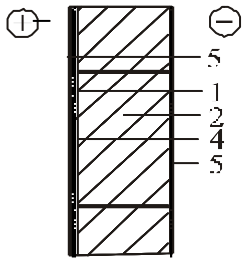
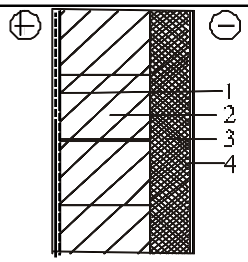
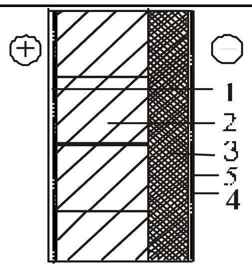
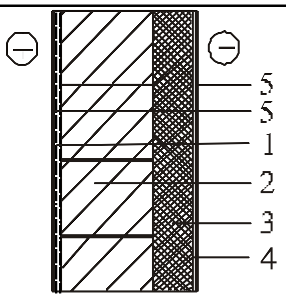
We began to count since October, considering that external construction is dry till the September inclusive, i.e. 12 months. Values of thermal resistance R and water vapour diffusion – equivalent air layer thickness s_d, required for the calculations of walls layers, are provided in the Table 1.

Temperature ?, C^0, water vapour pressure value at saturation p_{sat}, Pa, water vapour pressure value p, Pa, relative humidity of air f, % were counted in all the contact interface of wall layers. These parameters, defining humidity, showed whether condensation is happening in the walls and exactly in which place.

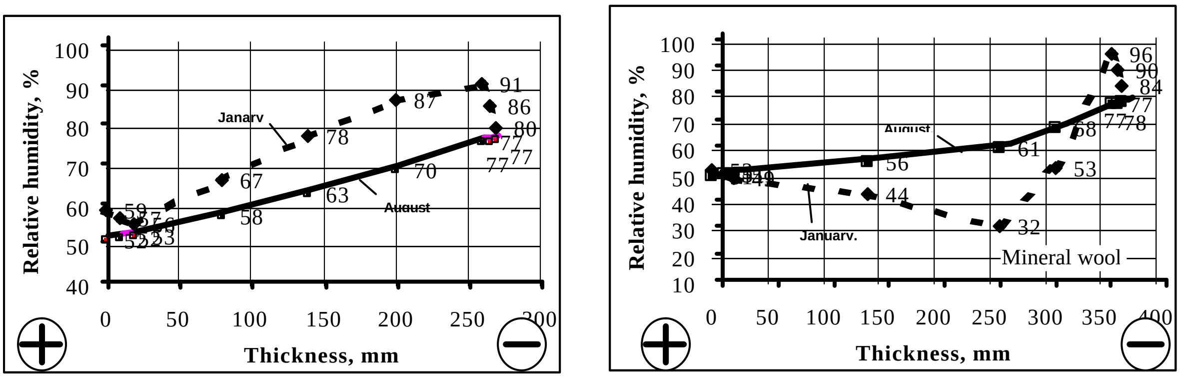
3. Results of calculation

Firstly the obvious moisture migration difference in January between the walls of lightweight concrete blocks and with ETICS was noticed after the moisture condition calculations in all constution were performed (Fig. 1). Relative humidity in the wall of lightweight concrete blocks during the cold period of the year gradually increases towards outside, reaching 91%

Table 1. Schemes and physical parameters of analyzed constructions

Scheme of construction	Name of layer	Material layer thickness d, mm	Density ρ, kg/m^3	Thermal conductivity λ, W/(m·K)	Water vapour resistance factor μ	S_d, m
1	2	3	4	5	6	7
	1. Render	20	1700	0,9	6	0,12
	2. Lihtweight concrete bloks	240	400	0,22	3,6	0,86
	4. Thin render	10	1700	0,9	6	0,06
	Thermal resistance of wall ΣR= 1,224W/(m.K) Water vapour diffusion-equivalent air layer thickness of wall S_d=1,04m.					
	5.Paint	0,1		1	-	0,3
	1. Render	20	1700	0,9	6	0,12
	2. Lihtweight concrete bloks	240	400	0,22	3,6	0,86
	4. Thin render	10	1700	0,9	6	0,06
	5 Paint	0,1		1	-	0,3
	Thermal resistance of wall ΣR= 1,226W/(m.K) Water vapour diffusion-equivalent air layer thickness of wall S_d=1,64m.					
	1. Render	20	1700	0,9	6	0,12
	2. Lihtweight concrete bloks	240	400	0,22	3,6	0,86
	3 Mineral wool	100	140	0,04	1	0,1
	4. Thin render	10	1700	0,9	6	0,06
	Thermal resistance of wall ΣR= 3,922W/(m.K) Water vapour diffusion-equivalent air layer thickness of wall S_d=1,14m.					
	1. Render	20	1700	0,9	6	0,12
	2. Lihtweight concrete bloks	240	400	0,22	3,6	0,86
	3 Mineral wool	100	140	0,04	1	0,1
	4. Thin render	10	1700	0,9	6	0,06
	5. Paint	0,1	-	1	-	0,3
	Thermal resistance of wall ΣR= 3,923W/(m.K) Water vapour diffusion-equivalent air layer thickness of wall S_d=1,44m					
	5.Paint	0,1	-	1	-	0,3
	1. Render	20	1700	0,9	6	0,12
	2. Lihtweight concrete bloks	240	400	0,22	3,6	0,86
	3 Mineral wool	100	140	0,04	1	0,1
	4. Thin render	10	1700	0,9	6	0,06
	5. Paint	0,1	-	1	-	0,3
	Thermal resistance of wall ΣR= 3,924W/(m.K) Water vapour diffusion-equivalent air layer thickness of wall S_d=1,74m.					

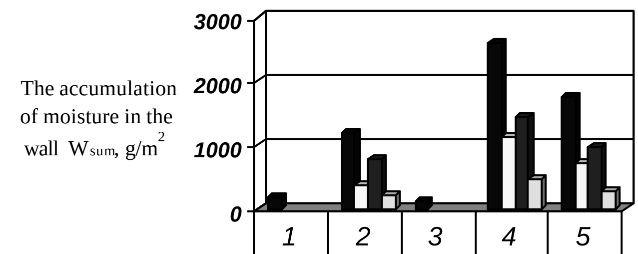
beside the border of external render. When insulating such the wall with ETICS based on mineral wool, the distribution of relative humidity in the interface of layers changes completely.



a b

Fig. 1. Distribution of the relative humidity in the layers when the temperature of rooms is 18^0*C, relative humidity of air 50 %; a) the wall of lightweight concrete blocks (1 variant); b) the wall with ETICS (3 variant)*

Relative humidity in the lightweight concrete block decreases and besides the thermal insulation it is 35%, further it suddenly rises, and in the interface of mineral wool and external render it reaches 93%. This is resulted by the large mineral wool and less external paint layer water vapour permeability values.



	1	2	3	4	5
22oC/70%	182	1190	136	2606	1761
22oC/50%		369		1130	725
18oC/70%		780		1445	976
18oC/50%		217		467	282

Fig. 2. Total amount of moisture, that is able to cumulate during the process of condensation

Room air conditions do the influence to the cumulation of moisture in the wall during the winter season. We provide graphical analysis of all types of constructions which shows cumulated total amount of the moisture (Fig. 2). Calculations show that room air conditions determine intensity of moisture cumulation. Especially important part in this process is being played by the relative humidity of air. Together with the increasing room relative humidity of air, humidity cumulates faster.

However additional moisture factors, appearing after painting of the external wall, do more influence to the appearance of the condensation inside the wall. Calculations show that moisture cumulation of construction types 2, 4, and 5 is determined by the water vapour diffusion equivalent air layer thickness s_d of paint film in regard with the whole wall. This dimension shows of the resistance paint film to the water vapour diffusion, i.e. drying rate of the wall construction. As dimension s_d is bigger, as worse drying conditions of the material (thin render), lying under the paint film, because the small water vapour permeability of paint film will block the movement of the moisture towards outside.

It is seen (Fig 2) that when the wall is insutated with ETICS and painted from the outside (variant of constructions 4) the amount of condensate is the largest. This is resulted by the different coefficients of water vapour permeability of the separate layers. Comparing with the coefficient of water vapour permeability of mineral wool, which is equal to d_p˜0.5 mg(m·h·Pa), the coefficient water vapour permeability of paint film is greatly less (up to 10 times). In this case paint film becomes the barrier for the water vapour diffusion and causes preconditions for the moisture cumulation in the wall during the cold season of the year. In the ETICS walls (variants 4, 5) moisture cumulates under the film of paint and becomes destructive factor in the interface plane of thin render and paint film (Fig. 3).

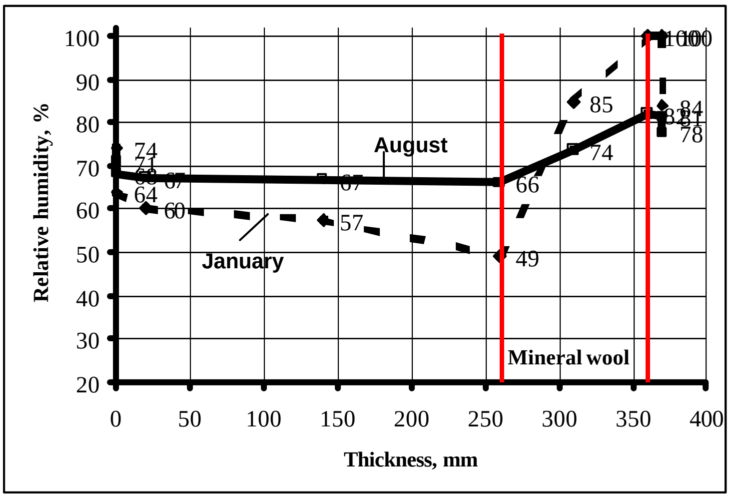


Fig. 3. Distribution of the relative humidity in the layers of ETICS walls (variant 5) when the room temperature is 22^0C and relative humidity 70%

Comparing variants 4 and 5 of construction, we may state that as the walls from painted the inside, intensity of the water vapour diffusion is decreased and the cumulative amount of moisture drops too.

4.Conclusions

According to the results of the calculations, following conclusions are stated:

- Moisture movement mechanism changes after the insulating the wall with ETICS. Different water vapour permeability values of separate layers influences the distribution and the cumulation of the moistute in the wall.
- Room air conditions influence intensity of the moisture cumulation. With the increment of room air temperature and relative humidity, moisture cumulates faster.
- Paint film on the surface of the thin render harms the balance of the moisture exchange and, according to this, durability of the external layer decreases.

- Additional moisture factors, that together with the climate increase intensity the degradation of the external layer, appear after the external wall surface is painted.

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A REVIEW OF ENVIRONMENTAL BUILDING PERFORMANCE ASSESSEMENT METHODS AND THEIR PERFORMANCE ON A TYPICAL POLISH DEVELOPMENT

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1. Abstract

New building regulations aim for the reduction of CO_2 emissions by reducing the buildings primary energy consumption as outlined in the Kyoto protocol. However, the environmental impact of buildings on site ecology, water consumption and conservation, recycling and reuse of building materials, and the environmental impact of construction and transport have not found their way into the global legislation as parameter defining sustainable design.

A variety of countries including Great Britain, United States and Germany have developed schemes such as BREEAM, LEED and the Guideline for sustainable building (GSB) to raise the public awareness towards sustainable design as well as to assess buildings using benchmark figures, credits and points in order to allow for an environmental performance certificate. The schemes are recognised by the local construction industries and therefore add considerable value to the developments assessed.

The socialist heritage creates a big challenge for Poland to catch up with western European developments in sustainable design. This paper compares three assessment methods BREEAM LEED and GSB, and analyses their applicability to the Polish region on a typical office development. The findings will be documented and recommendations will be made on how to adapt the most applicable scheme for the Polish region to create a foundation for future assessments.

2. Introduction

Poland's central European location, its political integration – as indicated by its status as a member of the European union and NATO, as well as its economic and political stability has proven to be very attractive for foreign investors.
In parallel to Poland's economic growth, environmental issues have risen on the Polish government's list of priorities. Since 1989, Poland's annual energy consumption decreased by 30%. However, comparing Poland's Energy Intensity (Total Primary Energy Consumption Per Dollar of Gross Domestic Product until 2002) with western European countries indicates its current efficiency of energy use. (1)

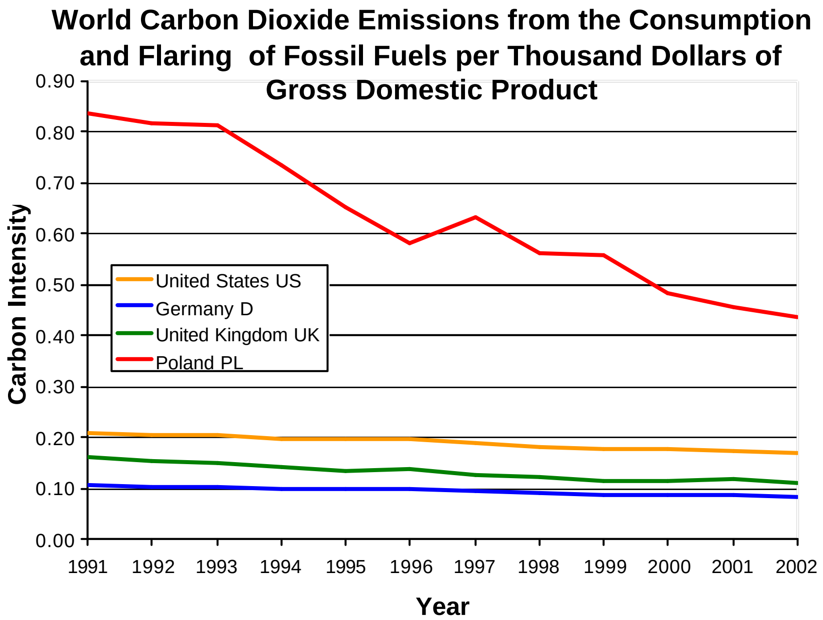

Figure 1, Carbon Dioxide Emissions Comparison – US, UK, D and PL

Energy efficient and environmentally sound building design was neglected for years because of the emphasis standing on volume production over efficiency or quality.
The International Energy Agency calculated that improvements in Polish energy usage could decrease the consumption by 17 to 45 percent. As building construction and operation accounts for 1/3 of the total Carbon emissions the construction industry has a great potential to contribute significantly the reduction in the use of energy. The environmental impact of anyone buildings is directly related to its operational costs. Therefore, an environmentally sound building should be of interest to the construction industry as well as clients and end users. The comparison of several internationally available environmental impact assessment methods and their applicability to the Polish market was the subject of this paper.

3. Assessment presentation

Worldwide, many environmental assessment methods are available to provide a foundation for the comparison of the environmental impact of buildings. Whilst local codes and standards are compulsory, limiting the carbon emissions by providing a comfortable building environment, aspects such as the buildings impact on the local ecology and socio-cultural awareness are usually not part of the requirements to be met.
Countries with well-defined environmental assessment methods are Canada, United States, United Kingdom and German. For the purpose this paper the following three methods were considered:

LEED **L**eadership in **E**nergy and **E**nvironmental **D**esign, United States
BREEAM **B**uilding **R**esearch **E**stablishment **E**nvironment **A**ssessment **M**ethod, United Kingdom
GSB **G**uideline for **S**ustainable **B**uilding, Germany

3.1. LEED (2)

The LEED Green Building Rating System™ is a voluntary standards and certification program that defines high-performance green buildings, those which are more environmentally responsible, healthier, and more profitable structures. LEED is the only recognized rating system in the US to assess the environmental impact of individual buildings. Buildings with LEED ratings receive national commendation for stepping forward to improve the quality of indoor environments and reducing negative impacts on the global environment. Currently 113 buildings have been certified and more than 1497 are registered.
The assessment method was developed and is run by the United States Green Building Council (USGBC), a national, non-profit organization based in Washington DC. The USGBC has members from across the building industry: architecture firms, engineering firms, builders, manufacturers, service contractors, government entities, real estate developers, and others.

The LEED assessment is applicable to a variety of buildings types and offers five different tools:

LEED (NC) - for commercial constructions and major refurbishments
LEED (EB) – for existing building operations
LEED (CI) – Commercial interior projects
LEED (CS) - Core and shell projects
LEED (H) - Homes

LEED™ was created to:

Define "green building" by establishing a common standard of measurement
Promote integrated, whole-building design practices
Recognize environmental leadership in the building industry
Stimulate green competition
Raise consumer awareness of green building benefits
Transform the building market

3.1.1. Certification

There are 69 possible points in LEED version 2.1. The LEED ratings that can be achieved are silver, gold and platinum. Each rating correlates to a required number of points, as indicated below:

Certified: 26 points.
Silver: 33 points.
Gold: 39 points.
Platinum: 52 points.

Table 3.1, LEED Assessment parameter - Summary

Assessment Parameter	**Description**
1.Sustainable Sites	Considers the impact of buildings with their immediate surroundings, the impact of transporting people to/from the building, and the initial selection of the building site.
2.Water Efficiency	Looks at the efficiency of potable water usage in the building, encouraging rainwater collection, low-flow fixtures and grey water recycling.
3.Energy and Atmosphere	Investigates the impact of a building's energy consumption on the global atmosphere. Discourages ozone-depleting refrigerants and fire suppressants.
4.Materials and Resources	Evaluates the impact of a building on its global resource usage (wood, steel, stone, fossil fuels), regional landfills, local industries (manufacturing and harvesting), and the embodied energy of building materials.
5.Indoor Environmental Quality	Considers the impact of a building on its occupants, particularly volatile organic compounds (VOC's), natural light, fresh air and other contaminants.
6.Innovation and Design Process	Looks at the non-conventional strategies the design team has implemented that have not been rewarded for in the previous sections. Also rewards exceptional performance above and beyond the levels required for points.

3.2. BREEAM (3)

BREEAM is the leading tool for the assessment of buildings from an environmental viewpoint. Its purpose is to carry out a review of a building or a design of a building and to identify its environmental strengths and weaknesses. A certificate can be awarded if appropriate, or the client can choose to take steps to improve the building before having the assessment formalised. In this way BREEAM aims to play a part in the improvement of the environmental impact of buildings.

There are separate BREEAM schemes for 4 building sectors:

Offices;
Homes;
Retail and
Industrial Units / warehouses.

Additionally bespoke assessments can be prepared and carried out on mixed-use buildings. These may be developments which do not necessarily fall into one of the above categories or which lay within a single development accommodating a wide range of functions, occupancy patterns or servicing strategies. The offices scheme has been the most successful, because the clients for this sector have seen the greatest potential for commercial benefit.

The offices scheme was re-launched and updated in 2004, and covers both existing and new buildings. This means that some aspects of the assessment do not apply to all cases, i.e. it is not possible to influence the materials in the fabric of an existing building, nor is it possible to assess the management of a building that is not yet built. The scheme will be updated on an annual basis to take account of current legislation and best practice.

Therefore there are three components to the assessment, and one or two of them will be carried out in each case. For an empty building, or one newly occupied, only the core performance issues can be carried out. For a design project both the core and design and procurement aspects would be included. For an existing occupied building both the core and the management and operation issues can be assessed.

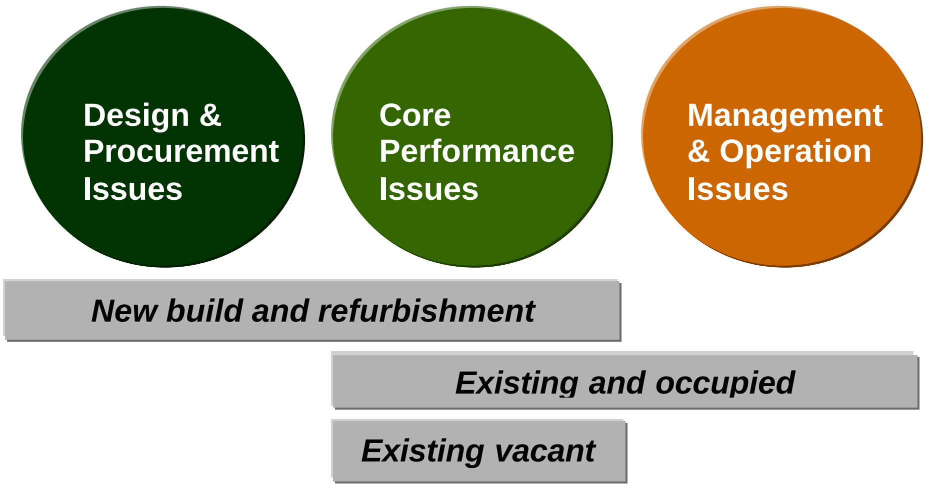

Figure 3.1, BREEAM - applicability

3.2.1. Certification

The output from the assessment depends on the type of assessment carried out. There is always a core performance result that is expressed as an Environmental Performance Indicator (EPI), which is on a scale of 1 to 10. Assessment credits are gained over a range of categories, which are in turn weighted to reflect relative environmental impact. These weighted scores are then combined into a single score. Where one of the other parts is carried out an assessment is expressed on the scale below:

Pass:	25%
Good:	40%
Very Good:	55%
Excellent:	70%

A descriptive summary of each category is given in the following sections.

Table 3.2, BREEAM Assessment parameters - Summary

Assessment Parameter	**Description**
1. Management	This part of the assessment is concerned with ensuring that management structures are adequate to achieve maximum benefits and minimum environmental impacts through the correct commissioning, and also assesses the measures that have been taken to reduce the environmental impact on the construction site.
2. Health and well-being	The aim of this section is to ensure that practical steps are taken to minimise the negative affects of a building on the occupants and those of its neighbours in terms of their health and well-being.
3. Energy	The Energy used in buildings is obviously an important part of the environmental impact. This section rewards those who have taken steps in terms of the building fabric and systems and in planning for future monitoring of energy use.
4. Transport	The energy used in transporting staff to an office is often roughly the same as that used in running it. Therefore it is important to consider transport use in any assessment.
5. Water Consumption	For reasons of increasing usage and concern over changing rainfall patterns, the supply of water to buildings is of growing concern. This section addresses the main issues in this area, and rewards good design.
6. Materials	The materials in a building represent a significant part of the impact of the construction process; with an estimated 10% of energy use annually associated with their production, together with a range of land use, bio-diversity and pollution issues. It is at the design stage that the largest benefits can be achieved, through the reuse of existing materials and evidence of the sustainability of the source of the timber used.
7 & 8 Land Use and Ecology	In a crowded island like Great Britain, there is growing concern about the use of land. There is strong preference for the re-use of land, and this is addressed in this section. The ecology part of this section relates to the variety of species on the site. The aim is to minimise the impact of development on the natural life on the site, and ideally to enhance the species variety.
9. Pollution	The final section relates to a range of pollutants that are produced by operation of, or for use in, buildings. The main issues are ozone depleting chemicals, NO_x and pollution of watercourses.

3.3. Guideline for sustainable building (GSB) (4)

The guideline for Sustainable Building is intended to integrate the concept of sustainability to the whole life cycle of a building including planning, construction, operation, maintenance and use of buildings and land holdings. The guideline is a working aid for federal buildings including offices, residential buildings, Schools, Hospitals etc. It is also indented to act as a role model for privately funded developments.

Fundamental principles:

- Lowering of energy demand and the consumption of operating materials
- Utilisation of reusable or recyclable building products and materials
- Extension of the lifetime of products and buildings
- Risk-free return of materials to the natural cycle
- Comprehensive protection of natural areas and use of all possibilities for space-saving

The assessment consists out of three main sections, the ecological, economic and socio-cultural assessment. Each design team participating a competition will define target values prior planning based on the guidance of existing building codes and experience.

Table 3.3, GSB Guideline parameters - Summary

Section	**Key points**
Ecology	Analysis of building requirements Protective use of building land and natural resources Durability and multipurpose-functionality of the building Health and environmental friendly construction and fitting of materials Operation costs Building specific requirements
Economy	Construction costs Costs of operation and use Costs of building maintenance
Socio-Cultural Assessment	External impact/Integration into the surroundings Internal impact (users/ visitors) Barrier-free construction

3.3.1. Certification

The three separate parts of the assessment will be weighted equally resulting in the overall rating. A detailed written explanation will explain as to what extend the design meets or fails the sustainability criteria.

4. System comparison

The assessment methods have many similarities but also significant differences. The following gives a brief summary of the assessments history and identify the most significant differences.

Out of the three assessment methods, BREEAM is the one most established – it started in 1990 and since then has gone through a number of iterations of the standards by adapting to the requirements and feedback from various market sectors. LEED was introduced in March 2000. Since then there have been three versions released: 1.0, 2.0, and 2.1 – which was revised in March 2003. The GSB was introduced in January 2001. An extension to cover works on existing buildings is planned for 2005.
The three assessment methods are most effective when used as design tools, revisited at various points during the design.

The **forms of the assessments** vary significantly. LEED and BREEAM follow a point or credit scheme implemented into a specific computational assessment tool calculating the success or failure of the design allowing a great deal of flexibility. In GSB the design team defines target values based on experience and current standards to be met by a variety of measures.

The **applicability** of the methods is also dramatically different. Whilst one assessment method covers a great variety of buildings types using LEED and GSB, four fundamentally different BREEAM schemes are available for offices, homes, retail and industrial units.

Whilst **the body of competence** for BREEAM and LEED are independent, not-for-profit organisations the GSB and its assessment are controlled by the Federal Office for Building and Regional Planning.

The **certification process** differs for the three assessment methods. Whilst LEED and GSB certify the building after completion of its construction, BREEAM certifies after building design. However the next issue of BREEAM will force the assessor to revisit the building after completion to make sure the measures specified to obtain the certain BREEAM rating have been successfully implemented.

Note: Due to the fact that the GSB does not define specific target values to be met and due to the non-transparent weighting of the three assessments (ecologic, economic and socio-cultural) for the overall rating, it was not taken forward for comparative purposes.

4.1. BREEAM versus LEED – Schematic comparison

The comparison of LEED and BREEAM was conducted firstly, identifying specific differences and secondly, investigating certain assessment parameters and their weighting in the overall rating.

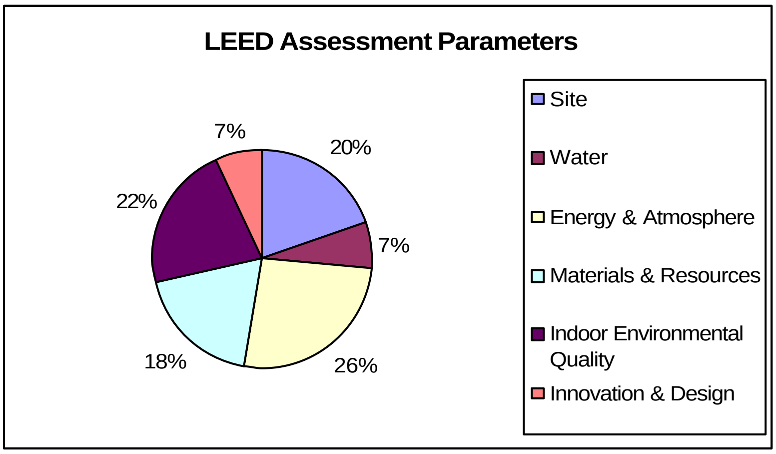

Figure 4.1 LEED – Impact of assessment parameters

LEED consists of 6 main assessment parameters that determine the final rating. 52 out of 69 points are required to achieve the platinum certification. Figure 4.1 indicates the weighting of assessment parameters. Whilst Energy and Atmosphere is shown as the most significant, accounting for 26% the total scores, the least important is water with 7% of the total scores.

The basic BREEAM assessment contains 9 fundamental assessment parameters, which govern the final scoring. 70% out of 100% can achieve the excellent rating. Whilst the building management is considered most important accounting for 16% of the rating, land use only accounts for 3% of the total rating.

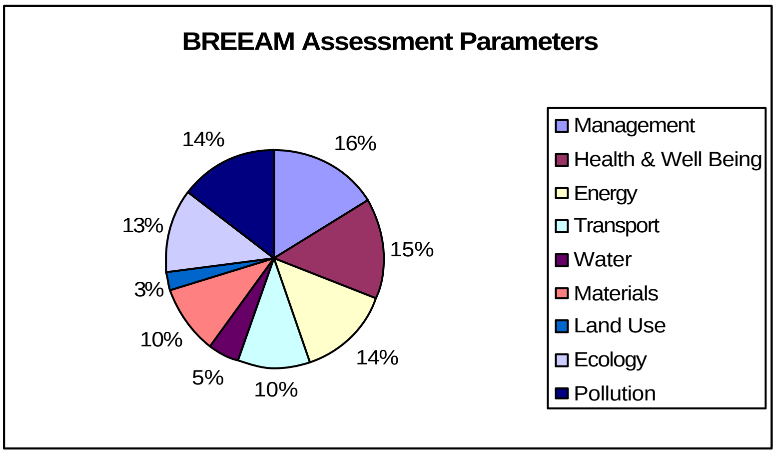

Figure 4.2 BREEAM – Impact of assessment parameters

Generally, it can be noticed that LEED's assessment parameters Site, Energy and Atmosphere, Materials and Resources and Indoor Environmental Quality form four, nearly equal weightings. Two parameters with less weight are Innovation and Design and Water Efficiency with 7% weighting each.

BREEAM's weighting for offices is different as there are nine assessment parameters as compared to six present for LEED. Whilst the weightings for Management, Health & Well Being, Energy, Pollution and Ecology are the highest with approx. 15% each, Materials and Transport account with 10% each followed by Water and Land use with 5% and 3% respectively.

By analysing LEED it can be noticed that the assessment parameter Site incorporates issues such as Ecology, Land Use and Transport, which are identified as separate parameters in BREEAM. It was also found that the LEED parameter Energy and Atmosphere combined the criteria for Energy and Pollution, again separately identified for the BREEAM assessment.

Summarising the above, it could be shown that no major parameter is missing for the one or the other method.

4.2. BREEAM versus LEED, Parameter comparison

Five assessment parameters: Energy, Indoor Environmental Quality, Water Use, Commissioning and Innovation in Design, were chosen to identify similarities and differences in between BREEAM and LEED.

Energy credits are given in both assessment methods for reducing the annual energy use of the building significantly over that of a notional building. The units of measurement are vastly different - BREEAM measures annual energy in total CO_2 emissions per annum, whereas LEED compares annual energy costs, which are based on local utility rates.

There is a stronger emphasis on **Indoor Environmental Quality** in LEED than BREEAM. Both look at issues related to comfort, natural lighting, and controllability of systems, but LEED also focuses on the impacts of building materials on air quality. 6% of LEED points are available for the use of low-emitting materials – including adhesives, sealants, paints, carpets, and composite wood.

3% of LEED credits and 5% of BREEAM are available for the reduction in potable **Water** use. Calculations must be completed for both requirements, demonstrating that occupancy based potable water consumption is reduced. LEED's credit is based on a comparison of the current design to national fixture performance ratings. Results are shown as percentage reduction in annual water consumption. BREEAM's credit is based on straight prediction of water consumption values.

6% of BREEAM credits are available for **Commissioning**, where in LEED there is only one credit (1.5% of total). The LEED commissioning credit is very strict with five detailed requirements to achieve one credit. Many of these requirements are parallel to those of BREEAM, such as the use of an independent commissioning authority to review documentation, and the creation of a commissioning manual. BREEAM allows for more flexibility in earning points – credit can be achieved in varying levels as opposed to a strict pass/fail.

LEED's **Innovation in Design** provides credits for innovation performance in green building categories not specifically addressed in the rating system. Points can also be awarded for exceptional performance above the requirements of particular credits. BREEAM does not have points available for innovation in design, but its expansive point system covers a number of design issues not specifically called out in LEED such as acoustic performance, NOx emissions, and building fabric performance.

There are many common features in LEED and BREEAM as indicated above but also specific points that vary in between the two schemes. The following specific points differentiate LEED and BREEAM.

Table 4.1, Specific differences between LEED and BREEAM

LEED specific points	BREEAM specific point
Alternative fuel vehicles Parking capacity / carpool accommodations. Storm water treatment on site. Reduce heat islands (roof and non-roof). Light pollution reduction. Water efficient landscaping Local/regional materials (manufactured and/or extracted) Tobacco smoke control. Construction IAQ management plan (during construction / before occupancy). Low emitting materials (adhesives, sealants, paints, carpets, composite wood). Indoor chemical and pollutant source control. Allowance for design innovation	Fuel consumption/related emissions from construction. Air pollution from site operations. Detailed equipment design parameters such as cooling tower location, DHW systems. Calls of particulars in lighting design – that which is covered in ASHRAE. Acoustic criteria. Envelope assessment. Asbestos abatement. Building materials rated by ENVEST software. Detailed boiler emission levels. Water meters. Leak detection.

4.3. Comparison conclusion

Whilst the GSB acts as a federal guideline, its application is mandatory, when forced upon a development. It consists of three separate assessments for project ecology, economy and socio - cultural project impact and is applicable to a great variety of buildings. Unique for the three assessment methods, every individual planning step must be economically assessed in parallel with the overall economic efficiency of the project. The guideline defines an assessment structure and makes references to codes and standards in order to define target values and calculation algorithms. GSB has been indented as a role model for privately founded projects, although it is hardly used in the private sector due to its extensive references to federal codes and guidelines and is unclear when it comes to the parameter weighting and project certification. As there is not an easy to use computational assessment tool like those present for LEED and BREEAM, it was not compared in detail with the other assessment methodologies.

The tools available to conduct the LEED assessment differentiate between commercial and residential buildings, as well as building interiors and external shell. LEED is a design tool to be used from design until the building's completion. If the building meets the required standards it will become certified after completion of the site works. The assessment is conducted by using a computational assessment tool.

BREEAM also uses a computational assessment tool. Four different tools a re available to date for offices, homes retails and industrial units. Thereby BREEAM separates four rather than two building sectors as for LEED. Each of the four allows the application for existing buildings. Certification is met by obtaining planning permission rather than completion of the building works, which has the potential to lose control over the implementation of the sustainable measures once the project kicks off on site.

5. Typical polish office development, Sustainability Assessment

In order to compare the performance rating of LEED and BREEAM a typical Polish office building was the subject of a sustainability assessment. The sustainability assessment was undertaken post building completion.

The 13.000m^2 office building is located in the centre of Warsaw and comprises of 10 storeys, 2 below and 8 above ground. The centre, a corner of the existing, office block was demolished and rebuild. The building is heated and cooled by fan coil units. Its minimum fresh air rate is provided by decentralised air handling units located in plant rooms on every office floor. The building operates in mixed, natural ventilation in midseason and mechanical ventilation in winter and summer. The windows are openable manually.

5.1. Results of LEED

An example LEED assessment was conducted for the office building, post completion. The assessment however, is most effectively used as a design tool and revisited at various occasions during the design. The fact that there was no opportunity available to influence the building design, lead to a less than satisfactory LEED rating. Whilst a minimum of 26 points are necessary to get the building certified only 14 points were achieved. (See attachment 1) 26 points correlate of 37,7% of the total scoring. The following points are accounted for as reasons for the low LEED rating.

Table 4.2, LEED - Rating

Category	Score, Achieved	Score, Maximum	Percentage, Achieved
Sustainable sites	4	14	28%
Water efficiency	3	5	60%
Energy & Atmosphere	0	17	0%
Materials & Resources	1	13	8%
Indoor Environmental Quality	5	15	33%
Innovation & Design Process	1	5	20%
Total	**14**	**69**	**20%**

As noted above, the categories achieved the least points are Energy & Atmosphere with zero points and Materials & Resources with 1 point. LEED assumes a minimum design standard that will not result in any scoring at that level. Every measure above the standard will be accounted for. However, in some instances a number of design criteria need to be met to obtain one point. Should one of those criteria not be met, the point cannot be achieved – there is no credit available for partial compliance.

5.2. Results of BREEAM

An exemplary BREEAM assessment was conducted for the office building, post completion. The assessment however, is most effectively used as a design tool and revisited at various occasions during the design. The fact that there was no possibility left to influence the building design lead to a less than satisfactory BREEAM rating. Whilst a minimum of 25% is necessary to pass the BREEAM assessment 47% were achieved.

Table 4.3, BREEAM - Rating

Category	Score, Achieved	Score, Maximum	Percentage, Achieved
Management	2	10	20%
Health & Well-being	7	15	47%
Energy	8	17	47%
Transport	11	13	85%
Water	2	6	33%
Materials	5	12	42%
Land Use	1	2	50%
Ecology	4	9	44%
Pollution	5	12	42%
Total	**45**	**96**	**47%**

As can be noticed the least scoring categories are Management with 20% and Water with 33%. However, mid table assumptions made for the energy consumption and carbon emissions going in line with the standard of the building services results in a GOOD – rating.

A particular feature of the Management section is the use of the "Considerate constructors" scheme to address site impacts. This impacts with 60% on the total score achievable for the management assessment section and only exists in the United Kingdom. Since a comparable calculator as a guideline for the side works does not exist for Poland the credits could not be awarded, which partly explains the low score in this area.

5.3. Assessment conclusion

Two sustainability assessments have been conducted for a typical polish office development. The assessment information were partly provided by the developer and partly assumed. To gain access to all the relevant information proved to be difficult due to the fact that the building has been finished and is in operation, and the design team members were not available. Assumptions were made for carbon emissions and energy consumption and used for both the LEED and BREEAM assessment.

Comparing the results obtained, it can be noticed that the building achieves a GOOD rating for the BREEAM assessment, whilst it does not qualify for certification for the LEED assessment. This fact that the building does not qualify for certification with LEED can be explained by the high minimum building standard and the limited number of assessment parameters. The minimum requirements for four out of six assessment parameters mean for the Polish office development that it does not qualify for any of the points available for the Energy and Atmosphere category. Energy and Atmosphere requires the proof of a Fundamental Building Systems Commission scheme, Minimum Energy Performance and CFC Reduction in HVAC&R Equipment. The failure of being able to prove any of these requirements means the building loses out on one of the most important of its six assessment parameters.

Compared to LEED, BREEAM is more flexible that is does not have defined minimum requirements, and nine instead of six parameter categories. The 96 possible credits for the design and procurement assessment means that it is more diverse and due to its shallow hierarchy, less restricted by still defining stringent building performance parameters.

6. Summary - One sustainability assessment for the polish construction industry

Most simply, the idea of sustainability is to ensure that our actions and decisions today do not inhibit the opportunities of future generations. The aim to minimise the building's environmental impact is the common feature of all three methods.

The subject of this paper was to compare the three international sustainability assessment methods LEED, BREEAM and GSB and to investigate what scheme could be used as a base model for the development of a Polish assessment method.

Looking at the applicability of one of those assessment methods to the Polish construction industry, BREEAM is the best-suited method. The widespread, low hierarchy and flexibility of the scheme houses the greatest potential to be successfully adapted to the Polish marketplace. The system was the foundation for assessment methods developed in Canada, Hong Kong, Australia, New Zealand, Singapore and Norway.

Although the structure is thought to be the best fit, it needs to be determined how certain assessment parameters such as benchmarks for energy consumption and carbon emissions need to be modified.

The adaptation to the Polish market place should be aimed towards cutting building costs and adding market value resulting in increased resale or lease value. High assessment ratings present an ideal marketing tool to attract tenants to vacant space.

To be able to use the ratings as a marketing tool, the assessment rating needs to be recognised by the construction industry. It is therefore essential to allow typical Polish developments to achieve an appropriate intermediate scoring appreciating its current national technical standard against a standard i.e. not less than 5 years old. Therefore, the aim is to push the industry (developers) to define a score at the beginning of the design process that is to be achieved after building completion as guidance for the design team. However, a high score should become a challenge to the design team, thus pushing the limits currently experienced within the Polish market place.

The scheme, once adapted for Poland should be revised regularly - introducing a more stringent methodology with each issue.

However, to ensure its successful industrial implementation a controlling body of either voluntarily or governmental nature needs to be present. Following the German example, the Guideline for sustainable building, controlled by the Federal Office for Building and Regional Planning, the responsibility for the schemes implementation could be handed to KAPE (The Polish National Energy Conservation Agency), which is already active in fields such as renewable energy sources, environmental protection, energy planning and sustainable building.

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(4) Guideline for Sustainable Building, Federal Office for Building and Regional Planning on behalf of the Ministry of Transport, Building and Housing, January 2001, 1st reprint

8. Appendix 1 - Building data sheet

Category: Office building
Client: not to be made public
Main contractor: not to be made public

The centrepiece of the existing corner building was fully demolished. The created space between the two left parts of the existing building was filled with the office building.

Building characteristics:

Area	Value
Foot print	1328.9m^2
Floor area total, brutto	13016.0m^2
Floor area total, netto	11312.9m^2
Let able area total	7583.9m^2

Storeys	Number
Above ground	8
Below ground	2

Transportation: 4 lifts in lift lobby open to the entrance area

Fire safety devices: Sprinkler heads in car park, Sprinkler tank 153m^3
Smoke detectors on office floors

Car park: 76 spaces on two floors

Floor rental: max three tenants per floor
Preferred 1 to 2 tenants
600-700 people

Accountability: separate meters for cooling heating and electricity for each tenant

WC/Kitchen: 1 for each floor, one shower room for entire building

Window spec: UniSun Neutral 66/38 35db; Frerichs Glass UG04
7th and 8th floor small windows
0st to 6th windows floor to ceiling
All windows equipped with internal blinds
Manually openable

Heating, Cooling, Ventilation: Mixed mode ventilation
Six AHU located one on each office floor provide the minimum fresh air rate preconditioned locally.
Fan coils provide required heating and cooling capacity.
Central water to air chiller on the roof provides cool water. Warm water by district heating.

9. Appendix 2 – LEED Assessment data sheet

LEED — LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

Version 2.1 Registered Project Checklist

Warsaw – Typical office building

Yes	?	No			
4		10		**Sustainable Sites**	14 Points
Y			Prereq 1	**Erosion & Sedimentation Control**	Required
1			Credit 1	**Site Selection**	1
1			Credit 2	**Development Density**	1
		1	Credit 3	**Brownfield Redevelopment**	1
1			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
		1	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
		1	Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	1
		1	Credit 4.4	**Alternative Transportation**, Parking Capacity and Carpooling	1
		1	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
		1	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
		1	Credit 6.1	**Stormwater Management**, Rate and Quantity	1
		1	Credit 6.2	**Stormwater Management**, Treatment	1
1			Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
		1	Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
		1	Credit 8	**Light Pollution Reduction**	1

Yes	?	No			
3		2		**Water Efficiency**	5 Points
1			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
1			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
		1	Credit 2	**Innovative Wastewater Technologies**	1
1			Credit 3.1	**Water Use Reduction**, 20% Reduction	1
		1	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

Yes ? No

Yes	?	No	Energy & Atmosphere		17 Points
		8			
Y			Prereq 1	**Fundamental Building Systems Commissioning**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**CFC Reduction in HVAC&R Equipment**	Required
		1	Credit 1	**Optimize Energy Performance**	1 to 10
		1	Credit 2.1	**Renewable Energy**, 5%	1
		1	Credit 2.2	**Renewable Energy**, 10%	1
		1	Credit 2.3	**Renewable Energy**, 20%	1
		1	Credit 3	**Additional Commissioning**	1
		1	Credit 4	**Ozone Depletion**	1
		1	Credit 5	**Measurement & Verification**	1
		1	Credit 6	**Green Power**	1

Yes	?	No	Materials & Resources		13 Points
1		12			
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
		1	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
		1	Credit 1.2	**Building Reuse**, Maintain 100% of Shell	1
		1	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
		1	Credit 2.1	**Construction Waste Management**, Divert 50%	1
		1	Credit 2.2	**Construction Waste Management**, Divert 75%	1
		1	Credit 3.1	**Resource Reuse**, Specify 5%	1
		1	Credit 3.2	**Resource Reuse**, Specify 10%	1
		1	Credit 4.1	**Recycled Content**, Specify 5% (post-consumer + ½ post-industrial)	1
		1	Credit 4.2	**Recycled Content**, Specify 10% (post-consumer + ½ post-industrial)	1
1			Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
		1	Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	1
		1	Credit 6	**Rapidly Renewable Materials**	1
		1	Credit 7	**Certified Wood**	1

Yes	?	No	Indoor Environmental Quality		15 Points
5		10			
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
		1	Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
		1	Credit 2	**Ventilation Effectiveness**	1
1			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
		1	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
		1	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
		1	Credit 4.2	**Low-Emitting Materials**, Paints	1
		1	Credit 4.3	**Low-Emitting Materials**, Carpet	1
		1	Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber	1
1			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1			Credit 6.1	**Controllability of Systems**, Perimeter	1
		1	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
		1	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
		1	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
1			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1			Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Yes	?	No	Innovation & Design Process		5 Points
1		4			
		1	Credit 1.1	**Innovation in Design**: Provide Specific Title	1
		1	Credit 1.2	**Innovation in Design**: Provide Specific Title	1
		1	Credit 1.3	**Innovation in Design**: Provide Specific Title	1
		1	Credit 1.4	**Innovation in Design**: Provide Specific Title	1
1			Credit 2	**LEED™ Accredited Professional**	1

Yes	?	No	Project Totals (pre-certification estimates)	69 Points
14		34		

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

TIME IS MONEY.
QUITE IMPORTANT LESSON ON SUSTAINABILITY FOR EMERGING MARKET ECONOMY.

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1. Introduction

This paper explores some obscured assumptions which need to be brought to light for cities wishing to follow the way in which Warsaw became a leading center of the successful Polish economy. It has been observed that the economical growth as measured by indicators such as Net Domestic Product or number of cars per capita is not correlated with the willingness of neither citizens, nor investors to locate their businesses there. Recently both office and primary residential markets have been undergoing a serious crisis. One could say it is due to a "normal" fluctuation of the aggregated investment cycles. A closer look at the way in which construction investments are developed may take researcher's attention to subtle, but powerful observations that some threshold of satisfaction has been achieved on the basis of the supply-demand mechanism. Nevertheless from the point of view of what Warsaw could offer to both companies and people, it seems that the game either is, or soon will be over. It is believed that no details are of little significance in the development of the city of Warsaw since they make up investors' and citizens' minds in their investment decisions.

2. Legislation in Practice.

The City of Warsaw underwent a set of turbulent historical events in the past century. The Warsaw uprising in 1944 resulted in physical destruction of the city and its population, followed by uprooting of remaining citizens. Unfortunately legislation passed in direct subsequence of World War II (Warsaw Real Estates Nationalization Directive 1945, the one that enabled city reconstruction), occurred to be imperfect, resulting since then in a never resolved legal debate on ownership rights to real estate in the central district of the city. In

1989 the transition to a free market economy in Poland was given full acceptance by the government. Although the new Land Planning Act was passed in 1994 to face the needs of a market economy, local governments were unable to live up to the of the Act. This resulted in a special pattern of land development in which market forces dominated over democratic legitimate planning. A serious backward step was then taken by parliament – amendment to the Land planning act that postponed for 5 years the deadline for completion of local studies for spatial development – the basic documents for spatial policy. For eight years and up to 2003 planning permissions have been based on obsolete knowledge and incomplete urban studies.

Table 1
Percent of obligatory planning studies completed (2002)

Type of territorial administration unit	***Number of units***	***Number of units with completed spatial development studies***	***percent***
Voivodship (Region)	16	13	81
Powiat (County)	373	89	24
Gmina (Municipality / Commune)	2489	748	30

Source: Instytut Gospodarki Przestrzennej i Mieszkalnictwa, December 2002 [1]

Planning studies are the auxiliary tools intended to establish binding regulations for zoning plans and in Warsaw there was a zoning plan in force up to the end of 2003. As the plan was dated from before 1995, it was canceled by a new Planning Act (2003) therefore a range of new opportunities for purely market-driven investments has been opened. Despite of the fact that the current situation seems to be exceptional from the point of view of urban planning, it is not much different from the planning perspective to that period of 1995-2003. The “General Spatial Development Plan for the Capital City of Warsaw” then in force was much criticized as being obsolete and too flexible - practically any desired intensity of land development was allowed, if conformed to the rules of Polish Building Code. This paper explores the period 1995 – 2002, when the practice was marked by the investors’ freedom from any planning restrictions.

3. Warsaw Development Strategy.

“The Warsaw Development Strategy to the Year 2010” (the document issued by the Municipality in 1999) [2] was revised by Alain Bertaud from a market perspective in his report for the World Bank [3] where he represented a free market approach to spatial distribution of the land value. One of his recommendations there was: “The largest area possible should be submitted to market forces to promote land redistribution and increase the intensity of its use". Bertaud argues that the intensity of a market driven land use would increase the density of the city and integrate the spatially fragmented labour market. However, the report also mentions that market forces are "*usually not able to develop the primary infrastructure required to use land to its best potential*". Another statement from the report indicates that "*Historical and natural zones have to be protected by a weakening of market forces inside clearly delimited perimeters. Without a regulatory shield historical monuments would soon disappear being replaced by either new structures, or by adjacent modern buildings which, with height and bulk equal to the value of the land on which they are built, would dwarf them*" [1]. However, it is not recognized in Bertaud's report whether the environmental quality has market value that is threatened by the market forces themselves, or simply collides with another market-sound land uses. This is one of the key discussion points in this article. It should be pointed out that the historical heritage traditionally has a strong protection in Poland regardless of town planning regulations, but historical scenic views for example may be protected only if incorporated in zoning plans.

4. Land development in Warsaw.

As mentioned above, the history of legislation in Warsaw has been marked by irresolvable legal disputes that caused, due to uncertainty of property rights, freezing of considerable land area for investment. On the other hand urban zoning by-laws were practically reduced to non-significant in the process of obtaining planning permissions.

A study has been done to assess spatial distribution of the most intense developments in the years 1995-2002. It revealed that in the lack of strict zoning laws, the pattern of investment shows the extensive consumption of any value of public space up to the point of its disappearance. High-rise buildings especially, consume public realm at an uncontrolled pace. On the other hand there exists in the centre of Warsaw a vast area of land that is underdeveloped from a classical market perspective. This area is the one in which normal investments are proclaimed to be frozen by aforementioned property rights uncertainty. The most interesting observation is that they are far from being "frozen". A certain type of high user-intense temporal commercial investment takes place there. Architectural idea of temporal city dates back to Archigram Group. Here, in Warsaw, uncertainty about property rights caused the creation of constructions that perfectly encompass the sustainability ideas: the use of better technologies and calculations of the operational cost for the life cycle "from cradle to grave".

One can observe therefore two different types of investment strategy: the first one based on solid property rights and the other one on owners' uncertainty. Having in mind practically irrelevant significance of urban planning (see Table 1) one can match those two types of market-driven approaches.

The main question is how do property rights shape urban environment?

Do proper land ownership relations help to make development sustainable? It is believed that property relations do matter [4]. One can apply two different measures to land value in the city – private discount rate and social discount rate. What exceptional is observed in land development in Warsaw, is that some private construction enterprise strategies are based on social discount rate because investors use the land without a legally sound, clear and permanent private ownership basis.

5. Private and public space – market-driven difference of discount rates.

It is recognized that there is a difference between public and private discount rates which depend on redistribution of responsibility for the final cost of undertaking [4]. Political game in a free market economy in a democratic system is subsequently focused on proper relations among stakeholders with the public considered an important part of them. The city as a whole is a public asset as a concentration of individual efforts that create new quality to be used and developed recursively. One of the free market assumptions is that proper ownership rights are vital for the proper use of resources. On the other hand, according to the concept of sustainability, the value of the stock of different types of capital should not decrease.

One can make an effort to evaluate changes of value of different capital types – the city as a public good, attractiveness of the city for high educated labour force, attractiveness of the city for investment capital, range of human activities supported in public realm, adequacy of housing stock to meet the needs and adequacy of road networks and other land consuming utilities.

There is an important question to be asked: do we have complete tools to express the different types of capital value in common measure like money value? It is a common practice to estimate money-value of land based on the Net Present Value. Then construction commensurate with the value of the land is developed.

From the investor's point of view, the most important is the proper location placed within the city's spatial focus of range of externalities, as it makes his investment in the city culture.

In Warsaw it is clear that it is the set of externalities that shapes an investor's strategy. Private investment adds some value to the public realm and the overall economy. In the city one can distinguish two types of surplus for the public. One is connected with an economic activity, the other one with impact on the urban system. One of the free market assumptions is that economically effective market equilibrium is achieved not by the public interest in overall effectiveness of economy, but by the dynamic negotiation of particular profits. Then what about dynamics in the city structure?

In Warsaw one can take some interesting observations on this subject.

6. One City – Two Business Cycle Patterns.

There is a conflict in Warsaw between traditional use of space and new developments.

Tradition of direct producer-to-consumer sale markets in Poland never yielded in the course of history. In fact it was supported by a socialist government in some areas such as e.g.: fresh fruit and vegetables – goods of short validation period – to be free private enterprises.

Conforming to this tradition, especially in the early days of transition from a centrally planned to a market economy, the citizens of Warsaw widely supported emergence of low investment – intense activities such as little kiosks or tents in central places of the city, lots of them located near main public intersections.

In the course of time new global ideas found their way into consciousness of local governing bodies. Street markets suddenly were considered to collide with the image of the city and were promptly combated by use of legal acts and regulations. Nevertheless, considerable pressure exercised by the public managed to save some areas from being cleared from street markets and at the present time it is clear how the pattern of land use fits the array of market and political forces.

As it was mentioned earlier in the article, town planning factors may be considered to be practically absent. One can then focus on the centre of the city to reveal some interesting interrelations of public realm, social and private discount rates and sustainability of construction activities. In the strict centre of Warsaw two different types of development have taken place. One located on the west side of Emilii Plater Street is based on sound land property rights and the other one, comprising northern side of Jerozolimskie Avenue and Defilad Square, reveals NPV of location into which the social discount rate is calculated. As it is understood, difference between social and private discount rates is a measure between NPV of free market private enterprise and public enterprise. If market-driven behaviour of private investor is to be applied to land development, it must have been the difference in land property rights that caused the divergence in land use. The difference is clearly coincident with investors having or not having the land in their exclusive possession.

The subsequent hypothesis is:
1. Land ownership is more important in the city than any business activity in terms of a profit expectancy
2. It is economically sound from the point of view of an individual investor to develop a short-term enterprise based on short-term land tenancy even if the cost of demolition is to be included.
3. There is a difference in the land use depending on the period of tenancy. Some businesses such as retail are more adaptable to quick changes, while hotels or offices tend to be located in stable environments even if the offices are usually quite adaptable to other uses.

7. Basic Survey of the Subject.

After a few years of a direct retail market in some of the most traffic-intense places in Warsaw such as Konstytucji and Defilad squares and underground passageways characterized by benches, umbrellas or kiosks, retailers got organized in the form of local retailers' associations to face the threat of liquidation of their businesses by the municipality. Subsequently new architectural forms emerged. The most interesting and controversial became part of the contemporary image of the city - Illustration 1.

Illustration 1
Retail hall on pl.Defilad – in the core of Warsaw City

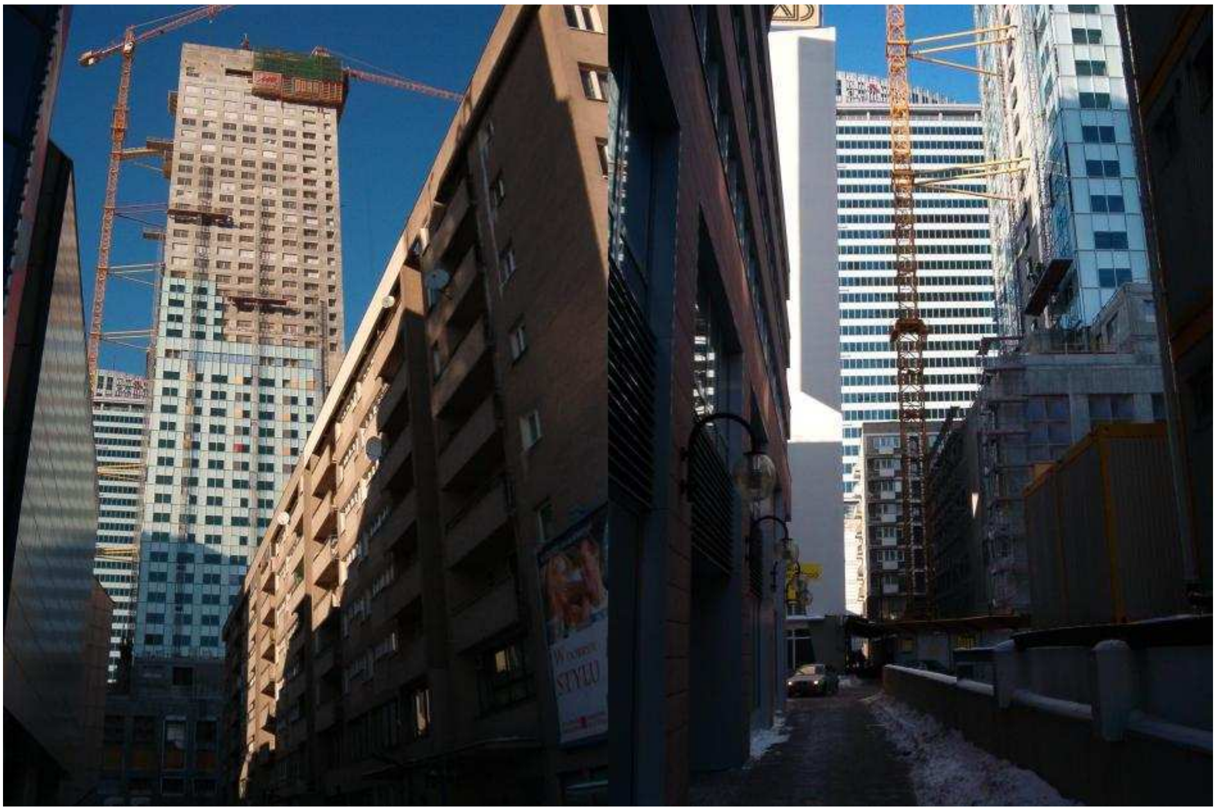
Basic characteristic of this structures is their temporary character due to unregulated tenancy. Another interesting observation is that the process is not only marked by rooting and development of traditional direct retail into more structured form. Illustration 2 depicts that attractiveness of localization is much the same for both local and international companies despite tenancy problems or limitations in architectural form. It is largely believed that the Marks & Spencer store was built on the basis of "construction site facility" building permission, but the relevant documents are difficult to be examined by the third party.

Illustration 2 International capital.

Observed development contradicts widely propagated argument, that foreign investment capital avoids unfavorable planning restrictions of development intensity.

On the other hand equally valuable land exists on the opposite to Defilad Square (western side of Palace of Culture - a high rise soc-real style building in the background of Illustrations 1 and 2). It can be observed here that both pace and intensity of development is of considerable larger scale (Illustration 3). In fact, it is the most intensively developed land in whole country. One can see there a difference not only in an intensity but -more important- **in primary function of buildings and their relation to public realm.** It was mentioned above in the article that what makes the difference is land tenancy and not planning regulations. Therefore one can observe clearly the evidence of ownership's related investment strategies and subsequently, with the investors' ownership rights granted, the consequences for the overall development of the city.

Illustration 3
West side of the city core



8. Ultimate Capital for Capital City.

Before further exploration of the subject of this article, there is a question of evaluation to be asked. There is an argument widely shared even within the Sustainable Development movement, that proper value for money should be sought in every investment. It is hard to discuss it if there is no clear evidence how the money value of investment serves the "total benefit". The Coase theorem states that for the efficient allocation of capital it does not matter how entitlements and liabilities are allocated once they are defined. The theorem concerns also existing money value. What is sought in SD is more than existing practice in evaluation, as the concept implements an evaluation model in which long term gain is compared with short term based calculation of NPV. It is proposed that sustainability is first of all an act involving time and sequencing.

Here is a closer look at those factors in Warsaw: there are two different approaches to the concept of decent money value. One is based on the effectiveness of a free market allocation which requires fast and unrestricted flow of capital. The second one can be based on sustainability of urban structures. The very question is what does money value represent? The common misconception about money is that one can buy money with money. It is possible as particular, but false if aggregated. That means we should seek money value not in money value of money, but in money value of urban realization.

How do you evaluate urban development then? Traditional approach deriving from European culture is based on a culture-business feedback. It is underestimated in Central Europe that this approach is outdated. What Central European cities do face is the adjustment to global economy rules. One of the false beliefs, still present in Poland, is that urban planning is a part of central planning exercised extensively in the late industrialization period following World War II and as such is unfortunately associated with the communist regime – so being a political matter. And on this wave of propaganda foreign capital builds its position in Warsaw. Without further reference one can estimate the money value of investment by consequences of putting land on the free market on the west side of city core:

- Public realm diminishes below the required technical capacity (e.g. traffic between public road networks and underground parkings)
- Intensity of development is driven by **current** market value of land regardless of impact of development on overall city performance.

Value of land depends on externalities and one of them is the quality of the public realm which, as a public good, is excluded from the free market mechanism of the supply-demand. The public realm is best used by the most demanding investor but dependent on the rule of diminishing benefits from the public realm including its road infrastructure, amenities and capacity of technical systems. So the market value of land diminishes with intensity of adjacent developments, because the supply-demand principle cannot be applied to the public realm.

To make this point clear one can examine the following example of traffic of vehicles:
an individual investor has at his disposal a capital, within which he can make a decision of splitting it into usable area and parking area in an economically sound fashion. In each case the public good is consumed by the fact of traffic generation on a public road. As the investor isn't obligated to pay the cost of the road, he is free to "consume" the city's road network, while the cost is imposed on the city's road network users (and including, in a way, also the investor as a user) .
The diminishing benefits are best illustrated by the traffic itself. If the public road is overused, the velocity of any vehicle on that road decreases up to the point in which phenomena like traffic jams occur. The same principle applies to some other loadings imposed on the public realm by individuals.

9. Scope Matters – Importance of Scale.

When performance of the city is considered, several different approaches are at one's disposal to determine problems of harmonious, optimal development. Indicators do matter, provided that one can interpret their background – SD issues ought to be addressed within the particular frame of problems, which may depend on ecological, political, economical, cultural, spatial, historical and other conditions. Without the proper set of benchmarks the aggregated SD indicators may veil mechanisms of city development. It is possible that the aggregated data looks promising, while the underlying process shows another direction. There is no practical use of measures which are not aligned with basic forces shaping the city. Therefore, one needs to find direct translation of basic process into the bigger picture. In other words – SD researchers and practitioners must have a clear image of how the process of urban development could induce the sustainable development. It seems more important if one faces a transition from centrally planned economy into the free market. The process of dismantling of the central planning system had severe negative impact on urban planning, which didn't manage to present itself as a tool for democracy enforcement in Poland, but quite on the contrary, is considered by carefully shaped public opinion as a barrier in "democratic" (that means individual) rights to act on one's free will. Illustration 4 depicts the problem in more precise terms.

It is not impossible that the overall progress of the city would be struck by a local shock to the sensitive area like the city centre. No matter what is the capacity of the city infrastructure to internalize strong impacts, the careful watch should be present in the name of SD rule, i.e.: “to not compromise the needs of future generations”. Traditionally it was an ultimate issue in urban planning to make the city survive. Nowadays, since the idea of globalization is clearly more important in shaping cities than the idea of fortress, one should ask the universal question again: “how to make the city survive?”. SD factors pose another question: “how to make the city perform better?” It is important to set the right order of questions:

1. If one considers the city as an environment for people to live and takes for granted that it is our common asset then one preserves it and takes care for its longevity. This corresponds to the rule of the survival of a city.
2 If one considers a city as a medium to achieve some goals – economical, personal, political, ecological etc. - one cares for its performance.

In conclusion we could say that one can split urban issues into two complementary processes:

1. How do citizens build a city
2. How do citizens use a city

The simple market economy models consider that it is the proper use of resources that create common good. Scarcity rent is applied to improve capital allocation. It is far from the interest of transitional economies of the former socialist block to follow directly the evolved market economies. There is a chance to correct some processes to avoid certain imperfections of the free market capital allocation, especially in the face of real confusion about what an economic model for the country should be.

Illustration 4
Urban assessment ought to reflect the meaning of urban structure, especially different approaches to public realm and private property.

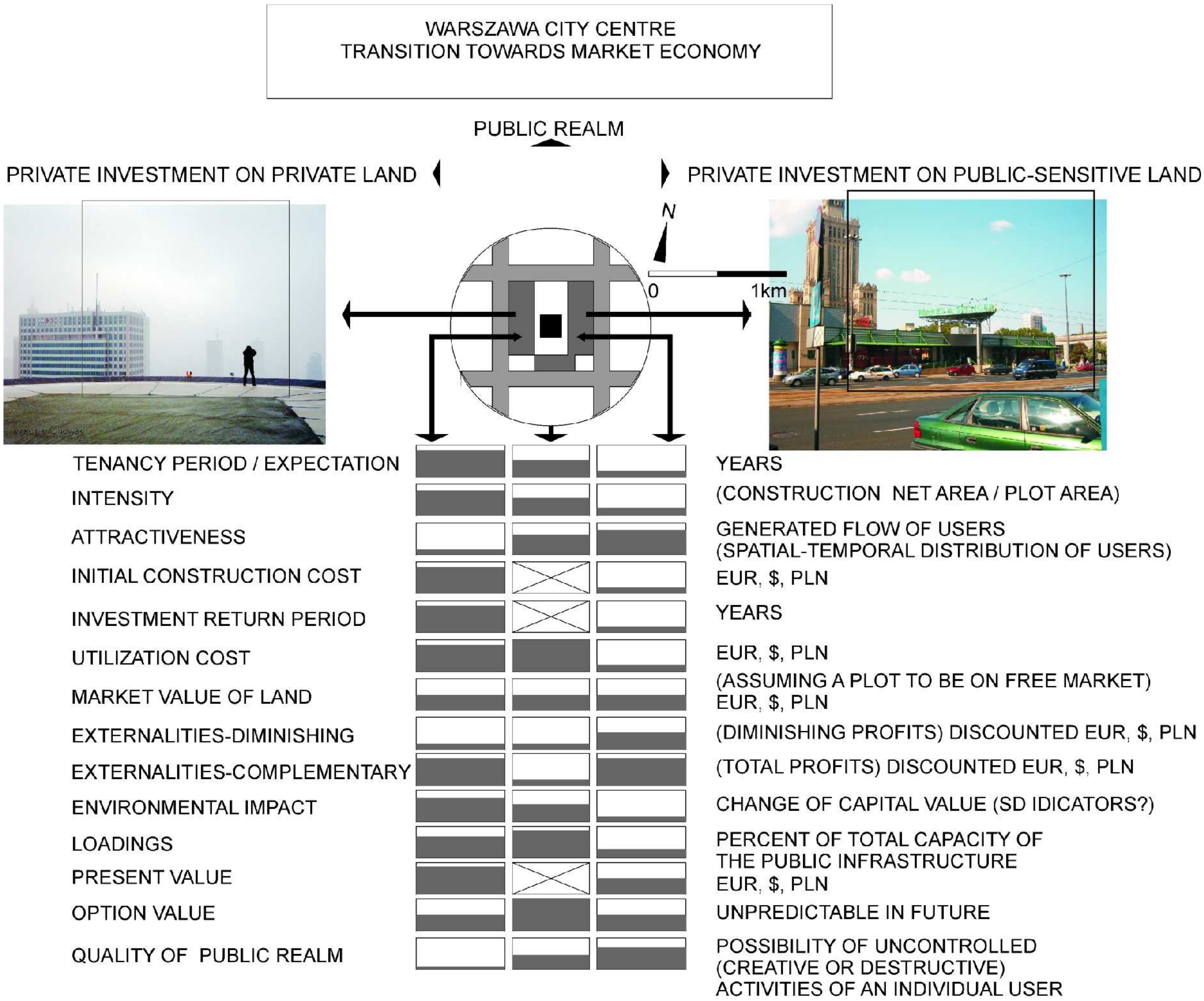


Illustration depicts incomplete, ongoing research.

Illustration 4 shows that the scarcity rent is a subject of regulation. There is a direct correlation between the type of development and property rights to use the land. In Warsaw one can observe the extremes with the dynamic nature of capital allocation clearly revealed. The data visualised in boxes are the subject to ongoing study not to be treated as complete. The whole picture can be observed from the direct field survey. Despite the fact that regulation of property rights is unintended, it is in force due to aforementioned historical reasons. And it does work!

One can observe how powerful the law can be and therefore consider the property rights regulation as a tool to achieve proper development scale. Usually effective contribution of investment for common good is resolved with the help of zoning plans which state the local spatial policy. It is resolved with a set of obligations imposed on investor known as “modus of exercising property rights”.

Nevertheless, due to a rule of private property and a Roman legal maxim “*superficies solo cedit*” [anything on my land is my own] (the Polish legal system is based on the Roman Law) , common good is in a conflict with private one. As it could be seen at Warsaw’s example, the

limitation of tenancy period can be quite effective way of regulating the pace of development regardless of any complex negotiations between the private land user and the public. There is no place and time here to discuss the issue in extent, but it is proposed to consider more use of time as a planning tool in urban policies.
Due to the fact that time plays primary role in the flow of capital, an old saying - “time is money” - perfectly applies here. Why one should allow the scarcity rent and discount rate to be so imperfectly tied together there? There is no way of effective performance of the city because:

1. Proper time-scale for money to grow is internet time.
3 Proper time-scale for city to grow is at least a technical lifespan of a single construction.

One can consider subversive way of achieving Sustainable development: **“Do not impose the indicators of performance on investor. Just cut the time of his responsibility down to a time span of his activity”**
This is the proposition to be further explored. The authors of the article realize practical obstacles in introducing the idea, but there is still a chance to prove that it may be worth, since it is derived from the real situation in Warsaw, both exploring and perhaps using in democracies where political awareness is more mature.

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Keywords:

Emerging market, economy, planning, urban planning, town planning, policy, Warszawa, Warsaw, time, scale, dynamic capital allocation, life span, sustainability indicators, aggregated data, indicators, public realm, time is money, NPV, NNP, city centre, city center, scarcity rent, sustainable development, transition economy, globalization, democracy, intensity, dynamics, Central Europe, city, labour force, labor force , people, GBC case study, GBC regional policies,

A CASE STUDY OF ENERGY EFFICIENT WINDOW SYSTEM DESIGN FOR A RENEWAL OF A HISTORICAL BUILDING

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1. Introduction

In recent years there has been a growing awareness of the impact that buildings have on environmental degradation and in response to that interest has grown in pursuing sustainable building design. For architecture sustainable design means design that delivers buildings with lower environmental impacts while enhancing health, productivity and quality of life. In this context, windows are one of the most significant elements in the design of any building impacting the building energy use and related environmental consequences [1]. In the last 20 years, the energy efficient properties of windows have been improved by innovations in glass coatings, low conductance spacers and frames that result in multiple glazing layers. Properties of window systems in the external envelope have a significant effect on the overall thermal performance of buildings and on the thermal comfort indoors [2], [3]. Because of the special constrains, requirements and objectives related to a historical building, the design of a window system of a renewal is much more important in achieving energy efficiency.

In the paper a case study comprising the methodology and implications of the design of an energy efficient window system is introduced. A renewal project of a roof and the attic space below, as an extension of a historical 19^{th} Century building in Istanbul has been completed recently. One of the objectives in the design of the exterior envelope is to achieve an environment for education with high level of thermal comfort and low energy consumption. It becomes necessary to design all vertical exterior surfaces as transparent components for a lighter and more open appearance because of the limitations of the existing built form. The challenge is to design a window system for the east and west façades of the extension, fulfilling the objectives of thermal comfort and energy efficiency as well as creating positive interior environment that improves occupant's productivity. A four-step methodology for energy efficient window system design is introduced, comprising market search, computer simulations on product and building level and evaluation stages. The thermal performance of the extension is determined with different double glazed window system alternatives. The window system with optimum performance from energy efficiency and thermal comfort point of view is presented for this special case.

2. Taskisla Building and Design of the Extension

Taskisla; is a masonry building with three floors and 130 m x 100 m in width and length, with a 70 m x 40 m courtyard and towers on each of its corners. It is located on the European part of Istanbul viewing the Bosphorus and was designed by the British architect James Smith in the 19th century in a neoclassic style. Construction of the building was started in 1847 and was finished in 1852. Although the building was originally designed as a military medicine school, its function was changed into a hospital and later into military barracks. After its renovation in 1944, the building is being used as the Faculty of Architecture of Istanbul Technical University (Figure 1).

Figure 1. Taskisla Building

With the objective to create new design studio spaces, the roof and the attic space below that had been constructed in the fifties as an extension in Taskisla, is renewed. In the scope of the renewal, the structural system and the exterior envelope of the extension are redesigned and constructed. The renewal has a simple plan layout with studio spaces on both sides of a corridor between the northeast tower and the southeast tower. The open space studio with separations, faces the east is 77 m in length and 9 m in width (Figure 2). Seven "single room design studios" are placed on the other side of the corridor, facing the west and the courtyard of the building. Steel structure, aerated concrete prefabricated roof slabs, shape of the roof, external wall plane, plan layout with the studio spaces on both sides of the corridor are the constrains in the design (Figure 3).

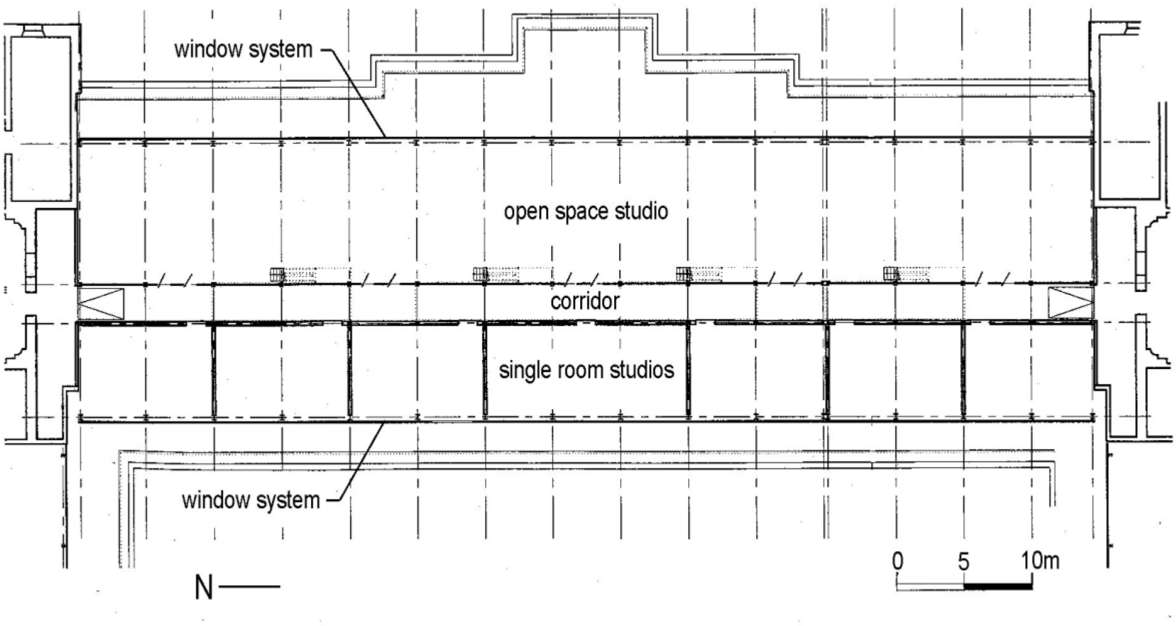


Figure 2 Plan of the renewal

Figure 3 General view to "the open space studio" with window system facing the east.

3. Methodology for the Design of an Energy Efficient Window System

In making decision about window selection, there are many factors leading to decision-making criteria and the basic criterion relate to the original purpose of having windows in this building providing the energy efficiency in the heating season. The design process of an energy efficient window system comprises four main steps considering the objectives, requirements and constrains related to the whole attachment in general. The four main steps are; market search, quantifying energy performance data at product level with Window5 [4] simulations, quantifying energy performance data at building level with DOE 2.1E [5] simulations and evaluation / decision-making. It becomes important for the designers to integrate these criteria into a broader set of design issues and values while understanding the long-term implications of their decisions.

3.1. Market Search

At the “market search” stage, appropriate glass types and their combinations are determined, with the main requirements like local availability, initial cost, system weight, aesthetics and durability [6]. The local glass company is one of the worldwide leading companies that support the research and development with its products used in this study. The appropriate glazing systems for the study are developed by using the determined glass types as a 6/12/6 mm system with air filled gap.

3.2. Energy Performance at Product Level

At the second step, the energy related properties of the window system alternatives are determined by Window5 computer program. Window5 is a well known computer code, developed by Berkeley Laboratories, capable to compute glazing systems and window characteristics, considering the layers and materials (optical coefficients, conductivity, thickness and others), gaps (thickness, gas mixture, pressure, and others) and frame (U-value properties). The program is found to be quite efficient and reliable. Its results can be stored as a library file readable by other programs in particular DOE 2.1E [4]. U-value, solar heat gain coefficient (SHGC), visible transmittance (VT) and light-to-solar gain ratio (LSG) are the properties of the window systems, which can be used as the basis for quantifying energy performance and allow accurate comparison at window system level before proceeding the building level simulations. The U-value of a window system represents its overall heat transfer rate or insulating value. The ability to control the heat gain through windows by direct or indirect solar radiation regardless of outside temperature is characterized in terms of the solar heat gain coefficient (SHGC) of the window while visible transmittance (VT) is an optical property that indicates the amount of light in the visible portion of the spectrum that passes through a glazing material. The LSG ratio is defined as a ratio between visible transmittance and solar heat gain coefficient, which reflects the concept of separating solar heat gain control and light control [1].

3.3. First Level Evaluation

The window systems that cannot meet the requirements are eliminated according to their performance values of U-value, SHGC and VT obtained by Window5 at the pre evaluation stage. For example the glass systems with high U-value, low visible transmittance and low solar heat gain coefficients can be eliminated before going on the simulations at building level.

3.4. Energy Performance at Building Level

At the third step, performance data of the proposed glazing systems calculated with Window5 are used as the input data for energy simulations to appraise their thermal performances at building level. The heat loss through windows, total solar heat gained from the windows and the annual heat loss of the building with glazing system alternatives are calculated by means of DOE 2.1E computer program. The DOE 2.1E program is designed to explore the energy behavior of buildings and their associated HVAC systems, which requires as input a geometrical description of the building and a physical description of the building construction, mechanical equipment, end-use load schedules, utility rates and hourly weather data to determine the energy consumption of the building [5]. The hourly weather data of

Istanbul that is located on the latitude of 41-degree north and longitude of 28-degree east, is prepared as 'Typical Meteorological Year-TMY' file and used for the simulations [7].

For the simulations one temperature zone is accepted and interior air temperature is kept constant at a temperature of 21°C throughout the year in calculating the heating energy consumption of the extension. All windows of the building are designed as double pane windows and the windows are assembled in 6cm wide white coloured aluminium frame with a thermal transmittance of 3.97 W/m^2K. Aluminium spacers between the glass layers are modelled for all glazing units. The lighting type is assumed to be recessed fluorescent and maximum output is specified as 16 W/m^2. The area per person is assumed to be 5.6 m^2 and total 250 people are modeled to be occupying the studio at the education period. The infiltration method is defined as air-change method and the rate of air changes per hour is specified as 0.5.

3.5. Final Evaluation / Desicion Making

At the final evaluation / decision making stage, the energy impacts of optical and physical properties of the developed window systems on the building's thermal performance are analyzed in terms of annual heat gain and loss of the window system and the appropriate window system for the building is selected. The performance data determined at the product level and building system level are used together for evaluation / decision making stage. Since the building is used for education generally in the heating season, window system annual heat loss (WSHL), window system annual heat gain (WSHG), window system annual net heating load (WSNHL), building system annual heating load (BSHL) are used as the energy performance indicators at the building level. The methodology for the design of an energy efficient window system, expressed in the form of a flowchart is given in Figure 4.

4. The Effects of Glazing System Alternatives on the Thermal Performance of the Historical Building

In the case study, the appropriate glazing systems that can be used for the historical building are constituted by using 5 different glass types such as tinted, reflective, Low-E and spectrally selective Low-E coating, as well as clear glass. The coated glass types are available in the local glass market such as multifunctional (IMF-170), titanium blue (ITB 130), inox (IIN 143) and Low-E (ILE-174) [4]. The optical and physical properties of each glass type used in the developed glazing systems are given in Table 1.

Overall U value, solar heat gain coefficient (SHGC), visible transmittance (VT) and light-to solar heat gain (LSG) values of window systems are calculated with Window5 computer program for the comparison at product level by taking account of the frame properties as well. The calculated data is given in Table 2.

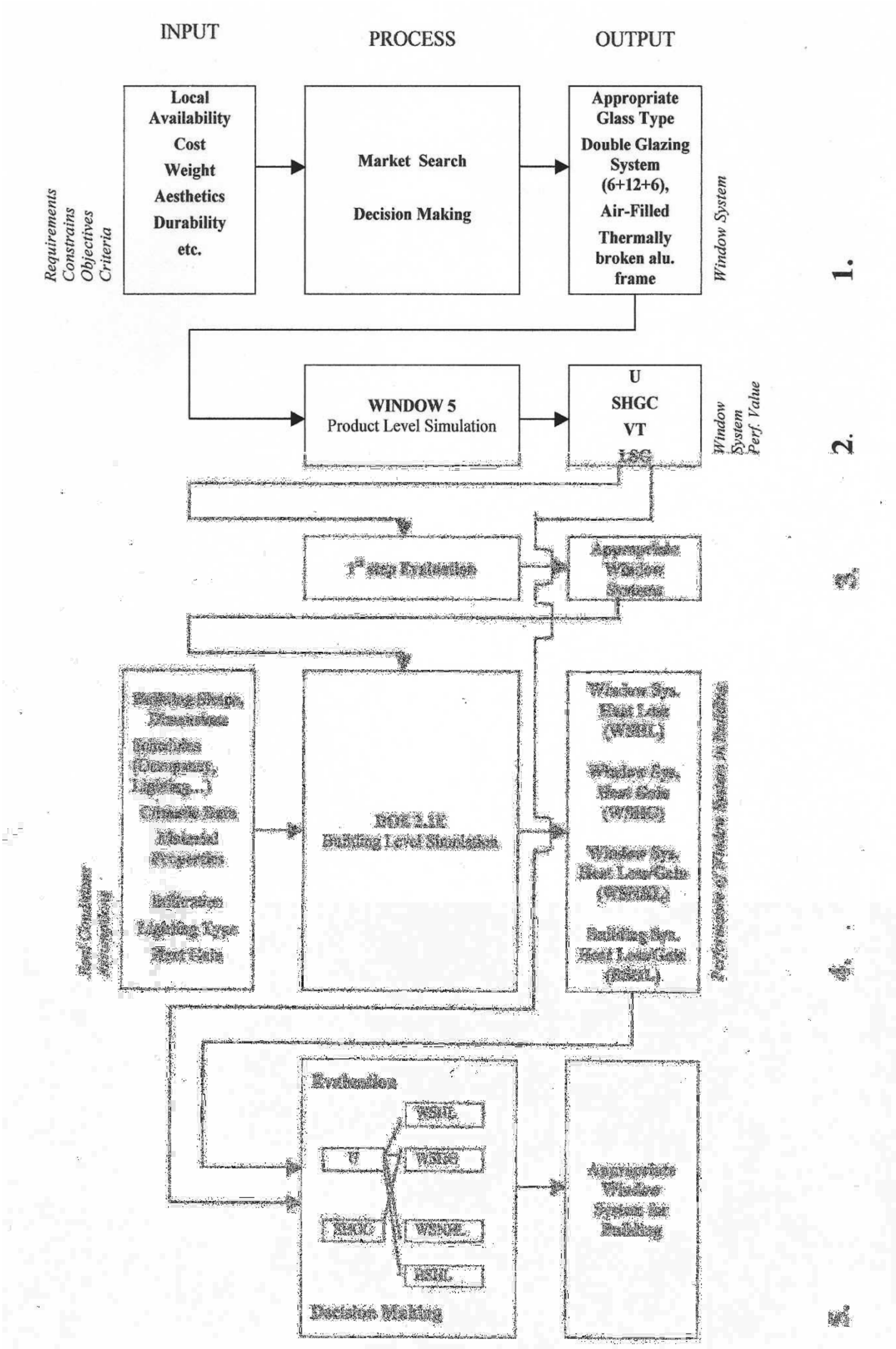


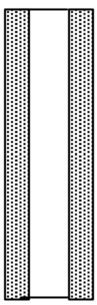
Figure 4. Flowchart describing the methodology for energy efficient window system design.

Table 1. The physical properties of the glass types.

Glass Type	Glass ID	Description	Tsol	Rsol #1	Rsol #2	Tvis	Rvis #1	Rvis #2	Emiss. #1	Emiss #2
Multifunctional (IMF-170)	7000	Spectrally Selective Low-E	0.486	0.213	0.320	0.792	0.082	0.049	0.840	0.060
Titanium blue (ITB-130)	7001	Tinted	0.208	0.152	0.328	0.300	0.121	0.265	0.840	0.550
Inox (IIN-143)	7002	Reflective	0.385	0.064	0.188	0.427	0.077	0.204	0.840	0.790
Low-E (ILE-174)	7003	Low Emissivity	0.574	0.218	0.144	0.825	0.041	0.055	0.100	0.840
Clear	7004	Clear	0.770	0.070	0.070	0.880	0.080	0.080	0.840	0.840

Tsol: Center-of-glass solar transmittance for the glazing layers at normal incidence
Rsol #1 and Rsol #2: Center-of-glass solar reflectance for the glazing layers for radiation incident from the front (outside) and from the back (inside), respectively at normal incidence
Tvis: Center-of-glass visible transmittance for the glazing layers, at normal incidence
Rvis #1 and Rvis #2: Center-of-glass visible reflectance for the glazing layers for radiation incident from the front (outside) and from the back (inside), respectively at normal incidence
Emiss#1 and Emiss#2: Thermal emmissivity of the front surface and back surface, respectively

Table 2. The appropriate window systems and their performance values.



#1 #2 #3 #4

Window ID	Glass ID (1)	Description	Glass ID (2)	Description	U W/m^{2}K	SHGC	VT	LSG
A	7000	IMF 170 #2	7003	ILE 174 #3	1.67	0.39	0.65	1.67
B	7000	IMF 170 #2	7004	Clear	1.71	0.45	0.70	1.56
C	7001	ITB 130 #2	7003	ILE 174 #3	1.78	0.22	0.25	1.14
D	7001	ITB 130 #2	7000	IMF #3	1.71	0.20	0.24	1.20
E	7001	ITB 130 #2	7004	Clear	2.47	0.27	0.27	1.00
F	7002	IIN 143 #2	7003	ILE 174 #3	1.79	0.34	0.36	1.06
G	7002	IIN 143 #2	7000	IMF #3	1.71	0.31	0.34	1.09
H	7002	IIN 143 #2	7004	Clear	2.72	0.42	0.38	0.90
I	7004	Clear	7003	ILE 174 #3	1.79	0.59	0.73	1.24
J	7004	Clear	7000	IMF #3	1.71	0.52	0.70	1.35
K	7003	ILE 174 #2	7003	ILE 174 #3	1.70	0.47	0.68	1.45
L	7000	IMF 170 #2	7000	IMF #3	1.65	0.35	0.63	1.80
M	7004	Clear	7004	Clear	2.76	0.69	0.78	1.13

According to the results of the product level the window systems with blue tinted glass (E), reflective coated glass (H) and clear glass (M) do not thermally perform well due to their higher U-values, which vary between 2.47 W/m^{2}K and 2.76 W/m^{2}K when compared with the other alternatives. Moreover Windows E and H have lower visible transmittance values as 0.27 and 0.38, meaning that these systems reduce utilizing visible light in the building as well. However in case of considering heating loads for the performance evaluation of the window system, the U-value of the glazing system becomes the most significant criterion, which is affected primarily by the total number of glazing layers, their dimension, the type of gas within their cavity, and the characteristic of coatings on the various glazing surfaces. In this case the optical characteristics of the glass types are the main parameter affecting the performance of the window system.

The windows with tinted glass (C and D) and with reflective coated glass (F and G) seems to outperform related with their lower visible transmittances between 0.24 and 0.36 although their thermal performances are higher due to their low U-values varying between 1.71 W/m^{2}K and 1.79 W/m^{2}K. Other window system alternatives developed with spectrally selective Low-E and Low-E coated glasses (A, B, I, J, K, L) have rather low U-values between 1.65 W/m^{2}K and 1.79 W/m^{2}K and high visible transmittances between 0.63-0.73 while their solar heat gain coefficients vary between 0.59 and 0.35 (Figure 5).

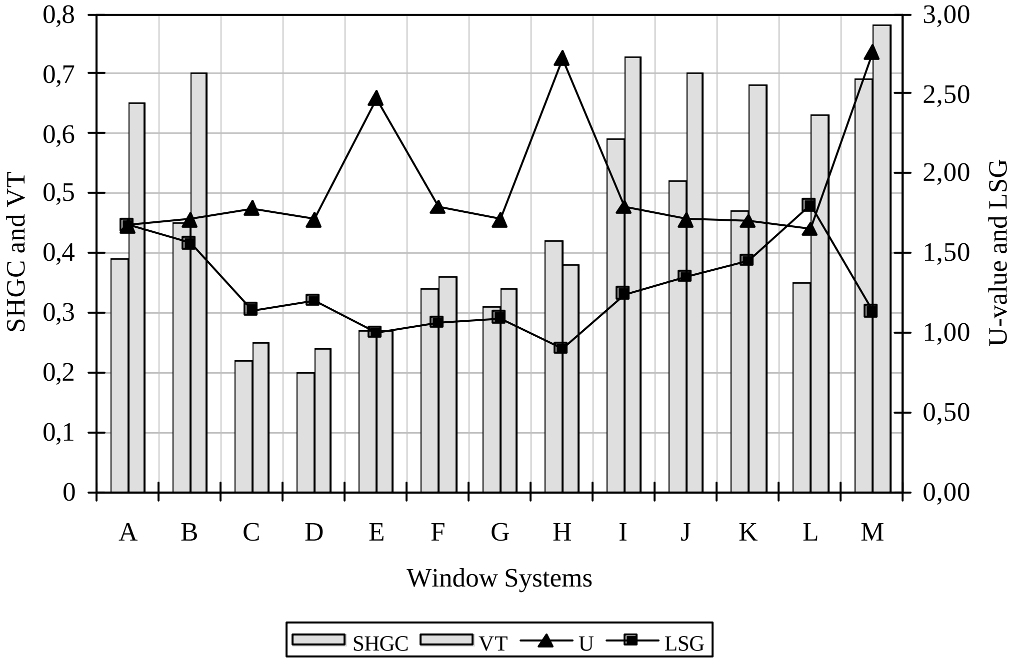


Figure 5. Comparison of the performance values of the window system alternatives

Windows A, B, I, J, K and L have LSG ratios higher than one meaning that utilizing visible light is higher while their solar heat gain is lower. However higher solar heat gain coefficients contribute to reduce heating loads in winter. Although light-to-solar gain ratio is an indicator of performance but does not directly correlate with actual energy use. Therefore at this stage, building level simulations are required for understanding the thermal performance of window systems related with the design conditions and characteristics of the building. Although the window design and selection issues related with the window performance values as solar heat gain coefficient, visible transmittance and U-value can be overwhelming for making a design decision if there were a simple sequence of steps, sometimes it is not easy to reach right solution based on the defined performance criteria.

In order to provide performance information for the selection of the appropriate window system, the heat loss and gains of the building at the education period are taken into consideration and annual heat loss and gain of the windows, overall heat loss of the building and the ratio of heat loss through windows to overall building heat losses are calculated by the aid of computer simulation and the results are given in Table 3.

Table 3. Annual heat loss and gain of the windows and overall heat loss of the building

Window ID	**Window Sys. Heat Loss (WSHL) MWH**	**Window Sys. Heat Gain (WSHG) MWH**	**Window Sys. Net Heat Loss (WSNHL) MWH**	**Building System Heat Loads (BSHL) MWH**	**Window/Building Heat Loads (%)**
A	-34.872	7.816	-27.056	-36.984	73
B	-35.510	9.515	-25.995	-36.077	72
C	-39.016	4.400	-34.616	-43.483	80
D	-38.082	3.926	-34.156	-43.037	79
E	-49.502	5.896	-43.606	-51.271	85
F	-37.216	6.614	-30.602	-40.061	76
G	-36.365	5.931	-30.434	-39.896	76
H	-51.202	9.325	-41.877	-49.880	84
I	-34.606	9.823	-24.783	-34.863	71
J	-34.002	8.943	-25.059	-35.200	71
K	-34.529	8.471	-26.058	-36.111	72
L	-35.068	7.231	-27.837	-37.654	74
M	-49.327	14.263	-35.064	-44.015	80

The window area comprises 25 % of the area of the total opaque and transparent components in the building and the percentage of the heating loads occur from the different window systems vary between 71 % and 84 %. This indicates the importance of the window system design and selection process for achieving energy efficiency since the thermal insulation levels of the opaque building elements are very high.

U-values of the window systems affect the total heat loss through windows and overall heat loss of the building in heating season. However, although the U-values of the Windows H and M are very close to each other as 2.72 W/m^{2}K and 2.76 W/m^{2}K, respectively, the building heat losses associated with these window systems are quite different depending on their solar heat gain coefficients as 49.88 MWH and 44.02 MWH. While heat loads decrease by reducing the U-value, it is also influenced by solar heat gain coefficient. The relationship between the U-values and the annual heat loss through windows and overall heat loss of the building with different glazing systems are given in Figure 6.

The minimum annual heat losses are attained by the Windows B, I, J and K according to the annual heat losses of the building with window system alternatives. Since the solar heat gain from windows is related with their solar heat gain coefficients, higher coefficients contribute to reduce the annual heat losses of the building, (Figure 7).

Double pane clear Window M can be considered as the base case since this type of window system is common on the new building constructions. Window E and H outperform since the rate of decrease in overall building heat loads are –16 % and –13 %, respectively while Window I and J performs best since the savings provided by these windows are 21 % and 20%, respectively when compared to the base case. From the viewpoint of sustainable design, reducing the heat loads by 20 % will contribute to the heating energy savings that will eliminate the environmental impact. Window I with Low-E coating on the second pane provides the minimum heat loss through windows and building with its highest solar heat gain coefficient although it's U-value is not the lowest value among the window systems in consideration. Therefore for thermal performance evaluation of the window systems building level performance evaluations give more confident results than product level evaluations in terms of energy efficiency by taking account of the window parameter values used at the product level evaluations. Moreover Window I meet the budget when compared to the other window system alternatives for this application.

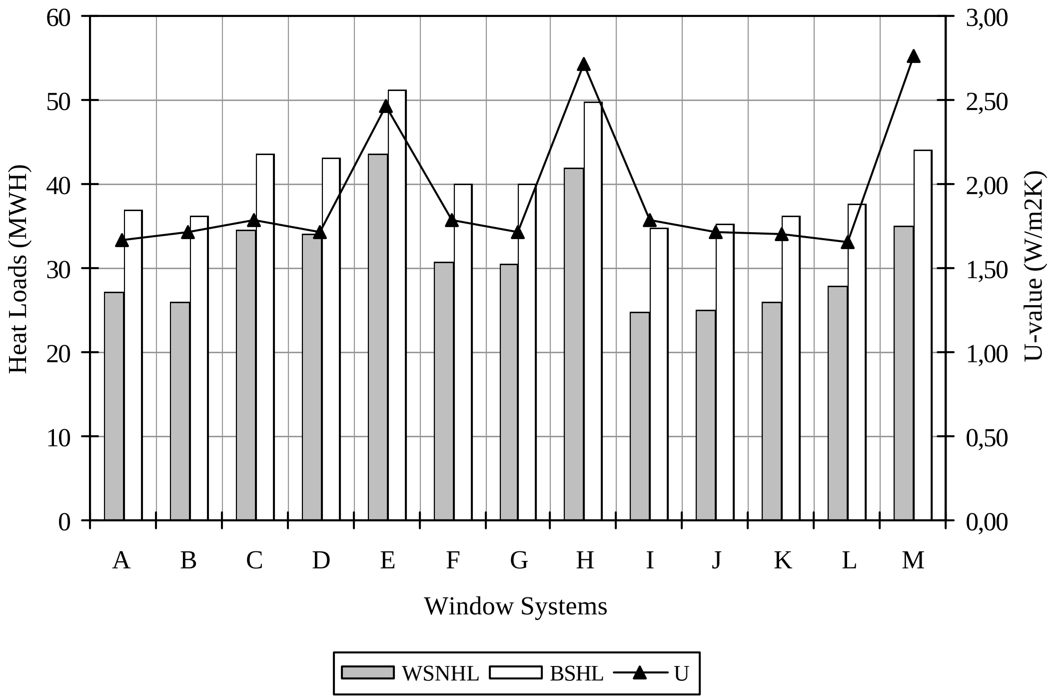


Figure 6. The relationship between the U values and the annual heat loss of windows and building

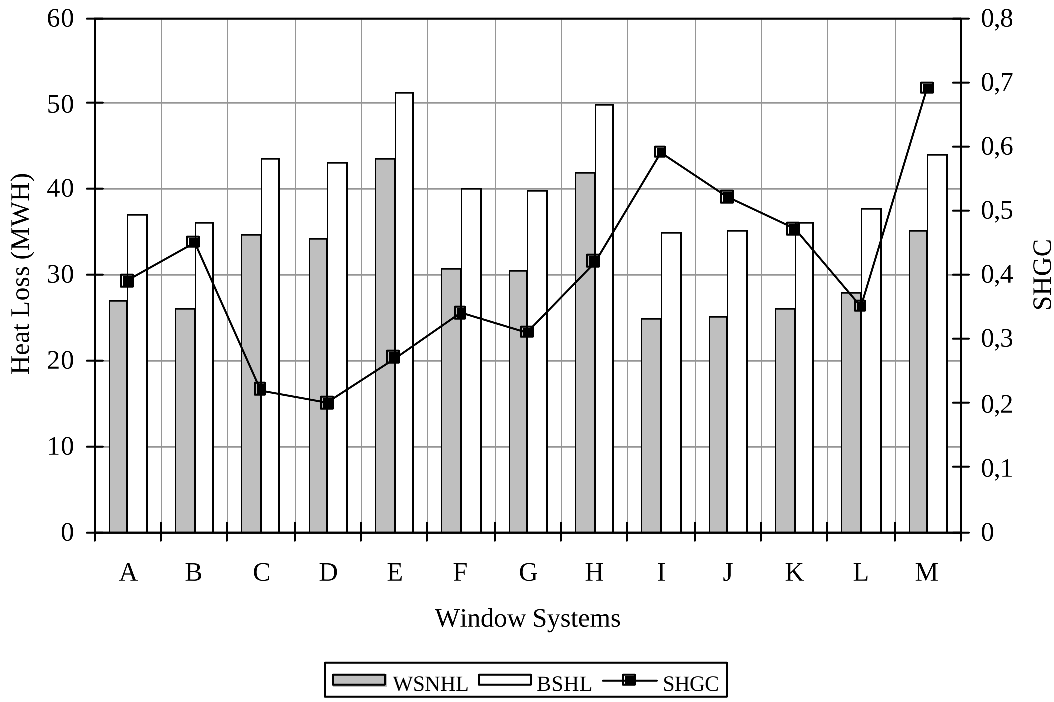


Figure 7. The relationship between the SHGC and the annual heat loss of windows and building

5. Conclusions

A series of comments that summarize the most significant outcomes of this work are:

- In order to achieve sensitive results in energy efficient window system design, a methodical approach is introduced in the context of this study.
- While most windows in buildings today have a negative impact on a building's energy load, the technological potential for windows to be designed could make a positive contribution to the building's annual energy load. Therefore the physical properties of the glazing system such as U-value and SHGC must be taken into consideration with their effect at building level during window design process.
- Visible transmittance (VT) of glazing system should take place in window design process as another criterion to fulfill other performance attributes such as utilizing the daylight.
- The light-to-solar gain ratio does not directly correlate with actual energy use but it can be used as an indicator of performance involving both visible transmittance and solar heat gain coefficient.
- Although the information obtained at the level of the material or product can be used as the criteria for an energy efficient window design, the effort focusing on the building level impacts of these products helps to evaluate their performance in the building and to understand their energy saving potentials.
- In this case solar heat gain coefficient of the glazing system is as significant as U-value in terms of heat loss/gain in the heating season.
- According to the results the glazing system with a Low-e coating on the third surface that has higher solar heat gain coefficient, is the most efficient window system in terms of

heating loads of the building and initial cost. Moreover it provides daylight utilization with its high visible transmittance value as 0.60.

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ENERGY SUSTAINABILITY BY THE PASSIVE HOUSE STANDARD

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1. Introduction: No Sustainability without Energy Sustainability

We would like to speak about "sustainable housing" instead of sustainable buildings, because housing is by far the main part of the life cycle of a building. Generally speaking the energy demand of housing in now common buildings is more than 95% of the total energy input from their construction to their demolition.

Strongly defined and clearly spoken: Sustainable energy supply for space heating and hot water preparation is only possible on the basis of renewable sources like solar energy and bio-energy, also, in case of the usage of electricity for heat production.

The usage of natural gas, oil and coal as well as electricity from fossil sources causes global warming with its catastrophic follow-up now already appearing in storms and floods of higher frequency and greater extent. They give us an idea of what is coming.

Additionally, fuels and electricity from fossil sources are not durably available.

Our present task for achieving energy sustainability of housing is to speed up switching to renewable energy sources! One obstacle is the higher price of energy from renewable sources.

We can accelerate the transformation if we introduce buildings with extremely low energy demand. The issue at hand are not the energy prices from renewable sources but the additional costs for the transformation. They get **payable** – quite independent from the price of the energy supply – if their amount is insignificant in the household costs because of the energy demand being close to zero.

Our good news for this conference is: Demand reduction down close to zero is possible! The Passive House enables warm housing without nearly any energy for heating. Together with the fuel demand it reduces the emissions (not only of $CO_{2)}$ down to between one quarter until one-tenth (both for new buildings) in comparison to good national standards of heat loss protection in Europe (without switching to energy from renewable sources).

2. What is the Passive House Standard?

A Passive House is

- so thickly and correctly **insulated** (outside walls, windows, roof and ground) and
- so well **tightened** (against convection, not against diffusion!)

that the energy consumption for heating decreases close to zero, to

< 15 kWh/ m²*a

in Central Europe. The **passive** energy inputs:

- Heat from the inhabitants,
- solar energy through the windows and
- the waste heat from the electric devices

provide the essential contribution (2/3) for covering the heat losses of the building. Only the rest is heating [1]. The thermal living comfort improves. Also, the air quality in the building increases due to the ventilation system.

The Passive House principle was developed by Dr. Wolfgang Feist, formerly at the state-owned Institute for Environment and Housing (state Hessen in Germany), now director of the Passive House Institute.

The 15 kWh are related to the area used within the thermal shell **for residential** purposes. What the thermal shell is will be explained later.

There is a side criterium: The demand for primary energy of all energy usage in the building is limited to up to 120 kWh/m²*a at standardised energy use for electric appliances and at standardised energy losses for hot water preparation within the thermal shell.

Primary energy is energy found as fossils or uranium in the underground. This prevents that low effective electric devices and bad insulation of equipment for hot water preparation plus distribution replace heating energy to a higher extent than set by the standard.

3. Passive House Essentials

3.1 Overview

There is no specific additional and no specific active element for providing more energy to the building. Therefore, the houses are named **Passive** Houses. The Passive Houses have only the same elements as used in any ordinary house, but of better quality and better co-ordinated, controlled and managed by the planning tool: the Passive House Planning Programme.

What must be better, by necessity, in Passive Houses?

1 Insulation

2 Tightness

3 Windows and

4 Ventilation.

Table 1. Characteristics of the main features of the Passive Houses

1	**Insulation of the outside walls, the roof and the base**: A closed thermal shell with increased thickness of the insulation.	U< 0,15 W/m²*K
	Thickness of the insulation of the outside walls of new buildings:	Min. 30 cm thick at ?= 0,04 W/m*K
	Outside walls after thermo-modernisation of existing buildings:	Min. 25 cm, depending on the climate region
	Preferably without heat bridges with the heat bridge coefficient:	ψ< 0,01 W/m*K
2	**Tightness** against uncontrolled convection: Shell at/in the outside areas of the building, tight against convection but open for diffusion provided by diffusion open folios or reinforced cardboard. Air exchange rate in the blower door test at 50 Pascal pressure difference in both directions:	n_{50}< 0,6 h^{-1}
3	**Windows** and outside doors with the best available heat loss protection. Glass: 3-fold with mirror shifts and gas between the panes. Frames: Super-insulated. Energy inlet rate of the glass:	$U_{w(glas+frame)}$< 0,8 W/m²*K g>/= 0,5
4	**Ventilation unit** with heat regain Volume stream (Input = Output): Effectiveness of heat regain:	30 m³/h pro Person > 85%

The register of the formula characters may be found at the end of the paper.

3.2 The Thermal Shell

This is the closed insulation of all exterior areas (outside walls, ground and roof). It has to be free of interruptions and preferably without heat bridges, like a heavy sweater! For the thickness of the insulation of the outside walls see Table 1. The thickness of the roof insulation can be approx. 0–50 cm and 40 cm of the base insulation.

The thickness of insulation is subject to an optimisation process by the Passive House Planning Programme. Co-ordination with the parameters of other elements like quality, direction and size of windows, and the effectiveness of the heat ventilation regain unit etc. is necessary.

Free of heat bridges means: The heat bridges cause an additional heat loss of less than 0,01 W/K (= 0,35 W at Delta t =35 K) for point heat bridges and of less than 0,01 W/K (= 0,35 W at Delta t =35 K) on a length of 1 m for the linear heat bridges.

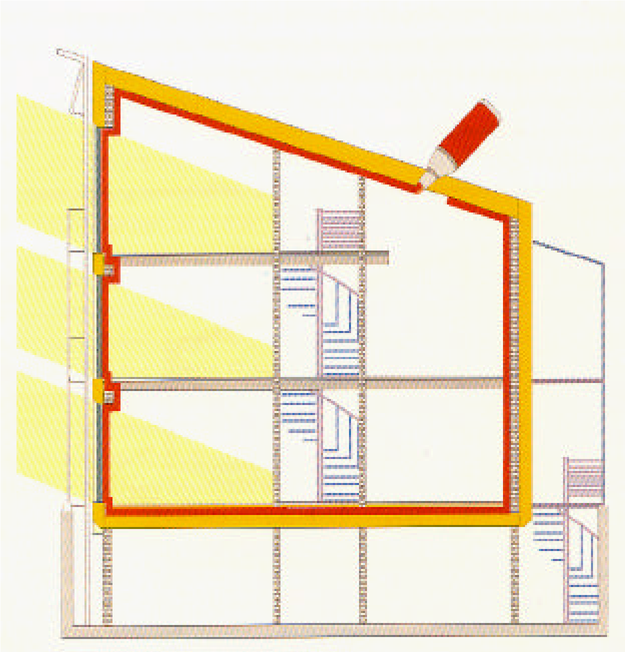

Figure 1.
Both of the shells of a Passive House. The thermal shell (yellow) and the convection tight shell (red)

Figure 2: Insulation with mineral wool, 30 cm thick

3.3 The Convection Tight Shell

The convection tight shell (CTS) consists of diffusion open folios or reinforced cardboard pasted together with adhesive tape or a special glue.

On the outside walls of new houses the CTS is the internal plaster with the airtight casings for electric switches, distributors etc., or they are made airtight with adhesive paste. Each passage of cables or pipes going through the convection tight shell has to be made airtight.

All folios (or cardboard) that are to be connected to the walls or to the ground must be attached by adhesive paste. Likewise, the window frames must be attached to the walls. Hereby, close attention must be paid!

The proof of the success of all efforts made is the blower door test at the end of the raw construction phase. The air exchange rate has to be lower than 0,6 at a pressure difference of

50 Pascal in both directions. The tightening activities have to be continued until this result is achieved.

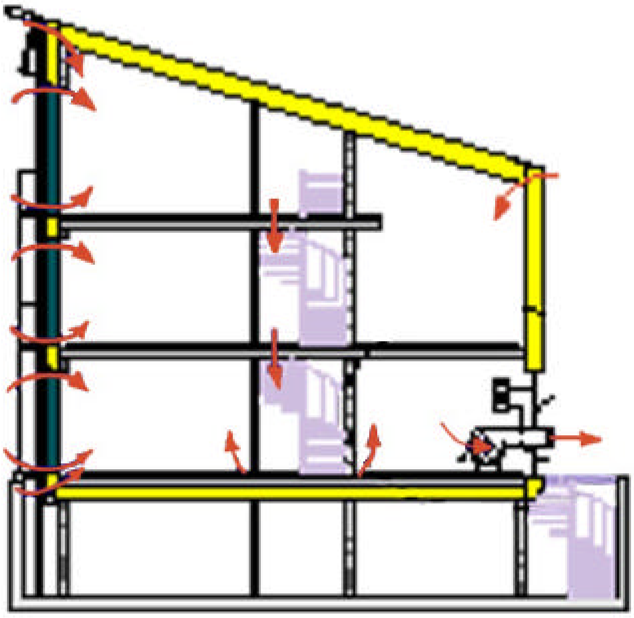

Figure 3. The leakage streams into the house during the blower door test

Figure 4. The blower in the door during the test

3.4 The Passive House Windows

The “high tech” of the Passive Houses is in the windows. They have to be certified by the Passive House Institute. Otherwise, we cannot ensure that the Passive House will have the energy demand as calculated. Where else would we obtain the guaranteed parameters for the calculation?

For later our aim is the Passive House windows to be produced and certified in the countries where they are used. We look for production partners in the window industry and for neutral national transfer and consultation centres, which will be qualified for certification.

The windows consist of three main elements: Glass, frame and draught excluder.

Some details are mentioned in Table 1. The max. value of 0,8 W/m²*K for U_w can be achieved only with the U_g for glass of max. 0,7 W/m²*K. The special 3-fold glass with mirror shifts and gas fill-in of the spaces between the panes are commercially available as well as the complete windows now, even those made only of wood!

The best windows are the double windows made according to old patterns as shown in the following figures.

Passive House windows have a positive energy balance throughout the year if they have their exposure from the south to the west or to the east. Their area in these directions has to be large enough to provide enough solar energy for the passive house during the heating period, but small enough to prevent overheating of the building in summertime. The Passive House Planning Programme can control this optimisation. The windows from north to west and north to east should be as small as possible.

*Figure 5. Double Passive House windows System "Leipzig" with Uw =0,68 W/ m²*K*

Figure 6. The window doesn't need any prote ction facility against overheating in summertime

The cross section of a simple Passive House window is shown in the following figure:

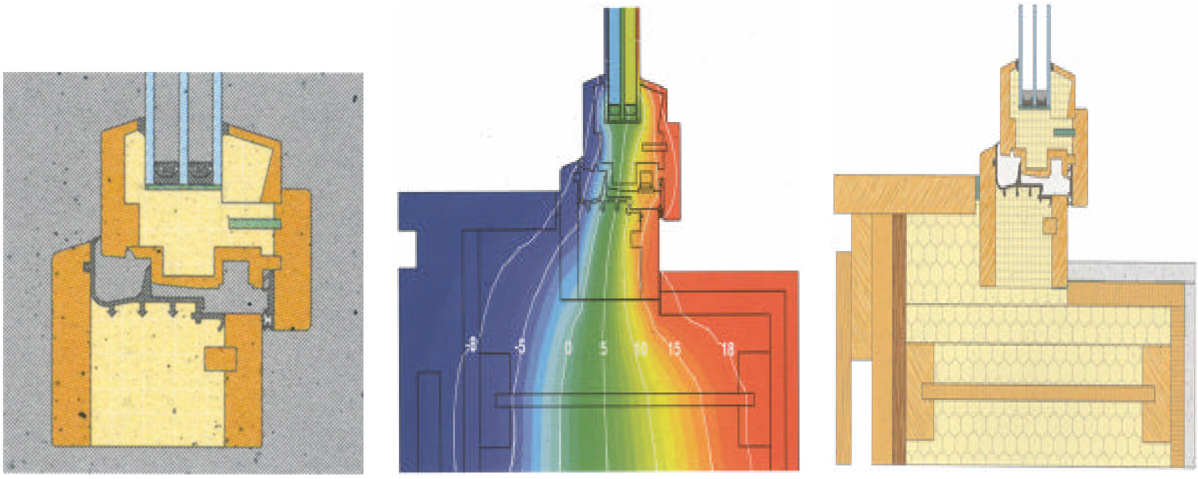

Figure 7. Cross-section of a Passive House window with the isotherms. The window is correctly assembled into a wood construction wall

In the following picture you can see the influence of the Passive House design onto the size of the windows in the southern facade. A large increase in the size of the windows was necessary for developing a Passive House from the traditional rural design protected by the regional administration.

Figure 8. The increase of the area of the windows in the southern facade for achieving the Passive House Standard creates an improvement of the architecture

In this picture, thermal solar equipment with a collector area of 16 m², feeding the central storage containing 800 l heating water, supporting the hot water preparation (by 70 %) as well as heating (ca. 50 %), can be seen. This is a good addition to the windows and makes easy switching to wood as a fuel for the yearly rest heating demand of about 7,5 kWh/ m².

3.5 Ventilation with Heat Regain

Because of the high-grade tightness of the buildings, the leakage rate through the exterior areas is very low and the air input and output are compelled to go through the ventilation device and the heat exchanger between the input stream and the output stream. Its heat exchange rate should be higher than 85 %; the best devices have more than 90 %.

During the heating period it is not necessary to open the windows. The Passive Houses always have clean air because of the controlled air exchange and the inhabitants lose the feeling that the windows need to be opened. This is the experience of thousands of Passive Houses and flats used and also the experience of the passive house of my own family.

4. Positive Side Effects of the Passive Houses

4.1 Overview

The main positive side effects are:

- Improvement of thermal living comfort
- Excellent air quality in the building
- Prevention of mould, even in the most unfavourable cases
- Better quality of buildings because of project certification and more intensive implementation control

Attention: There is no Passive House without trained planners and certification, trained handicraft people and trained supervisors during the implementation !

- No air-conditioning system necessary for the summertime, not even for office buildings
- Heating costs are only 15 – 25 % of these for new houses with the actual standard of protection against heat loss and most of all:
- **Easy switching to** energy supply for the rest demand from **renewable energy sources.**

4.2 Thermal Living Comfort

The thick insulation provides high temperatures (min. 19 °C) on the internal surface of the outside walls. This gives a warm and pleasant feeling to human skin.

The windows with the large glass areas are also warm (min. 16 °C), even if there is no sunshine. The cold fall-down of the natural air ventilation from the windows no longer exists.

The radiators of the heat distribution system are small because of the low energy demand and do not have to be located below the windows any more for preventing the cold air fall-down.

The whole house within the thermal shell has nearly the same temperature. If one room, for instance the be room, is to have a lower temperature, then it is proposed to plan and perform the thermal separation for this room. But it is not necessary. Calculations have shown that an open window in one room at night during the winter period increases the key figure, “yearly specific energy consumption per m² residential area within the thermal shell”, by about 3 kWh/ m².

4.3 Easy Switching to Renewable Energy Sources

According to our opinion this is no side effect but the goal of the effort. How easy it is, can be seen from the following very rough calculation:

The rest energy demand for heating of one Passive House residential unit is max.

$$(60\ m^2 * 15\ kWh/\ m^2*a)\ /\eta = 1125\ kWh/a\ \ fuel$$

where:

η - Efficiency of energy transformation from the fuel into the heated rooms
taken as 0,8 for modern facilities.

The rest energy demand for hot water preparation to one Passive House residential unit is max.

$$(1{,}5\ kWh/(person*d) * 365\ d/a * 3P)*0{,}5\ /\eta = 990\ kWh/a\ fuel,$$

where:

η - Efficiency of energy transformation from the fuel into the hot water
taken as 0,8 for modern facilities.

- 50 % of the energy demand of the hot water preparation is covered by the thermal solar equipment.

For the sum - heating and hot water preparation - are necessary:

(1125+990) kWh/ H_u = **490 kg wood** (as chips, pellets etc.) during one year,

where:

H_u – Heat content of the fuel. In the case of naturally dried wood it is 4,3 kWh/kg.

This amount of wood can **sustainably** grow in an area of energy forest of

$$490 \text{ kg*a/ } E = 0{,}05 \text{ ha} = 500 \text{ m}^2,$$

where:

E = 10 000 kg/ha*a sustainable yield of an energy forest.

For this purpose, only

$$0{,}05 \text{ ha} * 10 \text{ Mio} = 50\,000 \text{ ha}$$

are needed for approx. 10 Mio residential units in Poland. Including possible reducing factors, this will not be more than 100 000 ha.

5. Additional Investment Costs of Passive Houses

Leaving aside investment costs, this speech will concentrate on the full housing costs.

Nevertheless, a comparison of the investment costs of 9 Passive Houses built with all in all 250 flats in Sweden, France, Germany, Austria and Switzerland to houses built according to national standards has presented additional investment costs of only 8 % [2-4]. As long as some key elements have to be imported, this amount will be higher in the CEE countries. This is also due to the lower base costs. This comparison is a reliable base for providing a successful economy for Passive Houses, also in the CEE countries.

6. Conclusions

The Passive House Standard is not protected. We would like to encourage every administration (national, regional or communal) to introduce the Passive House Standard for ensuring survival during the coming period without uranium, oil and natural gas. This lecture is to help house owners not to feel compelled to go back to hard coal and its follow-up products as the only long-range fossil energy source which would double the CO_2 emissions!

Not depending on the implementation as the legal standard, everybody is invited

- to use the experiences made in Germany, Austria, Switzerland, Denmark and Sweden and
- to apply the Passive House planning tools and the Passive House technologies

for achieving the Passive House Standard in new buildings and to reduce the energy demand by thermo-modernisation down to the limit which is double the one for new houses.

This is not unrealistic. The authors offer their consultation, experiences and facilities.

7. Register of the Formula Characters

	Unit	Definition
U	W/m²*K	Heat transmission coefficient of an outside area: The heat stream in W, which goes through 1m² of the outside area, if the temperature difference between the internal and external space is 1K
U_w	W/m²*K	Heat transmission coefficient of the windows or outside doors: The heat stream in W, which goes through 1m² of the whole of the outside area for the window, if the temperature difference between the internal and external space is 1K
?	W/m*K	Heat conductivity of a construction material: The heat stream in W, which goes through 1m² of the area of a test piece with the thickness of 1 m, if the temperature difference between the both sides is 1K
n	-	Air exchange number: The air stream in m³/h related to the internal volume of the building
?	W/m*K	Heat bridge coefficient of a linear heat bridge: The heat stream in W, which goes through the heat bridge with a length of 1m, if the temperature difference is 1K
?	W/K	Heat bridge coefficient of a point heat bridge: The heat stream in W, which goes through the heat bridge, if the temperature difference is 1K
	-	Solar cover rate of a thermal solar equipment: The share of the energy supply of the solar equipment in the energy demand.

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URBAN STRUCTURAL UNIT APPROACH TO MODEL FUTURE LAND-USE AND RESOURCE-CONSUMPTION FOR HOUSING – THE GERMAN HOUSING STOCK 2025

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A team of scientists of the Institute of Ecological and Regional Development, the Institute for Applied Ecology and TU Dresden developed a software-tool (BASiS-2) which describes the existing housing stock of Germany and allows the modelling of development paths. The model uses findings from empirical analyses of material-flow and land-use in the housing sector in Germany taking into account the building stock and the essential technical infrastructure facilities. Statistical data on a national level and empirical findings allow to estimate the environmental impact of the housing sector. Through the introduction of a scenario editor the user can check on different development options and find out, whether and how Germany will match its sustainability targets set by the cabinet-decision from April 2002. The BASiS-2-Project was financed by the Federal Environmental Agency of Germany.

Model components

The model BASiS-2 consists of seven major components:

1. Housing Demand (households and dwellings, prognoses of future demand and developments),
2. Region Types (to differentiate the degree of urban density according to agglomeration, suburban-areas and rural areas),
3. Urban Structural Units (characteristic patterns of built up areas),
4. Technical Infrastructure (elements, products, net-systems),
5. Building Types (as representatives of time, technology and design),
6. Building Products (a database on building elements and products, distributed accordingly to their market share),
7. Resources (incl. effects of process chains, database of GEMIS 4.0).

Essential for the project is the “urban structural unit” approach and the scenarios. Urban structural units (USU) are defined as: “areas with physiognomic homogenous character, which are marked in the built-up area by a characteristic formation of buildings and open spaces" (E. Wickop, 1998, Pauleit 1998). Thus, they integrate areas with similar environmental, infrastructure conditions and similar use (functions). They can provide an impression of the morphological situation of the urban area. To cover the objectives of the project – the simulation of the German housing stock - , seven Urban structural Units were defined. In addition the age of the buildings by statistical data is needed to hitch up information on the different historical building techniques and materials. Representatives of building-types and infrastructure-types containing this information are used as bottom-up empirical data for the assessment of USU.

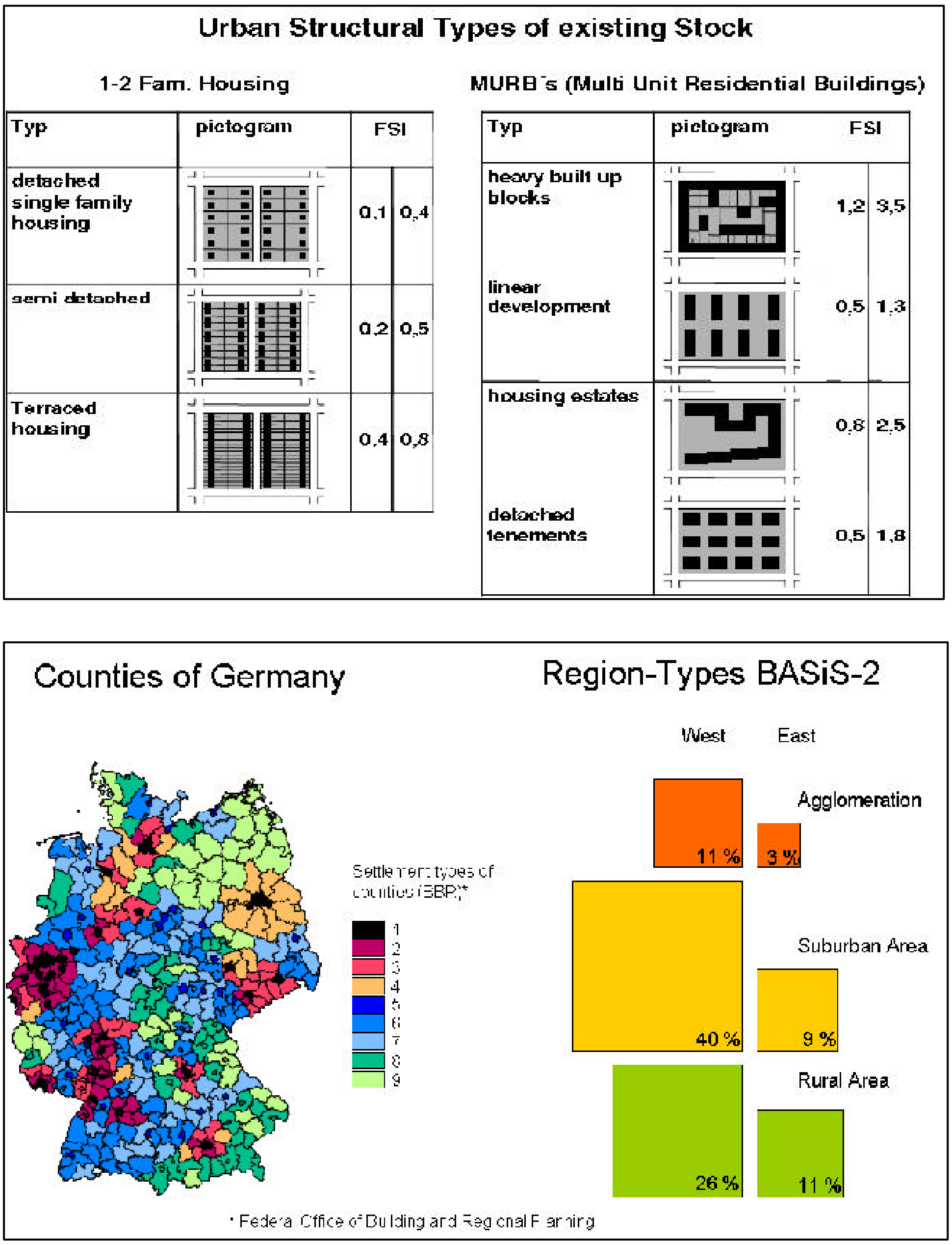


Fig 1 Urban Structural Types and Regional Types

BASiS-2 as database contains housing types and quantities, land use and induced mass flow by infrastructure needs for residential areas. In order to simulate the future demand of housing in more detail regional aspects had to be considered. The building types had to be allocated to the seven urban structural units and these within the three principal spatial types (regions of agglomeration, suburban areas and rural areas). A further differentiation was needed to reflect the different development paths in the post-war-period in East- and West-Germany. The regional aspects were necessary to consider the different degree of settlement density (for land take and infrastructure) and to define the mix of building representatives.

BASiS-2 enables to estimate the future use of resources

In order to picture the future housing situation two scenarios were developed. Keyfactors had to be defined and assumptions made on the variables. This was done in an intensive dialog with experts on urban- and housing issues. The assumptions of the scenarios were cross checked with the Federal Environmental Agency of Germany (UBA).

The software BASiS-2 is made available to end user with two pre-installed development scenarios for the German housing stock (trend and sustainable). The assumptions can nevertheless be changed by the user of the software-tool BASiS-2. It is possible to calculate up to 6 different scenarios parallel and compare.

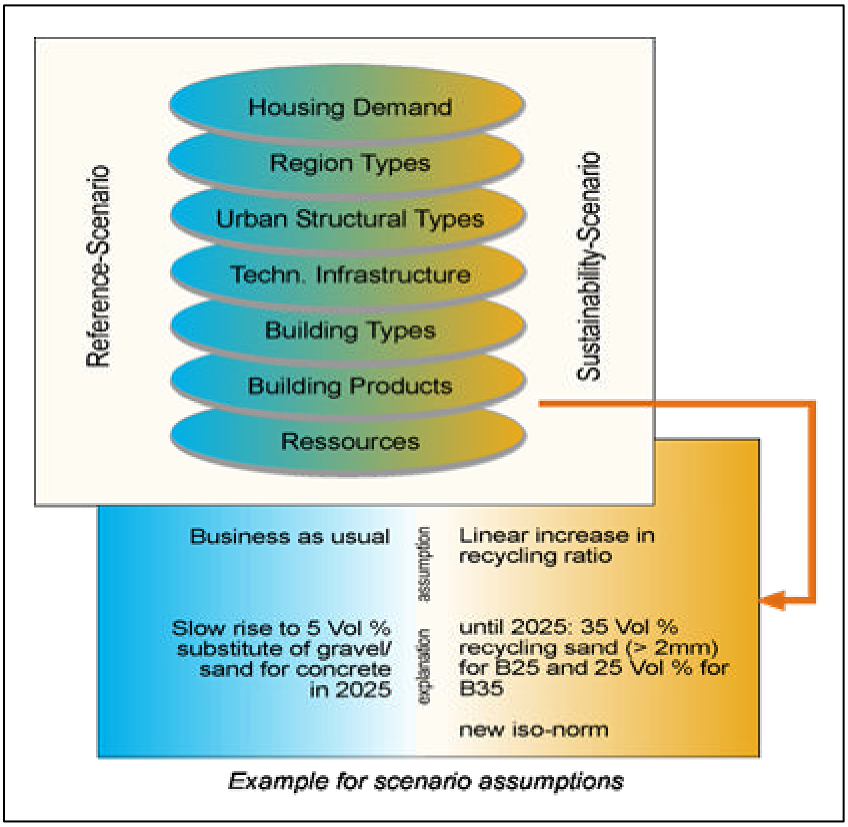


Fig 2 Scenarios – Thematic areas

Due to the integrated modelling, it is possible to estimate the resource consumption until 2025 for residential purpose along different fractions (wood, metal, minerals) or branches (brick-industry, aluminium industry etc.) to estimate relevant emissions like CO_2, SO_2 etc. and to estimate the future land use (green field, brown field etc.).

The model BASiS-2 allows furthermore to spot the essential influencing factors of alternative paths and options to act by isolating specific variables of the scenario. E.g. in order to check the effects of different land use patterns, one can compare slight changes in the ratio of single to multi-unit-housing with the effects of brown field versus green field development paths.

Two selected findings

Both scenarios assume that Germany has 82.5 Mill inhabitants in 2000 as well as in 2025. The average floor space per inhabitant will grow from 39,2 m² in 2000 to 47.7 (Reference scenario) to 46.2 m² (sustainability scenario). A significant difference in the scenarios is the new land take by residential areas. Factor 5 between the scenarios indicates the importance of the municipal land use planning and the challenges to guide a sustainable development. The options to act towards more inner city development, less free standing single family homes, to improve the existing housing stock instead of new construction, to reuse brown fields etc.. The sensitivity analyses proves, that the mix between single family homes and multi unit residential buildings is a key issue. Looking in more detail at the distribution of new land take with regard to the regional types, it becomes evident, that less the cities, but the rural and suburban areas are responsible for the high increase in land use.

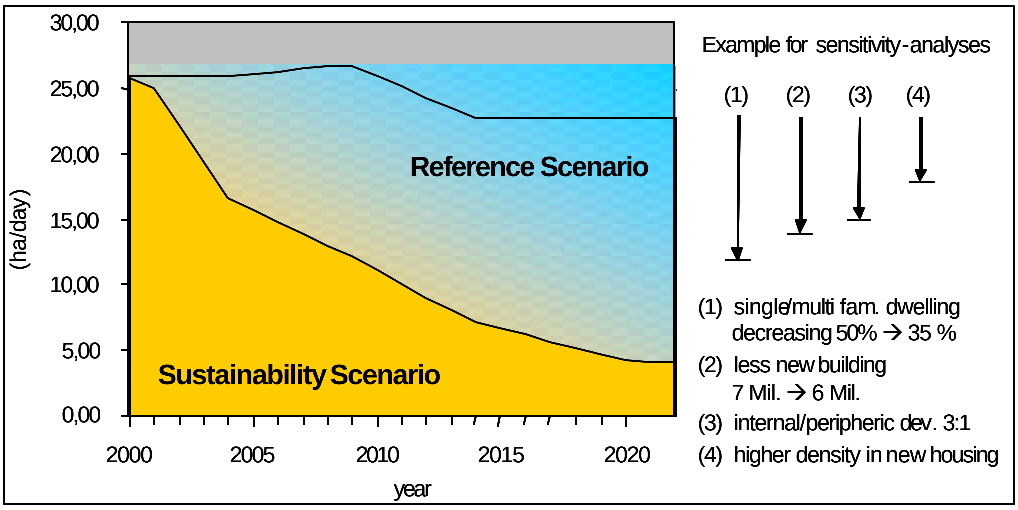
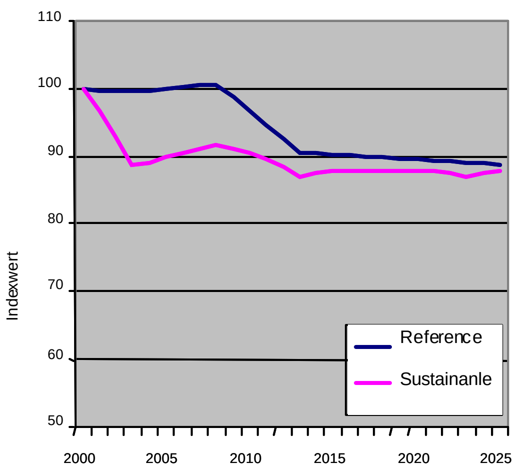


Fig.3 Scenario-Aspect: Net building land use per day in Germany

BASiS-2 was developed more to estimate future material consumption than the land take. Therefore the model was designed for material flow analyses which can illustrate the effects of the different scenarios on the different branches of the building industry.



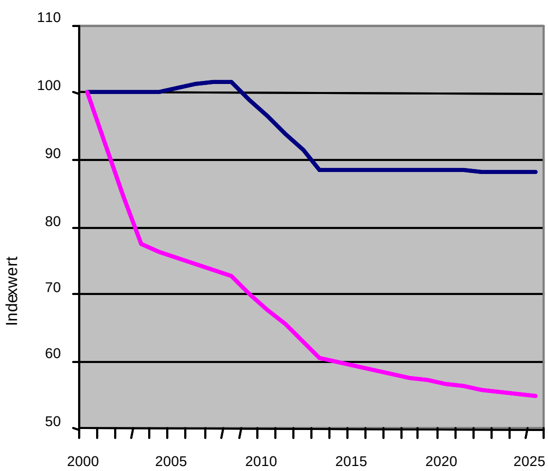


Fig 4 Indices of housing development on the wood- (left side) and concrete-industrie (right side) (Year 2000 = 100)

The effect on the wood- resp. the concrete industry is shown the figure below. The future slow down in building activities will hit the concrete industry in the sustainability scenario far more than the wood industry. Two reasons are: The orientation of housing policies towards refurbishment and modernisation of the existing stock instead of new housing construction and the assumed higher proportion of wooden instead of massive construction in housing.

The full length research documentation contains a lot of further interesting results. The software-tool BASiS-2 can be ordered by the Federal Environmental Agency of Germany or the author.

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USE OF ECONOMIC INSTRUMENTS FOR SUSTAINABLE CONSTRUCTION AND CHALLENGES FOR 2010 IN PARIS REGION

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ABSTRACT: This article presents firstly the results of a forward-looking survey entitled "HQE challenges for 2010 in the Ile-de-France Region", and secondly American and European cases of economic incentives directed toward building owners, developer or occupants like tax abatements, specialized investment fund and improved mortgage conditions… or directed toward construction companies or architects with lower insurance premium, lower VAT on ecological materials… The findings of this survey show to the contracting authorities the different arguments of economic gains resulting from sustainable construction using such instruments, instead of providing classical subsidy programs.

Conference topic: economy of sustainable building
Keywords: economic instruments, high environmental quality

Introduction

The "HQE" (High Environmental Quality) approach focuses within 14 targets on criteria for reducing consumption of natural resources and the discharge of pollutants (eco-construction and eco-management) as well as for enhancing the comfort and the health conditions of buildings. It concerns especially the design and the construction phases both of refurbishment and of new building projects [1].

To promote this approach among public authorities (departmental (county) councils, communes (municipalities), social housing backers) or private contracting authorities (banks, enterprises, developers), the ARENE (Regional Agency for the Environment and New Energies of the Paris Region) proposes innovative tools in the field of technical assistance, networking and education of key players.

The 14 targets of environmental quality for buildings	
Keeping the impacts on the outdoor environment under control	Creating an indoor environment that is satisfactory
Eco-construction :	Confort :
- 1 buildings blend in harmoniously with their immediate environment; - 2 integrated choice of building materials and products ; - 3 low-noise and low-pollution building site.	- 8 hygrometric comfort; - 9 acoustic comfort; - 10 visual comfort; - 11 olfactory comfort.
Eco-management :	Health :
- 4 energy management; - 5 water management; - 6 industrial waste management; - 7 cleaning and maintenance management.	- 12 health conditions; - 13 air quality; - 14 water quality

1. "HQE challenges for 2010 in the Ile-de-France Region" [2]

The aim of that survey was to present the overall reduction in environmental impacts, the economic benefits on saving measures in energy, waste, water, and greenhouse gas emission fields, and the job creation that would result from individual eco-building initiatives spreading in the period leading up to 2010.

For this purpose, 11 sectors and 7 environmental themes were examined both for new building and for refurbishment:

Sectors	*Themes*	*Aspects considered*
Housing - individual housing - social housing - private collective housing Tertiary - offices - secondary schools - primary and infant/nursery schools - health - gymnasiums - swimming pools - canteens	energy	Consumption (heating, hot water, lighting / natural lighting, specific electricity), Contribution to reducing the greenhouse effect
	Water	Consumption of drinking water Rainwater harvesting
	Maintenance	Cost of operating the building
	building site	Building waste Noise pollution generated by the building site; Occupational accidents
	noise and comfort	Acoustic comfort
	Materials	Wood
	Overall cost of operation	

Two development scenarios:

- an approach driven by strong political will: 100 % of the new construction or refurbishment operations between 1999 and 2010; and
- a more gradual "going with the flow" approach taking account of the commitments already made, and of the growing awareness of the players, with the following hypotheses:
  - 100% of the new and refurbished "lycées" (high schools/sixth form colleges) by 2006;
  - 70 to 80% of new or refurbished secondary schools and indoor swimming pools, and of new primary and infant/nursery schools by 2010;
  - 20% to 40% of new or refurbished sports establishments and social housing, and of refurbished primary and infant/nursery schools by 2010; and
  - 3 to 15% for new or refurbished offices, individual and collective private housing, healthcare establishments, and canteens by 2010.

As regards methodology, the survey firstly calculated energy and water consumption, and maintenance costs per major sector of buildings for 1999 in the Ile-de-France Region.

For the energy , the unit consumption in kWh/sqm x building stock in million square meter = Regional consumption in TWh. With considering the distribution between the uses (heating, lighting, hot water, cooking etc…) and the type of energy, we have got the expenditure by use x Stock in million square meter = regional expenditure in millions euros.

For the water, the unit consumption in m3/sqm x building stock in million square meter = regional consumption in million m3. The expenditure per use (washing, dishes, toilets, cooking, outdoors in Euro/sq) x Stock Msqm = regional expenditure in millions euros.

Secondly, working hypotheses were adopted concerning the unit consumption and spending for a building of the eco-building (HQE) type, compared with a conventional reference building.

The energy savings for HQE building compared to reference building stand between 50 % in new housing stock for heating and hot water use and 25 % for other use in HQE refurbished building of tertiary sector

The maintenance costs could be pulled down for new HQE educational establishment of 15 % and 10 % for the refurbished stock with two years return on investment.

Using this database, the survey was then able to explore two types of results:

- the total cost of an HQE operation with the cost per metric ton of carbon avoided, as calculated for each standard building of each of the sectors; and
- the consolidated impacts of generalising the HQE approach throughout Ile-de-France in 2010 in terms of overall savings in energy, in water, and in site management…

The impacts of HQE (eco-building) for the Ile-de-France Region in 2010 using the will-driven scenario

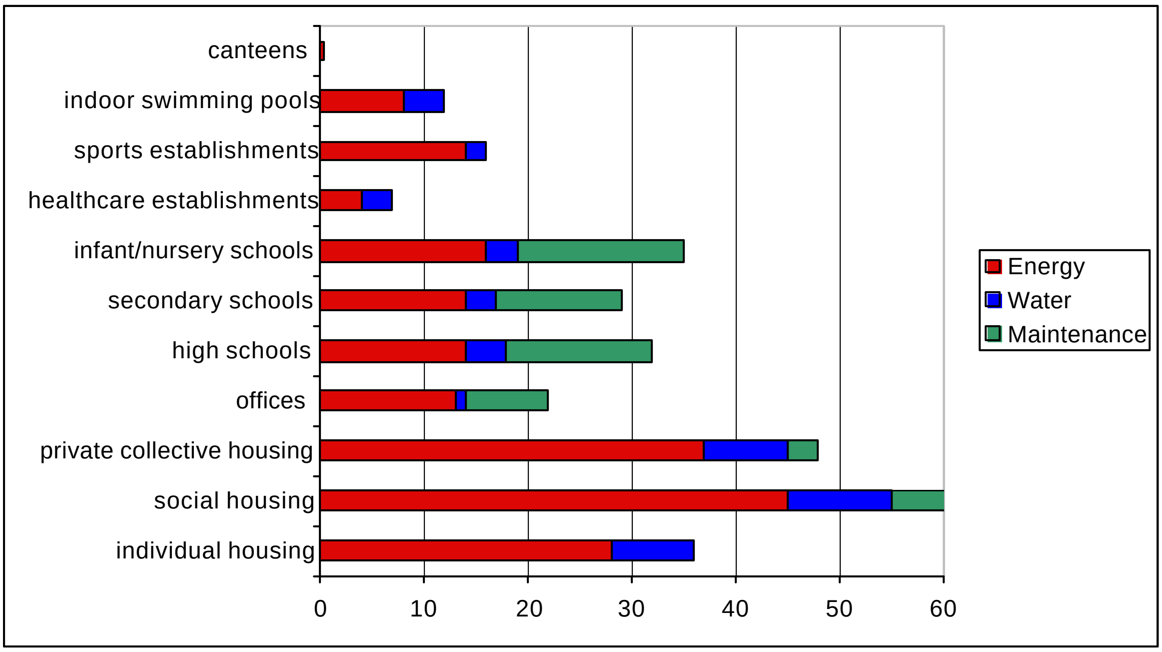
- 30% energy savings in the residential and tertiary sectors;
- 40% of the target for reduction of national greenhouse gas emissions, converted to regional level, i.e. 1.6 million tons of carbon avoided;

- 16% drinking water savings for the sectors surveyed (100 million cubic metres per year);
- a saving of 228 euros per year and per capita on the operating costs and maintenance costs for the buildings of the 11 sectors in the survey, i.e. as much as the annual budget of the Regional Council of Ile-de-France;
- savings on building waste management through sorting and selective demolition;
- greater use of recyclable materials and of renewable raw materials, such as wood;
- a reduction in the noise levels in housing, with 60,000 fewer people complaining about noise;
- a reduction in occupational accidents on building sites through quality approaches;
- 40,000 direct or indirect jobs generated for the building work and the infrastructure and fittings work, the average extra cost of HQE investment being 49 euros per square metre built or refurbished;
- average savings (net of depreciation) of 2.3 to 4.6 euros per year and per square metre built or refurbished; and
- overall, net savings (5% updated) of 8.2 billion euros over 15 years for an HQE investment for the period 2001-2010 of 17.5 billion euros.

The gradual "going with the flow" approach would make it possible to achieve only 10% of these potential savings. The largest percentage savings can be expected from teaching establishments, but in terms of volume, housing is the most promising sector for overall savings.

In all, the operating or usage savings for a building can reach 6.1 to 9.15 euros per square metre built or refurbished per year.
Such savings represent, for example, 8 to 10% of the cost of a social (subsidised low-rent) dwelling (rent + service charges): HQE could offer its occupants one month's holiday from rent per year!

Will-driven scenario : total savings in million euros in 2010



The results of the survey [2] as described also in the above figure, show the importance of global potential savings generated by HQE. At the same time, the level of needed subsidies to cover the first over-prices of investments for more environmental friendly building is a wrong question.
That is why the ARENE has investigated the interest to use other economic instruments as only the usual public subsidies programs.

2. Economic instruments for sustainable construction

Even if they are much more superior to the costs, the economic benefits of sustainable building usually don't motivate enough the decision-makers. One reason of this, is that the contracting authorities when they don't occupy themselves the premises or the dwellings recoup only a small part of the direct economic benefits. The occupants receive a bigger part of the direct benefits through the gains on operating costs. Secondly, the decision-makers don't get any profit of the global benefits for the local community [3 & 4].

To get round this difficulty, several economic and financial instruments could be set up in France or in others countries. Today the most current approaches are coming from the public authorities with fiscal tools and subsidies.

For this purpose, a study [5] was commissioned by the Paris Region Environmental Agency to gather information about possible uses of economic and financial instruments in accelerating the diffusion of sustainable construction

It was prepared by the research and consulting firm RDI-Recherche Développement International (www.rdi_consultant.com), on the basis of a questionnaire survey submitted to selected experts, primarily based in Europe and North America in mid June 2003.

Some 70 contributions from 12 countries (Belgium, Canada, Denmark, Finland, France, Germany, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, the United States) provided relevant information.

Economic and financial instruments considered are either already in use or being studied for possible future application.

2.1 – Classification of instruments in 10 categories with examples

➢ *1 – Preferential credit conditions for sustainable buildings*
- Improved mortgage conditions (e.g. "energy-efficient mortgages"; mortgages extending this rationale to other sustainable building features)
- Financial assistance for social housing awarded under specific sustainable conditions.

In Canada, Green Mortgage proposes reduced interest rate mortgage for homes built or upgraded to energy-efficient GreenHome standard. (eg : Yukon Housing Corporation, Caisse Desjardins)
In France, the Banque Populaire du Haut Rhin has created the Prévair: preferential green loans offered on the basis of a list of sustainable building criteria
The german Kreditanstalt für Wiederaufbau KfW has a CO2 Reduction Programme as well as a CO2 Building Rehabilitation Programme; OekoGeno (ex Oekobank) proposes also: preferential green loans

Most of the 24 County Banks in Switzerland offer green mortgages or energy - efficient mortgages.
In United States, HUD's Energy-Efficient Mortgages Program enables the financing of adding energy-efficiency features costs) ;
In United Kingdom, the Ecology Building Society, is a mutual organization founded in1981, who grants mortgages for ecological renovations, energy efficient housing, etc

➢ *2 - Reimbursement, rebates and investment aid offered by water or energy utilities, equipment suppliers, etc*

- Free water or energy audits
- Rebates or "Cash-back" schemes (e.g. for the purchase of water or energy efficient appliances, insulation materials, etc)
- Credit solutions offered for customers investments (eg : adapted leasing)
- Internal performance contracting

In Belgium Electrabel (Suez Group) offers subsidies and paybacks to customers installing solar heaters
In France the Energy service companies (ESCO) bundle lease offer to finance customers energy savings investments with energy management service offer
In Germany municipal enterprises in Germany (Stadtwerke) offer solutions to customers for financing energy – efficiency or water – saving investments. At the same time, several big municipalities like Stuttgart, Berlin has developed energy performance contracting between several departments within the city administration
In United States, several US electric utilities offer free energy audits relates on thermal in salutation material and reduced interest loans for insulation work. (eg : Seattle, Portland)

➢ *3 - Preferential insurance conditions for sustainable buildings; new insurance products*

- Lower insurance premium for sustainable building owners or occupants, for professional liability
- Insurance covering the predicted performance of Greenbuildings (e.g. : "energy-savings insurance", "indoor air quality insurance", etc)

In United States, Hanover Insurance Company : 10 % credit on omeowner property insurance premiums to energy – efficient homes) ; insurers in Massachusetts have offered 10 % discounts to people who take a free 6 h course in weatherization, home repair, etc ; a one-time credit of 10 % offered on Professional Liability policies to architects and engineers who receive training in building commissioning; the Building Air Quality Alliance and the Clair Odell Group have developed an IAQ risk assessment protocol and an IAQ insurance policy ; Willis Corroon is developing a new type of IAQ policy (bundling insurance with audits and guidelines)

➢ *4 – Setting up specialized funds for sustainable construction*

- Investment funds
- Guarantee funds

In Canada, the "Energy efficiency fund" launched in 2000 by Quebec energy utility to help finance energy efficient social housing, individual houses and commercial buildings.

In Germany, Kreditanstalt für Wiederaufbau KfW KfW : financial funds for energy – efficient buildings
In Netherlands, trio des Bank has a special funds for social and environmental projects
In Switzerland, Geneva County "Energy policy fund" offers reduced interest loans and guaranties to builders of energy – efficient individual houses and apartments buildings
In United States Green Building Loan Fund (CL Fund) to assist building owners with the implementation of green building practices; the Kresge Foundation also offers financing for greenbuildings
In United KingdomAston Reinvestment Trust, a social investment fund makes loans to housing organization based in Birmingham

➢ *5 - Fiscal bonus for the construction or renovation of Greenbuildings*

- Tax abatement (e.g. : property tax, income tax, business tax, etc)
- Tax credits for specific investments; lower VAT on ecological materials
- Exemption or reduction on specific tax or charge (eg : for solid waste or wastewater)

In Belgium, tax credits offered by the Belgian federal government for 7 energy – efficiency measures in building
In France, 15 % income tax credit for households investing in solar heaters, thermal insulation material; property tax credit considered for social housing (based on greenbuilding criteria)
In United States, New York State Green Building Tax Credit Legislation.
In United Kingdom, Lower VAT rate for energy efficient construction materials.

➢ *6 – Heavier fiscal burden on non- sustainable construction*

- Tax on virgin building material extraction
- Tax on water or energy consumption

In Denmark, tax on virgin building material extraction.
In Netherlands, « Regulatory Energy Tax » - REB on households; landfill tax
In Sweden, tax on virgin building material extraction; carbon dioxide tax on households
In United States, "Deposit and refund" program to encourage the recovery of construction & demolition debris (San Jose) ; EPA penalties against companies failing to control erosion and manage storm water at construction sites.
In United Kingdom, tax on virgin building material extraction

➢ *7 – Grants, subsidies*

- Grants for professionals (eg : incentive for training in sustainable construction practice)
- Subsidies to building owners (eg : to help obtain sustainable construction-related certification)
- Competition for social housing construction subsidies based on sustainability criteria

In Canada, Commercial Building Incentive Program ; Subsidies for training and R-2000 certification;.
In France, grants and subsidies for investments in energy efficiency and renewable energy (new and existing buildings)
In Netherlands, financial help for green buildings; CO2 reduction programs
In United Kingdom, financial help for training social housing corporation personnel to

become qualified Eco-homer Assessors
In United States, the State of Massachusetts offers subsidies for LEED certified buildings ; the City of Seattle provides financial help to pay for consulting

➢ *8 - Developers awarded added density allocations (density bonus) for sustainable buildings;accelerated building permit processing for sustainable construction*

In Switzerland, density bonus applied in the County of Vaud (Lausanne), being discussed by the Parliament of Geneva.
In United States, density bonus applied in Arlington County – Virginia, under study in Seattle and Santa Monica ; accelerated building permit process established in several US cities.

➢ *9 - Business rating indexes stipulating specific sustainable building management criteria among criteria used to assess the sustainable performance of firms*

In Finland, a rating system is developed for construction and real estate firms.
In Germany, the OEKOM rating agency asks companies one global question : "have they established environmental guidelines for facility management ?".
In Switzerland, Crédit Suisse integrates building environmental and energy management data on building management in its "Energy and materials" report.

➢ *10 - Trade of CO2 – Certificates*

In Germany, some preliminary discussion by the Gesamtverband der Wohnungswirschaft
United States New Jersey, Michigan and Texas have an open market emission trading program.
In United Kingdom, some preliminary discussion on a system involving energy distributors rather than building owners; a system of tradable permits for construction & demolition waste is considered following the recent "Consultation on the landfill allowance trading scheme" by the Department for Environment Food and Rural Affairs.

2.2 – Return of experience available per instrument type

The following table summarizes return of experience available per instrument type, combining a "level of application" indicator (frequency of application and number of countries where applied) and a "length of use" indicator.

Level of application in the building sector	Length of use in the building sector		
	First applications in the 1980's or earliers years	First applications in the 1990's or early 2000's	Still under study
Multiple applications in several countries*	Grants, subsidies Fiscal bonus (energy-related) Reimbursement, rebates, etc by utilities or suppliers Energy efficiency mortgages Specialized funds (energy aspects)		
Intermediate application level**	New insurance products (energy-savings insurance) Heavier fiscal burden on non-sustainable construction	Specialized funds for sustainable construction Fiscal bonus (non-energy-aspects) Improved mortgage conditions (non energy-aspects)	
Limited application***	Preferential insurance conditions	Density bonus Accelerated building permit processing	
Not applied yet			Financial assistance for social housing under conditions New insurance products (indoor air quality) Trade CO_2 -Certificates Improved business rating indexes

* Applied in most countries surveyed ; several hundreds or thousands cases
** Intermediate situation ; only a few countries concerned
*** Only a few cases identified (in 1or 2 countries).

According to our contacts, only a limited number of evaluation studies are available to assess the impact of economic and financial instruments on the construction sector. No evaluation studies were identified for some categories.

2.3 – Public and private players involved, current involvement levels

Both public and private players contribute to the availability of economic and financial instruments for sustainable construction. Contributions per instrument category are summarized below

Categories of economic and financial instrument.	Proposed by public organizations or institutions	Proposed by private players
1 – Preferential credit conditions for sustainable buildings	Additional bonus is sometimes offered by public sector players	Traditional banks, “new banks”*
2 – Reimbursement, rebates and investment aid offered by water or energy utilities, equipment suppliers, etc		Energy and water distributors, energy service companies, equipment and material suppliers
3 - Preferential insurance conditions for sustainable buildings; new insurance products		Insurance companies
4 – Setting up specialized funds for sustainable construction	Co-funding is sometimes offered by public sector players.	
5 – Fiscal bonus for the construction or renovation of Greenbuildings	National (sometimes state) or local	
6 – Heavier fiscal burden on non-sustainable construction	National (sometimes state) or local	
7 – Grants, subsidies	National (sometimes state) or local	
8 – Density bonus and/or accelerated building permit processing	Local authorities	
9 – Business rating indexes including sustainable building management criteria		Business rating firms
10 – Trade of CO2 – Certificates	Public operator of trading scheme	Private operator of trading scheme

* Newly founded financial institutions, specialized in sustainable economic activities (such new players are, in Europe, often member of INAISE, a network of financial institutions working for positive social and environmental change).

One or several active public players can be identified among national, regional or local public organizations or government bodies in most responding countries.

The current situation regarding private sector players is more varied: overall involvement levels vary among player categories and between countries (following table)

Categories of private players	Involvement level	Examples of leading countries
Traditional banks	***	Switzerland, Netherlands, United States, France
“New banks”	***	Germany, Netherlands, Belgium, United Kingdom
Energy distributors	***	Germany, United States, Belgium
Water distributors	**	Germany, United States
Energy service companies (ESCO)	**	United States, France, United Kingdom
Facilities Managers	**	Netherlands, Finland, Sweden
Equipment and material suppliers	**	Most countries
Insurance companies	*	United States
Private foundations	**	United Kingdom, United States
Business rating firms	-	Sweden, Finland (methodological aspects)
Private operators of certificate trading schemes	-	United States

*** 10 or more players belonging to this category offer economic or financial instruments for sustainable
construction.
** Intermediate situation
*Only a few “pioneer-type” players identified
- no player in active operation (future involvement under study).

As we see, private players are offering a raising number of instruments. Sometimes the public authorities imposes the involvement of private players for example through the law or with economical incentives promoting the regulation demands by final users asked by public regulators toward water or energy suppliers. Both public and private players could be also associated e.g. for loan co-bonus or private funds with public participations.

Conclusion

The ARENE, acting as interface between demand that has been growing strongly for the last 5 years and supply, architects, design offices, and builders, is thinking now about the contribution of economic instruments within a regional strategic development plan involving private players like bankers, insurance companies, energy providers in co-operation with the Regional Council Ile-de-France.

Description of the ARENE

The Regional Agency for the Environment and New Energies (ARENE) of the Paris Region was created in 1994 and is supported by the Regional Council of Ile-de-France. Its mission is to improve quality of life for the inhabitants of the Paris Region (population of 12 million) by making it easier for the relevant economic, social, and cultural players to incorporate the issues of the environment, of renewable energies, and of energy savings into the regional sustainable development programmes that they are currently drafting.

ARENE is a tool for implementing sustainable development on a regional level, and it conducts territorial action in seven fields: energy savings and renewable energies; industry and the environment; employment and the environment; local Agenda 21; sustainable transport; environment-focused education; and HQE ("Haute Qualité Environnementale" - high environmental quality or eco-building).

Such action involves supporting reproducible pilot projects, providing expertise and practical assistance, promoting exemplary actions and leading networks of participants.

ARENE assisted the Regional Council with the first implementation in France of the "HQE" approach to building a secondary school, the “Collège Maximilien Perret” (architect Maximiliano Fuksas), in Alfortville in 1997.

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SUSTAINABLE HOTELS – ECO-CERTIFICATION ACCORDING TO EU FLOWER, NORDIC SWAN AND THE POLISH HOTEL ASSOCIATION

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Abstract

Over their lifetime (including construction, operation, maintenance, and eventually demolition), buildings require appreciable amounts of energy, water and many other resources. The built environment is undoubtedly the origin of a considerable portion of the overall air, water and soil pollution, as well as waste generation in our society.

Hotel buildings, due to their very specific and unique function and operational patterns, generally have a much larger ecological impact than other commercial buildings of similar size. At the same time, the well-being and development of the tourism and the hotel industry, relies heavily on the availability of a clean, natural environment. It is crucial for the sustainability of ecological systems, as well as business operations to ensure that hotel facilities are designed, constructed, operated and refurbished in a manner that is least harmful to the environment. If the environment is part of your business, protecting the environment means protecting your business.

For many years, the hotel industry was reluctant to acknowledge any significant influence on the natural surroundings. Recently, however, attitudes have started to change. In order to help hoteliers incorporate more environmentally sound practices into daily operations, branch associations, various NGOs, academic communities and hotel companies continue to develop guidelines and manuals. Industry self-regulation, in the form of certification and labelling schemes, has proved to be a valuable additional tool. Numerous certification and labelling schemes are offered internationally, nationally or locally by industrial organisations, as well as by governmental and non-governmental institutions (EU Flower, Nordic Swan, Green Globe 21, Green Leaf, The Green Key, and others).

This paper will focus on the criteria and requirements developed for the EU Flower and Nordic Swan ecolabels, as well as those prepared by the Polish Hotel Association for the EKO HOTEL label. The mandatory and optional criteria listed in the documents will be presented, analysed and compared, followed by a brief summary of the schemes' current status, as well as suggestions on how similar policies/projects could be launched in other countries.

Keywords: hotels, ecolabels, criteria, EU Flower, Nordic Swan, EKO HOTEL

1. Introduction

Over the years, a number of documents aimed at incorporating environmental and socio-cultural responsibility into tourism business practice have been published. Among the most significant are the 1995 "Lanzarote Charter for Sustainable Tourism" (issued jointly by the World Tourism Organisation, the United Nations Environmental Programme, UNESCO and the Commission of European Communities), and "Agenda 21 for the Travel and Tourism Industry: Towards Environmentally-Friendly Sustainable Development" (launched in 1996 as a result of a co-operation between the World Travel and Tourism Council, World Tourism Organisation and the Earth Council). The mere existence of these documents, however, cannot initiate and sustain the significant processes of change needed in the travel industry in order to achieve greater environmental responsibility. Proper implementation tools need to be developed, and strategies need to be elaborated to assist the industry in willingly embarking on a course of change.

The primary instruments of action include the enforcement of binding legal regulations (health and safety requirements, planning and building regulations, regulations on water, waste and emissions), environmental taxes (on the use of energy and water), as well as voluntary standards.

Industry self-regulation has recently been gaining more and more attention, and has demonstrated to be convincingly successful. The most significant types of self-regulation include codes of conduct and various certification schemes (awards and labels). Environmental certification schemes are a fairly new concept in the business world. The first ecolabels originated in Europe and appeared in the travel and tourism industry in the mid-1980s. Their number and diversity has significantly increased during the 1990s. Currently, over 100 ecolabelling and certification schemes are available for tourism and the hospitality industry worldwide [1, 2]. Europe alone has almost 50 labelling schemes [3].

The primary objective of ecolabels and other recognition schemes is to stimulate environmental concern both from the perspective of the producer as well as the consumer, by providing reliable environmental information to the consumer and thereby influencing his/her preference and choice when acquiring goods and services. Ecolabelling may further improve the product image and sales. Indirectly, ecolabels may have an innovative effect, by stimulating the development of new products and practices in the industry. Their main function is to assure commitment to continuous improvement and to provide sound motivation for introducing new technological solutions.

The focus of different certification schemes may be regional, national or international, and ecolabels may be awarded for a single product, service, or a group of services. Certification schemes focused on accommodation facilities include HVS EcoServices Ecotel (worldwide), Green Leaf (Thailand), Green Key (Denmark), Nordic Swan (Scandinavia), EU Flower (European Union), and others. Despite existing differences, certification schemes have many common components, including voluntary enrolment, utilization of easily recognizable logos, required certification criteria (some of which may even be more stringent than existing regulations), documented commitment by companies to pursue sustainable practices, compliance assessment and auditing requirements (preferably performed by independent bodies, such as accredited organizations), as well as membership and fees [4].

2. The development of labels

2.1 Nordic Swan

Among the three labels for the tourism accommodation facilities considered in this paper, the Nordic Swan may be referred to as a veteran. In 1989, the Nordic Council of Ministers adopted a measure of implementing a voluntary ecolabelling scheme in the Nordic countries, and in 1999 the first criteria document for hotel facilities was produced [5]. Eversince, the criteria were revised and extended to include different types of hotels, including youth hostels. The second criteria document is valid from October 3, 2002 until September 30, 2006 [6].

2.2 EU Flower

Following repeated requests for a single, universal and commonly recognized European label, the European "Eco-Label Award Scheme" was adopted by environmental ministers in December 1991, and set up under the Council Regulation (EEC) 880/92 of 23 March 1992. It came into force in October 1992. In April 2003, directives for the EU Flower label for tourist accommodation were established and a criteria document was published (*"Commission Decision of 14 April 2003 establishing the ecological criteria for the award of the Community ecolabel to tourist accommodation service"* – 2003/287/EC) [7]. The criteria specified by the Decision of European Commission 2003/287/EC are valid between May 1, 2003 and April 30, 2007. If the revised criteria are not adopted on April 30, 2007, the current Decision should apply until April 30, 2008.

2.3 EKO HOTEL

In response to requests by the Polish hotel sector, the Polish Hotel Association – PHA (Polskie Zrzeszenie Hoteli) decided in 2003 to investigate the issue of environmental protection in the hotel sector. Approximately 500 hotels are to be targeted by a questionnaire survey. Based on the outcome of the study, PHA is planning to establish criteria for its own ecolabel for hotel accommodation – EKO HOTEL [8].

Similar, questionnaire-based surveys were earlier performed by Kulesza in 1999 [9], and by Bohdanowicz in 2002 [10, 11]. Unfortunately, neither of these studies were supported by PHA, and response rates were typically low (123 participating facilities in the study by Kulesza among 1700 hotels targeted, and 124 participants in the study by Bohdanowicz of 942 targeted).

Unfortunately, the Ministry of Economy, Labour and Social Policy decided not to support the PHA initiative financially, thereby causing a delay in the project [12]. The authors will nevertheless discuss the specifics of the Polish labelling scheme, as well as the practicability of this certificate in Polish conditions.

3. Costs

Application and annual fees for the Nordic Swan vary among countries. The relevant costs in Denmark, Finland and Sweden are compared in Table 1 [13, 14, 15, 16]. Application fees vary from approximately € 460 in Denmark to € 2440 in Finland, while the annual fees varied between 0.2% (in Finland) to 0.4% (in Denmark) of the annual company turnover (for the product/service in question). Extension and renewal fees are also compared.

Table 1. Nordic Swan fees [13, 14, 15, 16]

Country	Application fee	Annual fee	Extension or renewal fee
Denmark	€ 460 (DKK 3500)	0.4% of annual turnover, max. € 32 700 (DKK 250 000)	€ 460 (DKK 3500)
Finland	€ 2000 + 440 (VAT)	0.2% of annual turnover, min. € 675 + 149 (VAT), max. € 34 000 + 7480	€ 1000 + 220 (VAT)
Sweden	€ 1950 (SEK 18 000)	0.3% of annual turnover, min. € 970 (SEK 9000), max. € 37 800 (SEK 350 000)	€ 970 (SEK 9000)

In the EU Flower scheme, applications and annual fees are regulated by Decisions of European Commission 2000/728/EC and 2003/287/EC [7, 17]. Basic application fees are in the range of € 300 to € 1300, with possible reductions of between 25% (for small and medium size enterprises - SME) to 75% (for micro-enterprises and mountain huts). These fees cover verification and certificate issuing costs. The annual fee is based on the annual volume of sales, but cannot be lower than € 100. It is calculated as 0.15% of 50% of the annual volume of sales. SME can apply for annual fee reductions of up to 25%, while facilities already certified with ISO 14001 or EMAS can have the fee reduced by 15%.

The Polish Hotel Association initially planned to award EKO HOTEL certification to 10 facilities free of charge during the first year of the scheme. In case of a successful acceptance of the scheme, relevant fees would have been established for subsequent use (while application fees of € 600-800 were envisioned, no concrete information on the actual annual fee amounts could be obtained from PHA) [18].

4. Criteria and procedure

Two of the labels have criteria classified as mandatory and optional, i.e. as so-called point requirements (Table 2). So far, a number of areas of concern for the EKO HOTEL scheme have been identified but no criteria document has yet been established.

Application/certification procedures for all three labels are similar. Generally, hotels contemplating certification should first contact the cognizant authority responsible for certification in order to obtain information on application procedure and labelling criteria. After all of the necessary documents have been collected by the hotel management, a team from the cognizant authority inspects the appropriateness and correctness of all documents, and performs an independent hotel audit (in the case of EU Flower and Swan). Once all of the documents are approved and the application fee is paid, the facility is awarded a label. The certificate is valid within the time period stated, and if desired, can be prolonged following an external audit.

Table 2. Division of criteria [6, 7]

Criteria	Nordic Swan	EU Flower
Mandatory	21 – 24* + 12**	37
Optional	58 – 76***	47****

* depending on the type of facility and services offered (kitchen/restaurant, conference department, pool, garden)
** requirements in the area of environmental management
*** a minimum of 65% of all point requirements, and 60% of the point requirements within the area of operation and maintenance must be met
**** total of 72.5 credits, with a minimum of 16.5-19.5 credits having to be attained, depending on the type of facilities and services offered (kitchen/restaurant, fitness facilities, green areas – 1 point for each area)

4.1 Nordic Swan

In addition to a set of mandatory requirements, the Nordic Swan scheme identifies four basic limit values, two of which need to be fulfilled by a hotel in order to be certified. Each limit value is divided into three distinctive sub-levels, depending on the annual facility turnover, size and the facilities offered, as well as climatic location [6]:

- Energy consumption (limit of 235 – 460 kWh/m^2);
- Water consumption (limit of 200 – 300 litres per guest-night);
- Active chemical-technical content (limit of 25 – 35 grams/guest-night);
- Volume of unsorted waste (limit of 0.5 – 1.5 kg/guest-night).

These limit values make the Nordic Swan certificate unique among the labels investigated, as well as among other certificates on the market.

The Nordic Swan criteria are divided into departmental sub-classes: operation and maintenance; consumables; fixtures, fittings and equipment and other equipment; guest rooms; kitchen and dining room; cleaning and laundry; waste; and transport.

The Nordic Swan criteria are very specific in identifying materials that can be used on the premises. For instance, the facility has to operate on a CFC-free basis, and without the use of any active chlorine compounds. Newly purchased products cannot contain PVC (polyvinyl chloride), or be treated with brominated or chlorinated flame retardants. At least 90% of chemical products used must consist of easily degradable tensides. The water supply and wastewater management of a facility must comply with national and local laws, and all new toilets are required to use no more than 6 litres of water per flush. The facility is responsible for the sorting of waste and hazardous waste into at least 4 fractions at source, ensuring hazardous waste disposal in the best possible way from an environmental point of view, as well as maintaining information on how ordinary waste is being processed. No disposable articles, portion packaging or small packets are allowed in guest rooms or on the breakfast buffet (with the exception of toothpicks, napkins and teabags), and at least 60% of rooms are required to be smoke free. The vehicle fleet must be regularly inspected and serviced. Moreover, 30% of the suppliers are required to make their regular deliveries using renewable packaging.

Mandatory environmental management criteria include the company compliance with relevant environmental legislation, possession of environmental policy and action plan for constant performance improvement, as well as regular staff training in environment- and Swan-related issues. In addition, the facility is required to have documented routines for “green” purchasing, technical services, management of chemicals and continuous monitoring of compliance with limit values. Information regarding pro-ecological initiatives at the hotel and the compliance with Nordic Swan certification requirements must be readily accessible to hotel guests. Environmental requirements are required to be followed up annually using a Nordic

Ecolabelling checklist, which must be signed by the person responsible for the Swan licence and returned to the relevant ecolabelling secretariat.

Among optional criteria, points are awarded for the use of non-fossil and non-nuclear energy sources for electricity generation and heating purposes (depending on the percentage share), efficiency of systems and existing controls. The use of ecolabelled consumables, detergents, fittings, fixtures, equipment and food is strongly encouraged. The criteria document further requires automatic dosage of chemicals, as well as the reuse or recycling of consumed fixtures, fittings and equipment. Points can be achieved for renewably powered vehicles, as well as bicycles available to guests. Information about public transport to/from the hotel should be made available to guests, together with commuter transportation. Extra points are granted if the hotel passes more than two mandatory limit values.

Not all requirements listed in the Nordic Swan criteria document have been presented above, instead, an overview of the areas of concern has been made.

4.2 EU Flower

EU Flower criteria are divided into broader categories relevant to management, the utilization of energy, water, waste and chemicals, and a set of other issues.

Due to a much broader regional scope of EU Flower, as compared to Nordic Swan, different market conditions need to be considered. As regards the utilization of renewable energy, waste sorting and recycling, or the use of disposable items, the EU Flower scheme states that particular criteria need to be fulfilled, *local conditions permitting*. In case of inability to comply with specific requirements, an explanatory document needs to be submitted by a qualified local authority.

Directive 2003/287/EC specifies the minimum efficiency ratings of boilers, air conditioners, and light bulbs to be purchased within the period of validity of an ecolabel, as well as the proportion of energy-efficient lighting to be achieved one year after the adoption of the labelling scheme. The directive further specifies the maximum allowed sulphur content of fuels used in facilities (0.2%), as well as the maximum allowable water flows from taps and showers (12 litres/minute). The EU flower label requires hotels to ensure proper treatment of wastewater, as well as separation and proper handling of waste (hazardous and municipal). Most of the remaining mandatory criteria deal with behavioural issues, including requirements to display information encouraging water and energy preservation in hotel rooms and public areas, information on possible public transport options, as well as the provision in guest rooms of adequate receptacles for waste sorting. Hotel personnel should be trained in enforcing environmental measures at their facility as well as in performing regular inspections of systems and ensuring their maintenance. Tourist accommodation facilities should, further insure that data on the consumption of water, energy and chemicals, as well as the volume of waste generated is monitored and evaluated. This information should be made available annually to the relevant ecolabelling secretariat.

The EU Flower provides optional criteria concerning the on-site installation of renewable energy systems or heat pumps, the utilization of energy-efficient systems and equipment, adequate controls, as well as the incorporation of bioclimatic architectural design. Further criteria relate to the use of water-conserving equipment, low-flow faucets and toilets, water-flow control systems, as well as the utilization of rain and recycled water. Additional criteria concern the use of chemicals, ecolabelled detergents, paints and varnishes, as well as organic gardening procedures. Composting, as well as the reuse or donation of used textiles and furniture are encouraged, while disposable and single dose packaging (where allowed) is strongly discouraged. The scheme gives explicit preference to the utilization of eco-labelled durable goods, paper products, refillable soft drinks bottles, local food products and organic foods. Extra credits are awarded for EMAS registration or ISO certification of the facility or its suppliers, the installation of additional energy and water meters, as well as the provision to guests of environmental questionnaires. Additional credits can be earned for environmental initiatives not covered by the Directive or by the possession of a national or regional ISO Type I ecolabel.

While being far from complete, the above list, aims at providing a representative overview of the broadness and the depth of the issues included in the criteria document.

4.3 EKO HOTEL

As mentioned earlier, the criteria document for the EKO HOTEL scheme is intended to be developed after the completion of an investigation of the current state of environmental protection in hotels in Poland. However, the Polish Hotel Association (PHA) has already identified a number of criteria for assessing hotel performance. These include wastewater management; waste management; water supply and conservation, energy supply and conservation, environmental management, noise protection in hotels and their immediate surroundings, green areas, building materials and architecture, initiatives for the natural environment, the siting of hotels and their surroundings, the quality of hotel-owned/-managed beaches, water-levels in aquifers tapped, as well as information about environmental protection in hotels. The final set of criteria will be further developed based on international standards and Environmental Management System concepts.

5. Market penetration

To date, 80 hotel facilities have been certified with the Nordic Swan label in Scandinavia [19]. This number will increase, as all Scandic Hotels in Sweden are currently being certified. In addition, all 18 Norwegian Scandic hotels are expected to be Swan-labelled by the end of 2005 [20]. So far, two Norwegian hotels have already been certified [19].

The EU Flower has been awarded to four hotels (Hotel Florian in Austria, Sunwing Resort Kallithea in Greece, as well as Gala Mountain Resort Hotel & Chalets and Park Hotell in Norway). A number of other hotels are in the process of applying for certification [21].

Originally, 10 hotels were to be awarded the EKO HOTEL label in October 2004 during the Tour Salon and Hotel Market Fair in Poznan. However, due to cutbacks in funding, the future of the label is uncertain.

6. Barriers

Despite the benefits offered by environmental labels, their market penetration is still extremely limited. In Europe only 1% of all accommodation facilities are ecolabelled [22]. This is due to a number of factors, undoubtedly including the large number of labelling schemes, which cause appreciable confusion among customers and industry professionals. It is expected, however, that attitudes may change, once the EU Flower scheme will have become available to hoteliers all over Europe. While some labels, such as the Nordic Swan and EU Flower, are widely recognized by the public, it is not uncommon for hotel management to ignore the existence of such schemes. It is frequently claimed that application procedures are too costly, complex and time consuming, and that certification eventually results in very limited economic benefits [23]. Other common complaints relate to the complexity of technical measures and procedures required, as well as the disruption of regular operational procedures caused by their implementation. Ironically, it is not uncommon for certification requirements to be in direct opposition to local or national laws, rendering compliance impossible.

By contrast, the environmental coordinator of the Sunwing Resort Kallithea in Greece, an EU Flower certified facility, stated that 42 points were easily achieved at the resort by meeting voluntary criteria (whereas only 19 points were required) [24]. A similar opinion was expressed by a Scandic representative, stating that Nordic-Swan-labelled facilities would easily comply with EU Flower criteria, should they decide to apply for the label [25]. He further believed that even those Scandic hotels that are not yet Swan-labelled should be able to comply with EU Flower criteria. It is worth mentioning that Scandic has been involved with environmental issues for over a decade now, and is recognized as an environmental pioneer and leader in this domain.

Several European studies [23] indicate that a segment of hoteliers believe that the enforcement of laws and local standards (e.g. those concerning waste-separation) is an efficient tool in bringing about environmental responsibility. The same studies show that some hoteliers perceive the concept of efficient equipment as being equivalent to "new" equipment, and eco-certified products and appliances as being those branded by manufacturers with names containing the terms "eco-" or "bio-" (irrespective of certification by cognizant authorities).

Environmentally certified establishments undoubtedly need to be promoted and marketed more efficiently. Ecolabelled facilities should be promoted in hotel catalogues / directories, city guides as well as by booking and travel agencies. Such inititatives would, for example, be appreciated by 12 million German travellers as indicated by the 2000 FEMATOUR study [26].

A number of customer surveys reveal that some travellers believe ecolabelled services to be more expensive and not worth paying for [1]. Other studies show that travellers would be willing to pay more for the privilege of staying in ecolabelled facilities [10, 27].

7. Opportunities – social reception

Recent studies have shown that the environmental awareness in Europe is continuously increasing [26]. Although environmental concerns still have little influence on the choice of tourist accommodation, it is likely that the proportion of "green" hotel customers will increase in the coming years.

A survey carried out in 2002 by Small Luxury Hotels of the World for the International Hotel Environment Initiative revealed that 54% of American, 60% of Australian and 87% of British travellers would prefer to stay at environmentally friendly / eco-certified facilities during their travels (given the location of the facility was acceptable, the level of service high, and the price reasonable) [28]. Approximately 40% of Europeans in the Ecotrans e.V. study [29], and almost 60% of the respondents in an investigation performed in 2003 among the customers of four Finnish and Swedish hotels shared the same opinion [10]. According to an investigation performed on the German market and published in *German Reiseanalyse 2002*, 25 million Germans believed it to be important to stay at environmentally friendly hotels [22].

Middle-aged and highly educated Scandinavian business and conference travellers, seemed more inclined to chose eco-accommodation during their travel [10]. This rhymes well with the findings of the American Travel Industry Association and the National Geographic Society *Geotourism Study*, which identified eight types of travellers within the American society [30]. Three of the sub-groups, GeoSavys, Urban Sophisticates and Good Citizens are believed to be most prone to opt for eco-travel. These groups typically consist of middle-aged individuals with a higher education, representing 55.1 million Americans, i.e. more than 30% of the entire travelling American public [30].

Other studies revealed that 30% of all British adults [27], and 20% of Scandinavian hotel guests interviewed [10], were willing to pay more for a stay at an eco-certified facility. Based on the data available it may be difficult to judge how representative these figures are of all European travellers. Nevertheless, it appears reasonable to expect that hotel customers will increasingly demand "green alternatives" in the future, and that this will motivate hoteliers to gradually become more environmentally responsible.

8. Benefits

In an initial phase, eco-labelling criteria can actually be used as guidelines for how to improve the environmental performance of a hotel facility, without having to apply for certification *per se*. When a sufficient amount of improvements is achieved it is always possible to apply for formal certification.

Ecolabels may have a positive influence on hotel staff, which is significant, considering the relatively high personnel turnover in the tourism industry. In addition to improved working conditions, resulting from compliance with certification requirements, ecolabelling was found to increase productivity. A higher degree of identification with the ecolabelled workplaces was further found to contribute to lower staff-turnover. Scandic team members are typically very proud of the environmental achievements in their facilities and are highly aware of the fact that they have contributed significantly in the process [11].

As regards the economic aspects of environmental certification, it is important to emphasize that environmental responsibility and higher profitability clearly need not be mutually exclusive. On the contrary, there exist a number of convincing examples of facilities where proactive environmental management, including lower water consumption, waste-water treatment, lower energy consumption and a variety of other measures were successfully combined with increased profits [10].

The hotel industry is highly competitive, and substantial effort is invested in business profiling and conquering increasingly specialized market niches (as can be seen from the increasing number of boutique hotels). Eco-labelling has the potential of becoming a valuable tool in this context. While it need not at all be more costly to operate a facility in an environmentally responsible way, evidence exists that some travellers would actually be willing to pay a premium for the privilege of staying in a "green" facility. Irrespective of whether this is based on genuine environmental concern, or on sheer trendyness, this still remains a potentially untapped marketing asset.

As usual, early users are likely to reap the largest share of the economic and other benefits.

9. Conclusion

Hoteliers are increasingly encouraged to incorporate environmentally sound practices into their daily hotel operations. Industry self-regulation in the form of eco-certification and ecolabelling has demonstrated to be successful, and has led to the creation of almost 50 labels for tourist accommodation in Europe alone. Some labels remain of local importance, while others, including the Nordic Swan, have become widely recognised (on the Scandinavian and European markets).

In order to help both hoteliers and tourists in their decision making process, the EU Flower ecolabelling scheme has been extended to include tourist accommodation services located throughout EU member states, and some neighbouring countries.

The availability of a single ecolabel on the European level need not result in the discontinuation of all previously developed certification schemes. Some labels may be gradually withdrawn, primarily those with a short life span, limited product scope and area range, while other labels, widely recognized and with criteria more strict than the EU Flower are destined to remain. The Nordic Swan ecolabel belongs to the second category, being recognized by 91% of the population in Sweden, 85% in Norway, 75% in Finland, 56% in Denmark and 52% in Iceland [6]. Due to the fact that the Scandinavian countries are generally more environmentally oriented than the rest of Europe, the criteria of the Swan label are more specific and frequently much stricter than those specified by the EU Flower. Relinquishing this label would in many ways amount to an environmental setback. Nordic-Swan-labelled hotels are likely to not apply for EU Flower certification, unless this would be pursued for pure marketing reasons, as indicated by Siw Sandnes at the Park Hotell in Norway [31]. The

Park Hotell received the Swan label in 2001, and renewed its certification in 2003. Management at this facility, however, believe that the Swan label is less known in the rest of Europe than in Scandinavia, and that being EU-Flower-certified would afford them recognition beyond Scandinavia. In the Nordic countries, the EU-Flower-certification could be employed as the first step in complying with Nordic Swan criteria.

The authors believe that an independent labelling scheme for Polish hotels is not likely to be useful. As members of the European Union, Polish hoteliers are entitled to apply for EU Flower certification, a labelling scheme recognized throughout Europe. As to marketing potential, being recognized and duly appreciated is crucial in today's business. While visitors from France, Italy or Finland cannot be expected to distinguish between local or national labels existing in different European countries, they are likely to recognize the EU Flower. Funds allocated for the development of the EKO HOTEL certification scheme should rather be used for nationally promoting EU Flower certification, as well as for establishing the necessary educational, training and institutional framework.

An investigation of the state of environmental protection in Polish hotels should nevertheless be performed. Also, a Competent Body responsible for EU Flower certification in Poland should be designated as soon as possible. The Polish national certification system has traditionally been harmonized with the European system, and the most recent certification criteria are based on EU Flower requirements [32]. However, until adequate legislation is adopted and a Competent Body established, Polish authorities will not be able to practice EU Flower certification. So far, no promotional campaigns have been launched in the country, and, only a single press release concerning hotel certification has appeared in national industry journals [33, 34, 35].

All stakeholders concerned should join in the effort of promoting the EU Flower certification scheme, preparing the ground for its adoption by all EU member states, assisting producers and service providers in qualifying for the label, and contributing to greater environmental responsibility in the industry throughout Europe.

If the environment is part of your business, protecting the environment means protecting your business.

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ENVIRONMENTAL EDUCATION AT SCANDIC HOTELS – APPROACH AND RESULTS

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Abstract

Energy is one of the most crucial resources utilised by the hotel industry. High proportions of fossil fuel generated energy, with the utilisation of renewable energy sources still at a marginal level, directly translate into significant pollution of the environment, both locally and globally. At the same time, the very essence of tourism is based on the availability of a clean natural environment. The need for more effective environmental protection measures is being increasingly recognised by both travellers and industry. The successful implementation of more sustainable practices in the hotel industry is, however, highly dependent on the active support and cooperation of all stakeholders involved.

In this paper the development of Scandic's environmental program in Sweden will be presented, followed by a comparison of the level of environmental awareness and involvement in energy conservation activities pursued by Scandic and other Swedish hoteliers. Moreover, an analysis of energy consumption patterns resulting from the incorporation of the "Resource Hunt" program will be presented. The analysis is based on data reported in the Scandic Utility System (SUS) database. Finally, benefits resulting from environmental/energy education will be discussed.

Keywords: hotels, education, energy, Scandic, energy conservation

1. Introduction

Hotels typically represent only about 3–5% of a nation's building stock [1, 2, 3], yet they constitute one of the most important sectors of the travel and tourism industry, and provide accommodation to 40–50% of all domestic and international visitors [3, 4, 5]. On the European scale this translates to 160–200 million guests per year [6].

Hotels are designed to provide high levels of comfort and services to customers on a 24-hour-a-day, 7-day-a-week, year-round basis. The competition on the hotel market is fierce. To attract more customers and remain profitable, hotels are continuously trying to offer more diverse and better services, as well as a higher quality and quantity of entertainment. This is typically done with little concern for associated environmental or socio-economic impacts, leading to many forms of overexploitation (not only of energy and other resources).

Hotel facilities rank among the top five in terms of energy consumption in the commercial/service building sector (minor only to food service and sales, health care and certain types of offices) [2]. European hotels were estimated to use 39 TWh of energy in 2000 alone [7]. Taking into consideration that three-quarters of primary energy in Europe are derived from fossil resources, the sector's contribution to global environmental problems, particularly acid rains, global warming and climate change is not negligible. Assuming a worst case scenario where all the energy used in hotels would be based on coal and electricity as a primary energy source, hotels located in Europe would be responsible for the annual emission of 13.6 to 16.77 megatonnes of carbon dioxide (emission factors for coal taken from [8] and for electricity from [9]). There is no data available specifying the exact amount of energy consumed by Swedish hotels, however, in 2002 Swedish hospitality properties (hotels, restaurants, student dormitories) were estimated to consume 2.14 TWh of energy in the forma of heating cooling and electricity [10]. It is believed that a significant amount of the energy used in this sector is wasted, leaving ample room for ambitious measures of energy-efficiency and conservation.

The willingness and ability of hotel management to advocate and implement state-of-the-art environmentally responsible behaviour and practices is crucial for the incorporation of more sustainable hotel practices. Hotel corporations, representing 20-29 % of all hotels in Europe and as much as 70 % in North America [11, 12, 13], may play a very important role in changing the image and performance of the hotel sector. Nowadays, environmental responsibility is frequently a corporate issue, and various pro-ecological initiatives proposed by top management are increasingly implemented at various corporate levels. A central approach to promoting environmental concern has been successfully implemented by Scandic Hotels.

Scandic, now a member of Hilton International, is one of the largest hotel companies in Sweden and in Scandinavia. Currently there are almost 150 hotels bearing the Scandic logo in northern Europe. In 1993, the management of Scandic Hotels decided to focus more on environmental issues in order to become "one of the most environmentally friendly hotel chains". The "Environmental Dialogue" project was launched and internal training material based on The Natural Step's System terms was produced. Over time, a new goal was set – "to become the most resource-efficient hotel company" and Scandic aims to achieve this "whilst retaining or increasing comfort and customer benefit". The work continues and the results already achieved are highly encouraging.

2. The development of the Scandic environmental program

2.1 The Environmental Dialogue

Environmental concern became a fundamental part of the Scandic agenda in the early 1990s. A new Scandic environmental profile was developed on the basis of The Natural Step concept [14]. The Natural Step defines its basic concept in the following manner [15]:

"In a sustainable society, nature is not subject to systematically increasing…

1. *…concentrations of substances extracted from the Earth's crust* (use all mined materials efficiently, and systematically reduce dependence on fossil fuels)*;*
2. *…concentrations of substances produced by society* (substitute persistent and unnatural compounds with ones that are normally abundant or break down more easily in nature, and use all substances produced by society efficiently)*;*
3. *…degradation by physical means* (use only resources from well-managed eco-systems, and use both resources and land more efficiently)*;*

and in that society…

4. *…human needs are met worldwide* (use all resources fairly and responsibly so that the needs of all people on whom we have an impact, and the future needs of people who are not yet born, stand the best chance of being met)*."*

During 1994, Roland Nilsson, the CEO of Scandic AB, worked together with Karl-Henrik Robèrt from The Natural Step and the environmental teams from both companies to develop the "Environmental Dialogue" training program for Scandic. The program focused on providing education in the area of environment, involving team members in various pro-ecological activities, and providing feedback on environmental performance of particular facilities and the entire chain. It contained the following four components: environmental guide, environmental meeting, an environmental program and an environmental barometer.

The environmental guide includes a description of the "Environmental Dialogue" process, the Scandic Environmental Policy and goals, as well as information on current activities and suggestions aimed at stimulating environmental concern. In 2001 a new interactive program was introduced and is currently available at the Scandic intranet platform, Kunskapsportalen. The opportunity of receiving environmental training is provided for all employees joining Scandic, and it is currently being incorporated at Hilton in the form of an "Eco-learning" program. The interactive environmental training, included in the "Get on Board" section, also termed "checkin@scandic", includes information on personal and hotel-related dependence on natural resources as well as impacts created. It also poses a series of questions concerning personal attitude towards proper environmental behaviour, as well as recommendations on how to become more environmentally conscious. The training lasts for approximately 2 hours, but does not have to be performed at once. Every hotel is equipped with a computer dedicated solely to the purpose of training team members, enabling personnel to visit Kunskapsportalen at a time suitable to them.

To facilitate the understanding of issues covered in the training pack, several intermediate tests are included, while, at the conclusion of the training, a 10-minute test is given, and upon the successful completion of this test (which can be repeated as many times as necessary) team members will receive employment benefits. The training program is initiated with a short overview of the history of life on Earth and human dependence on natural resources, followed by the introduction and explanation of the Natural Step concepts. Thereafter, information is divided into categories dealing with energy, water, waste and chemicals, their consumption and conservation options. It includes an indication of the most environmentally-sound choices, as well as information about the suppliers' role in the overall environmental performance, followed by an explanation of eco-labels, as well as information on organic and eco-food. The concept of environmentally-sound transportation is also examined, together with the choices of building materials used at Scandic. Most of the issues are analysed from a Scandic perspective and all Scandic-specific concepts are introduced and explained (i.e. 97% recyclable room, Scandic Environmental Construction Standard). Furthermore, relevant Scandic examples and success-stories are presented.

So far, 2100 out of 3200 Scandic team members have successfully completed the basic environmental training [16], and a total of 9000 Scandic and Hilton-related people have learned to think environmentally [17]. While new Scandic team members typically need time to become acquainted with the practice of environmental training, long-term employees generally treat this issue as part of the company's own culture. Nevertheless, the majority of Scandic employees are proud to work in a company that has clearly defined environmental goals and programs. For team members interested in expanding their environmental knowledge, complimentary courses are arranged at the Scandic Business School, approximately once a year. Furthermore, during the recent process of Swan-labelling of facilities, team members have received a considerable amount of knowledge on environmental protection.

An environmental meeting is arranged about one week after co-workers have received the environmental guide. Alternatively, the interactive environmental training is performed in a group. The meeting should ultimately result in the development of an environmental program – an improvement action plan for a particular hotel. The environmental meeting is also treated as a forum for the environmental coordinators from all Scandic hotels, who can regularly meet in order to discuss various issues.

The environmental program is displayed in every hotel in an area accessible to team members only. It divides activities into three categories: those already accomplished, those in progress / or at the research stage, and those requiring significant capital investment and consequently included in the long-term planning. To facilitate the process, a specific deadline is set and a person responsible for the incorporation and completion of each activity is designated. The action plan is constantly updated to ensure continuous improvement of performance. The presence of individual hotel environmental programs proved to be of significant assistance during the eco-labelling of hotels, as this was one of the requirements stated by the Nordic Swan eco-certificate.

The environmental barometer was developed as a semi-annual or annual publication containing status reports from every hotel, summarizing how particular facilities have succeeded in meeting the goals set in the environmental program. It is not used currently since the hotels are assessed according to the Nordic Swan criteria.

2.2 Resource use efficiency and benchmarking

In order to assess the environmental performance of Scandic hotels in a more detailed and uniform manner, the Environmental Index benchmarking tool was developed in 1995. Approximately 60 environmental measures were identified in 9 areas, defining how specific operations at Scandic should be carried out, based on an ideal case scenario. The environmental index has been deactivated when the majority of Scandic facilities became eco-labelled and currently the Nordic Swan criteria are used.

The next step undertaken by Scandic aimed at focusing more on the resource use efficiency. In 1997 the "Resource Hunt" program was implemented. A specific and detailed action plan within the "Resource Hunt" program has been developed by each hotel. It divides activities into those immediately incorporated, those requiring further investigation, and/or capital investment, and those proposed to become a corporate target. A computer database, the Scandic Utility System – SUS, was developed and incorporated to allow for the monitoring of resource consumption, and is presented further on in this paper. Although the "Resource Hunt" program includes an employee reward system, where financial rewards are transferred to a special fund at the hotel and allocated for various activities designated for use by hotel team members, its success at any particular hotel is highly dependent on the commitment of individual team members or environmental groups responsible for the incorporation of an action plan. A new version of the database is currently being introduced (Hilton Environmental Reporting - HER).

The Scandic environmental department has further developed the Best in the Class system (BINC) based on SUS, and measuring 18 key indicators over time-intervals of different length. The results achieved are displayed in the team members' access areas at each facility.

2.3 Supply-chain involvement and certification

The decision to take the environmental message outside the company by involving Scandic suppliers in the company's environmental program followed, accompanied by the commitment to purchase products with a low (lifecycle) environmental impact. Since the end of the 1990s all new suppliers have been expected to document their corporate environmental policies, and required to sign the Scandic's Supplier Declaration. Starting in 2004, all Scandic suppliers are requested to sign the Declaration [16]. Already since 2000, most of Scandic hotels in Sweden have been powered by hydro-based electricity. In January 2004 an official contract was signed with Vattenfall (one of the main energy companies in Sweden), and currently all Swedish Scandic facilities are supplied with the "green" electricity (originating from wind- or hydro-plants), and thereby further endorsing the environmental friendliness of the chain [18]. In several cases, Scandic successfully persuaded producers and suppliers to make their products more environmentally-sound (low-energy lamps from Auralight and Ahlsell) [16, 19].

Scandic has also recognized the continuous retrofitting of its facilities as an excellent opportunity for further improvement of its buildings' performance and reducing environmental impacts. The concept of eco-room (a 97% recyclable hotel room), was introduced in 1995. Materials used to construct these rooms are 97% recyclable and include wooden furniture and floors, pure cotton or wool textiles, and limited amount of fittings made of chrome, metal or plastic [15]. At present, Scandic stock includes more than 10 000 eco-rooms, and 7 environmental hotels [18].

In a further step Scandic developed its own Environmental Construction Standard, listing materials, which may not be used in their facilities, and specifying acceptable alternatives [15]. The basic concept of any project should be the 4R's rule: reuse - renovate – recycle – re-construct, while all materials and products used should be well documented. Furthermore, all materials and equipment should be resource-efficient and sustainable in a lifecycle perspective. Materials containing or suspected of emitting potentially harmful substances must not be used. On the other hand, eco-labelled materials should always be given a purchase priority. More specifically, no PVC is allowed to be used in Scandic hotels, while only windows with U-value lower than 1.5 W/m^2K should be installed during refurbishment or new construction. Demand-controlled heating, ventilation and air-conditioning systems should be incorporated and equipped with energy recovery at every air handling unit. CFC- and HCFC-based refrigerants must not be used at all. Electricity should not be used for heating purposes, with the exception of direct electric floor heating in bathrooms. Whenever possible, lighting should be demand-controlled and based on Compact Fluorescent Lamps, while hotel rooms should be equipped with main electricity switches or master key cards. Only low energy equipment is allowed, including TV sets of maximum 5 W power and minibars with the maximum energy consumption value equal to 1.2 kWh/day. Synthetic flooring, furniture and textiles, as well as exotic wood types are "checked out", while the use of local, and preferably, eco-labelled wood, furniture, textiles and paper is encouraged.

At the beginning of the millennium, there was a common feeling among Scandic team members that in the aftermath of the intense pro-ecological efforts of the mid-1990s, environmental issues were not receiving enough attention. In an effort to bring environmental efforts back into focus of team members and customers, corporate management decided to eco-certify all of their Swedish facilities with a Nordic Swan eco-label by the end of 2004 [17]. This decision was highly appreciated by Scandic team members, and 48 Scandic and two Hilton facilities in Sweden are currently Nordic Swan-labelled [20]. Furthermore, all Norwegian Scandic hotels are expected to be Swan-labelled by the end of 2005 [21].

A network of environmental coordinators has been created to facilitate the dissemination of information, the general process of environmental education, as well as participation in various activities. Feedback on facility performance is continuously provided through various publications, as well as by the Scandic intranet. The environmental performance is further communicated to guests and the general public.

3. Managers' survey

The results of an independent survey performed among Scandic managers and other Swedish hoteliers in the autumn of 2002 and spring/summer of 2003 further confirmed the benefits of corporate pro-ecological policy and environmental education. The study has been described in more detail elsewhere [22, 23]. For the purpose of this comparison, Scandic respondents were excluded from the total sample, leaving a total of 177 hotels in the Swedish and 49 facilities in the Scandic sample.. The response rates obtained in the study are 20.1% and 75.3% for Sweden in general and among Scandic hoteliers, respectively. All Scandic respondents and 77.4% of Swedish respondents in the survey emphasized that environmental protection has been essential for the performance and further development of the tourism industry. The results of Scandic corporate efforts in promoting environmental awareness are further apparent as more than 79% of respondents declared having some knowledge of activities aimed at developing "greener" hotels (75% listed at least one improvement possibility), as compared to 62.7% (respectively 57.6%) in the Swedish sample. All Scandic hoteliers further declared to be involved in some type of environment-oriented activity, as compared to 91.5% among Swedish hoteliers.

All Scandic respondents declared being involved in energy saving measures (mainly energy-efficient lighting, Figure 1), as compared to 84.2% among Swedish hoteliers in general.

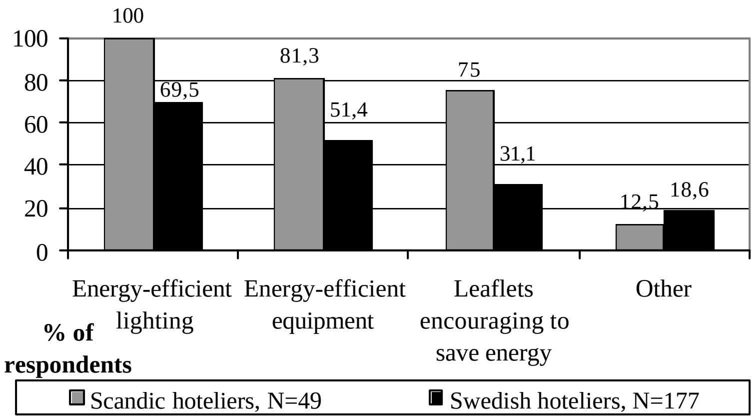

Figure 1. Energy-oriented initiatives at Scandic hotels and other Swedish hotels.

Such a high rate of positive responses among Scandic managers can be attributed to corporate policy on energy saving and energy-efficiency, and, as will be shown later, actually contributes to significant energy savings.

4. Scandic Utility System Database

4.1 The history of SUS

Since 1997 the company has been working with energy, water and waste issues under the umbrella of the "Resource Hunt" program. A measurement system called SUS (Scandic Utility System), has been developed and incorporated to help in keeping track of resource usage and and its variation over time. Currently a new, more sophisticated, version of SUS, namely Hilton Environmental Reporting (HER), is being incorporated in all Scandic and Hilton establishments. It is available via Hilton intranet but can only be accessed by authorised team members.

Within SUS Scandic hotels were required to send monthly reports documenting the consumption of electricity for appliances and heating, energy in the form of district heating and cooling, fuels for heating and other purposes (oil, propane/butane, town gas, LPG), water and unsorted waste, as well as a number of other key parameters (property area, number of guestnights, turnover). Being located between 56º and 68º northern latitude, Sweden encompasses a number of different (northern) climate zones. In order to compare the heating energy consumption of hotels in various climatic zones, heating degree days are used and included in the database.

In HER, two levels of reporting are used [24]. First, a hotel profile form is created for each facility, which includes basic facility information such as brand, city, floor area, number of floors and rooms of various types, restaurants and kitchens, as well as additional services (health club, pool, jacuzzi, etc.), mechanical systems (air conditioning, CHP units, cooling towers, solar energy systems), as well as a list of central suppliers, including those environmentally approved. The second level of reporting needs to be performed on a monthly basis, and covers all the issues previously reported to SUS, including a few additional areas. The new additions to the database include information on the energy mix used to generate electricity, district heating and cooling, as well as the types of fuels utilised by the vehicle fleet. As Hilton hotels are located in many climatic zones worldwide, heating as well as cooling degree days need to be reported, where applicable. Types and amounts of refrigerants used need to be documented, while waste generated is reported as unsorted, sorted and hazardous. In addition, monthly expenses relevant to resource consumption and engineering expenses need to be included in the report.

4.2 Limitations

The SUS database has suffered from a number of limitations. Some of those have been overcome with time, others remain.

Initially, some team members responsible for resource use reporting encountered difficulties in understanding what exactly should be reported, and had problems with handling different types of energy units. While most of these problems can be solved by additional education and through experience, these difficulties are likely to recur whenever a new employee is appointed to the task of HER reporting. Also, some hotels keep reporting their monthly electricity consumption as being between 0.9 and 1.1 MWh, whereas their real consumption is likely to be much higher based on their size and the climate they are located in. Spelling or typing errors also do happen, sometimes resulting in the reported monthly resource use being off track by at least one order of magnitude.

Often, reports for single or multiple months are missing from the database. Some hotels do not report at all, which may be a result of the existing ownership/management situation. Sometimes Scandic rents buildings at fixed or flexible rates, and its staff may not have access to meters located in the building. In other cases, buildings may house more than just a Scandic hotel. There may still exist only a single central meter, with individual costs distributed based on some formula relevant to assumed usage, while values reported to SUS may include more than what has actually been consumed at the facility.

Some hotels report identical values every month, which makes it very difficult to correlate the data collected with weather oscillations or variations in occupancy rates. This problem is typically encountered with the reporting of the amounts of unsorted waste generated, but also as regards the utilization of electricity, district heating or fuels. To further complicate issues, meter readings may be collected on different days every month, further affecting the comparability of monthly data. The Nordic Swan team is currently assessing the credibility and value of the various types of data collected, as well as their compliance with relevant limit values.

Over the years, both the reporting skills and SUS itself have been improved. Nevertheless, there still remains room for improvement. The newly developed and currently implemented Hilton Environmental Reporting scheme is much more comprehensive, and is believed to allow for the establishment of a reliable benchmark for all Hilton hotels.

In order to avoid some of the problems faced by SUS, a number of innovative solutions were incorporated into HER. First, an automatically generated e-mail message reminds key team members of upcoming report deadlines and provides a direct link to the electronic report form. Next, when a form for a new month is created, the latest reported values are automatically filled in, to reduce the risk of incorrectly entered data. To safeguard the validity of the information collected, a double-check process has been introduced, with the general manager of each facility being responsible for accepting and signing all forms before these are submitted to the central system. For additional safety, in Sweden the environmental coordinator at the company headquarters performs periodical checks on the data submitted.

4.3 Results

For the purpose of this analysis, only hotels providing complete monthly reports on energy-related data and number of guestnights were selected [25]. Hotels missing at least one monthly report in any category were rejected, as were those reporting identical values for electricity, district heating or fuel use for each month. Also, if the magnitude of values reported was in disagreement with common sense (e.g., utilization of 1.1 MWh electricity/month in a 10 000 m^2 property, or the amount of district heating for 11 months reported as double-digit, while a single summer month showed a triple-digit value, i.e. several times the average consumption) the data were adjusted and used.

Due to the limitations mentioned above, this analysis does not include the entire Swedish branch of Scandic hotels, since some facilities still do not report to SUS. Also, a number of hotels were rejected in each annual sample due to incomplete or unrepresentative data (Table 1). Nevertheless, the authors will attempt to interpret the trends indicated by the analysis.

Table 1. Statistics for hotels analysed.

Year	Properly reporting hotels	Non-reporting hotels	Rejected hotels
1996	44	1	5
1997	45	1	4
1998	46	0	6
1999	42	2	12
2000	46	3	14
2001	48	6	13
2002	43	6	19
2003	47	6	16

The total area of Scandic-operated properties has been fluctuating over the years following sales and acquisitions, as well as due to the refurbishment and modernisation of facilities. In a 10-year perspective, however, a trend of increasing area is evident, as indicated in Figure 2 (it has to be kept in mind that this analysis does not cover all Scandic facilities). As can be seen from Figure 2, the changes in the consumption in the Scandic chain of electricity and heating energy (space heating and domestic hot water production – DHW), is related to the fluctuations in the total area.

If the energy consumption is analysed as a function of occupancy, it can be seen that the number of guests accommodated seems to have little influence on the total energy used by the chain (Figure 3).

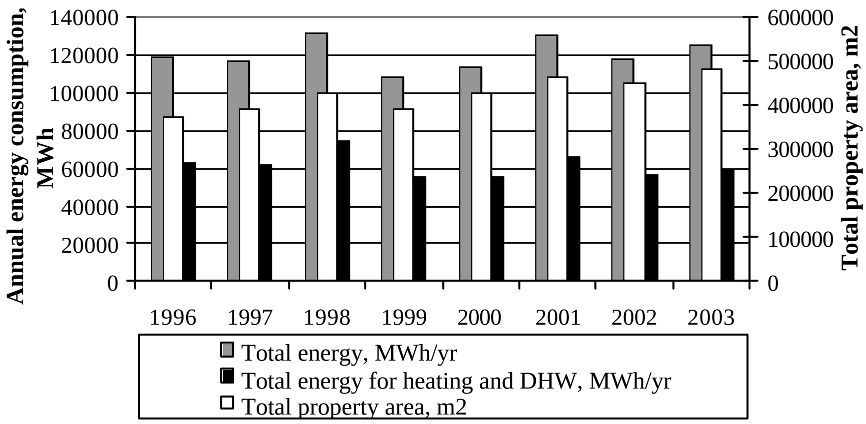

Figure 2. Consumption at Scandic facilities of total energy and energy for space heating and domestic hot water generation related to total property area.

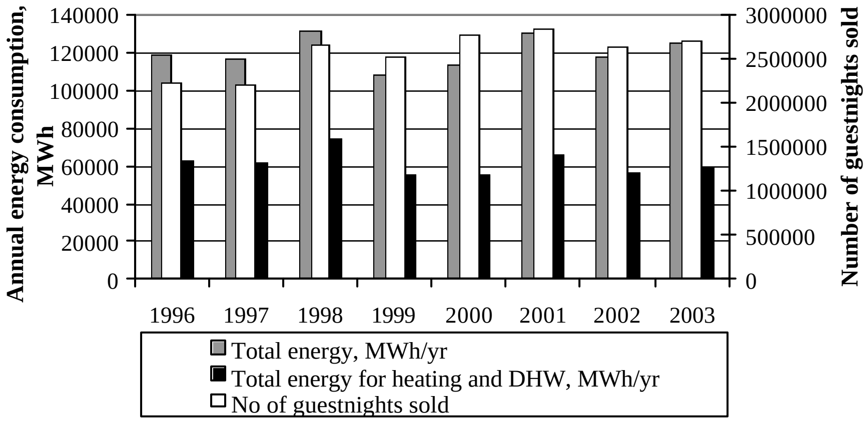

Figure 3. Consumption at Scandic facilities of total energy and energy for heating and domestic hot water generation related to occupancy (expressed as number of guestnights).

The correlation coefficients for the annual variations of (total energy used versus property area), (total energy used for space heating and DHW generation versus property area), and (total energy utilization versus number of guestnights sold) are relatively high. They range from 0.43 to 0.74 for the total energy used in relation to the property area, 0.11 – 0.43 for heating energy to area, and 0.35 – 0.62 for total energy vs. guestnights sold. This indicates that both property area and the amount of guests served have an impact on the overall energy consumption at a facility. Correlation factors are relatively high for the year 1996 (0.64, 0.24, and 0.57 respectively). In 1997 they drop to 0.43, 0.11 and 0.35 respectively, showing a rising tendency in subsequent years, Table 2.

The results shown in Table 2 indicate that the energy management at individual Scandic facilities has improved over time. Relatively low correlation coefficients for the variations of heating energy demand to property area are most likely due to the heating demand being more dependent on climatic conditions than on property area alone. Further investigation will include an analysis of the heating demand variation as a function of climatic variations. It is also intended that further investigation will separately report the amounts of energy used for domestic hot water generation and space heating.

Table 2. Correlation coefficient, R^2, for 1996-2003.

Year	Total energy vs. property area	Total energy for space heating and DHW generation vs. property area	Total energy vs. number of guestnights sold
1996	0.648	0.246	0.579
1997	0,431	0.113	0.355
1998	0.578	0.174	0.486
1999	0.619	0.230	0.529
2000	0.617	0.290	0.526
2001	0.694	0.421	0.620
2002	0.744	0.415	0.601
2003	0.742	0.432	0.603

Over time, energy saving efforts, as well as increased energy utilization efficiency have lead to a gradual decrease in total energy consumed per unit property area (see Figure 4), although the overall energy utilization in 2001 was unusually high.

It is worth mentioning that during the first two years of the "Resource Hunt" program most of the savings achieved can be entirely attributed to education and behavioral changes among the hotel team members. Technical improvements were incorporated later.

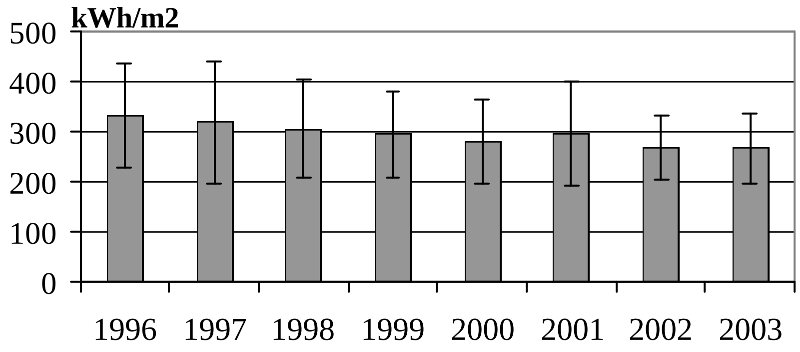

Figure 4. Variations of Energy Use Index – total energy consumption per floor area, mean value and standard deviation, kWh/m^2.

With regard to the energy consumption per guestnight, the downward trend, though present, is less evident. Values have not changed significantly since 1999 (see Figure 5).

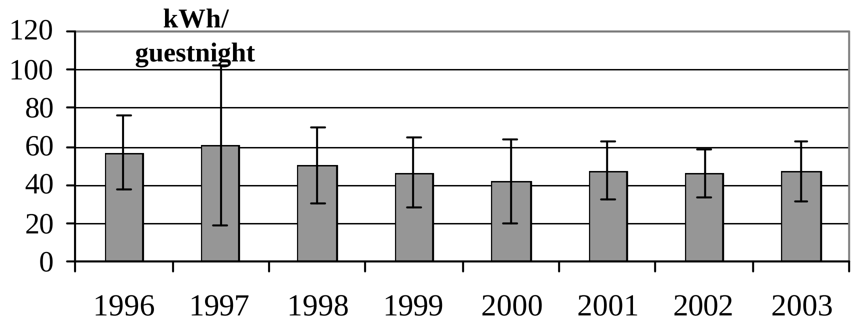

Figure 5. Energy consumption as related to the number of guestnights, mean value and standard deviation, kWh/guestnight.

The above analysis shows that Scandic corporate efforts in promoting, incorporating and enforcing energy efficiency and energy conservation have paid off. Though the hotel sample for which the data was collected does not include every single Scandic facility, it is reasonable to assume that the above conclusions may be extrapolated for the whole chain. It can also be assumed that the general trends established here would be valid for the entire chain. Similar downward trends were observed in the analyses of water consumption and waste generation patterns at Scandic, and have been presented elsewhere [26].

5. Conclusion

A decade of ecological education and training, as well as many environmental initiatives have all significantly improved the knowledge of Scandic team members and management on the environmental impacts of chain operations, as well as on appropriate strategies of environmental control and prevention. Over the same period, the environmental awareness among company employees has improved substantially. The incorporation of various efficiency and conservation measures into daily hotel operations has further resulted in a significant decrease in resource consumption, as evident from the information provided by the SUS database.

After the first 24 months of implementing the "Resource Hunt" program in the Scandic Nordic facilities, a 23%-reduction (on a kWh/guestroom-used basis) in energy consumption was achieved [27]. Between 1996 and 2003, the energy consumption in the Swedish Scandic branch was reduced by approximately 15% on a kWh/m^2 basis (with 1996 as the reference year), and approximately 12% on a kWh/guestnight basis. It is estimated that the "Resource Hunt" program generated direct financial benefits in excess of 6 MSEK (USD 800 000) in 1997 alone [14].

During the more recent Nordic Swan labelling process, the SUS database proved to be an invaluable source of data covering a number of consecutive years. Such information is necessary to estimate the degree of compliance with Nordic Swan requirements with regard to the consumption of energy, water and chemicals, as well as waste generation. While it is expected that Nordic Swan certification will stimulate additional improvements in performance, these effects may take some time to show.

Scandic's strong environmental commitment has already earned the chain global brand recognition. Scandic's competitive advantage is bound to increase even more, once Scandic has achieved its goal of becoming the first international hotel chain to eco-certify all of its facilities with a label awarded by an independent cognizant authority.

Scandic's environmental program has substantially improved the quality of the employees' working environment. It has also stimulated a couple of thousand staff to become more environmentally responsible. Scandic team members express pride in their environmental achievements, environmental training programs, the incorporation of pro-ecological measures in their daily working routines, as well as the KRAV- and SWAN-labelling of chain services.

In terms of environmental performance Scandic has gone a long way since the beginning of the 1990s and can now serve as a role model for Hilton and other hotel chains, convincingly showing that environmental commitment does make good business sense.

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Adaptive Reuse of Old School Building Into Sustainable Campus: The Renovation and Addition to the Canadian Memorial Chiropractic College in Toronto

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1. Introduction

Old buildings often outlive their original purposes. *Adaptive Reuse*, or *Re-use*, is a process that adapts buildings for new uses while retaining much of their original historic and/or structural features. Adaptive Reuse is considered to be environmentally friendly as it saves the existing structures from going into landfills as demolition waste, and further prevents the extraction of raw resources for the construction of new ones. The Canadian Memorial Chiropractic College (CMCC) in Toronto, Ontario, purchased one such building to house their new facility. The existing building was an 115,000 square foot private Elementary School, which if it was to be reused, needed substantial renovation. When Young + Wright Architects Inc. were retained for the project, the college expressed that they were interested in a design solution which would embody the principles of wellness, healthy living and sustainability. The proposed design solution attempted to reflect this in every sense.

This school has now been renovated to suit the purposes of the college and a 35,000 square foot (3,200 m2) addition was added to the facility. Over 90% of the existing building structure and 50% of the building envelope were reused in the new design. The addition includes 2 auditorium style classrooms, administration offices, bookstore, library and an atrium as the main building entrance. The design goal for the addition was to provide a quality learning facility that is energy-efficient, cost-effective and incorporates principles of sustainable design.

2. Existing Building Description

The existing building was a three-story brick building containing classrooms, gymnasium, offices and an indoor swimming pool. The initial building was constructed in 1981 with additions made in 1984 and 1987. The building axis runs north-south with modest window areas on each façade.

Table 1 lists the envelope insulation levels in the existing building and those typical of new construction for the addition. The R-values are total values including the effects of thermal bridging and all materials in the assembly. The window U-value is representative of a double glazed window in a thermally broken aluminum frame.

Table 1. Building Envelope Characteristics

	Existing Building	Typical New Building
Wall R-value	R-10.2	R-10.4
Roof R-value	R-24.4	R-12
Window U-value	0.60 Btu/hr ft^2 °F	0.60

The existing building was heated by water loop heat pump system. A single water piping loop ran throughout the building. The loop temperature was maintained at close to room temperature. Each classroom contained a heat pump connected to the loop to heat or cool the space as required. Thus each heat pump either added or removed heat from the loop depending on its mode of operation. If the loop temperature becomes too low, a single stage gas boiler heated the water. If the loop temperature becomes too high, heat was rejected to a wet cooling tower. The stairwells and main foyer were heated with electric baseboard heaters.

Ventilation air was heated by a modulating gas-fired make-up air unit. Domestic water was heated by a gas fired boiler. The performance values for the mechanical and electrical systems are shown in Table 2.

Table 2. Existing Building Mechanical/Electrical Characteristics

	Size	Efficiency
Space Heating Boiler	627,000 Btu/h	80%
Cooling Tower	250 tons	EER = 8.5
Zone Heat Pumps (typical)	Cooling: 44,200 Btu/h Heating: 51,300 Btu/h	Cooling: EER = 12.0 Heating: COP = 3.8
Make-up Air Unit	1,485,000 Btu/h	80%
Domestic Water Boiler	1,400,000 Btu/h	80%
Average lighting power density	N/A	21. W/m^2

The existing building annual energy consumption was 184 kWh/m^2 of floor area with an annual energy cost of $150,500. An energy simulation of the existing building was made using the EE4 software. The total energy use was within 4% of the actual energy use (see Table 3). The energy costs used in the simulation were based on 2002 rates as noted in the footnotes to Table 3. With deregulation of the electrical market, wholesale electricity costs will vary hourly according to overall market supply and demand. The value in Table 3 is based on historical data and includes retail charges by the local municipal authority.

Table 3. Existing Building Energy Use in GJ

Energy Source	Simulated	Actual (2001)	% Difference
Electricity	5360	5297	+1%
Natural Gas	1294	1626	-20%
Total	6654	6923	-4%

The simulated energy use was lower than the actual building energy consumption for three reasons. First, the energy model did not include the energy consumption associated with outdoor lighting, elevators, humidification or any process loads. Second, the energy simulations were made using operating schedules, water loads and receptacle loads typical of this type of building. Actual schedules and loads may have been higher or lower than these values. Finally, the model assumed the building was constructed and operated exactly as shown on the drawings. The model could not account for poor workmanship (e.g., missing insulation or high air leakage) or equipment performing below specification.

Two changes are being made to the existing building as it was being converted to occupancy for the College. First, when the new addition was built about 30% of the exterior wall area in the existing building was covered up and no longer contributed to heating or cooling loads. Second, some of the building spaces were modified as a part of the renovation process, specifically, several of the classrooms were converted to offices. For the new office areas, it was proposed that a variable air volume system be installed to offer superior temperature control. Table 4 lists the expected energy use of the existing building after these two changes are made. These energy values represent the baseline energy consumption for the building.

Table 4: Simulated Baseline Energy Consumption for the Existing Building

Energy Source	Energy Use (in GJ)	Annual Energy Cost
Electricity	5296	
Natural Gas	1177	
Total	6473	$151,981

3. Energy Efficiency Measures For The Existing Building

An investigation was made to identify energy efficiency opportunities in the existing building. This section summarizes the results of the audit, the cost and performance of energy efficiency measures and if it was implemented or not.

3.1 Building Envelope

The building walls, roof and windows were in good condition and any renovation to increase the insulation value would likely have a payback in excess of 20 years. It was recommended to not upgrade the existing envelope at areas where no modifications to the exterior were being made.

3.2 HVAC and Lighting Systems

The water loop heat pump was approximately 20 years old. While the ductwork and piping were in reasonable condition, the heat pumps were nearing the end of their expected life. The heat pumps in the northwest section of the building were replaced as a part of the renovation to a VAV system. The remainder of the heat pumps were replaced by new ones with more efficient units to lower the electricity consumption. The expected savings from implementing this measure are given in Table 5.

A heat recovery system was easily retrofitted to the existing air handling systems. A heat wheel offers the advantage of high heating energy savings and reduction in sensible and latent cooling loads. The payback was estimated at 11 years.

The largest energy savings was achieved by replacing the existing lighting with more efficient lighting and lighting controls. The existing lighting was primarily T12 Fluorescent lighting with magnetic ballasts. This lighting was replaced with T5 lighting. Conversion from T12 to T5 lighting reduced lighting power by 35% for the same light intensity.

Table 5 lists several other measures that were studied but have long payback times and were not recommended for implementation. Replacement of the boiler (Case 5 in Table 5) to feed the heat pump water loop did not make sense when considering only the existing building, however the new high efficiency boiler for the addition was easily connected and serves the new and existing systems.

Table 5. Existing Building Energy Efficiency Measures

		Total Building Performance				Individual Measure Economics					
Scenario	**Description**	**Elec Use MWh**	**Gas Use eMWh**	**Total Energy MWh**	**Fuel Cost in $**	**Fuel Cost Savings in $**	**% Energy Savings**	**Capital Cost**	**Energy Innovators Incentive**	**Simple Payback**	**Action**
Baseline Building	Based on recent utility bills	1471	327	1799	$ 151,981						
Case 1. Upgrade Heat Pumps	High-efficiency heat pumps for replaced units	1423	328	1751	$ 147,106	$ 4,875	6.1%	$ 10,000	$ 1,292	1.8	Implement
Case 2. Enthalpy Heat Wheel	Heat recovery wheel for existing ventilation system	1472	242	1714	$ 147,845	$ 4,136	8.0%	$ 48,000	$ 2,274	11.1	Implement
Case 3. Reduce Lighting Power	Overall lighting power density reduced from 20 W/m2 to 13 W/m2	1212	347	1558	$ 128,316	$ 23,665	16.4%	$ -	$ 6,481	0.0	Implement
Case 4. Remove Electric Baseboards	Replace electric heaters with hot water radiatiors	1375	488	1864	$ 148,531	$ 3,450	0.0%	?	$ -	?	Further Study
Case 5. Replace Space Heating Boiler	Replace existing boiler with high efficiency unit	1471	326	1798	$ 151,812	$ 169	3.5%	$ 10,200	$ 28	60.2	Reject
Case 6. Variable Speed Drive Fans	VSDs for VAV system fans	1469	328	1797	$ 151,821	$ 160	3.6%	$ 3,000	$ 38	18.5	Reject
Case 7. Heat Recovery for VAV System	Plate heat exchanger for VAV air handling system	1472	322	1793	$ 151,657	$ 324	3.8%	$ 12,000	$ 148	36.6	Reject
Total	Cases 1,2 and 3	1186	245	1431	$ 121,623	$ 30,358	23.2%		$ 9,929		

4. Energy Efficiency Options For The New Addition

4.1 Building Envelope Improvements

Several energy efficiency options were investigated. These options are discussed below and summarized in Table 6.

Wall Insulation: The Energy Code requires only 50 mm of rigid insulation providing an R10 insulating value. In the new addition, the insulation was increased with an additional 50 mm of extruded polystyrene to R20. Because of the relative small amount of new wall in the new addition, the upgraded wall system reduces total energy use by only 0.5% or $130 per year. The payback on this upgrade is approximately 10 years. The additional insulation also offers improved thermal comfort.

Spandrel Panels: Although high insulation levels can be put in the spandrel metal pans, thermal bridging along the pan and through the mullions reduces the insulation value by 75%. A typical spandrel panel has only an R7 insulating value. The thermal performance of spandrel panels was improved to R18 by choosing a curtain wall system with a wide thermal break, not the typical 4mm. The payback on this measure is quite short at 2.6 years.

Roof Insulation: The Energy Code reference building has R12 roof insulation. By adding 100 mm of extruded polystyrene, the R-value can be increased to R30. The upgraded insulation reduces energy use by 4% or over $1,000 per year. The payback is 9 years.

Windows: The reference building window is a clear, double-glazed unit with a thermally broken aluminum frame and ½" airspace between panes. The selected upgrade is a glazing unit with argon gas fill and soft low-e coating (PPG Solarban 60). The low-e allows significant down-sizing of the cooling system. The savings in mechanical system costs offsets almost all of the additional capital cost. The edge spacer selected is a non metallic insulating edge spacers, which reduces window framing and edge-of-glass heat loss. The thermal break in the window framing is 8mm versus a typical 4mm in a typical commercial curtain wall. The upgraded framing and edge spacer save $340 per year but more importantly reduce the likelihood of condensation on the frame and lower glass regions. Although the payback is long for improved framing, this upgrade will provide a healthier environment and significantly reduce damage caused by condensation.

Total Savings: With the implementation of all of the above envelope measures, the total building addition energy use can be reduced by $4,400 per year or 12% at a payback period under 6 years.

Table 6. Envelope Improvements, New Addition

Scenario	Description	Total Building Performance							Individual Measure Economics					Action
		Peak Heating MBH	Peak Cooling MBH	Elec Use MWh	Gas Use eMWh	Total Energy MWh	Fuel Cost in $	% Energy Savings Rel. to MNECB	Fuel Cost Savings in $	% Energy Savings	Capital Cost[2,3,4]	Avoided Capital Cost[1]	Simple Payback	
MNECB Reference		393	771	509	463	972	$ 62,483	0						
Base Case		468	804	492	504	997	$ 63,651	-2.5%	$ (1,168)					
Case 1: Better Walls	R-20 walls (add 50mm of extruded polystyrene)	464	803	493	499	992	$ 63,524	-2.0%	$ 127	0.5%	$ 1,404	$75	10.5	Implement
Case 2: Better Spandrel	R-18	426	785	493	465	958	$ 62,499	1.4%	$ 1,152	3.8%	$ 4,455	$1,425	2.6	Implement
Case 3: Better Roof	R-30 Roof (add 100mm of rigid insulation)	431	804	493	464	957	$ 62,617	1.5%	$ 1,034	3.9%	$ 9,297	$0	9.0	Implement
Case 4: Improved Windows	Double glazed, e=0.05 coating, argon space, thermal break	431	731	483	493	976	$ 62,051	-0.3%	$ 1,600	2.1%	$ 5,780	$5,475	0.2	Implement
Case 5: High-performance Windows	Triple glazed, e=.1 coating, argon space, thermal break	407	736	485	467	952	$ 61,557	2.1%	$ 2,094	4.5%	$ 10,200	$5,100	2.4	Implement
Case 6: Improved Framing	Increase thermal break by 4mm and add warm edge spacer	453	801	493	490	984	$ 63,312	-1.2%	$ 339	1.3%	$ 4,080	$225	11.4	Implement
Case 7: External Overhangs	Continuous overhang that extends 0.4 m from building	468	790	490	507	997	$ 63,433	-2.6%	$ 218	-0.1%	$ 142,800	$1,050	>20	Reject
Total	Case 1 to 6	329	710	485	393	878	$ 59,216	9.8%	$ 4,435	12.0%	$ 35,216	$12,300	5.2	Implement

Base Design:

1. R-10.4 Walls
2. R-7 Spandrel
3. R-12 Roof
4. Double glaze, 13mm airspace, aluminum frame with thermal breal

1. Assumes $900/ton savings in peak cooling load
2. Assumes $2.25/m² for 25 mm of insulation
3. Assumes $17/m² premium for improved windows
4. Assumes $30/m² premium for high-performance windows
5. Assumes $12/m² premium for improved framing
6. Assumes $350/m of overhang

4.2 Mechanical/Electrical Improvements

A number of HVAC systems were analyzed using the EE4 software. The measures are described below and their performance is summarized in Table 7. HVAC/lighting upgrades generally have a greater impact on energy efficiency than envelope components, but rely on the insulation and air-tightness provided by the envelope.

Heat Recovery Ventilation: Ventilation air heating is the largest contributor to space heating energy consumption. Recovering heat from the exhaust air to preheat incoming air results in large energy savings. A wheel type heat recovery was selected for the project. Wheel type units can recover about 80% of the heat and 50% of the humidity of the exhaust air. These units are sometimes referred to as Energy Recovery Ventilators (ERV). Wheel type ERVs by recovering the moisture in the exhaust air, significantly reduce the amount or need for wintertime humidification. In the summertime, the moisture transfer is in the reverse direction reducing the latent cooling load in the space. A key advantage of heat recovery systems is that heating and more importantly cooling systems can be downsized to take advantage of the reduced loads. On this project, one third of the cost of the system was offset by reductions in cooling system size. The payback period for a wheel type heat recovery system on each rooftop unit was calculated to be approximately 4 years.

Demand-Controlled Ventilation: The classrooms and lecture halls will have widely varying demands for ventilation air depending on the occupancy level. Conventional practice is to size and operate the system at the peak rate. Alternatively, the ventilation rate for the air handling units (AHU) can be controlled according to the carbon dioxide level in the return air. If the CO_2 level is low, the room likely has no occupants and no outdoor air damper can be closed. When students return the CO_2 level will rise and the outdoor air damper opens to provide sufficient ventilation. CO_2 sensors offer the benefits of energy savings when the rooms are empty and better indoor air quality when classroom are full. The use of CO_2 sensors were calculated to reduce energy use by $3000 per year and have an estimated payback period of 3 years.

Energy Efficient Fans: The Energy Code requires supply fans to be 55% efficient. By careful selection of the fan and matching to the system pressure drop, it is easy to achieve fan efficiencies of over 60%. The incremental cost of higher efficiency fans is minimal but saves $336 per year.

Perimeter Radiation: Reheat energy for VAV systems can be provided by either heating coils in fan-powered mixing boxes or by radiators located in the ceiling along the exterior walls. The fans in the mixing boxes are small and relatively inefficient. As a result, they require significant electrical energy. Using radiators saves this energy and provides a more comfortable heat (less draft). Despite the long estimated payback period of 12 years, these were implemented.

High Efficiency Boiler: A typical boiler has a steady-state efficiency of 80%. Boiler energy use can be reduced by using a modulating gas valve and selecting a higher efficiency unit of up to 88%. The payback period for this type of unit is estimated at under 5 years. This boiler was also used for the boiler for the water loop heat pump system as the new and existing piping for the two systems were easily connected.

Energy Efficient Lighting: By using T5 and T8 fluorescent lighting with electronic ballasts, the lighting power density was significantly reduced while maintaining acceptable lighting levels. Energy efficient lighting provided the largest cost savings and estimated at over $8,000 per year.

Lighting Controls: One of the most effective means of controlling lights was with occupancy sensors. These sensors automatically turn lights on when someone enters a room and shuts them off when no movement is detected after a few minutes. Occupancy sensors eliminated the need to control lights through a building automation system. Day lighting sensors were used in select areas to shutoff lights when sufficient natural light is available. Due to the high cost of full dimming systems because of the need for dimming ballasts, this was achieved through use of stepped controls where individual tubes are turned off as required. With indirect lighting, the shutting off of lights is rarely noticed. The combination of occupancy and day lighting sensors is estimated to save $3500 per year at a payback of 2 years.

Total Savings: Through implementation of the above listed mechanical/electrical system improvements, the building energy consumption is estimated to be reduced by 32%. A combined packaged of envelope and M/E measures is expected to reduce total energy use for the addition by 42% and save almost $24,000 per year. The payback on the measures is calculated at 3.6 years.

4.3 Atrium Design

The initial design of the atrium featured a large glass wall along the north façade and a glazed roof. The atrium is intended to serve as the main building entrance and a communication corridor between departments. The atrium is to be a buffer between the workspaces and the outdoors and to provide natural light to the building interior. A major design goal was to see if the atrium could be designed to maintain comfort conditions most of the time without the aid of a mechanical cooling system. Early energy models during schematic design, demonstrated that through strategic use of a saw-tooth roof with glazing facing North, the peak-cooling load was reduced by almost 80% and was estimated to save over $3,000 annually. The south-face was designed as an insulated roof sloped at 10 degrees, with clerestory windows which, eliminated direct solar radiation and glare in the atrium while still proving lots of natural light. The south-face of the saw-tooth roof can be fitted with solar thermal or photovoltaic panels in the future.

Upgrading the clearstory windows as described earlier under building envelope improvements, further reduced the peak-heating load by 20% and the peak-cooling load by 45%. Energy consumption was estimated to be reduced by over 8%. The combination the saw-tooth roof and improved windows reduced the peak-cooling load by almost 90% to less than 5 tons of air conditioning.

Table 7. Mechanical/Electrical Improvements, New Addition

Scenario	Features	Total Building Performance					Individual Measure Economics					Action
		Elec Use MWh	Gas Use eMWh	Total Energy MWh	Fuel Cost in $	% Energy Savings to MNECB	Fuel Cost Savings in $	% Energy Savings	Capital Cost	Avoided Capital Cost1,2,3,4, 5,6	Simple Payback	
MNECB Reference		509	463	972	$ 62,483	0						
Base Case		492	504	997	$ 63,651	-2.5%	$ (1,168)					
Case 1: Enthalpy Recovery Wheel	70% effective heat recovery wheel	504	359	863	$ 60,441	11.3%	$ 3,210	13.5%	$ 21,000	$7,110	4.3	Implement
Case 2: Sensible Heat Recovery System	50% effective glycol loop heat exchanger	504	382	886	$ 61,131	8.9%	$ 2,520	11.1%	$ 17,000	$2,250	5.9	Reject
Case 3: CO2 sensors	demand control ventilation	487	440	926	$ 61,691	4.7%	$ 1,960	7.1%	$ 6,000		3.1	Implement
Case 4: Efficient Fan	60% efficient supply fan	489	506	994	$ 63,315	-2.3%	$ 336	0.2%	$ -		0.0	Implement
Case 5: Perimeter radiation	Perimeter radiation	474	512	985	$ 61,911	-1.3%	$ 1,740	1.1%	$ 27,300	$5,000	12.8	Implement
Case 6: Modulating Boiler	88% efficient fully modulating space heating boiler	492	395	888	$ 60,390	8.7%	$ 3,261	10.9%	$ 15,435		4.7	Implement
Case 7: Efficient Lighting	Reduced lighting power (12 W/m²)	382	584	966	$ 55,315	0.7%	$ 8,336	3.1%	$ -	$5,625	-0.7	Implement
Case 8: Lighting Controls	Occupancy sensors and daylight for library	444	542	986	$ 60,087	-1.4%	$ 3,564	1.1%	$ 7,540		2.1	Implement
Total	Cases 1, 3 to 8	335	336	671	$ 43,565	31.0%	$ 20,086	32.6%	$ 77,275	$17,735	3.0	Implement
TOTAL ALL	All recommended mechanical and envelope measures	329	244	574	$ 39,906	41.0%	$ 23,745	42.4%	$ 112,491	$30,035	3.5	Implement

Base Design:
1. Economizer on all systems
2. 80% Efficient Boiler
3. Chiller COP = 3.0 (at 35°C air temperature)
4. Average lighting power density = 20 W/m²

1. Assumes $10.5/ L/s for heat recovery ventilator
2. Assumes $8.5/ L/s for glycol loop heat recovery
3. Assumes $1200/AHU for CO2 control
4. Assumes $130/m for radiant heating
5. Assumes $140/occupancy sensor
6. Assumes $180/daylit sensor

5. Sustainable Design Options

5.1 Sustainable Site Development

The development of the site strived to preserve and enhance the natural environment and minimize storm water runoff. A storm septor was installed on site to filter suspended solids and automotive pollutants from parking lot runoff. To encourage the use of alternative transport in keeping with the mission of the College, bicycle racks, change rooms and showers were provided. Light pollution was reduced through use of shielded exterior lights and guards.

5.2 Water Conservation

The Ontario Building Code requires water-conserving fixtures in all new construction. In the existing building, existing toilets were replaced with 6-litre flush toilets. Each toilet replaced will save $60 pr year in water and sewer costs.

The landscape strategy reduced the landscape area requiring permanent irrigation and used native species, which require less water and demand less maintenance. For ground cover, Eco-lawn, no-mow lawn products were selected.

5.3 Material Selection and Resource Use

By the very nature of adaptive reuse, a great deal of existing building materials were saved for reuse. These included over 90% of the building structure, over 50% of the building envelope, plumbing and electrical systems, around 50% of interior partitions, toilet partitions, wood doors, black boards, pool with change rooms and full gymnasium. The demolition process had a recycling program to salvage and recycle much of the demolition waste with a landfill diversion rate of over 50%.

Material selection and application were considered carefully for their large impact on building air quality and embodied energy. Carpets and soft vinyl flooring off-gas formaldehyde and VOCs respectively. Furthermore, carpets hide dirt and condensation. The use of carpets was limited to only select office areas and vinyl flooring were avoided. The carpets that were used were supplied by Interface, with very high percentage of post industrial recycled content and low off gassing characteristics. Linoleum and ceramic tile were used predominantly throughout the new and renovated facility. Locally manufactured materials were chosen as much as possible to reduce transportation requirements and support local economies. In forming concrete, reusable Peri Formwork was used at a cost saving to traditional formwork.

5.4 Healthy and Superior Indoor Environment

There are five factors that make up a superior indoor environment, thermal comfort, humidity control, full spectrum glare-free lighting, occupant control of indoor conditions and superior air quality. These factors and design strategies for their inclusion are discussed in this section.

As discussed in previous sections, the design of the envelope and mechanical systems had a major impact on thermal comfort. The upgraded insulation and more importantly high performance windows reduced the likelihood of condensation and improved comfort when sitting close to the exterior wall. Radiators around the perimeter similarly improve the thermal comfort at the building perimeter. An additional advantage of the ERV recommended in Section 4.2 is that it provides some humidification and eliminates the need for a stand-alone humidifier.

Superior air quality requires careful selection of building materials, and adequate ventilation delivered to the occupants. ASHRAE 62 provides suitable guidelines for ventilation rates. CO_2 control of ventilation ensures adequate ventilation at all times. The effectiveness in delivering the air can be improved with displacement ventilation: supplying fresh air low and exhausting/returning air high. Another factor in superior air quality is the control of contaminants in the air. As discussed in section 5.3, zero or low VOC materials were used to ensure improved indoor air quality. Low VOC latex paints, water-based adhesives and caulking for flooring and sealing joints (both Eco-Logo certified) were used throughout as well as carefully selected flooring materials, which minimize off gassing.

A central feature located in the atrium which, will significantly improve indoor air quality at the college, is a plant wall or indoor air Biofilter. The biofilter, ,which will be added at a later date, is a vertical hydroponic green wall containing a range of plants specifically selected for use in the system. The plants include ferns, mosses and a range of other flowering and foliage plants. Air is actively forced through the green wall of plants and the highly specialized biological components actively degrade pollutants in the air into their benign constituents of water and carbon dioxide. The indoor air Biofilter in its most basic form is an interior plantscape that can effectively remove common indoor contaminants. Several studies conducted by the University of Guelph, indicate that, passing air contaminated with low levels of VOC's through the Biofilter removed substantial amounts of CO_2, formaldehyde, tolune, and trichloroethylene from indoor air, which are typically associated with 'sick building syndrome'. The Biofilter represents the hybridization of science and art to yield a technology soundly based on science to deal with real problems of indoor air quality in an aesthetic and sustainable manner.

Daylighting by definition is full spectrum and studies have shown that the rate of learning is improved when students are in daylit rooms. The window to wall ratio was maintained at minimum 35% to provide adequate daylight. The central atrium along with clearstory windows provides ample natural daylight to core of building including offices, labs and classrooms.

An initial LEED review at concept design stage revealed that the design was capable of achieving at least a LEED Silver rating with the potential for LEED Gold, however the client group was not interested in a formal certification.

Conclusions

This paper presents the sustainability measures that contribute to making the new Canadian Memorial Chiropractic College a sustainable campus. An energy efficiency study undertaken early in concept design which, examined three parts of the building: the existing building, the new addition and the new atrium identified potential energy efficiency measures for the College which were implemented with relative ease due to the very obvious business case with short paybacks. Sustainability measures related with material selection, water efficiency and indoor air quality were for the most part 'best practice' design measures and were not subjected to a life cycle cost analysis like the energy efficiency measures were. Some of the measures considered for their energy efficiency benefits had resulting positive benefits in the indoor air quality category and were seen as a bonus at no additional cost. Measures such as the Biofilter, which had no direct payback were seen as an investment, which would promote environmental consciousness within the institution and speak to the corporate commitment to healthy living, wellness and sustainability. The results of the capital cost increase; energy savings and payback for the new addition and existing building are summarized in the below table. The implementation decisions were made even easier by taking advantage of a number of government energy efficiency programs.

Building Area	**Annual Cost Savings**	**Incremental Capital Cost**	**Government Incentive**	**Simple Payback**
Existing	$37,000	$70,000	$10,000	1.6 yrs
New Addition	$24,000	$112,500	$45,000	2.8 yrs
Atrium	$4,700	-	-	-
Total	$65,700	$182,500	$55,000	1.9 yrs

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THE APPLICATION OF LCA METHODOLOGY TO ASSESS SAINT-GOBAIN ISOVER POLAND PRODUCTS

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Note about the author: Henryk Kwapisz completed studies at the Technical University in Warsaw and currently works as the Certification Manager in SAINT-GOBAIN ISOVER POLSKA, the manufacturer of glass and stone wool insulation in Gliwice, Poland.

1. Introduction

One of the ISO Technical Committees is ISO/TC 59/SC 17 ~~WG 4~~. The Secretariat is carried out by AFNOR from France. The name of this committee ~~and precisely the working group~~ sounds: "sustainability in building construction". The members of this group are currently busying themselves with the framework for assessment of environmental performance of buildings and constructed assets. The aim of this is:

- To identify and describe issues to be taken into account when using methods for the assessment of the environmental performance of new and existing buildings in the design, construction, operation, refurbishment and deconstruction stages
- To provide a general framework to improve the quality, transparency and comparability of building
- To create the assessment methods
- To be useful for the communication of assessment results
- In addition to the requirements of this International Standard, the principles set out in the ISO 14000s series of standards shall apply

2. LCA as a methodology ISO 14000 standard

One of the basic principles of LCA is to analyze the potential impact of the product on the environment, within the whole life of the good, starting with gaining the raw materials through production, usage, finally demolition and taking to the landfill site – from the cradle to the grave. Because any stage of the product life will not be missed, it is possible to make the full comparisons describing environmental risks created by the product.
Additionally, launching and describing LCA methodology in ISO 14040-14049 standards by ISO causes that it has an opportunity to become the most important tool to gain a certificate of

production conformity with the ISO 14000 standard. Therefore LCA could be irreplaceable method used in currently created new ISO standard.

3. Saint-Gobain Isover and LCA

The insulation branch of Saint-Gobain company (Saint-Gobain Isover) has been interested for years in LCA methodology and has been using it in many countries. As an example one could present Finland, which has created LCA study for complete partitions, not only for the product – "LCA for exterior wall structures"[1]. Isover Holland is engaged in a lot of activities related to LCA and as Isover Benelux has completed the assessment for the products, to contain them in the software used for environmental impact evaluation of the products at the construction stage (Eco-Quantum)[2]. Finally Isover France has prepared basing on LCA, Environmental Data Sheets (EDS)[3] for over 75 of the products according to French standard NF P 01 010, to enable providing reliable information to the customers. These answers refer to the influence of the products on the environment and they are provided to the designers, contractors and investors. Certainly not only above mentioned countries are involved in developing LCA methodology.

4. An Assessment of the Life Cycle of a Typical Building Product Manufactured at SAINT-GOBAIN ISOVER POLSKA, in Gliwice – Polish Bulding Research Institute (ITB) Study – NS-533/P/04

That is why SAINT-GOBAIN ISOVER Poland commissioned ITB to prepare the thermal-ecological characteristic of the mineral wool manufactured by SAINT-GOBAIN ISOVER POLSKA. The fact that LCA is virtually unknown in Poland and there aren't any tools in Poland to use this method doesn't mean that one should take the precursory steps in this field.
The aim of this analysis was to estimate the environmental impact of a mass unit of a typical product manufactured by SAINT-GOBAIN ISOVER POLSKA Sp. z o.o. of Gliwice using the LCA method. The aim of determining the thermal-ecological characteristics of the product is to increase the manufacturer's and consumers' awareness of the product's cumulative environmental impact from the stage of acquiring raw materials till the time the product reaches the exit gate of the factory, including the stages of use and recycling.
The thermal-ecological characteristic of the mineral wool manufactured by SAINT-GOBAIN ISOVER POLSKA Sp. z o.o. (Ltd.) has been identified with the help of Life Cycle Assessment methodology developed at the Environment Protection Division of the Institute of Construction Technology (ITB) in Warsaw. The methodology takes into consideration the ISO 14040-43 standard requirements as regards LCA application in estimating the environmental impact of a product during its life cycle. The methodology has been modified according to the criteria and conversion ratios developed at the University of Laiden in 1992 within the so called CML92 method. The intent of this approach is to move toward the level of ISO TR 14025 requirements with a view to subsequent certification of the environmental declaration.
The method developed at the Institute of Construction Technology allows for a uniform assessment of assorted construction products and elements, helps the consumer choose a product having specific environmental properties and makes it possible to compare products of the same category manufactured by different companies.

5. Scope

The analysis included the collecting of data on the raw materials and manufacturing processes, categorizing these data with respect to the environmental impact during the inventory process including the data collecting process and allocating in order to avoid the duplication or underestimation of ecological effects. The analysis included also the conversion of source data into the categories of the environmental impacts through classification, characterization, normalization and weighing. The report provides also a calculation of ecological-thermal effects resulting from the application of the mineral wool incorporated into a building. The result of the analysis has been presented in the form of thermal-ecological characteristics of the selected product.

6. Description of technological process (fig. 1)

6.1. Raw materials repository

Mineral wool is made from the following fusible raw materials (basalt, gabbro, dolomite, bauxite) as well as blast furnace ore (slag), coke, urea-modified phenol-formaldehyde resin, silane, 20% ammonia water, ammonium sulphate, oil emulsion. Raw materials are delivered to the factory by road transport. Fusible raw materials and coke are stored in a paved yard. From the repository, raw materials are transported by a conveyor belt onto the sieves and undergo a physical processing consisting in the isolation of undersize grain, i.e. grain fractions below 20 or 30 mm, depending on the kind of raw material. Then, after a desired quantity is weighed out, they are transported by conveyors to a cupola furnace.
Waste: undersize grain (basalt, gabbro, dolomite, bauxite), rubber and plastic bands.

6.2. Resin shop

Based on the a/m materials, a binder of assigned density is prepared in the resin shop. The shop also stores liquid raw materials in closed tanks.
Waste: containers (metal barrels and plastic barrels).

6.3. Cupola furnace

The raw materials are loaded into the top part of the furnace in layers. The frequency of charge is automatically regulated. The melting process takes place in the lower part of the furnace, on a hearth created by a layer of coke. The coke is loaded into the furnace at the time of ignition, before the fusible raw materials are fed. The raw materials melt at approximately 1600^{o} C. To improve the efficiency of the furnace, an air-oxygen mixture, heated to 500^{o}C, is forced through nozzles. After passing through fabric filters, afterburner (carbon monoxide), and a recuperator, the cupola furnace emissions are directed to the exhaust. The heat recovered in the recuperator is used to heat the air forced into the furnace.
Waste: dust from the dedusting of emissions, refractory materials, non-fiberized lava, ferrous metallic clods from the cupola, used fabric filters.

6.4. Fiberization device

The molten mineral charge flows as lava onto the fiberization device rotors. Pouring onto the revolving rotors, the lava fiberizes and the fibre is spun. The newly formed fibre is treated with a binder (a mixture of phenol-formaldehyde resin with components) and sent to a blow chamber.
Waste: mineral wool, non-fiberized lava, rubber pipes, plastic pipes.

6.5. Blow chamber

In the blow chamber, a mineral wool blanket is formed by drawing off the air with fans. The fibres settle on a conveyor mesh. The emission gases are dedusted in the filter chamber before being sent to the exhaust.
Waste: mineral wool.

6.6. Polymerisation chamber

The impregnated and shaped strip of mineral wool is carried to the polymerisation chamber. In the polymerisation chamber, the process of resin polymerisation and water evaporation takes place. The process is carried out at a temperature of approximately 220^o C. The temperature is obtained by blowing in hot emissions from burning natural gas. After leaving the chamber, the hardened strip passes through the cooling section.
Waste: None

6.7. The cutting zone

The cooled strip is cut to the desired size with longitudinal and transversal cutters. The trims left over as a result of cutting are granulated and returned to the blow chamber.
Waste: mineral wool and mineral wool dust.

6.8. Packaging and storage

The product cut to the desired size is packed in polyethylene film and put on wooden pallets. The finished product is transported to the storehouse with forklifts.
Waste: deficient products, packaging waste (wooden pallets, polyethylene film, paper, cardboard), laboratory tests samples.

6.9. Façade slabs manufacturing equipment

The manufacture of the slabs consists in mechanical (cutting to size) and thermal processing of the slabs manufactured along the basic production line. The refined slabs are packed in polyethylene film, put on wooden pallets and transported to the finished product storehouse.
Waste: packaging (polyethylene film, wooden pallets), dust, pieces of wool, deficient product, spent laboratory tests samples.

6.10. Lamella slab manufacturing equipment

The process of mineral wool slab manufacture consists in the mechanical processing (cutting to size) of slabs manufactured along the basic production line. The slabs are packed in polyethylene film, put on pallets and transported to the finished product storehouse.

7. System boundaries

This analysis covers the manufacture system from the acquisition of raw materials to the product leaving the Gliwice Plant (including the use phase).
The system consists of the following sub-processes:

- mining and manufacturing of raw materials and intermediate raw materials: Mulrex, gabbro, coke, basalt rock, resin, urea, ammonium sulphate, silicone emulsion, wooden pallets, packaging film, labels, oxygen, ammonia water and others
- transport of raw materials to the manufacturer and internal transport (burning of diesel fuel)
- raw material processing in compliance with the technological process
- acquisition and generation of process energy: use of oxygen, gas, cupola coke
- use of electrical energy
- preparing the products for sale

In the application phase, the calculations cover the thermal-ecological savings resulting from the use of mineral wool to insulate an external partition of the building and the roof based on the assumed parameters.

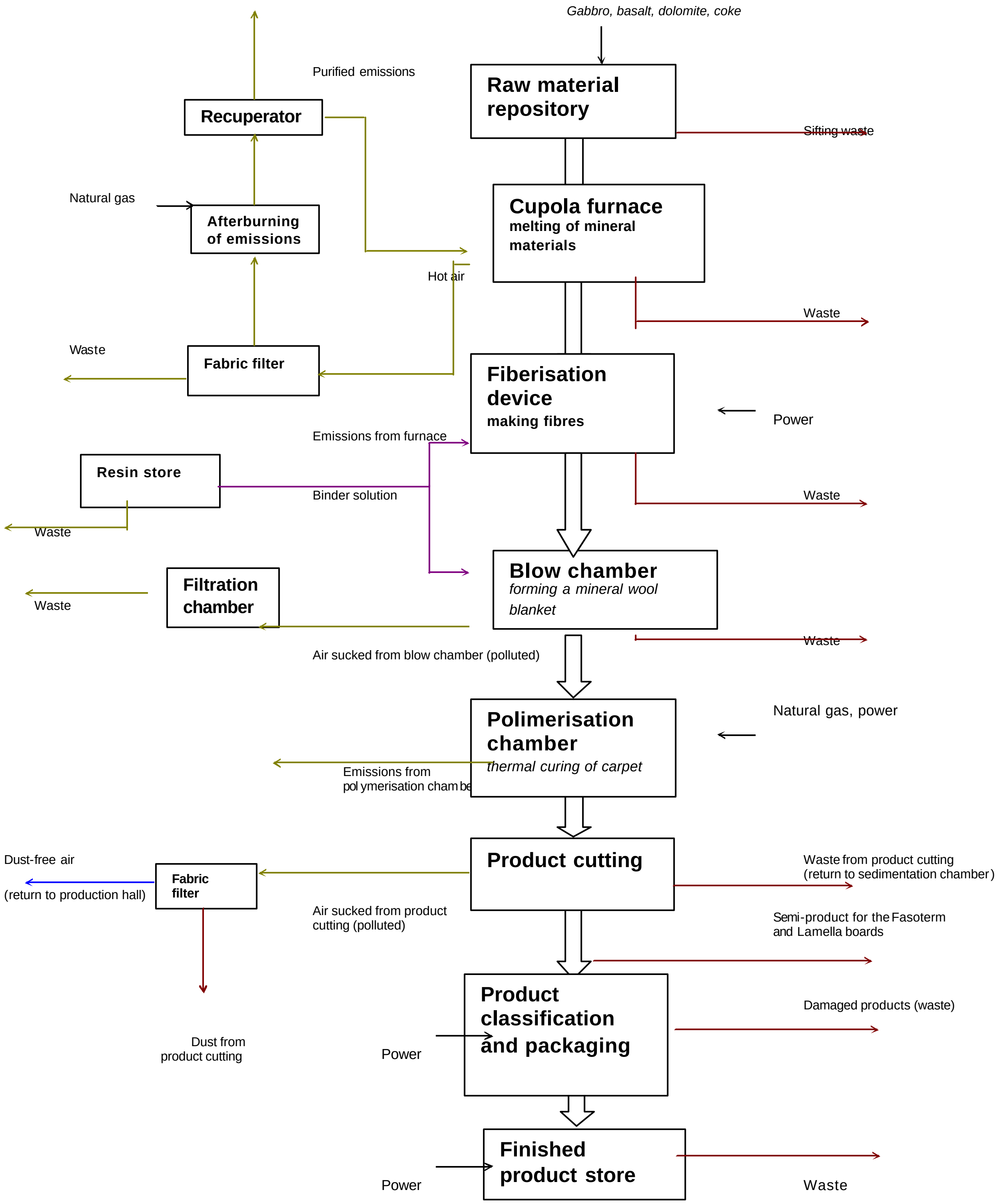

Fig. 1 – technological process flow chart

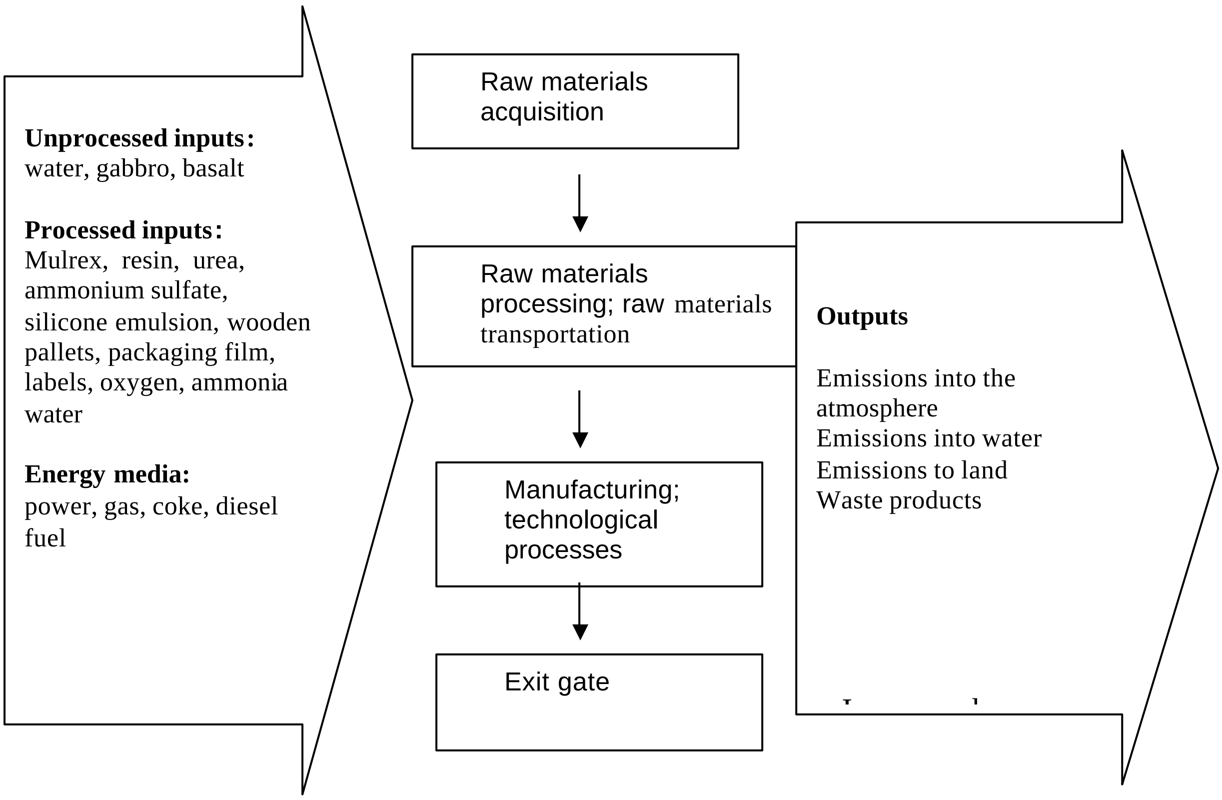

Fig. 2 – Diagram of the ISOVER product system subject of the report

The following processes have been included in the mineral wool system:

- energy consumption and impact resulting from the manufacture of: Mulrex in accordance with LCI ETH-ESU96 data base, resin in accordance with LCI-IDEMAT data base, ammonia water in accordance with The Buwal 250 data base, urea in accordance with ETH-ESU data base, resin according to ETH-ESU, oxygen according to the amount of energy used to generate it, pallets and packaging film according to ITB data, mineral mining on the basis of energy consumption, ammonia water in accordance with ETH-ESU96.
- consumption of primary energy used to obtain fuels including the production of gas and cupola coke
- impact due to the production of the process energy by the Plant, based on the Manufacturer's questionnaire
- impact due to the power purchased, data based on ITB calculations
- impact due to transport, i.e. diesel oil consumption
- impact due to technological processes, based on the Manufacturer's questionnaire
- water consumption and waste product manufacture, based on the Manufacturer's questionnaire.

8. Constrains of LCA methodology

The cycle adopted in this report spans a period from the procurement of raw materials to the sale to customer. In addition, the paper includes the ecological effects following from the application of mineral wool during the product's utility period.

The present characteristic does not take into account the 60-year period of the product's utility. The 60-year life period is to be applied to construction elements and structures.
The report does not deal with the subject of the management of mineral wool waste from demolitions since very few data are available on such management. It is assumed that when a balanced system of demolition waste management is developed in the future, it will be possible to recover almost in total the stream of used mineral wool and reuse it for the manufacture of the product. At present, the degree of recovery in Europe is a dark figure estimated at several percent. The waste from the mineral wool manufacture at SAINT-GOBAIN ISOVER in Gliwice is fully reusable in a new production cycle.
The LCA analysis made allows for the assessment of the ecological characteristics of the production process since it is the product manufacture stage that has the greatest impact over the entire life cycle of the product. On the other hand, there is the so-called relative ecological gain generated during the utility period of the product within the construction element.

9. Geographical limits

The geographical limits are the territory of Poland as most of the impacts result from raw materials, generation of energy, transport and processes that are based on Polish data. Some impacts which were estimated (since no component data were available) to complement the data supplied by the Manufacturer are based on the best average data coming from the EU databases. Such data are deemed acceptable in the LCA method all over the world when domestic data are missing.

10. Boundaries of product system

All the processes are estimated and added in such a way as not to lose more that 2% of the potential impact contained in the product. All the data whose summary mass fraction amounts to 95% of the total mass brought into the process were taken into account.
The impact resulting from the production of silane and silicone emulsion has been disregarded as negligibly small under the method. The methodology does not require that the product's impact includes the energy and raw materials which are part of the Plant's investment outlays.
Using wooden palettes causes negative emission of CO_2 in the wood life cycle.
Waste, such as slag, used in the process as recycled material has a zero environmental impact since its impact is contained in the final product of its primary system.

11. Types of impact categories, calculation method

All the criteria and impacts have been calculated based on the impact equivalents developed by the Centre for Environmental Studies (CML), University of Laiden, 1992 on the basis of permissible values and the toxicity of the substance in accordance with WHO recommendations. Table 1 lists the main types of impact categories used in the method.
The materials used in the production of mineral wool are assessed with a set of so-called equivalent emissions that characterise the definite categories of cumulative environmental impacts. The cumulative impact is the sum total of the impacts of all components. The categories of environmental impacts adopted in this report are the ones most often employed in the LCA assessments. Equivalent emissions are expressed as the quantities of substances that characterise the given environmental impact per mineral wool weight unit or so-called functional unit. The consumption of primary energy is the cumulative sum of all energy consumptions converted to primary energy. The sums of all the minerals used in the mineral

wool production processes are included in the criterion of consumption of non-energy resources while the sum of resultant waste is included in the 'waste' category. In turn, the 'transport' category is the sum total of all the transport processes expressed in tonne-kilometres.

Table 1 – List of main categories of environmental impact

It.	Impact Category	Category Description	Examples
1	Use of raw materials	Consumption of renewable and non-renewable raw materials	Production of coal and iron ore
2	Global Warming Potential (GWP)	Emissions into the atmosphere that raise air temperature	CO_2, CH_4
3	Ozone Depletion Potential (ODP)	Emissions into the atmosphere that destroy ozone in the stratosphere	CFC, HCFC
4	Acidification Potential (AP)	Emissions into the atmosphere causing acid rain	SO_2, NO_x, HCl, HF
5	Eutrophication Potential (EP)	Eutrophication of water and soil	Nitrogen compounds, phosphorus compounds
6	Photochemical Ozone Creation Potential (POCP)	Emissions into the atmosphere that cause the creation of ozone near the Earth	Hydrocarbons
7	Human Toxicity Potential (HTP)	Emissions into the environment that are harmful to people and genes	Heavy metals and dioxins
8	Aquatic ecotoxicity and terrestric ecotoxicity (ECA, ECT)	Emissions into the environment that are harmful to ecosystems	Heavy metals, acids

12. Sources of data

The basic source of data is the LCI questionnaire filled by the Manufacturer.
The information contained in the questionnaire prepared by the Institute of Construction Technology (ITB) is verifiable and can be documented.
The data from NFOS (National Environment Protection Fund) 1995, IDEMAT, *THE BUWAL 250*, ETH-ESU96 and the Environment Protection 2002 yearbooks were used to develop data on the cumulative pollution factors related to the emission factors in the production process of electric and thermal energy and the transport.

13. Listing of environmental impact values

Table 6 lists the summary impact values of one tonne of mineral wool from the Gliwice Plant in the cycle beginning from the disbursement of raw materials to the product leaving the factory, calculated by the LCA method.
In the second part of Table 2, the impact values of one tonne of mineral wool are matched percentage-wise with the impact of the entire domestic economy per one inhabitant of Poland.

Table 2 - Thermal-ecological characteristic of one tonne of mineral wool manufactured by SAINT GOBAIN ISOVER POLSKA

Ecological characteristic of one tone of mineral wool manufactured at ISOVER		
IMPACT TO ENVIRONMENT	Beginning date	April 2004
	Completion date	July 2004
	Data source	BUWAL250, CHALMERS91, ETH-ESU96, manufacturer's data
	Geography	POLSKA
	Representativeness	ISOVER POLSKA
	LCA methods	ITB2002
	Allocation	95% product, 65,5% production
	Data arrival date	May 2004
	Limits	from obtaining raw materials to the product leaving the factory
	Comment	
Impact criteria	**Unit**	**Criteria values (a)**
Greenhouse effect	kg CO_2 (100 yrs.)	1240
Destruction of ozone layer	kg CFC11	0,001
Acidifying effect	kg SO_2	7
Air pollution: toxicity to humans	kg tox	29
Air pollution: ozone creation potential	kg ethylene (POCP)	0,4
Energy use	MJ/t	5510
Water pollution: toxicity to humans	kg tox	3
Water pollution: toxicity to environment	m^3 tox	17760
Water pollution: eutrophication	kg PO_4	1
Use of water	Litre	51000
Waste quantity	Mg	420
Transport	Mg·km	1
Impact criteria	**Per inhabitant of Poland (b)**	**Standardised values (a/b*100%)**
Greenhouse effect	11 000 kg CO_2 (100 yrs.)	11
Destruction of ozone layer	0,0069 kg CFC11	14
Acidifying effect	80,4 kg SO_2	9
Air pollution: toxicity to humans	89,2 kg tox	33
Air pollution: ozone creation potential	32,23 kg C_2H_4	1
Energy use	2,27 toe=78275 MJ	7
*Water pollution: toxicity to humans**	*n.d.a.*	-
Water pollution: toxicity to environment	*170000 m^3 tox*	10
Water pollution: eutrophication	65,62 kg PO_4	0
Use of water	292 000 litre	17
Waste quantity	3,22 Mg	13
Transport	1191,3 Mg·km	0,1

(a/b*100%) for wood is -2,41; for PCV window 112,9 considering greenhouse effect [4]

14. Comparison of the LCA results for 1kg of mineral wool from Gliwice plant with other insulation materials

Table 3 - The environmental impact of 1 kg of ISOVER mineral wool in the cycle beginning from the disbursement of raw materials to the product leaving the factory; comparison with other products from the same group

Impact criteria	Units	ISOVER mineral wool	European mineral wool (ETH-ESU) [5]	European foamed polystyrene, average [6]	Mineral wool from other source [7]
Greenhouse effect	kg CO_2 (100 yrs.)	1,24	1,43	2,52	6,36
Destruction of ozone layer	kg CFC11	1E-6	4E-7	9E-7	n.d.a.
Acidifying effect	kg SO_2	0,007	0,009	0,019	0,001
Air pollution: toxicity to humans	kg tox	0,029	0,018	0,026	0,003
Air pollution: ozone creation potential	kg ethylene (POCP)	0,0004	0,00023	0,002	0,0002
Energy use	MJ	5,51	14,064	82	8,92
Water pollution: toxicity to humans	kg tox	3E-3	1E-3	3,3E-5	n.d.a.
Water pollution: toxicity to environment	m^3 tox	17,76	35,63	36,5	n.d.a.
Water pollution: eutrophication	kg PO_4	0,001	0,0009	0,002	0,0001
Use of water	litr	51	10,6	175,5	n.d.a.
Waste quantity	kg	0,42	2	1,6	n.d.a.
Transport	Mg·km	0,001	0,02	0,03	n.d.a.

15. Ecological gains from mineral wool in the utility period of building

The energy saved on heating in the utility period of a building as a result of the application of warming insulation is called an energy gain. In this report, the energy gain resulting from the application of 1 sqm of mineral wool of specific thickness to a given partition is converted to ecological gain understood in terms of emission to environment caused by fuel, gas in this case.

Table 4 - The manufacture energy (E) of mineral wool of a specific thickness is set against the quantity of heat radiated from a detached family house (Q) through 1 sqm of wall, 25 cm thick, made of cellular brick with the λ factor = 0,62 W/mK and mineral wool, thickness D, with the declared λ=0,004 W/mK.

D Thickness of wool layer [m]	U Partitions W/m^2K	R Partitions m^2K/W	Q GJ/m^2 year	E Manufacture energy GJ	E* Cumulative energy GJ
0,01	1,257	0,795	4,220	0,00825	4,228
0,02	0,983	1,017	3,300	0,0165	3,316
0,03	0,807	1,239	2,709	0,02475	2,734
0,04	0,684	1,461	2,296	0,033	2,329
0,05	0,594	1,683	1,994	0,04125	2,035
0,06	0,525	1,904	1,7626	0,0495	1,812
0,07	0,47	2,12	1,578	0,05775	1,635
0,08	0,425	2,352	1,426	0,066	1,492
0,09	0,389	2,570	1,306	0,07425	1,380
0,1	0,358	2,793	1,201	0,0825	1,284
0,15	0,256	3,906	0,859	0,12375	0,983
0,2	0,19	5,263	0,637	0,165	0,802
0,3	0,138	7,246	0,463	0,2475	0,710
0,5	0,086	11,627	0,288	0,4125	0,701

The diagrams in fig. 3 show the amount of energy used to manufacture 1 sqm of wool of specific thickness and the amount of energy which passes through the coatings during the utility cycle.
The diagram of the cumulative energy of mineral wool life cycle, in its flex point at the thickness 0.2 m, indicates the optimal thickness of thermal insulation for the purpose of optimisation of the energy phase of the life cycle. In other words, it is the minimal energy input at manufacture for which the loss of heating energy during the utility period is the lowest.

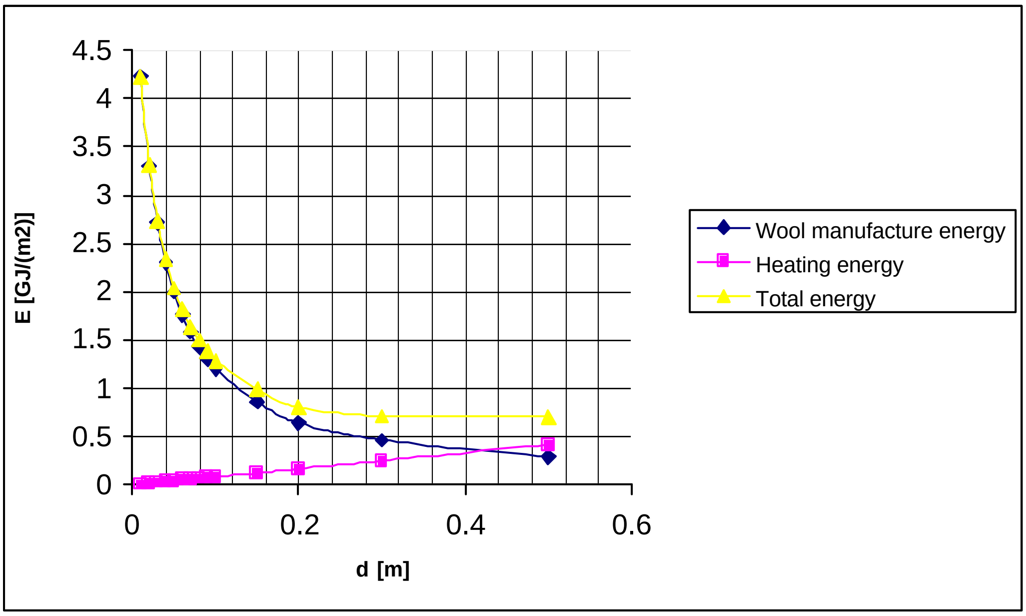

Fig. 3 - The diagrams of energy (E) consumed to manufacture 1 sqm of wool of specific thickness and the energy consumed to heat the building (Q), radiated through 1 sqm of partition over one year and the sum total of these energies as the total energy E.
By using 1 sqm of mineral wool in an external partition 25 cm thick, made of cellular brick, the ecological gains quoted in the table 5 for the given insulation thicknesses are obtained during one year.
Table 5 - Ecological gains from 1 sqm of mineral wool mat of specific thickness obtained during one year after application in a detached family house heated with gas.

Impact criteria	Units	Wool, 5 cm thick	Wool 10 cm thick	Wool 20 cm thick
Greenhouse effect	kg CO_2 (100 years)	222,72	269,7	302,76
Destruction of ozone layer	kg CFC11	4,45E-05	5,39E-05	6,06E-05
Acidifying effect	kg SO_2	0,264192	0,31992	0,359136
Air pollution: toxicity to humans	kg tox	0,78336	0,9486	1,06488
Air pollution: ozone creation potential	kg ethylene (POCP)	0,045312	0,05487	0,061596
Energy use	MJ	8486,4	10276,5	11536,2
Water pollution: toxicity to humans	kg tox	0,030682	0,037154	0,041708
Water pollution: toxicity to environment	m^3 tox	5414,4	6556,5	7360,2
Water pollution: eutrophication	kg PO_4	0,046464	0,056265	0,063162
Use of minerals	Kg	76,8	93	104,4
Water	litre	2592	3138,75	3523,5
Waste	Kg	3,84	4,65	5,22

Where insulation is made on the roof having U=1,123 $W/m^2 \cdot K$ (ceramic tiles, roof paper, pine boards on wooden beams) in a building heated with a gas stove of 0.94 efficiency, the values of ecological and energy gains as in table 6 will be obtained during one-year period.

Table 6 - Ecological gain from insulating a roof with a factor of U=1,123 $W/m^2 \cdot K$ (ceramic tiles, roof paper, pine boards on wooden beams) in a building heated with a gas stove of 0.94 efficiency.

Impact criteria	**Units**	**Wool, 10 cm thick**	**Wool 15 cm thick**	**Wool 20 cm thick**
Greenhouse effect	kg CO_2 (100 years)	156,02	172,26	182,236
Destruction of ozone layer	kg CFC11	0,000031204	3,45E-05	3,64E-05
Acidifying effect	kg SO_2	0,185072	0,204336	0,21617
Air pollution: toxicity to humans	kg tox	0,54876	0,60588	0,640968
Air pollution: ozone creation potential	kg ethylene (POCP)	0,031742	0,035046	0,037076
Energy use	MJ	5944,9	6563,7	6943,82
Water pollution: toxicity to humans	kg tox	0,0214931	0,02373	0,025105
Water pollution: toxicity to environ.	m^3 tox	3792,9	4187,7	4430,22
Water pollution: eutrophication	kg PO_4	0,032549	0,035937	0,038018
Use of minerals	kg	53,8	59,4	62,84
Water	litre	1815,75	2004,75	2120,85
Waste	kg	2,69	2,97	3,142

16. Summary

An LCA analysis of SAINT-GOBAIN ISOVER POLSKA Sp. z o.o. mineral wool manufactured in Gliwice has been made. The results of the analysis have been presented as the so-called thermal-ecologic characteristics illustrating the cumulative environmental impact of one kilogram of mineral wool. In comparison with the impact per capita generated by the entire home industry, it can be concluded that the impact resulting from the manufacture of one ton of mineral wool is several times less intense. The comparison of SAINT-GOBAIN ISOVER POLSKA mineral wool manufactured in Gliwice with other European insulation products shows that in the majority of environmental impact categories the SAINT-GOBAIN ISOVER product has either comparable or slightly lesser values. In the manufacture cycle, the product manufacture per mass unit uses less energy than the manufacture of other products. ~~Products manufactured by SAINT-GOBAIN ISOVER POLSKA Sp. z o.o. are environmentally friendly~~.

The application of mineral wool manufactured in Gliwice to the external partition and roof of a building brings about ecological benefits calculated in this report for the utilization period. The selection of materials with low environmental impact categories indexes and low overall heat-transfer coefficients is a significant indicator of the quality of the product from the point of view of environment protection. The results of the analysis prove that ISOVER mineral wool is a product meeting such requirements. The implementation of cutting-edge technologies such as ISOVER mineral wool leads to the reduction of heating energy consumption during the utility period of a building.

The present analysis of thermal-ecological characteristics of the products, based on the data supplied by SAINT-GOBAIN ISOVER POLSKA Ltd, can determine further course of action aimed at seeking improvement of ecological properties of the products over time, which should provide further incentive for incessant betterment of the quality and ecological friendliness of the product. The Manufacturer, who wants to advertise its products as ecologically friendly, has been implementing the elements of balanced development recommended by the Environment Protection Law and EU Directives.

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THE 3-LITER-HOUSE
AN INNOVATION IN THE MODERNIZATION OF OLD PROPERTIES

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1. BASF modernizes the Brunck Quarter

BASF's housing company, LUWOGE/GEWOGE Wohnungsunternehmen der BASF GmbH, is going to great expense to refurbish the 70-year-old Brunck quarter in the Friesenheim district of Ludwigshafen, investing about EUR 50 million in the project. The company has set itself the target of bringing this residential area, which is right in front of the gates to the BASF works, up to modern standards with regard to comfort and energy consumption.

The aim is to make the homes and their surroundings attractive again for young families with children, shift workers and elderly people. This is to be achieved with a sustainable urban development plan involving a combination of conservation and modernization of existing properties together with demolition and the building of new properties. When the refurbishment is complete, about 500 of the 850 apartments will remain. Because many of the old apartments are much too small, the total floor area will, however, remain about the same.

2. Attractive surroundings and a lot of greenery

The urban development measures are however not limited to improving the quality of housing. LUWOGE is also laying out new green areas; existing green spaces are being redesigned and the inner courts upgraded with small playgrounds and quiet areas. In conjunction with the Ludwigshafen municipal authority, LUWOGE has devised a traffic plan with traffic-calmed areas. Thus, the quality of the Brunck quarter as a residential area will be improved in as sustainable and exemplary way.

[1 published by approval of LUWOGE BASF Group]

As a result of attractive new buildings along Brunckstraße, this “Avenue” will become a more pleasant gateway to BASF and the town of Ludwigshafen.

3. Modern architecture in den Brunck quarter

In addition to the modernization work, new building is also underway in the Brunck quarter. Where the fabric of buildings was such that refurbishment was not possible at reasonable cost, properties have been pulled down. Three projects for new buildings have been carried out.

A modern block with 36 apartments which are specifically geared to the needs of senior citizens and shift workers is being built on Brunckstraße, between Sternstraße and Ruthenstraße. Tenants will be moving in at the end of 2001.

The Service Center, which is also situated on Brunckstraße and will accommodate LUWOGE and the BASF company health insurance fund, will be the showpiece of the Brunck quarter.

Modern row houses which are designed to meet the needs of young families with children are under construction directly behind the Service Center.

4. A good atmosphere in the Brunck quarter

Having been packed with composite thermal insulation systems, the modernized buildings in the Brunck quarter have an annual heating requirement of 70 kWh/m², which equates to 7 liters of heating oil per square meter. As a result, all the modernized old properties meet the thermal insulation requirements of German Energy Saving Ordinance 2000 (Energiesparverordnung 2000), even though it is common knowledge that these regulations are only binding in relation to new buildings. Together with the changeover to natural gas and the use of modern heating systems, the emissions of carbon dioxide (CO_2) from the entire residential area being cut by 80 percent.

5. Pointing the way ahead for property modernization

Very early on, the responsible people in LUWOGE developed the idea of using a building to demonstrate what was technically achievable and sensible within the context of an overall plan for the Brunck quarter in conjunction with BASF and partner organizations, to cut the annual heating requirement in old properties to 30 kWh/m², using a plan comprising optimum thermal insulation, efficient energy production and innovative building technology. That equates to a consumption of 3 liters of heating oil per square meter of floor area and a sevenfold saving compared with an unrefurbished old property. The vision led to Prototype I, which later developed into the House of the Future and now, as the first “3-liter-house” resulting from the refurbishment of an old building, offers comfortable and environmentally compatible accommodation to eight tenants and their families.

6. New prospects for old properties

Almost 95 percent of the total consumption of heating energy is accounted for by old residential properties. At least 24 of the 34 million apartments in old properties in Germany are in need of refurbishment. These figures show not only where the potential is, but also where the greatest challenge is, for bringing about noticeable cuts in energy consumption and significant reductions in CO_2 emissions in the future through extensive thermal insulation and advanced heating technology. The refurbishment of old properties is environmental protection in practice. LUWOGE's 3-Liter-House opens up completely new prospects in this market. It must not be forgotten that energy prices are continuing to rise.

The equation "environmental protection = increasing marketability" applies to housing companies. By investing in measures which reduce the consumption of energy in old properties significantly, housing companies can secure a competitive advantage for themselves. Lower incidental costs (heating, lighting and services), together with an increase in comfort, are top priority for tenants.

7. The know-how Verbund makes the 3-Liter House possible

LUWOGE's 3-Liter House is a good example of how an optimum system solution can be achieved through the combining of different core competencies and the sharing of expertise in a so-called know-how Verbund – not forgetting the financial aspects. Together with manufacturers from the building industry, building services companies and BASF, a plan was developed, under the leadership of LUWOGE, to use innovative components to create a building which was highly efficient with regard to energy use and in other aspects. A three-year scientific measurement program, collecting a large quantity of data in "Prototype I", provides valuable information for the development of property refurbishment as a market of the future.

8. Optimum thermal insulation in the 3-Liter House

In order to achieve an annual energy consumption equivalent to 3 liters of oil per square meter of floor area, a great deal of insulation work is required, especially in an old property where the fabric and construction fall far short of the present-day state of the art.

For this reason, the following rule in particular should be observed with regard to the refurbishment of old properties: cellars, walls, windows and roofs must not be viewed as individual, isolated solutions; instead, an all-encompassing energy plan is the key to success. Only in this way can a windproof and airtight envelope be achieved and thermal bridges avoided. Neopor®, a recently developed type of expanded polystyrene, played an important role in meeting these requirements in the refurbishment of the 3-Liter House.

9. Neopor® opens up new dimensions in external wall insulation

The difference between Neopor® and the familiar Styropor® as an insulating material is apparent immediately. Neopor® boards are not white, but silvery-gray. The new material is based on polystyrene and contains microscopically small flakes of graphite which reflect heat and make the boards virtually impermeable to thermal radiation. As a result, Neopor® has a considerably higher thermal insulation capacity than conventional insulating materials. A board of Neopor® can be up to 20 percent thinner than a conventional board of Styropor® with the same density (i.e. with the same insolating performance). Specifically in relations to the refurbishment of old properties, where it has not been possible to fit thick insulation packages in the past for constructional reasons, this is an aspect which opens up new prospects for the installation of composite thermal insulation systems.

The new insulating material is also attractive for ecological and economic reasons. Because less raw materials is needed for the same insulating performance, there are savings in costs and resources. Every board fitted on external walls eases the pressure on the environment. About ten liters of crude oil are needed to produce 2 square meters of Neopor® (10 cm thick).

But this same board will save approximately 1,200 liters of heating oil over a period of 50 years!

10. Windows help to cut energy consumption

The windows are an important element in the energy plan of the 3-Liter-House. Increasing the window area makes passive use of solar energy possible and also improves the natural lighting in the living areas. BASF's triple-glazed Vinidur® plastic-framed windows, filled with inert gas, provide thermal insulation; the U value is about 0.8 W/m^2K.

11. The 3-Liter House is full of innovations

The modernization of energy use in the 3-Liter House does not end with the optimized thermal insulation of the fabric of the building; it continues in the inherent qualities of the property. One cannot see, just by looking at the building, what technical refinements and innovative products have been incorporated in it. The only thing which counts is the benefit to the occupants and the environment, not any attempt to impress.

12. The air is always clean and healthy

A controllable ventilation system in the 3-Liter House ensures that all rooms get optimum ventilation at all times. At the same time, 85 percent of the heat produced is recovered.

13. The air-conditioning system in the wall

It is virtually inconceivable that a room can be warm in the winter and cool in the summer without a complicated an expensive air-conditioning system. But these conditions are possible in two rooms in the 3-Liter House. An interior plaster designed to retain latent heat ensures that the indoor climate there is always comfortable and pleasant.

This interior plaster was developed by BASF. Between 10 and 25 percent of it is made up of a material in the form of wax particles which stores latent heat. This means between 750 an d1500 grams of wax per square meter of wall. The heat absorption capacity of two centimetres of this plaster is equivalent to that of a 20 cm thick timber-bricked wall. If it gets too hot outside, the wax melts and thereby uses up retained heat; as a result, it stays cool longer inside. In order that the wax can be incorporated into paints or plaster, BASF researchers have "packed" it in microcapsules.

14. The fuel cell as a miniature power-plant in the cellar

The 3-Liter House is supplied by means of a fuel cell which is designed to provide some of the overall heating energy requirement of the building. Additional supplies come from a modern heating boiler and the public power supply network.

The fuel cell is an important factor in the energy plan of the 3-Liter House. As a result of improvements in insulation due to constructional features, new and innovative supply solutions are increasingly coming to the fore to meet the energy requirements for spatial heating and hot non-potable water in a more energy-efficient way. Fuel cell technology will play a key role here owing to its high efficiency and lower emissions.

The miniature power-plant in Ludwigshafen is based on the principle of the polymer membrane fuel cell. In this type of cell, natural gas is first converted into a hydrogen-rich process gas in the fuel gas reformer and then fed into the fuel cell stack. There, the fuel cell process takes place as air is fed in. The residual gases are burnt up completely in a catalytic “afterburner” and the emissions are considerably lower than those from a conventional heating system. Because it is one of the first systems of this kind in Germany, it is being tested over three years in the context of a scientific study and for this reason measuring equipment has been installed in the building.

15. Company housing policy – a welfare benefit with a history

LUWOGE and GEWOGE are BASF’s two housing companies and they are now responsible for a stock of 10,000 rented apartments. Now that there has been a very sharp decline in the amount of new building work over the past few years, the maintenance and modernization of the existing housing stock are becoming increasingly important. An up-to-date standard of housing, attractive ground plans, harmonious surroundings, social compatibility and tenant satisfaction constitute a unity here.

Since 1995 the housing companies have been active in large-scale urban regeneration projects. The improvement and revitalization of downtown residential areas has become a joint task with the local authority and the state, with housing programs and town-planning measures being combined into cooperative housing projects by committed partners. The Water Tower Estate project in Schwarzheide and the Brunck quarter project in Ludwigshafen are models which can also be applied far beyond the boundaries of Ludwigshafen.

16. BASF – a leading chemical company

BASF is a transnational chemical company that aims to increase and sustain its corporate value through growth and innovation.

The company’s product range includes high-value chemicals, plastics , colorants and pigments, dispersions, automotive and industrial coatings, agricultural products and fine chemicals as well as crude oil and natural gas. BASF’s approach to integration, known in German as “Verbund,” is one of its particular strengths, ensuring cost leadership and a unique competitive advantage. BASF is one of the world’s leading chemical companies. BASF acts in accordance with the principles of Sustainable Development. On the internet BASF can be found at www.basf.com.

For the construction industry BASF produces basic materials such as dispersions or expandable polystyrene for the manufacture of insulating materials. The most recent addition to this family of products is Neopor®. Neopor® is an expandable polystyrene for the manufacture of gray foams.

17. Summary

3-Liter House in Ludwigshafen/Rhein: Only three liters of heating oil per square meter per annum and an 80 percent reduction in CO_2 emissions at the same time – is that possible? It is in BASF’s Three-Liter-House in Ludwigshafen. This ultramodern building, which also known as the “House of the Future”, is a totally refurbished old property with nine dwelling units covering a total of 700 square meters. Compared with an unrefurbished old building, the annual heating requirement is between seven and ten times lower. Expressed in terms of money, this means that the annual heating costs for a tenant in a 100 m² apartment are cut from 700 Euro to less than 100 Euro and energy consumption is reduced by 80 percent. BASF is investing about 1,5 million Euro in the project.

The energy savings and the associated reduction in CO_2 emissions are achieved first and foremost by way of special thermal insulation. Neopor® is a type of expanded polystyrene, recently developed by BASF, which is particularly suitable for thermal insulation on outside walls. Over a period of 50 years 1200 liters of heating oil can be saved with ten liters of crude oil which are needed to produce a slab of Neopor®. Neopor® has another advantage over conventional insulation materials: infrared absorbers and reflectors also reduce its thermal conductivity.

Warm in the winter and cool in the summer: BASF has developed a new kind of interior render, containing a material which stores latent heat. Between 10 and 25 percent of the render is made up of this material, so this means 750 to 1500 grams of wax per square meter. The heat absorption capacity of two centimetres of this render is equivalent to that of a 20 cm thick timber-bricked wall. The heat-retaining material provides a pleasant and comfortable indoor climate. If, for example, it gets too hot outside, the wax uses up heat as it melts, and there is no increase in the room temperature. The wax max be solid or liquid, depending on the time of the year. In order that it can be incorporated into concrete or plaster, BASF researchers have "packed" it in microcapsules.

The windows in the 3-Liter House are triple glazed and have a U value of just 0.8 W/m^2K. The space between the panes is filled with inert gas for even greater energy saving. The frames, which are made from BASF's Vinidur® uPVC, feature a urethane foam core for optimal insulation.

The 3-Liter House is heated, amongst other things, by a fuel cell which uses natural gas as its source of energy. It is one of the first systems of this kind in Germany which are being used under real conditions and tested in the context of a scientific study with external partners. For this reason the building is equipped with the latest measuring instruments which record, store and show all the consumption data locally in a digital form. The scientists evaluate a total of 120 million items of measurement data annually. The quantities of atmospheric pollutants arising from the use of this highly efficient energy converter are very low because the main reaction product is water.

For more information regarding the 3-Liter House especially for more technical details don't hesitate to contact either Dipl.-Ing. Albrecht Göhring, Managing Director of the EnergyEffencyAgency Rhein-Neckar-Dreieck gGmbH, Phone 0049-621-60-47247, e-mail: info@e2a.de or Dipl.-Ing. Wolfgang Greifenhagen, Managing Director of LUWOGE BASF Group, Phone 0049-621-60-41011, e-mail: wolgang.greifenhagen@basf-ag.de.

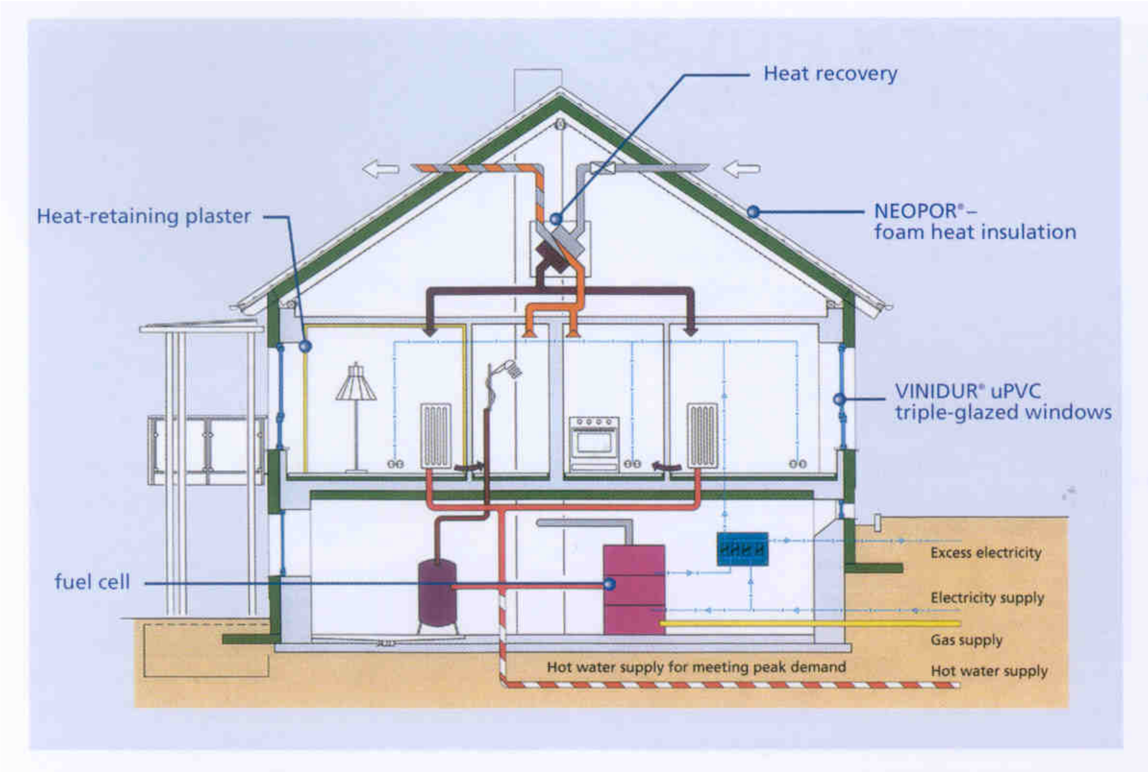
17. Photographs

1. View of the Brunck quarter with the site of the 3-Liter House (blue).

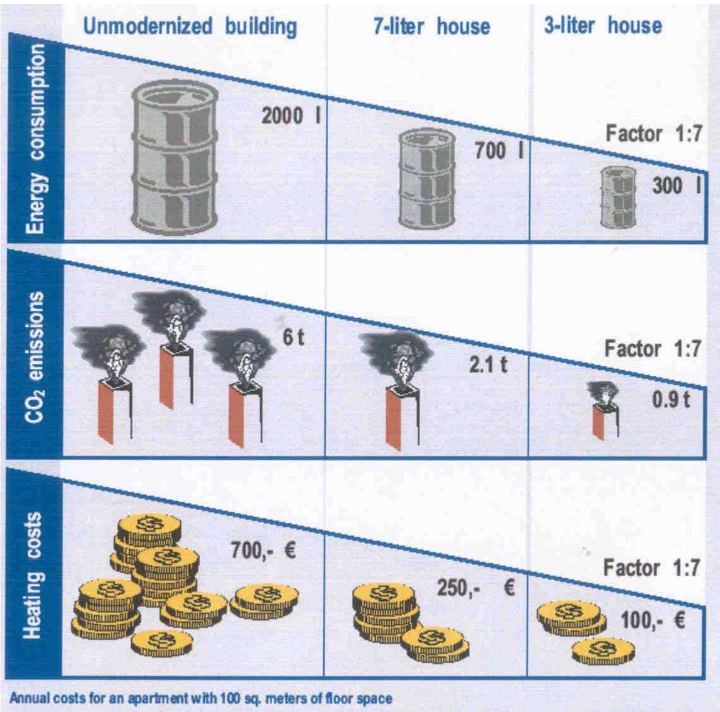
2. Arial photo of the Brunck quarter.

3. The 3-Liter House under contruction.

4. German Chancellor, Gerhard Schröder, Prof. Dr. Jürgen Strube, Chairman of Supervisory Board BASF AG and Kurt Beck, Minister-President of Rhineland-Palatinate.

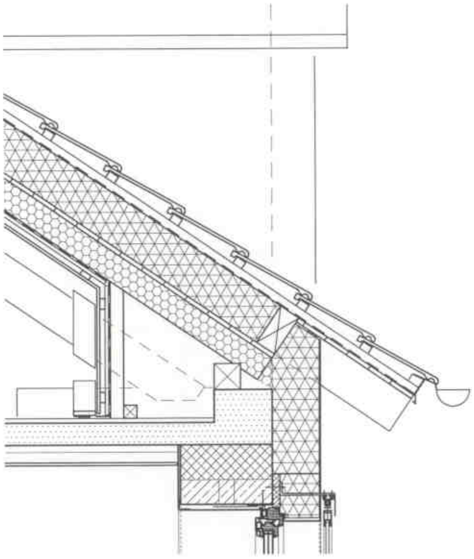


5. Cross section of the 3-Liter House.

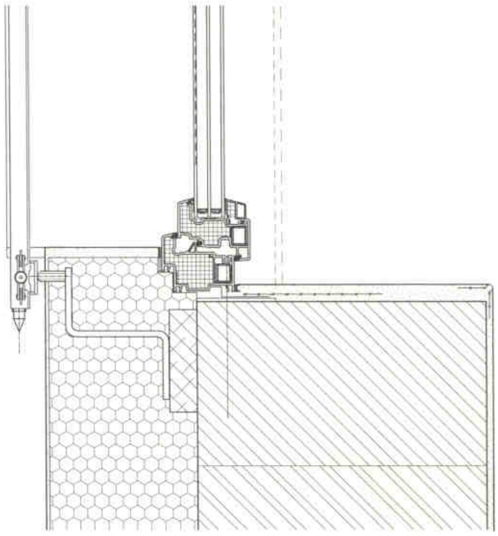


6. Benefits of energy saving.

7., 8.,9.: The entire shell of the 3-Liter House is encased in thermal insulation.



10. Detail of the roof.



11. Detail of the window.

12. Heat recovery.

13. Fuel cell.

14.,15.: Views of the 3-Liter House after refurbishment.

CRITERIA FOR ENVIRONMENTAL ASSESSMENT OF SCHOOL BUILDINGS IN POLAND AND NORWAY

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1. Summary

SURE-BUILD – *Sustainable Redevelopment of Buildings in Poland* – is a joint project between the Norwegian University of Science and Technology and Warsaw University of Technology, http://www.ab.ntnu.no/sure-build/. The project is focusing on rehabilitation of Polish schools based on the experiences gained by the work on sustainable buildings in Norway.

A part of this project focuses on defining relevant criteria for environmental assessment of school buildings as a background for determining the most beneficial measures for their re-development. The Norwegian EcoProfile (Økorofil) model has been used as a basis for testing out environmental assessment of 2 school buildings in Norway. Since this model is not specially intended for school buildings (but for dwellings and commercial buildings) – the model has been modified to better accommodate the assessment of school buildings in Norway. In Poland, the E-Audyt method has been developed for environmental impact assessment based on the generic framework elaborated within the Green Building Challenge project. One of the SURE-BUILD tasks is a comparison of the two methods and indication of a new combined set of criteria tailored for school buildings.

This paper briefly describes the Norwegian work on adaptation and testing of the EcoProfile model for school buildings in Norway. Further, the application of the model to a school building in Poland is described. This is a school in Zgierz that is part of the re-development

work in the SURE-BUILD project. The paper also discusses the relation to existing environmental criteria in Poland, and the needs for further adaptations in order to use an EcoProfile-related method for Polish school buildings.

During the last ten years considerable research has been focused on the development of systems to assess the environmental performance of buildings. The best-known existing system is the Building Research Establishment Environmental Assessment Method (BREEAM), developed by BRE and private-sector researchers in the U.K. Many spin-off systems have been developed by different countries world wide as HQE in France, EcoProfile in Norway, EcoEffect in Sweden, LEED in the US, CASBEE in Japan, etc. Some work has been initiated in order to standardize the assessment methods and to transfer knowledge about sustainable building across countries, e.g. through the ISO TC59, the IEA Energy Conservation in Building and Community Systems and the Green Building Challenge initiative. Comparative analysis supports efforts to identify critical environmental trends, track the success (or failure) of policy interventions, benchmark performance, and identify "best practices." The work presented in this paper represents a step on this path - by comparing, integrating and testing out the knowledge gained on environmental assessment methods in Poland and Norway.

2. The Norwegian EcoProfile Method

EcoProfile is a method for simplistic environmental assessment of buildings [1]. The method is intended to be quick and easy to use in order to reach a wide-spread us in the building community. Three versions have been developed; one for evaluating existing office buildings, one for evaluating existing dwellings, and one for use in the design of dwellings. The method assesses the buildings in three main criteria; "External environment", "Resources" and "Indoor climate". These main criteria are divided into sub-criteria (see figure 1), and several of these are again divided into sub-sub-criteria. Each sub-criterion contains a number of parameters, or indicators, at the lowest level. These parameters are used to assess the actual performance of the building, using an input sheet (in Excel). Figure 2 shows the parameters for the sub-criterion "Emissions to air". There are currently 82 parameters included in the method. Each of the parameters is given a grade. The grading scale ranges from 1 to 3 where:

Class 1 = Lesser environmental impact
Class 2 = Medium environmental impact
Class 3 = Greater environmental impact

Eventually a class 0 is going to be included that will represent a sustainable construction, but there is currently no basis for defining such a level. The grading is based on judgments by the assessor.

The final result of the EcoProfile assessment is presented in a bar diagram showing the 3 main criteria, see figure 3 (left diagram). For a closer view on the performance with respect to the sub-criteria, star-diagrams like the one to the right in figure 3, are provided.

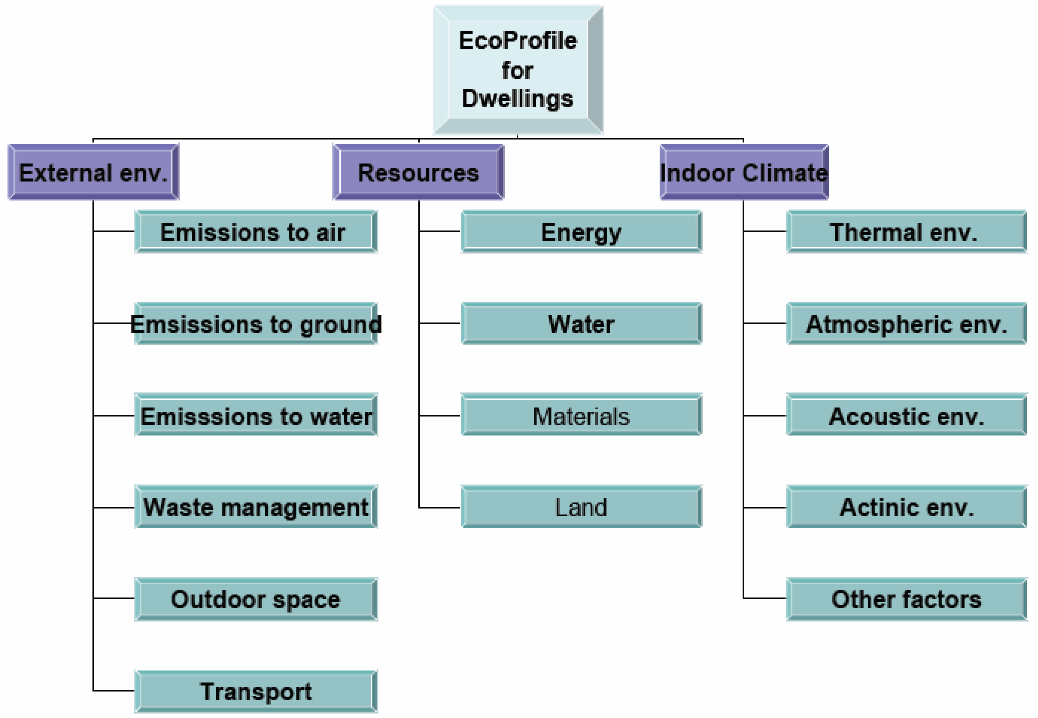

Figure 1. The main criteria and sub-criteria of the EcoProfile Method.

Y.1.1	Heating source	District heating, solar, heat pump	
		Electricity, combined oil/el, or bio	2
		Oil or gas	
Y.1.2	Maintenance of heating system	Not necessary	
		Established routines	2
		Not established routines	
Y.1.3	Cooling medium	Ammonia, CO2, or no cooling	1
		HFK (R134a)	
		KFK (R11, R12, R500, R502) or HKFK (R22, R123)	

Figure 2. The input sheet for the parameters to be assessed for the sub-criterion "Emissions to air".

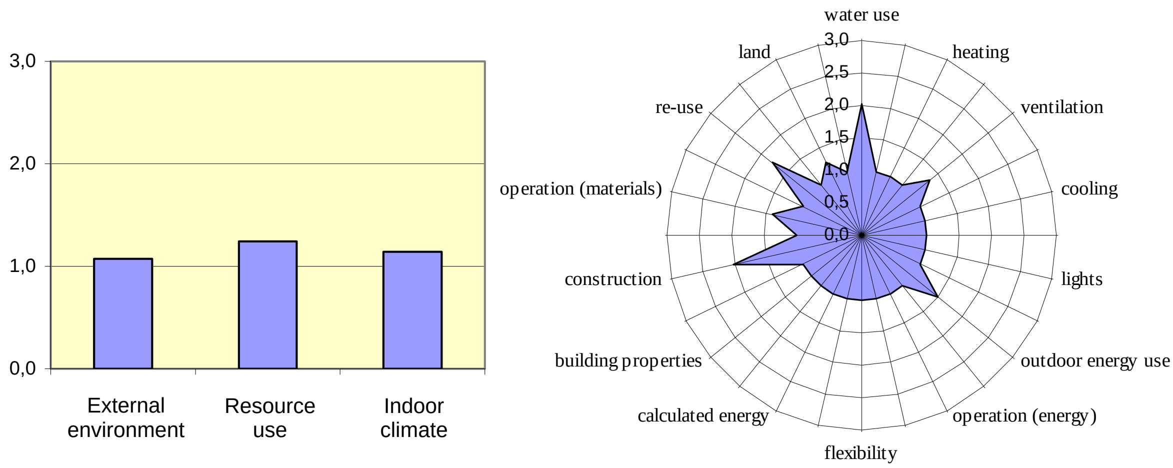

Figure 3. Examples of results of an EcoProfile evaluation.

2. The EcoProfile Method applied to 2 Norwegian School Buildings

In order to apply the EcoProfile Method to the design of school buildings, some adjustments were made. The adjustments involved using some parameters from the “EcoProfile for Dwellings” and some parameters from the “EcoProfile for Office Buildings” method. For example, the EcoProfile for Office Buildings does not contain any parameters related to material and land use, so for these issues, the parameters from the EcoProfile for Dwellings were used. Also, some parameters were slightly changed, and a few were left out, i.e. parameters related to the operation of the school that cannot be affected at the design stage. The weighting of the parameters was not altered, but this may be done in a later revision. This adjusted “EcoProfile for Schools” method was used during the design of two Norwegian Schools: Kvernhuset Secondary School and Borgen Community Center. This is documented in [2] and [3].

Since the results of the EcoProfile assessments were to be used in the further design of the buildings, the assessment had to produce very specific guidance to the design group. The results of the EcoProfile assessments were therefore presented as an OBS-list, i.e. a list of matters that needed special attention in the further design work. The OBS-list contained the following specifications (generalized):

1) Energy issues

1. Ensure good air tightness by careful detailing of building envelope
2. Minimum thermal insulation requirements for roof, walls, floor, and windows. Careful design to avoid thermal bridges.
3. Demand controlled services: minimization of lighting needs based on occupancy and daylight control, minimization of ventilation control based on low-emitting materials and controls based on occupancy, CO_2, temperature and moisture.
4. Avoidance of cooling installations by minimizing internal gains, using exterior shading, thermal mass, night free-cooling.
5. High efficiency heat-recovery
6. Clean and efficient energy supply systems

2) Indoor environment issues:

- Good daylight distribution (design of windows and surfaces)
- Avoid moisture (detailing, drying)
- Low-emitting materials for indoor surfaces
- Easy to clean (smoothness, avoid dust collectors)

3) Equipment and materials use:

- Minimize amount and size (multifunctionality, area-efficiency, flexibility)
- Use robust solutions (minimize moving parts, durable materials)
- Easy maintenance (access)
- Reuse
- Recycle
- Renewable
- Minimize hazardous waste/effluents

3. The EcoProfile Method Applied to a Polish School Building

The Primary School #1 in Zgierz was built in 1963, its construction is traditional masonry silica brick technology. The usable area is approximately 5970 m^2, of which 3110 m^2 is classrooms and 780 m^2 is gym area.

Figure 4. Primary School #1 in Zgierz. The Gym building.

Figures 5, 6, 7 and 8 show the results of the EcoProfile evaluation for the school building. So far, the evaluation has been based on drawings and a short description of the building construction. Later this year, the evaluation will be revised based on a detailed inventory and energy audit.

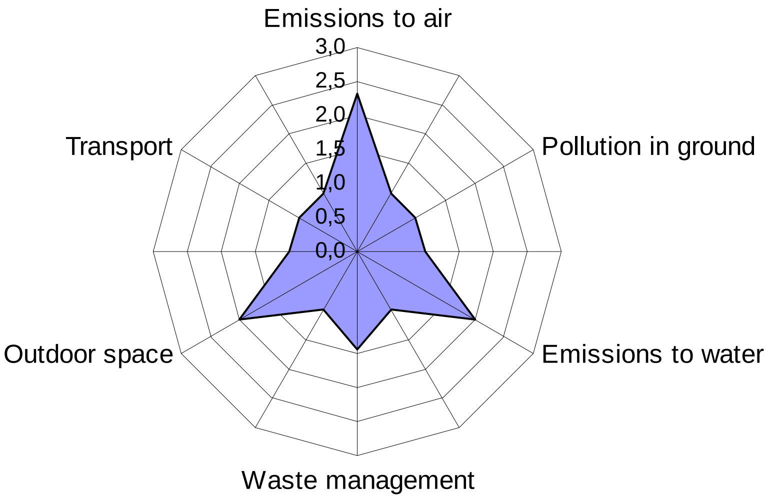

Figure 5. The EcoProfile star diagram for ”External Environment”.

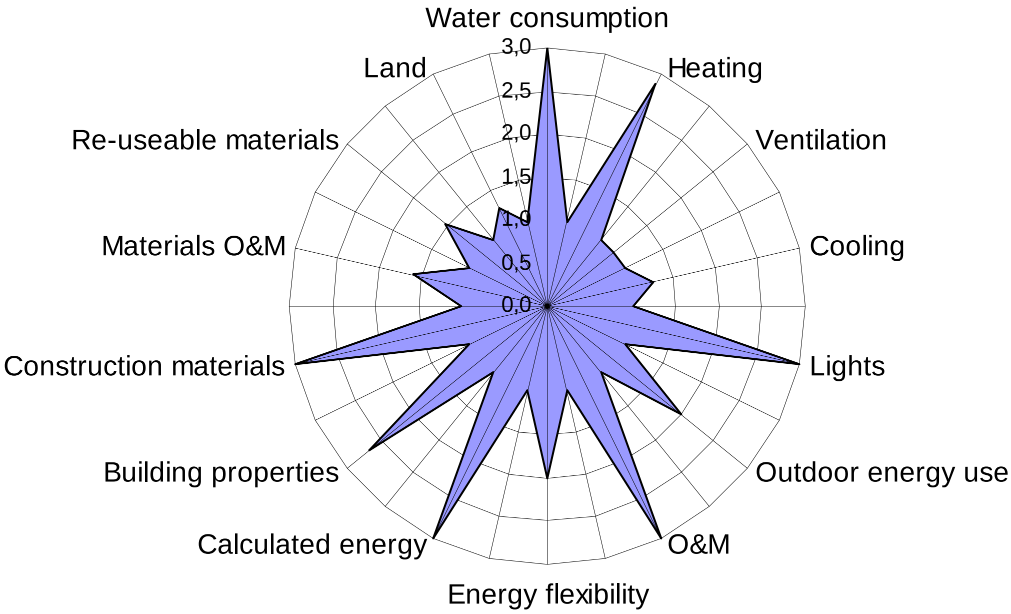

Figure 6. The EcoProfile star diagram for "Resource Use" (O&M is Operation and Maintenance).

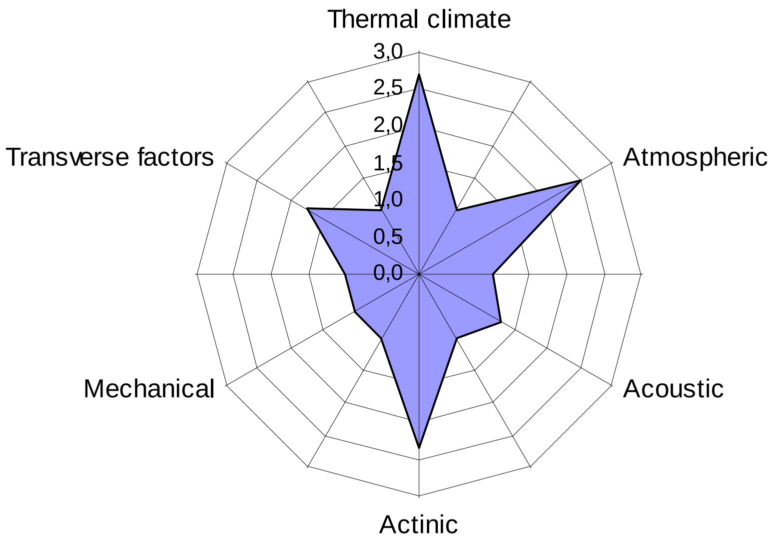

Figure 7. The EcoProfile star diagram for "Indoor Climate".

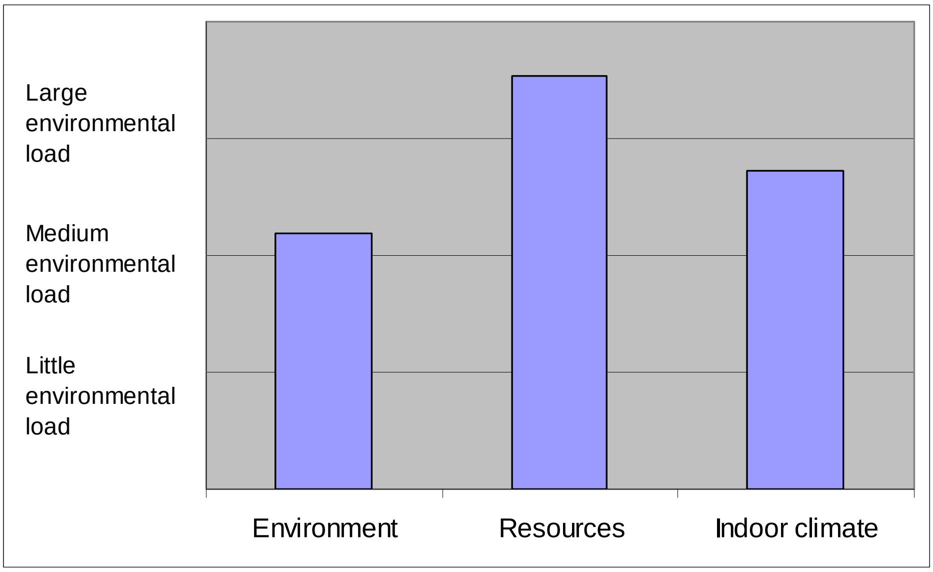

Figure 8. The overall result of the EcoProfile evaluation.

Looking at the star diagrams, one can easily sort out the factors that need special attention. Special attention should be given to the criteria with a score higher than 2, which means that they represent a rather high environmental load.

Concerning the external environmental loadings, figure 5 shows that it is only “emissions to air” and “waste management” that have a score higher than 2. The waste management is poor because there is no segregation of waste and there is no special procedure for the handing of hazardous waste. The “emissions to air” is high because the building has a heating system consisting of coal fired boilers that are over 15 years old. In the heating season of 2002/2003, 135 t of coal and 108 t of cinder coke were combusted.

Looking at figure 6, there are several items that receives a score higher than 2. The energy consumption for heating is high due to no thermal insulation, large air infiltration, and low-efficient heating system. However, there are no ventilation or cooling systems, which saves energy for running fans and pumps. The energy consumption for lights is high; gas discharge tubes and mercury discharge lamps are used, and there is no lighting control system. The building also receives a poor score on operation and maintenance (O&M), because there are no formalized procedures for energy management or the operation of the technical equipment.

The criterion entitled “Building properties” represents overall design and construction issues related to energy use, such as flexibility of space and effective use of space. These issues are judged to be poorly handled as the building has fixed partitions and quite specialized spaces. However, school is very spacious and offers a big potential for improvement.

The building also scores poorly on construction materials, which means that the materials which were used for constructing the building were not re-used or recycled, nor did they have any environmental label. The silica used as main construction material is quite deteriorated due to poor maintenance during the building life.

Finally, the building scores poorly with respect to water consumption; because there are no measures taken to conserve water (e.g. water saving equipment).

The last star diagram, figure 7, shows the result of the indoor climate evaluation. The figure shows that three issues require special attention; the thermal climate, the atmospheric climate, and the indoor climate. The thermal climate is poor due to poor ventilation, no exterior shading, and draft/cold radiation from windows. The atmospheric climate also suffers from poor ventilation, but the score is somewhat improved by the fact that the building has low-emitting interior surfaces. The actinic climate is quite poor due to insufficient electrical lighting, but this is somewhat counteracted by an ample provision of daylight.

Based on the preliminary EcoProfile evaluation, the following OBS-list of issues that needs special attention in the upcoming redevelopment process is produced:

1. *Reduction of heating energy needs.* This includes adding thermal insulation to the building envelope and replacing the windows with better insulating windows. The amount and type of insulation is to be decided based on technical/economical and architectural considerations. This will reduce the thermal losses through the envelope, reduce draft, and improve the thermal comfort. Care needs to be taken in order to avoid moisture in the construction and to ensure sufficient ventilation. Also, the heating system needs to be improved by using more efficient equipment, cleaner fuel, and efficient controls.
2. *Improved ventilation.* This involves designing a ventilation system with improved air exchange. The system may be based on mechanical or hybrid/natural ventilation principles. Utilization of natural driving forces, as well as easy operation, maintenance and use, should be emphasized.
3. *Improved thermal comfort.* This involves preventing high indoor temperatures by applying effective solar shading (e.g. exterior movable) and nighttime free cooling.
4. *Improved lighting*. This includes using high efficient lighting for energy savings and improved visual qualities. It also involves utilizing daylight to replace artificial lighting for energy saving and improved indoor environment, as well as occupancy controls.
5. *Improved waste management*. This involves having a strategy for collecting, sorting, and disposal of waste, including the provision of space and information programs.
6. *Water saving measures*. This includes installing water saving equipment such as low flush toilets and reduced flow showerheads. It may also include reuse of grey water for irrigation, etc.
7. *Visible environmental design and installations.* The Norwegian environmental school projects shows that using environmental design as a means for expressing and teaching the students and the general public about the environment, is an important success factor.

The EcoProfile evaluation of the existing building property needs to be revised after the visit to the site. Also, the structure and the specification of the criteria may be revised to accommodate local environmental issues. A blend between EcoProfile and the Polish E↻Audit method for environmental assessment of buildings [4], should be investigated. Then, a revised and more specific OBS-list will be produced as an input to the re-development work. During the re-development design work, one or more EcoProfile/E-Audit-analyses may be carried out to check the performance of the design alternatives. Finally, when the building has been re-developed and taken into use, a new EcoProfile/E-Audit evaluation may be carried out to check the result and possibly discover some further opportunities for improvement.

4. E↻audit Polish method

The E-Audit method of environmental performance assessment of buildings (new and existing) has been created as a result of analyses of existing methods, works of GBC and ISO, as experts' proposal. The E-Audit method could be a prototype of an official method for assessing environmental impact of buildings at the country scale. The method relies on building comparison in relation to a chosen standard. The standard is defined as a hypothetical building, a so-called reference building, designed and erected according to existing norms and local best practices, which is characterised by the same shape, volume, number of rooms, functions, number of users and location as the building assessed.

The assessment is a three stage hierarchical process. The lowest one is the sub-criteria, followed by criteria, and category which at the end forms the assessment of the issue. Features of the one level are the input to the higher level. Detailed description of issues, categories and their components criteria and sub-criteria are provided in [4]. Sub-criteria are related to the assessment on the lowest level, and after normalisation and weighting their sum present the assessment of higher level – the criteria. Within the criteria the founding sub-criteria can have the same units, but sometimes it happens that they have different units (like for Environmental Loadings different kind of emissions). The last case is a subject of normalisation in relation to some artificial scale. The features not related to the assessed buildings, as for example energy demand for cooling, in case of non existence of air conditioning system, the criteria is not considered and marked as non applicable - N/A. Every component of the assessment system has a value assigned from the relative scale, which allows objectivity and uniformity of the assessment at every level. The scale should have agreed graduation within the range containing recent demands for buildings and the demands beyond the existing norms and commonly used technologies. The range of the relative scale is from -2 to 5, where -2 represents building below the existing demands, and 5 reflects the best available solution.

All buildings are assessed with respect to 0 on a relative scale, which represents the reference building. It should be noted that some of the features are simple to assess (these are called direct). These direct elements, like for example the composting organic wastes feature, are assessed based on their existence, and are assessed in a two value process where -2 denotes non existence of the feature whereas 5 indicates its presence.

Assignment of values from the range of scale is performed on the level of sub-criteria or on a level of criteria for some simple features. The value assigned reflects the distance of the assessed building feature to the same feature of the reference building. For example, assessing seasonal heat demand, the reference building of some shape factor requires 283 MJ/m^3, and the case study building has 193 MJ/m^3, which is 32% less then the reference. The assigned value, from the scale is 4 which mean that the case study requires 30% less energy than the reference (0 on the scale). The resulting values are weighted (in order to reflect their internal importance) and summed. The definition of weights has been performed on the basis of the analytical hierarchy method.

The framework of the E-Audit system is the same as the framework of recent systems under development by ISO TC59 SC17 WG4, however for some of the features there are not reliable data in Poland. This includes for example the embodied energy in relation to materials and building components as it is required in Life Cycle Analysis. The E-Audit system is general and it can be applied to new and existing buildings of different types. Main and obligatory issues of the framework are: Resources Use, Environmental Loadings, Health and Indoor Environment.

The method does not provide benchmarks itself; it provides a list of issues of concern whereas the assessment methods are left for the assessor. The total number of criteria is more then 120 and depend on building type. E-audit is a comprehensive method which requires an adequate data base, which for many criteria does not exist in Poland.

5. Discussion of the applicability and relevance of the EcoProfile method in Poland.

Although different in many ways, Poland and Norway face many similar challenges with respect to sustainable building. Energy use is a main issue in both countries, and although the energy systems are very different, energy conservation stands out as the prime emphasis in both countries. Also, indoor environment is a prime issue in both countries. Schools in Norway suffer from bad indoor air quality and overheating, and so do Polish schools. Acoustics, however, seems to be a somewhat larger problem in Poland than in Norway. The quality of building materials is good in both countries, but their application and use need further attention. Water and waste management seems to be more advanced in Norway.

The Norwegian EcoProfile method and the Polish E-Audit method contain many similar environmental criteria. The strength of the EcoProfile method lies in that it is very quick and easy to use, the E Audit is complex and requires a lot of environmental data. Therefore, the combination of these features and the proposal of a framework adequate for school buildings is one of the tasks for future research in the SURE-BUILD project.

Some of the criteria in EcoProfile seem to be too superficially treated, considering their importance for the overall environmental performance of school buildings in Poland. Ventilation, daylighting and quality of space probably need to be elaborated, their high importance taken into account. Also, some criteria may probably be left out. Furthermore, the weights need further consideration. However, at this stage in the project, there is insufficient experience in order to draw any final conclusions about these issues.

Nevertheless, it is clear that an EcoProfile/E-Audit analysis is very useful as a basis for setting specific goals for the re-development work, and for following up the goals throughout the process. [5] lists a number of technologies for sustainable re-development and their strengths and weaknesses with respect to application in Polish schools. The SWOT analysis includes considerations about cost-efficiency, energy-saving potential, technical compatibility, skill and knowledge requirements, etc. Together with the EcoProfile/E-Audit analyses, this makes a useful basis for sustainable re-development of Polish schools.

5. References

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SETTING ENERGY PERFORMANCE REQUIREMENTS

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1. Introduction

Accepted, by European Parliament and the Council on 16th December 2002 Directive 2002/91/EC on the energy performance of buildings requires undertaking different legal ways for its adoption by member states. The due date for adoption has been set for 6^{th} of January 2006. The implementation process will be screened and its results will be monitored and published by EC. Member states have already established different national and international programmes and projects to exchange information and share experiences in relation to implementation process. The Directive is also a subject of many conferences and seminars of different group of stakeholders, as its provisions addressing needs for harmonization of calculation methodology and necessity for setting new energy performance requirements. Polish government, as other member states, has to implement the directive which will be a subject of notifications. The presented analysis has been prepared for the purpose of bilateral governmental Polish-Danish project dedicated to the preparation of Action Plan for implementation of EPD directive [1].

For the purpose of the adaptation some countries will use already existing regulations, and some will establish new Laws or Acts on different levels. The regulations will give mandate for application of procedures described in the referenced standards, and will introduce controlling and monitoring mechanisms supporting execution of their provisions. It is widely declared that the countries will seek rather for incentives not for penalties in relevant regulations. The overall estimated goal of achievement (however not officially confirmed) is 22% of savings trough the overall energy use in buildings in Europe. Goal of Directive cannot be achieved without introducing new more restrictive energy performance requirements.

Declaring certain % of energy use reduction indicates need for funds, as the higher energy standard requires increase of investment cost. The levels of these additional costs of energy use reduction depend on the country's economic capability and readiness for environmental stewardship of the society.

Same as with the cost of CO_2 reduction varying from country to country, the cost of introducing new energy standard will be different among the member states. Therefore decision makers have to decide about the level of sharpening existing energy performance requirements. Effects of setting new restrictive requirements have multi dimensional impact on economy: financial - on investor, fiscal - on contractor and on investor, environmental - because of energy savings, stimulating employment - in manufacturing and servicing facilities and others like costs of introduction of certification and system management.

The ideal situation would be if discounted fiscal budgetary income in some time would be equal to the worth of discounted savings achieved by the investor. Methodology of measuring and discounting these cash flows should be agreed and form a basis for evaluating countries' environmental stewardship. The general goal of the paper is presentation of procedure for evaluating countries efforts in order to adopt provisions of the Directive.

2. Options of requirements

An important issue in setting the procedure of new energy requirement is how these requirements are designed. Different buildings types would have different energy requirement. Two general approaches are possible [2]:

1) Use of real measured data characterised by following problems:
   - There will be a need to calibrate the calculation model versus set of measurements. This would be a serious task and a huge data base is required.
   - The good data sets do not exist for all the buildings
2) Second approach is generation of calculated values based on standard weather conditions, standard building use for each type of the building. This is understandable for residential buildings, and is unclear for other buildings. How to standardise energy use for the whole building composed of different building zones realising different functions (the energy use depends on building shape and location of zones).
3) Also one should consider whether specific requirements (insulation level, windows, etc) should be set or if on be should apply overall energy frame requirements

Two levels of requirements exist in Polish regulations: prescriptive (for non-residential) and performance (for residential). For the sake of directive it is a need for defining performance requirements for all types of buildings. There are several ways of doing this and many factors which must be taken into consideration. Also one should keep in mind that requirements should be reviewed at regular intervals which should not be longer than five years and, if necessary, updated in order to reflect technical progress in the building sector. The ideal way of setting requirements and hence establish the basis for political decision making would include aspects of all the options presented below.

The first option **"analogy",** for setting the requirements, is based on an analysis of requirements set up by neighbouring countries, and their adaptation to climate conditions. This approach is widely used for verification and has been sometimes used previously for defining prescriptive requirements.

The second option **"economic"** is calculation of costs and savings and definition of final prescriptive and further performance requirements based on energy efficiency analysis for different types of buildings. Such approach has been undertaken e.g. by Germany [3] and Norway [4] and by Poland for the sake of optimisation investment option for energy audit [5].

The third option **"impact"** is a mix of second option and calculation of impact on economy analysis described further in detail. This option encompasses the efficiency of the investment itself, and the strategic goal of the country expressed in terms of expected savings (e.g. some percentage of current use, or required reduction of CO_2 for assumed time span). Determination of final energy performance requirements has multidimensional consequences. As a result of the analysis of these consequences recommendations for decision makers can be indicated in relation to the scope and form of possible incentives to support certification. There are different types of probable incentives e.g. fiscal as exemption from real estate tax, soft loans for those who will follow energy plans, direct reimbursement of certificate costs and others. The implementation of specific incentive should be in line with European regulation in regards to public support.

Energy performance requirements are the most visual and easy to check provisions of the directive having very direct influence on erection of new buildings and renovation of large buildings. Some support in establishment of new requirements in Poland gives Thermo-modernisation Act, already in force for 5 years. Energy audits prepared under the Act provide information about potential savings and costs of different investment options. The Act introduces specific prescriptive requirement for renovated buildings. The minimum R value of the external walls after the thermomodernisation was set to 4 m^2K/W, and it is a demand to employ optimisation procedure to calculate thickness of insulation. The minimum U-value is more restrictive then the actual requirements for new buildings, as the system efficiencies usually are not as good as for a new buildings. However, the future requirements will be expressed in performance terms and would not be a need for defining the minimum permissible, instead the overall building energy performance will be regulated.

3. Impact estimation

3.1. Model of impact estimation

Determination of new more restrictive energy performance requirements can be elaborated based on specific assumption about the input data and model analysing dependences. The model takes into account basic impacts as: budget income generated trough investment and expressed as investment outlays; scope of undertaken modernisations and related energy or CO_2 emission reduction. The data is taken from:

- adequate energy audits, and available statistical data provided by the energy surveyors
- calculated energy savings related to specific investment measures
- estimation of investment costs and further prediction of income for budget and contractors

To predict the number of investment undertaken every year it was assumed that the most efficient investments will be realised as priority. This means that the building of worse standard is potentially a most favouring place for modernisation.

3.2 Input data

Data required for estimation of impact within environment, employment and budget can be divided into five main groups:

1. building stock – required for prediction of number of buildings, and their energy standards, considered to be modernised in a chosen time.
2. technical aspects of buildings – required for calculations of results of modernizations (energy savings assigned to specific measures) as well as investment costs of measures.
3. energy sources –needed for calculations of economic efficiency of investment and related environmental impact.
4. industry and employment –required for estimations of impact by increased volume of modernizations on industrial productions as well as on construction process and employment.
5. macroeconomy – required for estimation of budgetary income from taxes due to the undertaken investments.

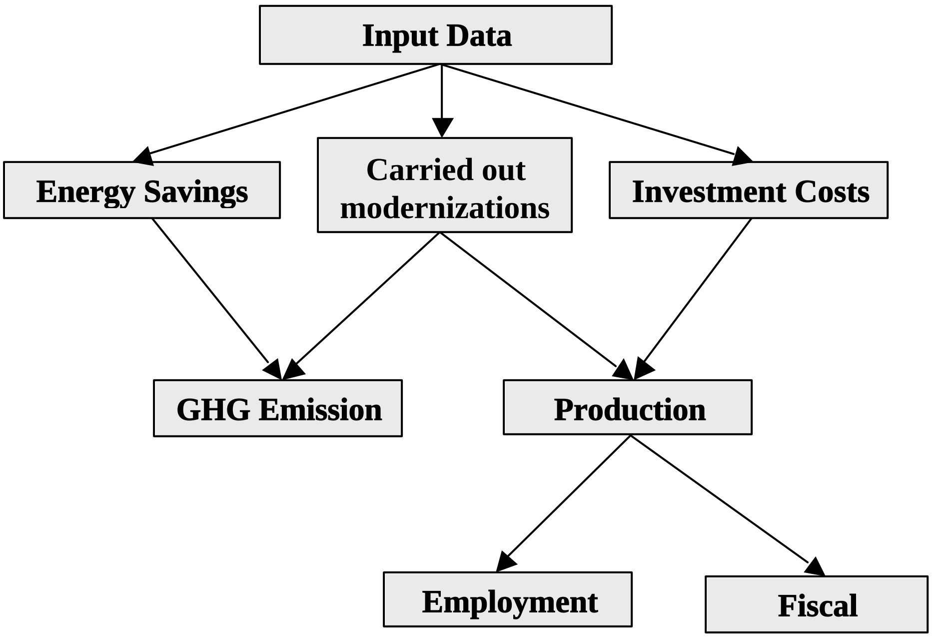

Fig. 1 Ideogram of data dependencies and aggregation

3.3 Scope of carried out modernizations

Scope of modernizations is crucial for consideration as it influences value of undertaken investments and energy savings. It depends on willingness to pay, a social factor, difficult to estimate. In here, the efficiency of specific measures has been used for ordering investment options.

The indication of efficiency has been defined based on SPBT (simple payback time) of modernisation measure. Due to its simplicity the SPBT value is widely used and easy to understand, and does not complicate the model, however it has some disadvantages.

It is assumed that investments characterised by lower SPBT will be carried out as first but social factor of different investments influences the general outcome and the precise number of possible investments will vary depending on the willingness of building owners.

For example, the assumed for further analysis dependence of range of possible investments vs. SPBT value is shown on figure 2.

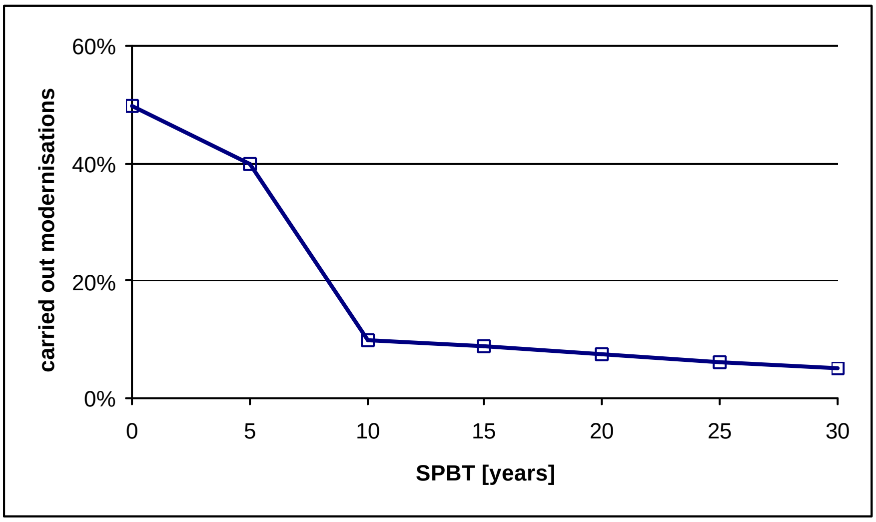

Figure 2. Dependence of range of possible investments vs. SPBT value

3.4 Environmental impact

Reduction of energy consumption due to the improved energy standard of buildings results in reduction of GHG emission. The value of reduction can be estimated using specific emissions of energy sources (fuels) and the data about energy sources efficiency in modernized buildings.

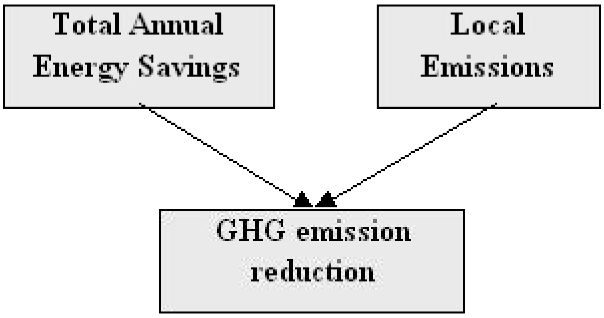

Fig. 3 Estimation of environmental impact related to energy savings

3.5 Production and employment

Increased volume of investments results in increased construction and production output. The factor that stimulates production is the total value of loans taken for realisation of investments; the down payments are recognised as the element of maintenance, thus they do not influence rate of production.

Increased production output requires higher employment. The number of workers can be estimated by the volume of total production increase and worker productivity. There is also negative factor of improved energy standards related to mining industry. While the industrial production increases the drawback of lower energy consumption, the requisition for fuels is dropping down. This causes lower employment in the mining industry. The number of workers which probably will loose their jobs is calculated using worker productivity in mining.

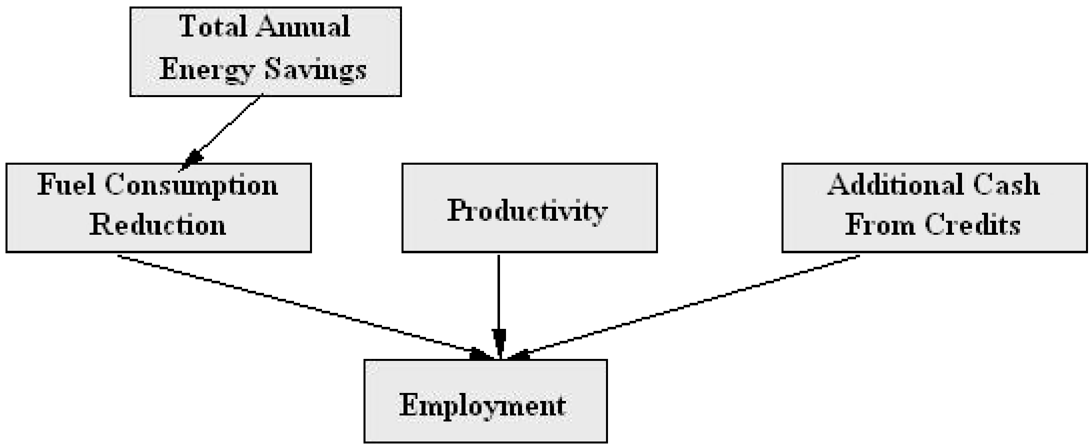

Fig.4 Elements influencing impact on employment

3.6 Fiscal impact

Budgetary cash flows, influenced by more restrictive requirements, are determined by income from taxes related to the increase of production output and increase of employment. The balance between volume of supporting modernisations and the potential indirect budgetary income is a problem of decision makers. The governmental support is necessary to trigger investments and can have different character: reduction of some % of loan taken for investment, establishment of lower then commercial interest rate, reduction of real estate taxes, direct subsidy and many others.

It is crucial for the government to propose a system to support energy conservation investments which will balance budgetary costs (incentives) and potential indirect income. Moreover, it would be of European benefit if member states will agree about methodology of evaluating such impacts because by this mean the real efforts of the country in sense of directive implementation can be evaluated.

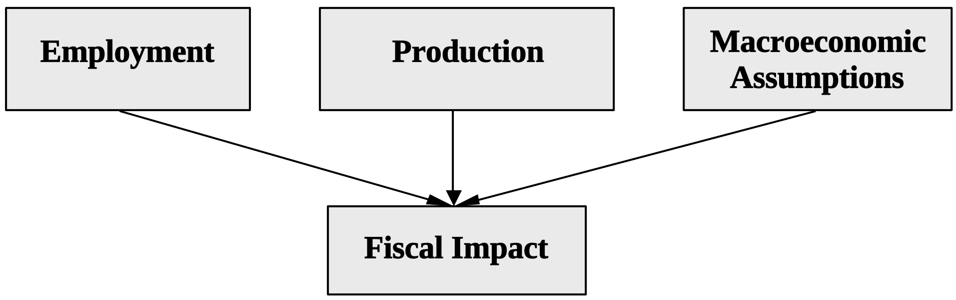

Fig 5 Elements of fiscal impact

4 Main assumptions for Poland

The estimation of possible energy savings in buildings in Poland requires characterization of buildings stock. The most important data for evaluation of total energy savings are scope of investments, distribution of energy standards among different types of building and used energy sources. Table 1 presents state of the art of average energy standard of most common building types normalised by usable area.

Table 1 Distribution of average energy standard for existing buildings

	Building Type	Area	Avg. en. Standard
		m^2	kWh/m^2
1	Housing	704 596 620	250
2	Hospitals	1 486 771	400
3	Schools	41 918 030	400
4	Commercial Buildings	31 572 680	300

Estimation of costs of saved energy is essential for calculation of economic efficiency. The energy costs vary over the country and depend on building location and eligible costs of energy production. For the sake of the analysis their averages have been taken, see Table 2.

Table 2 Cost of energy

	Description	Fuel Unit	Fuel Cost	Energy Cost	Avg. Efficiency
			PLN/kWh	PLN/kWh	%
1	Gas Boiler	m^3	0,19	0,221	85%
2	Oil Boiler	kg	0,21	0,266	80%
3	Coal Boiler	kg	0,18	0,360	50%
4	District Heating	kg	0,19	0,210	90%
5	Biomass	kg	0,11	0,166	65%
6	Electricity	kWh	0,21	0,213	97%

Calculations of environmental impact connected with improvement of energy standard of buildings require data about specific CO_2 emissions for different fuels. The figure 6 presents data taken for considerations.

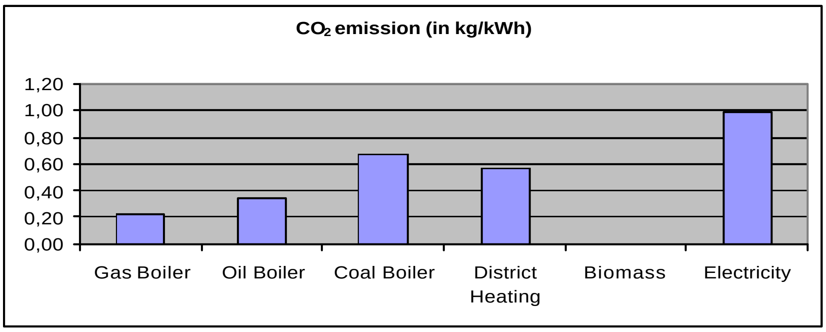

Fig. 6 CO_2 emission factors

There are several possible investments options improving energy standard of buildings. The ranges of savings depend on initial energy standard of the building, building type, building shape, orientation and location. It would be difficult to perform detailed estimation for all possible combinations of investment options and mentioned variables. Therefore, for analysis the average values have been taken. These average values are normalised per usable area of building type and are presented on figures 7 and 8.

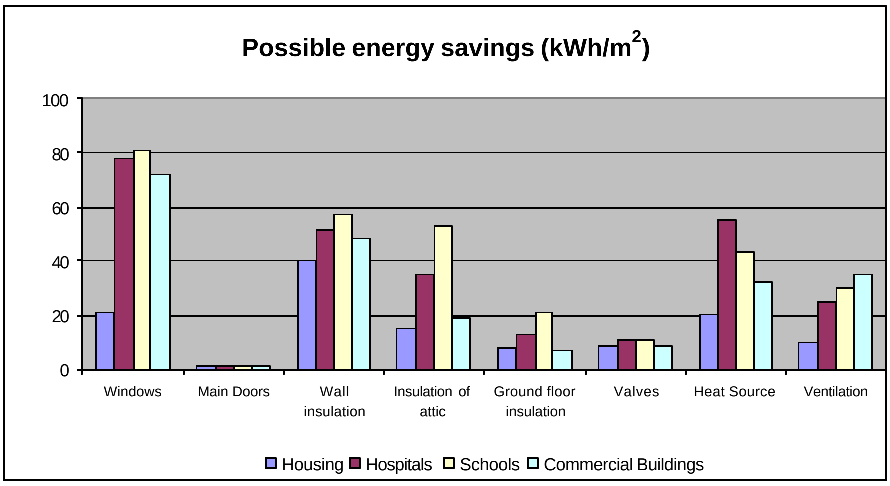

Fig 7 Predicted average savings of specific investment measure

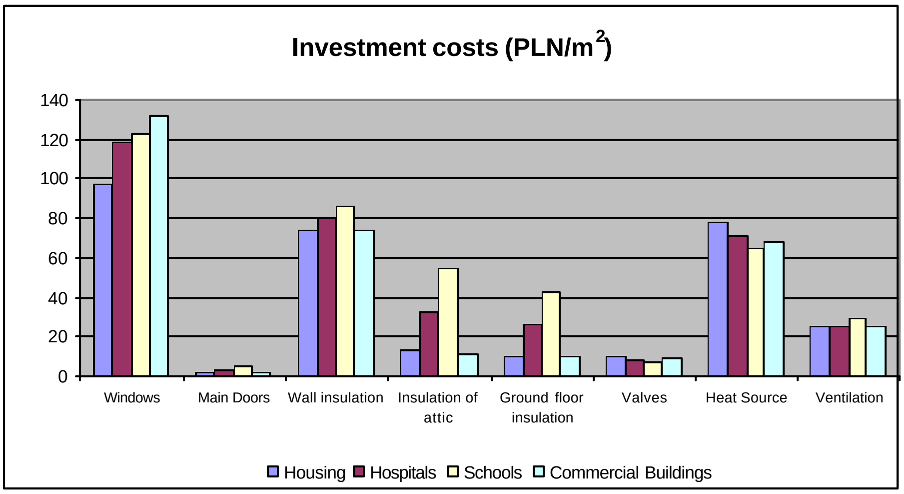

Fig 8 Predicted investment costs (2004) for different types of buildings

The estimation of fiscal impact due to the improved energy performance needs several macroeconomic assumptions and information about production capabilities. The adequate data have been collected in tables 3 to 6.

Table 3 Macroeconomic data used in calculations

Description	*Unit*	*Value*
Real Economic Discount Rate	%	4,70%
Inflation Rate	%	1,70%
VAT	%	22,00%

Table 4 Average wage and tax level

Description	*Unit*	*Value*
Averare Annual Salary	PLN	26 412
Average Tax on Average Salary	%	19%
Salary Increment	%/year	3,00%

Information about employment and fiscal impact due to an increased industrial production and construction is presented in Table 5 which contains the data about productivity in Poland.

Table 5 Productivity within the analysed sectors

	Description	Production Output PLN/Worker
1	Industry	182794
2	Construction	144710
3	Mining	128431

The fiscal costs depend on the incentives provided by the government. Financing investments from credits and incentives influences both fiscal income and costs. Table 6 presents most important financial assumptions.

Table 6 Financial assumptions

Description	Unit	Value
Credit Share	%	80%
Credit Period	years	10
Credit Rate	%/year	7%
Incentives	% (credit)	25%

5 Results of estimation

The scope of investments during the planning period (25 years) provides information about potential of the energy conservation market. The % of area for modernisation measure indicates a share of efficient investment within its total area. In other words, e.g. for windows, only 7% of widows area are subject of modernisation, as the remaining 93% does not fulfil efficiency criteria.

Table 7 Economically efficient potential of modernisation

	Measure	Housing	Hospitals	Schools	Commercial Buildings
		% of area	% of area	% of area	% of area
1	Windows	7%	31%	31%	24%
2	Main Doors	14%	9%	9%	17%
3	Wall insulation	20%	30%	31%	31%
4	Insulation of attic	40%	42%	41%	45%
5	Ground floor insulation	33%	18%	17%	34%
6	Valves	36%	44%	45%	42%
7	Heat Source	37%	45%	45%	44%
8	Ventilation	10%	41%	42%	44%

Results of estimation of global GHG emission reduction per one year under the condition of realisation of the whole potential of energy efficient investment are collected in Table 8.

Table 8 Yearly Emission Reduction for the economically efficient modernisations

	Description	Housing	Hospitals	Schools	Commercial Buildings	Total
		ton/year	ton/year	ton/year	ton/year	ton/year
1	CO_2	15166	62	1780	1182	18190
2	SO_2	111	0	13	8	133
3	NO_X	55	0	6	3	65

The increased requirements for production in manufacturing facilities will result in a need for new workers. From other side reduced energy consumption results in lost of work places in mining industry. Table 9 shows the range of these changes in Poland.

Table 9 Yearly changes of employment in sectors under consideration

	Description	Production Increase mln PLN	Employment Increase in thous.
1	Industry	1053	6
2	Construction	2106	15
3	Mining	-23	-0,2

The presented analysis allows different simulations in order to identify the inter relations of mentioned impacts. Analysis of cash flows and other consequences can help decision makers to decide about the scale and means of incentives to support the modernisation investment. Figure 9 shows a balance of two cash flows reached with the 25% of budgetary support, as it is today in Poland in case of existing thermomodernisation scheme. The analysis can be used either to evaluate required budget involvement or for identification of possible political goal to be announced as a country overall commitment about expected results of directive implementation.

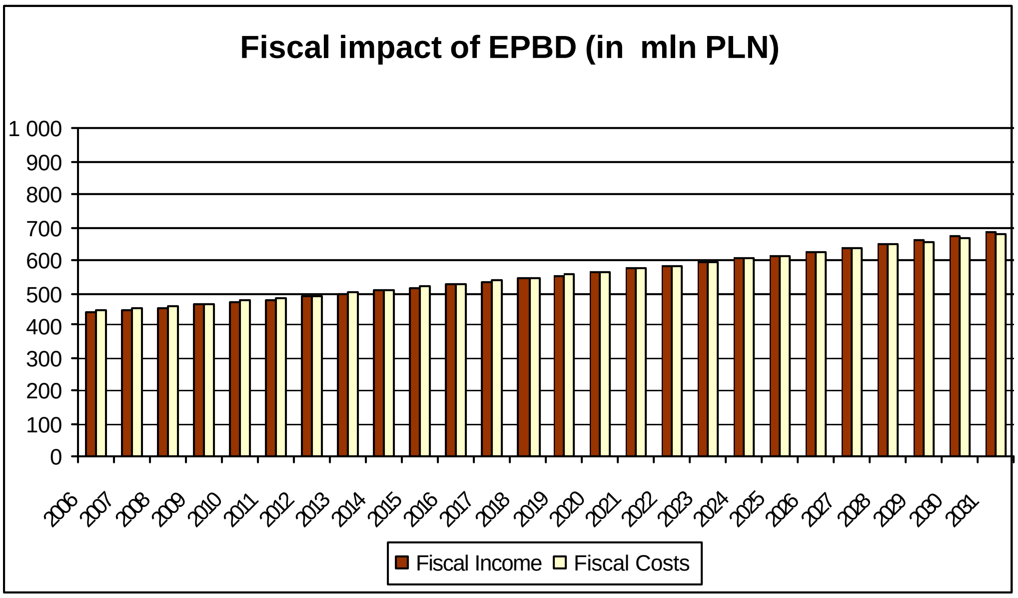

Fig. 9 Fiscal impact of considered scenario

6 Conclusions

Described in the article method of estimation of social, economic and technological impacts of implementation of new more restrictive energy regulation is rarely used by politicians as a basis for decisions. It is probably because their perspective is short term as an one fiscal year.

Declaration of politicians about the priority of sustainability in economic development, if serious, should change such direct short term approach, as the consequences of today's decisions influence the future. Moreover, in spite of the model simplicity, its wider use in other countries could provide conclusions which can help to understand the long term, direct and indirect consequences of directive implementation.

The described impacts have indirect character and the real interdependencies of savings, employment and fiscal cash flow are more complicated then the one presented in the article. Thus, there is an evidence about the need for further common, interdisciplinary work of economists and energy efficiency experts to get more precise and harmonised results.

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SURE-BUILD
POLISH/NORWEGIAN COOPERATION FOR SUSTAINABLE REDEVELOPMENT OF BUILDINGS IN POLAND

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SUMMARY

Much of the existing older building stock in Poland is deteriorated and in need of major redevelopment. Researchers working with sustainability issues in the construction sector in Warsaw, Poland and Trondheim, Norway, have joined forces in a 3-year project for sustainable redevelopment of existing buildings in Poland.

The project, with acronym SURE-BUILD, has as overall aim to develop knowledge, integrated solutions and technologies that will reduce the energy use and environmental impacts of existing buildings. The project is financed with funds from the Norwegian Ministry of Foreign affairs, earmarked for cooperation with the EU candidate countries.

In the first stages of the project, the national state-of-art in the two countries as to potential technologies for this purpose has been analysed. The project group has also studied the Polish buildings stock to find a suitable category of buildings for case studies. The conclusion here was to use Polish schools constructed in the Millenium tradition as case study, and a specific case in Zgierz was found for the next stage of the project.

The potentials for improvements with respect to energy and environment will now be analysed, and hopefully implemented in the chosen school, in cooperation with Polish and

Norwegian industry. The experiences gained in this process will later be generalized and made available for repeated projects through "user packages" for different actors in normal practise, this material will form a Design Guidelines for such projects in the future. The school in Zgierz will serve as a demonstration site for advanced redevelopment which show better energy management, better utilisation of materials, and less generation of waste.

1. Introduction

The construction sector in industrialized countries is often called "the 40% industry", because it typically consumes 40% of the material resources and the energy, and generates 40% of the refuse. Therefore, the construction sector is a major challenge in the development for a more sustainable society, and several international activities to further this goal have already been launched in the framework of United Nations and international organisations in the construction sector. The Global Alliance for Building Sustainability was formed to accelerate the achievement of sustainable development in the land, property, construction and development sectors.

Norway has been active for many years in UN forums introducing formally the sustainability paradigm. Poland is a country of new dynamic challenges with a great potential to follow the world's best practice. Poland has a large stock of buildings that need redevelopment and upgrading in order to meet new requirements for indoor climate and energy use in operation. By introducing the sustainability concept to such activities, Poland will contribute to a better local and global environment in the future. It is important to avoid repeating the mistakes made in other countries that started this type of redevelopment earlier.

In the period 2000 - 2002 two major technological universities in the two countries, Warsaw University of Technology (WUT), and the Norwegian University of Science and Technology (NTNU), exchanged visits and staged top-level discussions about cooperation in the field of sustainable energy developments. The SURE-BUILD project is a major outcome of these contacts.

2. The SURE-BUILD project

In 2002, relevant units at the two universities decided to propose a common R&D effort aimed at redevelopment of the building stock in Poland: SUstainable REdevelopment of BUILDings in Poland, SURE-BUILD. The units involved are the Faculties of Environmental Engineering, Architecture and Electrical Engineering at WUT, at NTNU the Faculty of Architecture and Fine Art, which is also responsible for the overall project management. The Norwegian SINTEF R&D institute is also engaged in the project through the division Architecture and Building Technology in the Department for Construction and Environmental Engineering.

Funding was secured through a programme for cooperation between Norway and the new (2004) EU candidate countries, financed through the Norwegian Ministry of Foreign Affairs. The main objective of this project is to develop new knowledge, integrated solution and technologies that will make it possible to reduce the energy use and environmental impacts of existing buildings in Poland. In particular, this will reduce the country's dependence on fossil fuels, and thereby contribute to sustainable development in Europe.

The main project's goals are:

- Support to scientific co-operation in the areas of specific importance for both countries Norway and Poland.

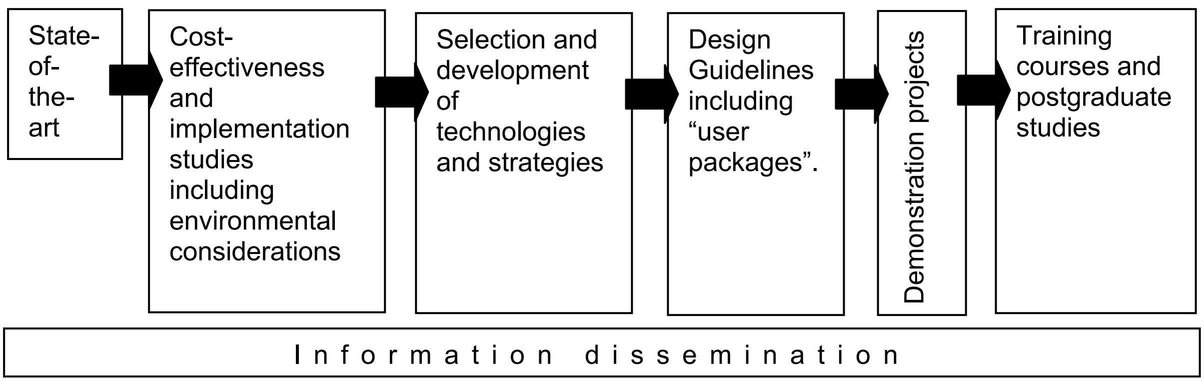
- Promoting the idea of sustainable development in lights of ratification of the Kyoto protocol.
- Recognition of countries' markets for future economical co-operation in the building sector.

Some important sub-goals for the project are:

- Development of a new area of co-operation between Norway and Poland within research and education.
- Development, demonstration and dissemination of concepts for introduction of sustainability into Polish building sector.
- Implementation and demonstration of sustainable energy technologies that have been developed within previous national and EU research projects.
- Proposal of new building integrated energy saving solutions that have the potential to reduce the energy use in existing buildings in Poland by about 50% of existing standard.
- Contribution to the EU goal of at least 18% energy savings and at least 10% reduction of CO_2-emissions by 2010.
- Strengthen education, research, economic growth, and sustainable development of industry and communities in Norway and Poland.
- Better understanding of countries' achievements and barriers towards the implementation of sustainability measures.

3. Project activities and outcomes

The project work is organised in 7 main tasks:



State-of-the-art analysis. A detailed recognition of the state-of-the-art of strategies and technologies for sustainable low-energy buildings in Norway and Poland, and world-wide.
Analysis of cost-effectiveness and implementation opportunities. This involves estimating the potential cost-effectiveness of different strategies and technologies, including an assessment of the environmental impacts.
Selection and development of strategies and technologies. Based on the previous research tasks, the most promising strategies and technologies for sustainable low-energy building in Poland will be selected and further developed to fit Polish conditions.
Definition of "user packages". The outcome of the previous tasks will be documented and operationalised in a Design Guideline aimed at practitioners.

Demonstration projects. The technologies and strategies that have been developed will be implemented and tested in an actual building project in Poland.
Training courses. The material and software developed in the project will be used in training courses and curricula of postgraduate studies for professionals.
Information dissemination. The results of the project will be actively disseminated through training courses and university education, through demonstration projects, and through articles and papers in magazines, journals and conferences both nationally and internationally.

4. Sustainability issues in the energy and construction sector

In both of the two participating countries there are many important sustainability issues in the construction sector that has to be addressed within the project scope. The state-of-art analysis has demonstrated that Poland has a large stock of buildings erected after the Second World War that is suffering from a long neglect of maintenance. Many buildings are also built with materials and construction methods that later proved to be of a quality insufficient to cope with the tear and wear of time. This is true first of all of publicly owned and operated buildings.

The thermal standard is also often inferior, considering the relatively severe heating requirements during winter. Energy prices has increased rapidly after introduction of market economy, this makes it important to improve the insulation standard of existing buildings [1,2]. The indoor air quality is also often low [3]. Another important energy related issue is that both thermal energy and electricity is often generated with brown or hard coal as fuel.

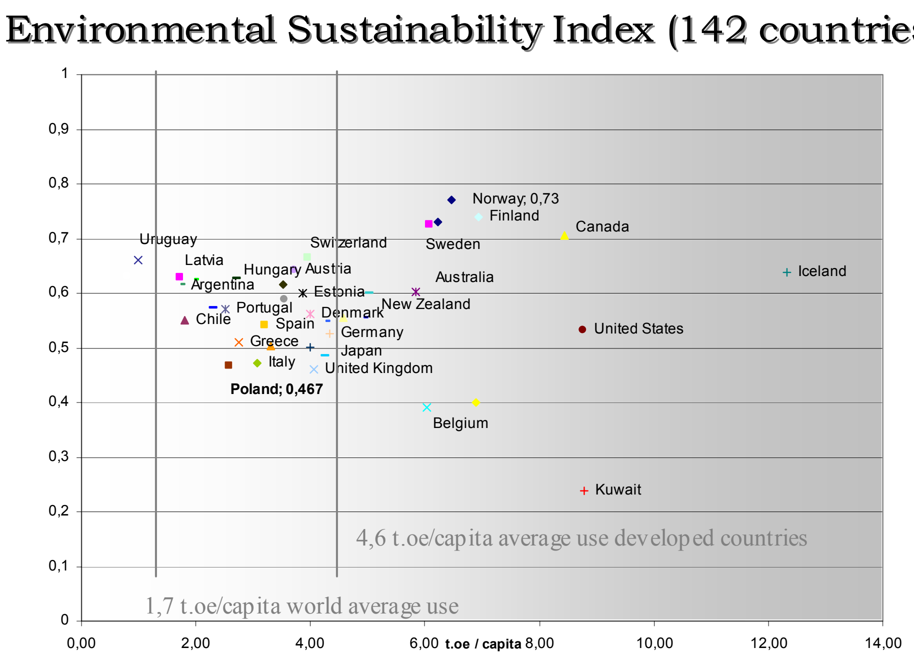


Fig. 1. The Environmental Sustainable Index (ESI) vs. energy use in toe. per capita for some industrialized countries [4].

Norway scores very high on UN-developed indexes of human development and sustainability. In general, the buildings have a better thermal standard than buildings in Poland, but then again the winters are longer and more severe. High on the energy agenda in Norway is the very high dependency on direct electric heating in buildings, mainly in housing. This is a result of many years of inexpensive electricity supply through large-scale hydropower developments. In the new deregulated market, the electricity prices are now escalating because there is no more hydropower capacity available for development. For Norway then, it is now very important to reduce the electricity demand in the construction sector, and switch to thermal energy when possible [5].

5. The state-of-art analysis

Furthermore, the state-of-art report [5] discusses other sustainability issues, and describes many national assessment systems for buildings. The E-Audit is used in Poland, the Eco-Profile is used in Norway.

The Polish building stock is also reviewed, and the developments in the housing sector since the Second World War is described in detail. Both countries have several completed and on-going R&D programmes that will be a source of useful information for the SURE-BUILD project, many of these are international, within the framework of the International Energy Society and the R&D programmes of the European Union.

The report also gives a menu of redevelopment technologies that are relevant for application to the SURE-BUILD demonstration building. These technologies cover heating, cooling, ventilation, electric lighting and daylighting, and included is also a some important advice on effective design processes.

6. The SURE-BUILD demonstration building

It was clear from the project planning phase onward that the best way to disseminate results from the project is to implement practical measures to case study buildings. Therefore, much effort has been centred on how to choose a suitable demonstration building. The first issue was type or category of building. Here are listed some of the parameters on the table when this issue was discussed by the project group:

Technological opportunities. The R&D results expected from the project will cover a wide range of technical opportunities for reducing the energy use in a sustainable manner, while at the same time improving the indoor conditions. This implies that the case buildings should encompass all types of energy using equipment and energy systems normally found in buildings.

Energy saving potential. The case buildings should in existing conventional state have high energy consumption, giving a large potential for improvement through new technologies. The number of buildings, and the number of square meters there, should in Poland be substantial within the category of buildings chosen to be case buildings.

National and local policy. It would be easier to find follow-up funding for improvement of the whole stock of case buildings in Poland, if national and local/regional policies for such improvement are already in place. Since the project will also exploit experiences with similar efforts in Norway, the project should also look for parallel policies there. The same tactics apply for official policies within the European Union**.**

Ownership and public impact. In order to make an immediate impact on a large stock of buildings and square meters, it is important to look for a class of buildings where there are few and easily identified owners. This could mean publicly owned buildings, or a category of buildings where there are large corporations involved in construction and/or facility management.

Existing R&D work and development programmes. The project would benefit from existing knowledge and experience if the class of case building chosen has already be subjected to R&D work and development programs in both countries

Architectural and functional considerations. The choice of project case building should also pose an architectural challenge: if the redevelopment measures could also include architectural and functional improvements, the public interest in the efforts may be raised, which again would give the project results a larger arena for demonstration.

Costs. It is important to find a class of buildings were major improvements can be introduced in a cost-effective manner.

After carefully considering all the criteria listed above for choice of building category for the project case buildings, the project group concluded that **school buildings** would be an interesting class of buildings. They offer many technological opportunities (some have also swimming pools), they have a large energy saving potential, and are normally owned and operated by local communities. Schools have also been subject to several international R&D programmes.

In Poland, a special opportunity for using school buildings as case study category is available: in conjunction with the celebration of the country's millennium, a large number of new of school buildings (around 1000) were constructed in the 1960s. These building are technically quite similar, even though they may differ in layout according to the local site. This means that new energy saving technologies developed within the project can be applied to a large number of case buildings, giving the project a potential for substantial impact on the energy use in Polish buildings.

The school demonstration building

After this conclusion was reached, the project group embarked on a search for a real case millennium school that gives optimal opportunities for the implementation of the project results. This search ended up with Primary School No.1 in Zgierz, shown in photos below.

The school state-of-art analysis completed in the project [6] included an analysis of feasibility of implementing all the technological opportunities given in the first state-of-art report. For each class of energy efficiency measure, it was performed a SWOT analysis: Strengths, Weaknesses, Opportunities, and Threats. An example is given below.

After completion of the analysis phase, the project will embark on implementation. It is hoped that both Polish and Norwegian construction industry will seize the opportunity to participate in the sustainable redevelopment of the Zgierz school.

Table 1. SWOT analysis of technologies for effective space cooling.

	Potential technology for sustainable modernisation of Polish schools	SWOT analysis			
		Strengths	Weaknesses	Opportunities	Threats
1.	Shading systems	Simple, effective, low cost. Do not use energy for operation.	Some outside shading solutions strongly affects architecture of building.	Reduction of direct solar gains.	Certain solutions may not fulfil requirements on minimum insolation time.
2.	Switchable glazing	Easy adjustment to the conditions.	High cost.	Promotion of new technology at Polish market.	Long term stability not proved.
3.	Cooling by ventilation using thermal mass	System environmentally friendly that does not use potentially harmful refrigerants.	Technology relevant rather for new buildings. Important thermal effects require intensive ventilation during night.	Promotion of new technology at Polish market.	May create problems at the beginning of the teaching day due to too low mean radiant temperature.
4.	Ground-air heat exchangers	Low cost, very low cost of energy.	Requires central ventilation system (mechanical or hybrid), schools are closed during hottest season. requires accessable ground, low temperature difference.	Promotion of renewable sources of energy.	May be impossible in urban situations.
5.	Heat pumps used for cooling	Energy efficient, low exploitation costs.	High investment cost, schools are not used in periods when coolings loads are maximum Needs for specific local conditions (water wells and dumps).	Promotion of renewable sources of energy.	May not be economically feasible. Still recognised as new technology.

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WITH LUXURY AND ABUNDANCE TOWARDS SUSTAINABLE BUILDINGS

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Summary

Within the debate of sustainable development there is far too much emphasis on technical issues and too little concern about the use of products and patterns of consumption. The extension of the life period of a building (durability, social acceptance) and use-factor per year (avoided vacancies, a better managed occupancy) can contribute significantly to higher efficiency in the housing sector. To support a long term future use, buildings got to have some redundancies or reserves (function, construction, aesthetic) in order to guarantee their futurity. Dematerialization as a concept for higher resource-efficiency might be convincing for other sectors of economy, but not for the building sector.

Introduction

Within the debate for sustainable building one can identify three principal strategies:

- Efficiency – with the intention to reduce the mass flow for products and services (Dematerialisation)
- Sufficiency – avoid new buildings, reuse and refurbish (Consume less)
- Consistency – closed loops, waste-less consumption, coherent system (combine quantity with quality)

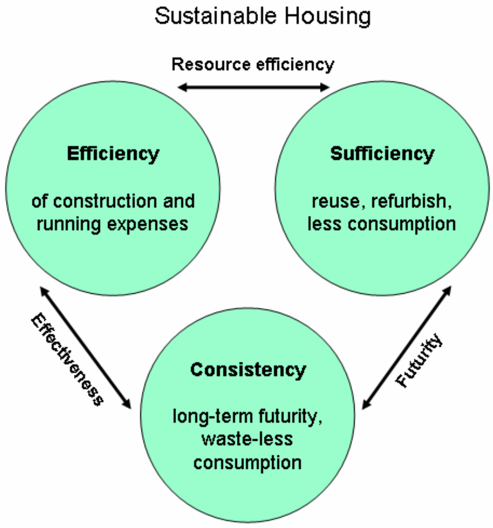

Figure 1 Three discussion-lines for sustainability

A specific approach towards more sustainability will always be a mixture of these strategies. As stronger the interlinkage or integration of these three strategies, as closer you get to a comprehensive approach that encompasses the entire field of a specific human activity. An approach, which supports the integration, is the concept of “activity field based energy and mass flow management”. The Research department for housing and sustainable construction within the IOER follows this concept, which was originally developed by the German Environmental Agency (UBA). Human activities are divided in fields and the relevant mass flows are allocated to them (fields of human activity are: health, communication, education + culture, nutrition, recreation, mobility, work and housing). The method orientates on the cradle to grave concept of products, but includes as well the critical reflection on the fundamental needs which originate these products and mass flows. Therefore it integrates the three sustainability concepts.

The contribution will present some of the findings along the integrated approach for more resource-effectiveness in the housing sector.

Two Sides to Every Coin

Ecological orientated building research has always looked at the improvement of the efficiency per constructed floor area (material flows to construct and to run the building). It was mostly not questioned, whether the product is used adequate and efficient. But there are always to sides to every coin. The effects of the extension of life period of a building (durability, social acceptance) and use-factor per year (avoided vacancies, a better managed occupancy) can be as significant for the overall efficiency as technical measures.

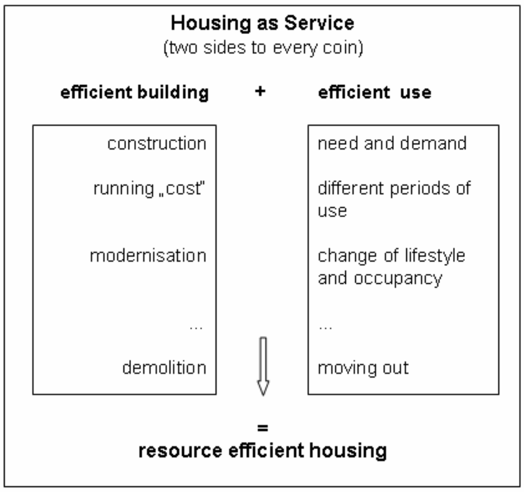

Figure 2 Two sides to every coin

Today's lifestyles and types of households cause a great variety in types of demands. It seems obvious, that only a more flexible housing market, an occupancy-management and incentives to move can help to match the demand more closely (Deilmann, C. 1998 [1]). The author developed therefore a calculation method, which enables to compare benefits (in energy and mass flow) by better management with those by technical improvements of buildings. To give two examples:

Vacancies in housing stock are a waste of resources. Today some municipalities and housing associations in East Germany have vacancies in their housing stock of up to 20%. In the whole of East Germany 1.000.000 dwellings are unoccupied - a tremendous waste of money and resources (Hutter, G., Iwanow, I., Müller, B. 2003 [2]). If 10% of dwellings in a block of flats are unoccupied, or a flat is only over 90% of its lifetime occupied, then energy-saving measures of 30% heating demand reduction are out weighted by the effect of vacancies. A vacant flat "consumes" about 1,7 tons of building materials per year and emits 1 ton of CO_2 per year in form of lost energy-input in materials and uncontrolled passive heating (by neighbour-flats). In the case of East Germany this means a waste of 1.000.000 tons of CO_2 per year. This specific case might at present be the exception in Europe, but lot of countries in EC will face decline in population by 2030 and therefore similar problems. The example shows that a good occupancy-management and good housing policy will become an important contribution to higher resource-efficiency in the housing sector.

Even a well occupied housing stock has potentials for higher efficiency through occupancy management. A large flat or a house that's used by a family over 35-40 years shows periods of higher and lower occupancy rates - before, during and after the family-phase of a household. If e.g. in the post-family phase the one-person-household (widower/widow) can find another smaller apartment and leaves the large flat to a family with kids, this will increase the use-intensity of the flat. Over the lifetime of the building a ten year earlier "adaptation" raises the use intensity by 20%. The elderly on the other hand may find a more suitable barrier-free apartment. The family on the other hand is pleased to fiend adequate living space. Some communities like the Hagen city council an active move-management installed. They construct new flats for elderly and less for families. Research findings from 300 case-studies in the town of Hagen prove that move-management and good occupancy can increase the resource-efficiency of housing even more than the prolongation of the technical building-life-time by 50 years. It is as effective as a 30% energy-savings in space-heating by thermal insulation over the whole lifetime of the building.

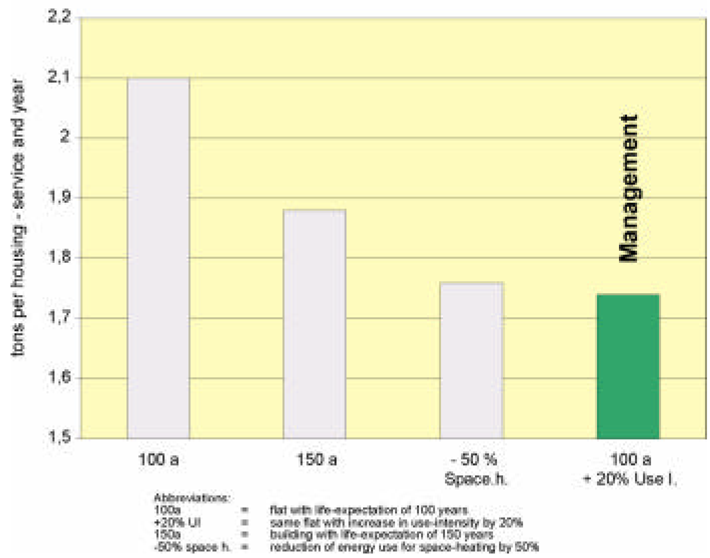

Figure 3 Comparison of different Measures to improve the Resource-efficiency of Housing (Materials and Energy Consumption) per 35 m²

Efficiency per W(h)att?

In the long run it is highly economic feasible to produce goods with less material input and nevertheless same performance. Both, Ecology and Economy do have benefits (WIN-WIN-situation). Yet, one characteristic of this perspective is, that the socio-economic system, which was the driving force for most of our present ecological problems will not be questioned. We still continue to hope that technical progress will solve our problems.

Looking at the housing sector and the material input per square meter floor area, one can see that over the last 100 years the material input declined in the sense of dematerialization. It looks as if we are on the right way.

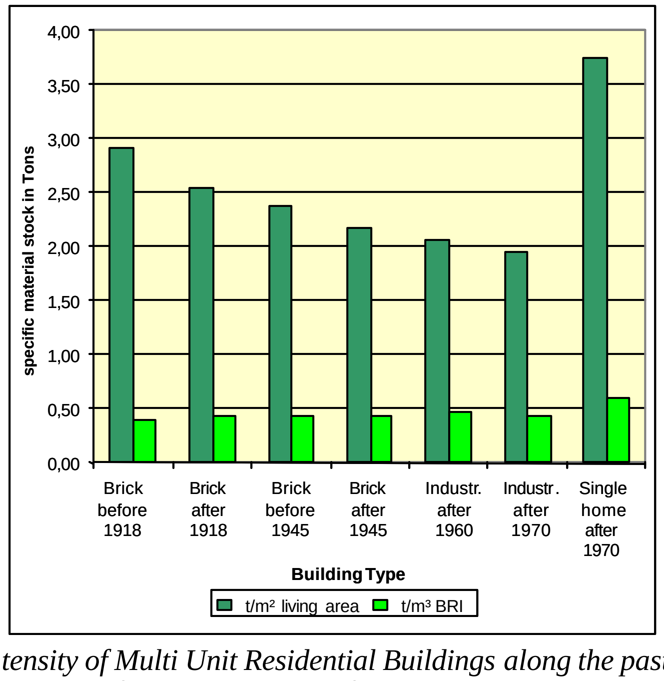

Figure 4 Material intensity of Multi Unit Residential Buildings along the past 150 years and freestanding single family home

The efficiency per square meter living area has increased considerably with exception of the single detached houses. But at the same time, the specific building volume (cubic meter per m^2) has decreased as well. This means we reduced the volume for construction, for functional areas, for storage space in roofs and cellars or remises and reduced ceiling heights in order to maximize the living area per cubic meter. (It is the floor area we pay rent for.) In this one-dimensional view, the old house from 1880 is inefficient and the prefabricated flat in a high-rise building is the most efficient. But consumers take other aspects into account. As soon as the housing market situation changes to a customer market, the preferences of the consumer will turn towards the inefficient old house, because of its functional and aesthetic "surplus", or they move to the detached single family home. It seems self-evident, that the long term futurity of buildings depends not only on technical aspects but also on cultural aspects. The Fig. 4 shows the efficiency in kg per square meter and per cubic meter. Recognizing additionally that one third of building materials of private homes are renewable resources (roof-construction, wood frame etc), the single home has similar resource characteristics per cubic meter as the pre-world war multi-family-house. Resource-efficiency depends on the used Divisor. So, how do we measure efficiency? The eco-efficiency debate discovered the problem of "dimension" and turned towards the much broader perspective of "performance" per resource input instead of square meter per resource input.

Redundancy for structural strength

It is the task of classic engineering to find a clever load bearing concept and to calculate the correct dimensions for walls, columns, reinforcement of slabs etc. From the point of money and material saving, one should minimize dimensions for construction elements. In countries with material and money shortage it is every day practice, like it was the case in East Germany before the wall came down. The research institute of the author is an example for the "scarcity" engineering. The static of the roof has no reserves, so there was no chance to put on a green-roof when the coating had to be repaired. Situated in the inner city area and visible from surrounding buildings it would have been of great benefit to the area to do so, but there were no reserves.

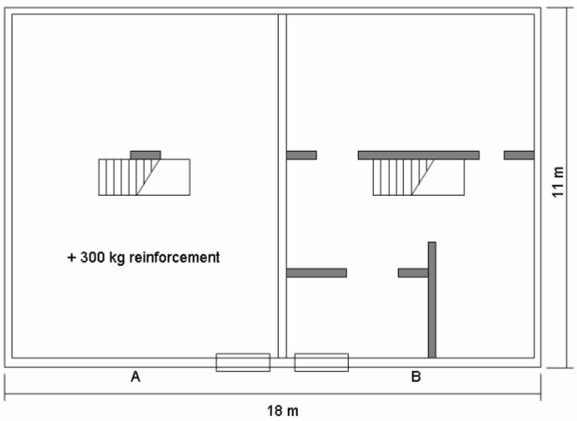

Figure 5 Open (A) and determined (B) ground floor plan for semidetached house

Another example for the importance of redundancy illustrates Fig. 5. It shows the ground floor plan of a semidetached house. The difference in reinforcement steel between the open plan and the one with load bearing walls is about 300 kg of steel or about 300 Euro. The material costs for the freedom to change the floor layout in the future are negligible in comparison to the overall building costs. It is a challenge for architects and engineers to find the right path towards a clever designed structure open for changes. It is very difficult to teach and communicate the way, how to find the right balance between static-reserves and minimized material input.

Functional abundance

A well known example for functional surplus is the floor plan of many "turn of the century buildings" in Germany (period of promoterism). They are characterized by large rooms of almost similar size and double access (from hall or from adjacent room). These dwellings allow the use of the rooms for different functions. They can suit a family or a small commune of students. In comparison, the rooms of a functionalistic post-war-design are determined in use, up to the position of plugs for the bedside light. They have no functional surplus.

Another example can be taken from the early 20ths. The picture below shows a floor plan by Le Corbusier and one from Oud.

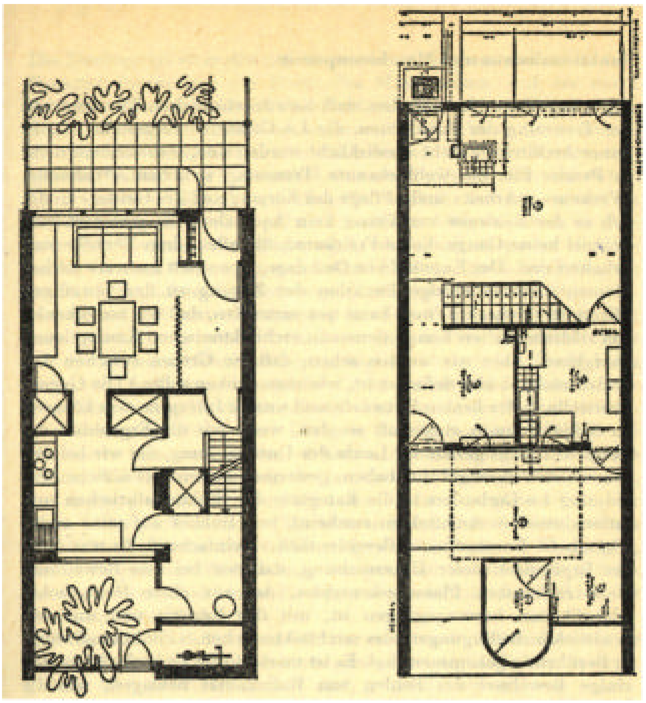

Figure 6 Rowhouse by Oud (left) and Le Corbusier (right)

The design by Le Corbusier consists of a big square room with an open stair to the top floor, two small rooms and a big semi open courtyard square partially enclosed by a small storage room. Rooms seem to be too big or too small. The courtyard seems open to a variety of uses. The plan from Oud is functionalistic. It is pretty clear where you have to cook, to eat, to sleep or to rest. The design by Corbusier for the residential area of Pessac was at first not well accepted. People found it strange. When the urbanisation "Pessac" was revisited 20 years later and the results of the findings were documented, the experts were astonished to find more than 30 different ways in which people had made changes to the room sequences (Fig. 7). A sociological survey in Pessac found out, that the people didn't really know at first sight how to live in the row-houses, but they felt, one could interpret them. Through some changes they learned to appropriate these houses (Boudon, P. 1971 [5]). It was the animating tension between art (aesthetic surplus), functional diversity and individual way of living that allowed a long term futurity of this particular building product.

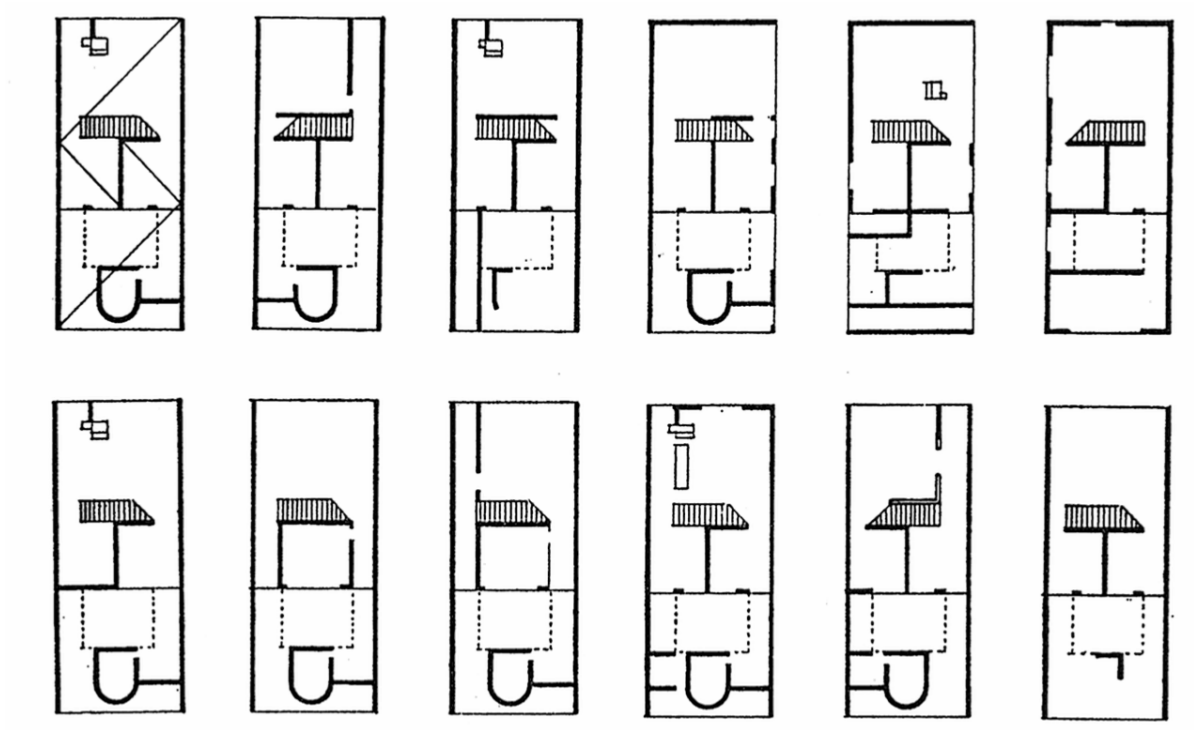

Figure 7 Examples for adaptations of the LeCorbusier floor plan (Fig.6) by customers in Pessac

Open Building Approach

The swap from an owner-market to a customer orientated housing market – due to demographic change and population loss – has re-surfaced the interest in Open Building in late 1990's. There are expectations that a variety of competing solutions and technologies will be developed, covering the specific needs of both new construction and renovation. Key requirement are: Enabling Technology Design (standardised service entry/exit points to any part of the plan, access to and capacity for maintenance/replacement or extension) and Subsystem Design (Modular dimensions, push-fit, plug-and-play and de-mountable junctions and connections, not requiring traditional on-site trade skills) (Richard Moseley 2001 [4]).

In preparation for a new ISO-Norm on "sustainable building" the durability aspect was discussed in a broad sense and seemed to take up ideas from the Open Building approach. The aim is, to prolong service life by creating more durable buildings and constructed assets. This could be realized by improving the ability to change and the adaptability of buildings, e.g., by designing with enough redundancy for structural strength, floor heights, adequate space for mechanical and electric service, and ease for replacement of components or elements.

International research groups (e.g. CIB W104) maintain the position, that adoption of Open Buildings in practice is exactly aligned with principles of sustainability. But these concepts of maximised flexibility are too mono-dimensional in my point of view. We need both "surplus design" and "surplus service subsystems". The example of Pessac illustrates, that the "open building" approach for customer-friendly houses doesn't necessarily have to rely on industrialized flexible infill systems or component-based fit out service subsystems.

Redundancy and Consistency

Nature isn't characterized by scarcity, but by abundance, diversity and richness. Nature teaches us the difference between Efficiency and Effectiveness. A cherry-tree e.g. produces thousands of flowers and fruits in order to reproduce itself with the help of a bird and good luck. That's not efficient but effective, because the thousands of flowers will be composted by late summer, when the tree needs nutrition to produce the cherries, and so help the fruits in spring. The example shows, that it is of greater importance whether the elements of a system are productively linked with each other, than the efficiency of a single aspect. Abundance can be useful, as long as it's not damaging other entities. Plentifully diversified luxurious systems (abundance) are not a contradiction with Effectiveness as long as there is no "waste". That's the key to a futurity in construction. We do have plenty of mineral resources. The renewable energy resources, which are technically accessible, outrage the present world-energy-consumption by Factor 2. It's enough to fuel all our technical processes, if we learn to use these resources.

The very old principle of ecological design – the closing of loops – does re-surface in the new light of the sustainability concept. Closing loops, avoiding waste can lead us to effectiveness within a coherent system. We have to try harder to think in loops and the consequent separation of biological nutrients and technical nutrients. Sources, which are of use for organisms should be kept apart from those we need for technical, artificial goods. Three principals we have to follow (Braungart, McDonough 1999 [3]):

- Waste is a nutrient. There should be no waste to be deposited. Without waste we have less environmental problems.
- Use solar energy! The process-energy for industry and manufacturing can be renewable.
- Prefer diversity and variety and keep a systemic perspective on how things are linked and related to each other.

If we stick to these principals, we will have very few restrictions for technical and economic development and growth. A whole new range of technological innovation will accompany us on this way. In front of this concept, even the ideology of the everlasting building products (durability) has to be critically reviewed. An eco-effective product can alternatively be one with a defined (short) lifetime. As long as the manufacture can count on the recovery of the source in the future, and uses it as nutrient for new products and runs the process on renewable energy.

It is good news for all those of us that associate with sustainability scarcity and abandonment! Abundance and productivity are no contradiction if we manage to produce and consume waste-less and use renewable energy resources to fuel the process of production.

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CONCEPTION OF BUILDING ENERGY FRAME IN LATVIA

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1. Introduction

Energy consumption of buildings takes a significant part of primary energy consumption in European countries. The buildings are responsible up to 50% of total CO_2 emissions. The most important part of building energy consumption is energy consumption for heating and ventilation purposes during the building's life-time. So the building energy consumption is the subject of constant attention of European countries.

There are two major possibilities for the reduction of energy consumption by buildings. One of them is stricter requirements to building heat loss for new buildings at the design stage. Another is building energy certification that creates energy awareness of inhabitants and has big potential of energy reduction.

Although a lot had been done in recent years in order to reduce the energy consumption of the buildings, by evaluation of European experts there is still considerable energy saving potential in building sector that is estimated as 22% by 2020.

The paper shows measures of building energy consumption reduction in Latvia, shortly referring to the experience of other countries. Among them is new requirements to building heat losses imposed by Latvian Building Code LBN 002-01 "Thermal performance of building envelope" since 1 January of 2003, further development of the requirements to building heat loss in form of building energy frame proposed in Latvian Building Code LBN 209-04 „Design of low storey buildings" and the trial implementation of Latvian building energy certification scheme in Ogre town in 2002-2004.

2. The requirements to building energy consumption

2.1. The existing practice in European countries

The oldest known way of the building energy consumption regulation is limiting of thermal resistance of separate building element. Till now this method is widely used either separately or in conjunction with other methods. Among the method disadvantages are:

-building energy consumption is not known at the design stage;

-building design data cannot be used directly in building energy certification;

-if the requirements to thermal resistance of building element are strict it is a great limitation to the architectural decision.

To avoid the last disadvantage and give more freedom to the architect is possible if thermal performance of a building is shown, for example, by "average heat transmission coefficient"[1]:

$$U=(a_1A_1U_1+a_2A_2U_2+\ldots+a_nA_nU_n)/A_o,\ \mathrm{W/m^2K} \qquad (1)$$

where:

$U_{1,2}$ - the heat transfer coefficients of the building elements, W/m^{2}K;

$A_{1,2}$ - the outer surfaces of the various constructions, m^2;

$a_{1,2}$ - the weighting factors correcting for crawl spaces and other unheated spaces.

Many European countries limit energy performance of the building as a whole rather than a thermal resistance of separate element. Although the heat transfer coefficients of separate building elements usually are given they may not be followed if total energy performance of the building corresponds to some approved level.

Building energy consumption may be limited on a basis of annual specific heat consumption of 1 m^2 of heated area or 1 m^3 of heated volume. This possibility is lately widely used in many countries.

In Denmark it is possible to choose one of the three variants [2]. The best possibilities for the architectural decisions are given by "energy frame" of a building. For residential buildings energy frame shows the total net heat demand for the heating and ventilation of building per m^2 of heated area. The energy frame should not exceed 250 MJ/m^{2}year (69,4 kWh/m^{2}year) and may be calculated by the formula:

$$q_r= 160+110/e,\ \mathrm{MJ/m^2year} \qquad (2)$$

where:

e - number of stories found as total heated floor area in m^2 divided by heated area footprint in plan in m^2.

The Moscow Building Code [3] limits maximal specific heat consumption of heated area m^2 during the heating season with 5207 degree-days. It ranges from 160 kWh/m^{2}year for 1-3 stories buildings till 95 kWh/m^{2}year for the buildings that have more than 10 stories.

In Poland [4] the energy performance of building is shown as a function of building compactness (*A/V*). It is the same for all climatic zones of Poland (from 3700 to 4400 degree-days) and range from 29 kWh/m^{3}year till 37,4 kWh/m^{3}year.

Some countries achieve the same goal by other means. So, for example, the Netherlands [1] in 80-ies used the thermal insulation index:

$$I_t = \frac{80(A_o/V)(1-U)+30}{4(A_o/V)+1}, \qquad (3)$$

where:
A_o - area of building elements, m^2;
U - average heat transmission coefficient, W/m^2K;
V - building volume, m^3.

Later in Netherlands the Energy Performance (EP) value was introduced. It shows the energy consumption of building in terms of natural gas consumed annually for heating purposes. So EP of 1,5 corresponds to a natural gas consumption of approximately 1500 m^3/year. The EP value of a dwelling was calculated:

$$EP = Q_{pres.tot} / (330\, A_{g;verw} + 65\, A_{verlies}), \qquad (4)$$

where:
$Q_{pres.tot}$ - the calculated characteristic energy consumption, MJ
$A_{g;verw}$ - the surface area of the heated zones in the dwelling, m^2
$A_{verlies}$ - the total heat loss area of the dwelling, m^2.

Till now there are still considerable differences in the levels of energy performance required by current European Member States standards as well as in considered energy flows, calculation procedures and even measure units. That situation gave floor to various international projects evaluating and analyzing existing differences in European countries.

Required building energy performance may be given in absolute values (kWh/m^2) or in comparison to a reference building [5]. Requirements in absolute values (EP<X kWh/m^2) are used in many countries. In Great Britain, Denmark and Norway required energy performance values depends on type of the building; in Belgium, Switzerland, Germany, Greece, Netherlands and Ireland it depends on the building type, shape and size. Comparison to the energy performance of a reference building is used in France, Norway, Great Britain, Portugal and Sweden. In the same time Finland, Spain and Sweden have no global requirements on building energy performance.

Calculation of EP is based on the requirements to useful energy in Austria, Denmark, Ireland, Norway, Portugal, Switzerland, and Greece. In Belgium, France, Germany, Netherlands and Switzerland there are requirements of calculation of EP on primary energy.

Calculation of energy performance may include thermal characteristics of building elements, air tightness, solar gains, ventilation, design and quality of heating and lighting installations, water supply systems and use of renewables. The results of ENPER project [6] had showed that common level today is EP calculation regarding properties of building envelope, air tightness, solar gains and ventilation that is used in 17 countries. But the calculation procedures itself are very different in all countries.

Differences are considerable even in the field of building transmission loss calculation where many European standards are available. Application of European standards in all mentioned countries is going with some difficulties. European standards are applied in 6 to 15 countries depending on the standard and made mandatory in 2 to 7 countries.

2.2. The requirements of Latvian Building Code LBN 002-01 "Thermal performance of building envelope"

The Latvian Building Code LBN 002-01 "Thermal performance of building envelope" [7] had radically changed approach to the limiting of building heat losses. Instead of limiting thermal transmittance for the particular building elements it uses the concept of reference building. The building heat losses should not exceed building heat losses of normative reference building:

$$H_T = H_{TR}, \qquad (5)$$

where:
H_T - building heat loss coefficient, W/K;
H_{TR} - building heat loss coefficient of reference building, W/K.

The heat losses of reference building are calculated with normative U-values of building elements (Table 1). The reference building has the same shape and size as designed building and its windows area is limited to the 20% of floor area of a building.

Normative building heat loss coefficient:

$$H_{TR} = \sum U_{RN_i} A_i + \sum y_{RN_j} l_j \text{ , W/K} \qquad (6)$$

where:
A_i - area of building element i, m²;
U_{RN} - normative U-value of building element i, W/m²K;
l_j - length of linear thermal bridge j, m;
$?_{RN}$ - normative heat transmission coefficient of j linear thermal bridge, W/m K.

Heat consumption of designed building is characterized by building heat loss coefficient:

$$H_T = \sum U_i A_i + \sum y_j l_j + \sum c_k \text{ , W/K} \qquad (7)$$

where:
A_i - area of building element i, m²;
U_i - real U-value of building element i, W/m²K;
l_j - length of linear thermal bridge j, m;
$?_k$ - real heat transmission coefficient of point thermal bridge k, W/K;
$?_j$ - real heat transmission coefficient of j linear thermal bridge, W/m K.

Table 1. Normative and maximal permitted values of heat transfer coefficients, W/m²K

Nr.	Building element	Dwelling houses		Public buildings		Industrial buildings	
		U_{RN}	U_{RM}	U_{RN}	U_{RM}	U_{RN}	U_{RM}
1	Roofs and slabs that are in contact with outside air	0,2κ	0,25κ	0,25κ	0,35κ	0,35κ	0,5κ
2	Slab on ground	0,25κ	0,35κ	0,35κ	0,5κ	0,45κ	0,7κ
3.1	Walls with ?<100kg/m³	0,25κ	0,30κ	0,35κ	0,4κ	0,45κ	0,5κ
3.2	Walls with ?=100kg/m³	0,3κ	0,40κ	0,4κ	0,5κ	0,5κ	0,6κ
4	Windows, doors and glassed walls	1,8κ	2,7κ	2,2κ	2,9κ	2,4κ	2,9κ

Note: κ is correction coefficient for inside air temperature that is equal to 1 when inside air temperature is 19°C and less than 1 if inside air temperatures are higher.

Building heat loss calculated with building elements real heat transmission coefficients and areas should not exceed normative building heat loss coefficient calculated with normative heat transfer coefficients of separate elements and other regulated conditions (for example, maximal permitted windows area is 20% from floor area).

That means that excessive window area or building elements with heat transfer coefficients bigger than normative values should be compensated with smaller heat transfer coefficients of other elements. Although the U-values of building elements in a designed building may be bigger then normative U-values they cannot exceed maximal U-values (Table 2) stated in the Building Code.

To simplify the calculations of the building normative heat loss coefficient for the dwelling houses it will be allowed to use tabulated (Table 2) normative specific heat loss. In that case building heat loss coefficient may be calculated as:

$$H_{TR}=h_A \cdot A, \text{ W/K}, \quad (8)$$

where:
h_A - building specific heat loss, W/m²K;
A - heated built-in area, m².

Table 2. Normative building specific heat loss in Latvia

Number of stories	1	2	3	4	5	6-9	Above 10
Specific heat loss coefficient, h_A, W/m²K in *LBN 002-01* first edition	1,1	1,1	0,9	0,9	0,7	0,7	0,7
Specific heat loss coefficient, h_A, W/m²K in *LBN 002-01* new edition of 2004	1,05	0,8	0,7	0,7	0,6	0,6	0,6

LBN 002-01 requires the calculation of all building elements U-value being made accordingly to various EN ISO standards adopted in Latvia.

Although new Latvian Building Code will have great effect on building energy performance it cannot be called an energy performance regulation as it deals only with one of the factors – building transmission heat loss. It is only the first step in the process of determining the mandatory value of Building Energy Performance.

2.3. The conception of building energy frame in Latvia

The next step in the determination of mandatory value of building energy performance would be limitation not only of building transmission heat loss but also energy for hot water needs, heating of outdoor air for ventilation and air conditioning, as well as energy for ventilators and pumps. Such energy consumptions would form "energy frame" that would allow architects and engineers to choose optimal set of decision for the building. First time in Latvia the concept of building energy frame is going to be implemented in new Building Code LBN 209-04 „Design of low storey buildings".

Until 1993 Latvian dwelling buildings had much bigger transmission heat losses than now. In that time mechanical ventilation systems in dwelling buildings were forbidden, the intake of ventilation air was organized by natural infiltration through windows frames, the necessary heat for the heating of ventilation air was calculated as 30% of transmission heat losses through windows and was added to the load of heating system. The heating systems of individual buildings were centrally regulated by the outside air temperatures at the district heating cogeneration power plants. The heating systems of buildings had direct connection to the district heating system and did not have any pumps.

Now transmission heat losses are up to 5 times smaller, windows became air tight and mechanical or hybrid ventilation systems are required, heating systems are independent from district heating systems and are operated by pumps. So if we have the reduction of energy consumption for the compensation of heat losses, we have also the increase of energy consumption for ventilators and pumps, and we have anyway to ensure heating of intake ventilation air. If designing the building we do not take into account all this factors and try to find optimal solution, the reduction of energy consumption in a building will be much smaller than expected.

The mentioned situation is known also in other countries. For example, in Sweden [8] annual specific heat consumption for space heating in dwelling buildings decreased from 255 kWh/m² in 1970 till 155 kWh/m² in 1990, but in the same time the electricity consumption had increased and total annual energy consumption in old type of buildings is about 200 kWh/m². In low energy buildings the smaller is the annual specific heat consumption for space heating the bigger is electricity consumption: from the graphs of the study [8] can be seen that buildings with annual specific energy consumption for space heating of 125 kWh/m² have annual specific electricity consumption 35 kWh/m²; for space heating 100 kWh/m² - 55 kWh/m²; for space heating 55 kWh/m² - 75 kWh/m² respectively, and total annual specific energy consumption still is 130-160 kWh/m².

So the Latvian energy frame was formed on the following assumptions:

1) In new buildings heat consumption for space heating is decreased to the level required by LBN 002-01 and is

$$Q = 0{,}024 \times h \times A \times DD, \quad \text{kWh/year,} \qquad (9)$$

where:
h - building specific heat loss, W/m^2K as in LBN 002-01new edition;
A - heated built-in area, m^2;
DD - number of degree-days in standard year in standard heating season from September till May and room temperatures +20ºC.

2) Hot water takes now 40% of total hot water and space heating total consumption, so in energy frame the proportion is kept unchanged and it gives additional 40/60=0,66 to the energy consumption for space heating.

3) Heating load for natural ventilation was calculated 30% of energy loss through windows with present U-values of windows and window area restricted to 20% of flow area. It gives additional 0,108.

4) The use of mechanical ventilation, pumps or other electric appliances in heating and ventilation systems should not increase total energy consumption of buildings comparing to the old building systems, or if it does – energy for space heating should be smaller to keep inside the frame.

Total annual heat demand of a building for heating, hot water supply, ventilation and cooling, including electricity for pumps and fans, should not exceed value calculated by the following formulae:

$$Q_{max}=112{,}52\ A(1{,}66h+0{,}108),\ \text{kWh/year}, \quad (10)$$

where:
A - heated built-in area, m^2;
h - building specific heat loss coefficient from LBN 002-01 new edition, W/m^2 K.

The values of energy frame calculated by Formula (10) for small dwelling buildings are given in Table 3.

Table 3. Energy frame for small dwelling buildings

Number of storeys	1	2	3-4
Building heated area, m^2	Annual total heat demand for heating, hot water supply, ventilation and cooling, MWh/year		
60	9,69	8,57	7,45
80	12,93	11,43	9,94
100	16,16	14,29	12,42
120	19,39	17,15	14,91
140	22,62	20,01	17,39
160	25,85	22,86	19,88
180	29,08	25,72	22,36
200	32,32	28,58	24,84
220	35,55	31,44	27,33
240	38,78	34,30	29,81
260	42,01	37,15	32,30
280	45,24	40,01	34,78
300	48,47	42,87	37,27

The proposed energy frame does not take into account energy for cooking (gas or electricity) as well as energy consumption for domestic electric appliances. There is not statistic or studies' data in Latvia on these energy consumptions till now and incorporation of these energy consumptions in energy frame is the next task.

3. Building energy certification

3.1. EC legislative requirements to building energy certification

The building energy certification was one of the measures required by the Directive 93/76/EEC [9] (so called SAVE Directive}). The Directive was aimed at reducing CO_2 emissions and environmental impacts by improving of energy efficiency. It obliged all EU countries to develop building energy certification schemes.

The oldest building energy certification schemes exist in Denmark and UK. In Denmark [10] since 1997 there are two energy management schemes: EK for the small dwelling and public buildings with area less than 1500 m^2 and ELO scheme for the buildings with area more than 1500 m^2. In EK scheme [11] rating is based on calculated heat consumption of the building, q, kWh/m^2. Calculation of the heat gain from inhabitants and heat consumption for the hot water supply is done for the standard number of inhabitants for the building of particular size; the heat gain from the appliances also is taken by the size of the building. In ELO scheme rating is based on measured heat consumption, q, kWh/m^2, which energy auditor corrects for standard number of degree-days.

In Great Britain there are separate schemes for public/industrial buildings and for dwellings. Public and industrial buildings are rated by measured annual specific heat consumption. Typical consumptions for each type of building are established and the energy consumption of building is compared with typical. The rating has three marks: good, fair and poor. The small dwelling buildings are rated using SAP rating [12]. The SAP rating is based on the energy costs for a calculated energy consumption of a building.

Although some the other European countries also had developed their energy certification schemes, not all countries had done so. Besides there are great differences among European countries regarding the structure and calculation methods of building energy performance {EP).

That caused EC to prepare new Directive 2002/91/EC on Energy Performance of Buildings [13]. The Directive proposes:

- development of common methodology for integrated energy performance standards;
- application of this standards on new and existing buildings;
- certification schemes for all buildings;
- inspection and assessment of boiler/heating and cooling installations.

It is expected that common methodology for calculation of energy performance standards will:

- integrate insulation, heating, hot water, cooling, ventilation, lighting, heat recovery, passive and renewable energy installations, indoor climate, position and orientation of the building;
- give flexibility to designers to meet energy reduction standards in the most cost-effective way;
- express energy performance in simple energy indicators;
- be adopted by all Member State for different categories of buildings taking into account climatic differences.

At the same time Directive 2002/91/EC asks to implement building energy certification until 2006 and it does not forbid implementation of national energy certification schemes. Generally energy certification may be done either on the basis of calculated energy performance of building or on the measured energy consumption. The Latvian scheme of building energy certification for existing multi-storey dwelling buildings was formed on the measured heat consumption of buildings due to the facts that procedures of building energy performance calculation are still under development and, in any case, the use of calculated energy consumption for the existing dwelling buildings would rather complicated and expensive.

3.2. Building energy certification and labelling project in Ogre town

Latvian scheme of building energy certification was developed taking in consideration two main assumptions: scheme has to evaluate thermal performance of buildings and it has to stimulate the behaviour of the inhabitants. So it was proposed to base the rating scale on measured annual heat consumption and to adjust it to the influence of weather conditions and differences in the level of occupancy.

The rating criterion that could serve both purposes was developed in 2000 [14] and it was called standardized specific heat consumption:

$$q_{st} = \frac{q_{s.h.} DD_{st}}{DD} + \frac{q_{d.w.} A}{30n}, \quad \text{kWh/m}^2 \text{ year}, \tag{11}$$

where:

30 - standard occupancy level, m^2 per person;
A - heated built-in area, m^2;
DD - degree-days of heating period in rating year;
DD_{st} - degree-days of standard year in favourable economical conditions;
n - number of inhabitants, persons;
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.

The values of the rating scale are based on the results of the study on building real heat consumption [14]. In calculation of standardized specific heat consumption degree-days of heating period in rating year is measured value in heating season that usually now lasts from October till April and has 3700-4200 degree days and inside air temperature of +18ºC. The degree-days of standard year in favourable economical conditions are considerable higher as it is calculated for heating period from September till May, mean outside temperatures of standard year, inside air temperature + 20^{o}C. The standard level of occupancy in standardized specific heat consumption was assumed as 30 m^2 of total heated area per person.

The structure of the rating proposed scale was harmonized [15] with GBC2000 concept. The numerical values of the scale were based on two main consumptions: common heat consumption, established during the mentioned study and best present consumption for which were taken the level of LBN 002-01 [7]. Energy consumption of all other levels can be calculated from these two levels. The numerical values of rating scale are shown in Table 4.

Table 4. The rating scale

Level			Rating Category		
Nr.	Description (as in GBTool)	Value, kWh/m^2year	Nr.	Description	Values, kWh/m^2year
5	25% better than 3 level	109		Gold certificate	109
4	10% better than 3 level	130		Silver certificate	130
3	Best present consumption	145	A	Excellent	= 145
2	3 level +1/3(0 level-3 level)	177	B	Very good	145,01-177
1	3 level +2/3(0 level-3 level)	208	C	Good	177,01-208
0	Common consumption	240	D	Fair	208,01-240
-1	15% worse than 0 level	276	E	Bad	240,01-276
-2	30% worse than 0 level	312	F	Very bad	>276,01

The trial implementation of the building energy certification by the proposed rating scheme supported by the EC LIFE Programme was done in Ogre town in April 1, 2002-October 01, 2004. The calculation of building energy rating for two rating years was done for 139 apartment buildings with total heated area of 354 265 m^2. Each building received an energy passport that is placed with the authority responsible for heat supply. Energy passports were publicly issued to ensure dissemination of the knowledge amongst the inhabitants. During the project we tried to create energy awareness of inhabitants using such means as informative bulletins, newspaper publications and TV, but probably main of the activities was energy labelling of buildings. Now each building has energy label from A till F.

The main results of the buildings' energy characteristics are shown in Table 5.

Table 5. Buildings' energy characteristics of 2002/03 and 2003/04 rating years

Nr.	Parameter	2002/03	2003/04	Difference in absolute values	Difference in %
1	Degree-days	4119,5	3700,8	-418,7	-10,2
2	Mean annual specific heat consumption, kWh/m^2	204,68	176,16	-28,52	-13,9
3	Mean annual specific heat consumption for space heating, kWh/m^2	128,92	102,78	-26,14	-20,3
4	Part of space heating in total heat consumption	0,62	0,59	-0,03	-4,8
5	Standardized specific heat consumption, kWh/m^2	215,86	195,55	-20,31	-9,4

The mean total annual specific heat consumption of buildings in Ogre town in 2003.06-2004.05 was 176,16 kWh/m^2, mean annual specific heat consumption for space heating was 102,78 kWh/m^2, the part of space heating in total heat consumption was 0,59. For comparison - the mean total annual specific heat consumption of buildings in Ogre town in 2002.06-2003.05 was 204,68 kWh/m^2, mean annual specific heat consumption for space heating was128,92 kWh/m^2, the part of space heating in total heat consumption was 0,62.

The mean specific heat consumptions of 2003/2004 are considerably lower than in previous heating season, but also winter of 2003/2004 was much milder. The heating season of 2003/2004 had 3700,8 degree-days and is rather close to the standard year degree days 3732,8. The heating season of 2003/2004 was by 10,2 % warmer than heating season of 2002/2003 with 4119,5 degree-days. But the reduction of mean annual specific heat consumption for space heating in the same time is 20,3%. That means that project had achieved planned results and gave reduction of about 10% for space heating.

The most correct comparison is achieved comparing standardized annual specific heat consumption that in 2002/2003 was 215,86 kWh/m^2 and in 2003/2004 is 195,55 kWh/m^2 or by 9,4 % smaller.

The reduction of heat consumption resulted in the changes of rating categories that had significantly improved in 2003/2004 (Table 6).

Table 6. Comparison of rating categories

	Rating category	**A**	**B**	**C**	**D**	**E**	**F**	Total
2002/03	Number of buildings	0	6	50	69	12	2	139
	Percents of total	0,00	4,32	35,97	49,64	8,63	1,44	100,00
2003/04	Number of buildings	1	20	87	29	1	1	139
	Percents of total	0,72	14,39	62,59	20,86	0,72	0,72	100,00

The biggest number of buildings (62,59%) in Ogre town now belongs to the rating C and only 20,86% belongs to the category D of common consumption level. There is considerable shift to the higher categories: now 78% of all buildings have better categories than common heat consumption level D and only 1,5% has worse consumption. The changes of rating categories are also shown at Figure 1.

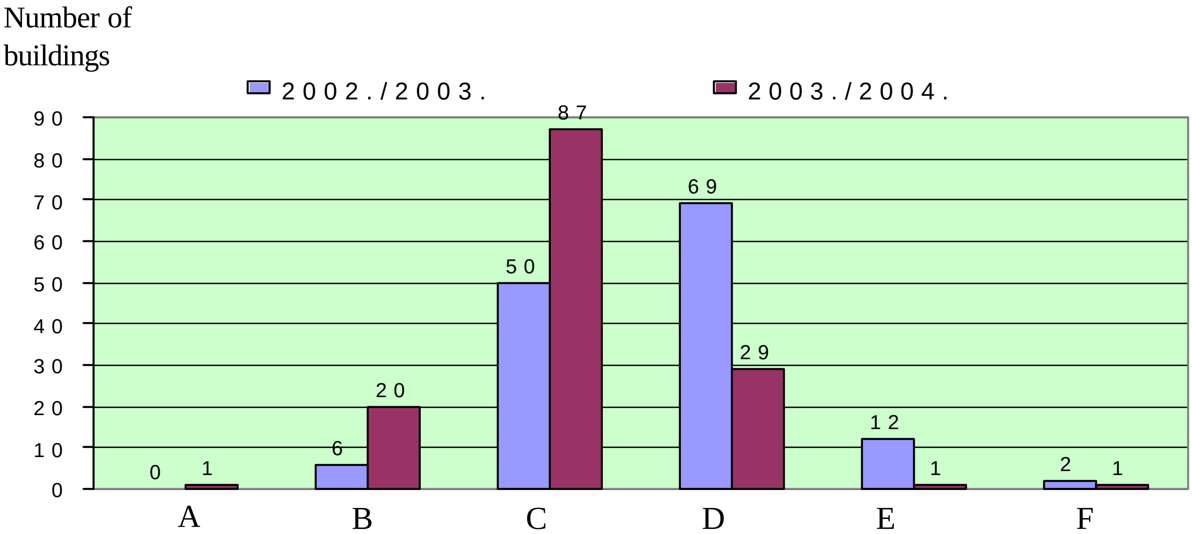

Figure 1. Changes of building energy rating categories in 2002/03 and 2003/04

Comparison of ENERLAB project buildings' energy certification results shows that project assumption was correct and it is possible to achieve 5-10% reduction of buildings' heat consumption by relatively cheap measures of energy certification and creation of energy awareness among inhabitants. More information about project results may be found at http://www.bf.rtu.lv/~enerlab/eng/results.html.

4. Conclusions

1. Limitation of building energy consumption on the basis of building transmission heat loss is necessary, but often it is not enough for the significant reduction of building energy consumption.

In Latvia since 2001 the limitation of building energy consumption for space heating is done not on the basis of heat transmission coefficients of separate building elements, but limiting whole building heat losses using for that purpose building heat loss coefficient of reference building.

The next step is determination of building energy frame that includes not only of building transmission heat loss but also energy for hot water needs, heating of outdoor air for ventilation and air conditioning, as well as energy for ventilators and pumps.

2. The Latvian energy frame first time proposed for small private buildings in Building Code LBN 209-04 „Design of low storey buildings" was formed on the following assumptions:

- In new buildings heat consumption for space heating is decreased to the level required by LBN 002-01;
- Hot water takes 40% of total hot water and space heating total consumption;
- Heating load for intake air in ventilation system should not exceed the heating load of previously used natural ventilation that is calculated as 30% of energy loss through windows with present U-values of windows and window area restricted to 20% of flow area.
- The use of fans, pumps or other electric appliances in heating and ventilation systems should not increase total energy consumption of buildings comparing to the old building systems, or if it does – energy for space heating should be smaller to keep inside the frame.

3. To fulfil requirements of the Directive 2002/91/EC on Energy Performance of Buildings, buildings' energy certification:

- for small private buildings may be done on the basis of building energy frame using European Standards for calculation of energy consumption by buildings and building systems;

- for existing multi-storey apartment buildings should be done using the already developed in Latvia buildings heat consumption certification scheme based on ***measured*** heat consumptions recalculated to standardized specific heat consumption as theoretical calculation of energy consumption for those buildings would be complicated, time consuming, expensive, and last but not least it would not stimulate energy awareness of inhabitants and the reduction of energy consumption.

4. The trial implementation of Latvian energy certification scheme for multi-storey apartment buildings done in Ogre town in April 1, 2002-October 01, 2004 had proved that:

- the scheme may be easily implemented for the buildings receiving heat from district heating systems;
- combining with information campaign it will lead to the 5-10% reduction of heat consumption comparing to the situation prior to the energy certification.

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ENERGY DEMANDS FACTOR FOR OFFICE BUILDING AS A FUNCTION OF OCCUPANCY

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1. Introduction

The main factors determine heating and cooling energy requirements for buildings are geometry, construction, location and usage profiles. The last factor is especially significant for non-residential, public buildings like office, schools etc.

This work is the first step in estimation of heating energy demands for office building as a function of event profile. The event profiles define the time dependent variations in building occupancy, lighting, plant control and miscellaneous appliance usage. These profiles also determine heating, ventilation and air-conditioning plant behaviour in particular zone or whole building, corresponding to zone operation like airflow rate and casual gain from people, lights and equipment. It can determine, for example, various switching strategies for heating and cooling system.

2. Office building

In this work the designed office building is analysed. It consists of four heated floors and two not heated underground partially opened floor with the parking garage. The building is located along west-east axis with main entrance in the south side and is arranged as three orthogonal rectangular prisms as main part with two wings. The west side of the main body of building interpenetrate with cylindrical part where is one space atrium – the main entrance. Offices, conference halls, technical rooms and toilets are in the main part of building and it's wings. The floor surface and internal cubature of the building is presented in table 1.

The building has been divided for energy simulation on 8 zones, six zones with full automatic air conditioning with internal temperature and humidity control and two with ventilation without automatic control of internal parameters.

This building will be equipped with **underground tunnel** for pre-heating or pre-cooling of ventilation air, **tri-generation installation** for producing electricity and heat and cold with gas engine / engine in combination with traditional gas heating boilers, **heat recovery** systems and **photovoltaic installation**.

Table 1. Geometry parameters of analysed building

Specification	Floor surface [m^2]	Cubature [m^3]
Atrium	670	10497
Conference halls	621	2720
Atrium offices	3984	11568
Offices – south side	2016	7490
Offices – north-west side	1384	5184
Offices – north-east side	1384	5184
Sub total for full controlled air conditioned space	10059	42643
Sanitary rooms and lavatory	692	2592
Technical rooms	115	348
Sub total for ventilated space	807	2940
Total	**10866**	**45583**

The building detailed specification is presented below:

Critical dimensions
4 office floors
2 underground parking floors
14,20 m floor depth in the wings (column free)
15,80 m floor depth in the central body (column free)
14,50 m height of the atrium
2,70 m finished floor to ceiling office height
2,00 m free height under the lowest beam and technical pipes in parking area

Atrium
Imposing Atrium to full building height with glass lifts and stairs to all floors and with restaurant serving hot meals;
A range of conference and meeting rooms will be available for the internal use of tenants and for seminars or training.

Open space
Highly efficient office floor plate (column free) delivered for flexible accommodation of open space office or subdivided enclosed office layouts.

Thermal specification of the building

Solid external walls	U = 0,27 W/m^2K
Roof	U = 0,19 W/m^2K
Floor over underground parking	U = 0,30 W/m^2K
Windows	U = 1,60 W/m^2K

Air-conditioning and ventilation

The office space will be fitted with ventilated cooling & heating beams, a complete cooling, heating and ventilation system in one monobloc unit recessed within suspended ceilings with possibility of individual control.

System is designed as a non-smoking environment, but smoking areas with increased ventilation extraction rates are provided locally.

The building has been divided into two air-conditioning zones: the north and south one, served by means of two independent Air Heating Units. Fresh air will be supplied using duct system. Last parts of ducts before the beams will be flexible, so as to make the beams' arrangement flexible in order to adjust them to the particular interior designs.

The amount of supplied fresh air will be of $50m^3/h$ per person, approximately.

The Air Heating Units have been equipped with heat recuperators that recuperate the heat from the air exhausted from the building.

Cool for the air-conditioning needs will be prepared by chillers located on the roof, co-operating with cold water storage.

At wintertime, the air will be moisturised by steam generators located in the mechanical room.

For summertime, an air drying system has been worked out. The air will be dried by a cooler.

The heat for the air-conditioning needs will be provided by two sources the gas boiler-room located on the roof and a gas engine located at –2 level.

Waste heat from the engine will be used to drive absorption refrigerator. The cool that it produces will be used for the air-conditioning needs.

The round shaped building with its own elevator accessible from the atrium and from each office floor will offer a range of conference and meeting rooms. Moreover the main building will give possibility to arrange meeting rooms on each office floor. In order to maintain thermal comfort of these zones independent Air Heating Units and fancoils using recircuilated air are foreseen.

Temperatures in the atrium:

At summertime, temperature inside the atrium will be kept at the level of 2 to 4ºC below the outside temperature.

For the wintertime, temperature in the atrium will be kept at ~16ºC.

Non-stop operating ventilation, based on individual ventilation exhaust system has been designed for toilets.

The parking lot has been designed as naturally ventilated, open structure.

Space heating

The heating system will be powered by the gas boiler located on the roof. Gas-engine will support the boiler-room. Pre-heating and pre-cooling of the air will take place in underground air duct (located around the building). Expected gains: ?t 3°C for summer season and ?t 10°C during winter.

For winter season temperatures inside the building assumed for calculation purposes are as follows:

- Relative humidity during winter: 45% - 55%
- Offices +20°C,
- Toilets +20°C
- Atrium up to +16°C,
- Unheated underground parking lot (open structure)

External conditions during winter taken as a base for calculations:

- -20°C, 100% RH

Water pump and two-pipe system has been designed for heating (using water). The central heating will feed the ceiling beams, which operate as heating or cooling devices.

Floor heating is designed for the Atrium. Its working parameters are 40/30°C.

Chiller installation
The chiller installation will guarantee that the refrigerating medium will be led to AHU coolers and cooling & heating beams in the 4-pipe set. Chillers supported by the cool storage system and the absorption refrigerator cooperating with the gas engine and supported by the air duct will be the source of cool for the building. For summer season temperatures inside the building assumed for calculation purposes are as follows:

- Relative humidity during summer (and middle seasons) 45% - 55%
- Offices ? t 4-6°C,
- The atrium ?t 2-4°C ,
- underground parking lot (open structure)

External conditions during summer taken as a base for calculations:

- +30°C, 65% RH

Power supply
The building is connected to municipal power network. Basic power will be supplied by a detached medium voltage station, PZO type (connection power: 920kW) and a150 kW generator powered by gas engine, which will be additionally used as an emergency source of power.

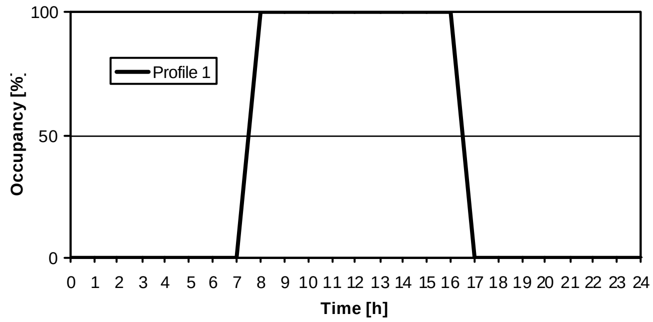
Pre-heating and pre-cooling of ventilation air by an underground tunnel
The additional part of the air-conditioning system will be a ground - air heat exchanger which will provide pre heating during winter and pre cooling in summer time. The fresh air will be taken into the ventilation system by external intake. The next part of the system is the ground exchanger, called tunnel for increase the temperature of the external air during winter and decrease the temperature of the external air during the summertime. At the intermediate part of the year the temperature of the ground will be stabilize by the temperature of the flowing air. At that time there will be not any significant influence on the intake air temperature. The tunnel consists of three 1 meter diameter and 130 meter length concrete pipes.

Installation of tri-generation gas engine for producing electricity, heat and cold – in combination with traditional gas heating boilers

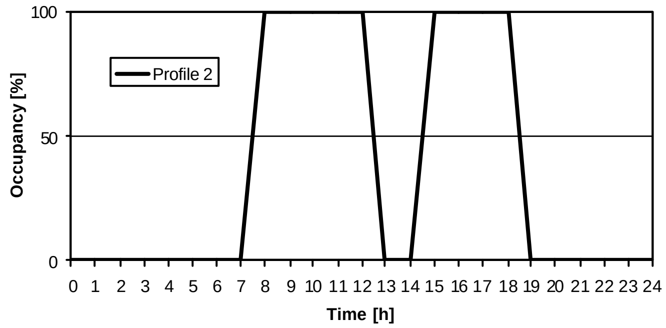
The tri-generation power-heat-cold generation system will be used as a main heat and cool source for the building. The space heating system will be powered by waste heat from gas engine/engine. Only the peak load will be covered by the gas boilers. The chillers will co-operated with combined system consisting of absorption chiller and gas engine with power generator. That gives us a possibility of covering major heat and cool demand by very effective source with full support of the gas boilers and chillers at the peak periods. Chillers supported by the cool storage system and the absorption refrigerator cooperating with the gas engine and supported by the ground exchanger will be the source of cool for the building. The cool for the air-conditioning needs will be prepared by chillers located on the roof, co-operating with Cristopia. The storage system for cooling needs will reduce the peak needs, that give us a possibility of reduce of the size of the chiller equipment and give us a possibility of flexible manage of the cool consumption. The storage system guarantees the full utilization of waste heat from gas engine for cold production during the summer.

Heat recovery elements
The heat recovery exchangers will be installed as a part of the ventilation and air conditioning system. The Air Handling Units will be equipped with the rotary heat exchangers, as a heat recovery section. That approach will significant reduce a heat consumption in the winter time and will support a reducing of the air temperature during the summer time. The efficiency of the heat recovery system of 50% was taken into consideration for energy simulation.

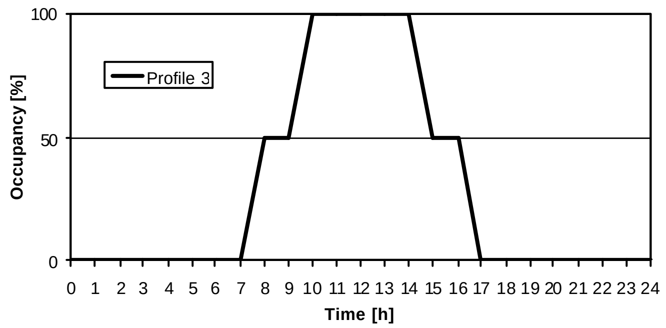
1. Standard constant profile, eight hours working day (8-16), five days per week



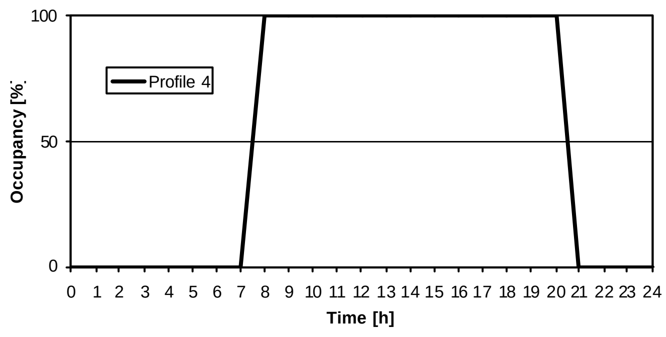
2. Standard constant profile (8-18) with lunch time break (12-14), eight hours working day, five days per week



3. Gradual profile with 100% of occupancy from 10:00 to 14:00, eight hours working day, five days per week



4. Long-term profile with 100% of occupancy from 8:00 to 20:00, twelve hours working day, five days per week



5. Long-term profile 8 – 20 with lunch time break (12 – 14), twelve hours working day, five days per week

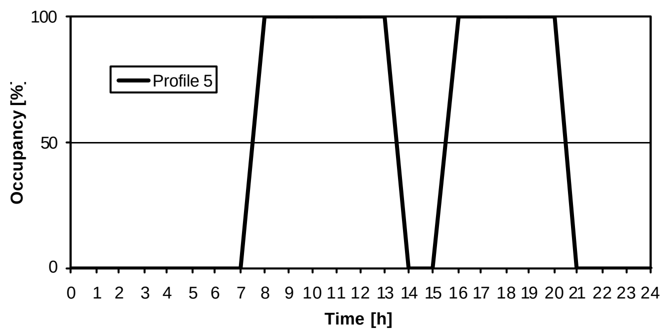


Figure 1. Occupancy profiles

3. Events profile

In most office buildings, the effects of infiltration/ventilation loads and internal heat gains can be considerable. The magnitude of these factors depends on building type and occupancy. Number of people determined infiltration rate and casual heat gains. People's activity terms gains from lighting and equipment. Office buildings can have few event profiles relatively to number of working hours, breaks and occupancy intensity. For the purpose of our work five office's activities have been prescribed and considered: standards, with breaks, gradual and long-term (fig. 1). Occupancy profiles not only determined heat gains and air flow inside the building but HVAC systems control action as well and assists in the definition of zones operation. Therefore, control loops are established to keep required internal conditions, defined by temperature and relative humidity, according to those profiles.

4. Numerical Results

The ESP-r [1] control volume approach was adapted to describe the physical elements of zones and networks. Eight, mechanically ventilated thermal zones were established to represent a multi-storey, low-energy office building, which have been selected for the purpose of our work. In our case the continuos heating with the ideal control set on 20°C (offices) and 16°C (atrium) was defined for the whole heating season from 6 a.m. to the end of working day. During the night, internal temperature in offices were reduced to 16°C. In summer, the temperature control point was 24°C for offices (with possibly overheating to 30°C during the night) and 30°C for atrium. Additionally, internal relative humidity was controlled on the level of 55% in offices during whole working day. The external boundary conditions (temperature, relative humidity, solar radiation, wind speed and direction) were defined due to the Typical Meteorological Year for Warsaw – Poland (52ºN) [2].

A one-hour time step was used within simulation. The values of heating and cooling energy requirements were considered for five occupancy profiles and saved separately for summer (1.V-31.IX) - cooling and winter (1.X-30.IV) - heating seasons. Results are presented in tables 2-6.

1 – standard constant profile (100% of occupancy from 8:00 to 16:00),

Table 2. Energy delivered

zone	heating energy [kWhrs]	cooling energy [kWhrs]
atrium	254 390	27 630
offices	388 118	372 595

2 – standard profile (100% of occupancy from 8:00 to 18:00),

with lunch time break (12:00 – 14:00),

Table 3. Energy delivered

zone	heating energy [kWhrs]	cooling energy [kWhrs]
atrium	260 577	30 933
offices	424 780	387 128

3 – gradual profile (50% of occupancy from 8:00 to 10:00 & 14:00 to 16:00 and 100% from 10:00 to 14:00),

Table 4. Energy delivered

zone	heating energy [kWhrs]	cooling energy [kWhrs]
atrium	257 997	27 518
offices	417 926	315 601

4 – long-term profile with 100% of occupancy from 8:00 to 20:00,

Table 5. Energy delivered

zone	heating energy [kWhrs]	cooling energy [kWhrs]
atrium	260 113	33 528
offices	428 260	501 474

5 - long-term profile with lunch time break (12:00 – 14:00).

Table 6. Energy delivered

zone	heating energy [kWhrs]	cooling energy [kWhrs]
atrium	263 607	33 440
offices	441 331	452 468

5. Energy demands factors

Energy demand factors were calculated for the atrium, the offices and for total atrium and offices for all five considered profiles. Two kinds of energy demand factors are presented in tables 7-12 and figures 2-4. The first of them is typical energy demand factor referenced to floor area. The second factor is related to the person and hour of occupancy in all five profiles.

Table 7. Energy demand factor for atrium

Atrium	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
Heating kWhrs/m^2	379,7	388,9	385,1	388,2	393,4
Cooling kWhrs/m^2	41,2	46,2	41,1	50,0	49,9

Table 8. Energy demand factor for offices

Offices	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
Heating kWhrs/m^2	44,3	48,4	47,7	48,8	50,3
Cooling kWhrs/m^2	42,8	44,2	36,0	57,2	51,6

Table 9. Energy demand factor for whole building

Total	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
Heating kWhrs/m^2	68,1	72,6	71,6	72,9	74,7
Cooling kWhrs/m^2	42,7	44,3	36,4	56,7	51,5

Table 10. Occupancy energy demand factor for atrium

Atrium	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
Heating kWh/person-hour	142,4	116,7	144,4	97,1	98,4
Cooling kWh/person-hour	15,5	13,9	15,4	12,5	12,5

Table 11. Occupancy energy demand factor for offices

Offices	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
Heating kWh/person-hour	16,6	14,5	17,9	12,2	12,6
Cooling kWh/person-hour	16,1	13,2	13,5	14,3	12,9

Table 12. Occupancy energy demand factor for whole building

Total	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
Heating kWh/person-hour	25,5	21,8	26,9	18,2	18,7
Cooling kWh/person-hour	16,0	13,3	13,6	14,2	12,9

The diagrams below show changes of the occupancy demand factor for the atrium and offices in relation to the considered occupancy profiles.

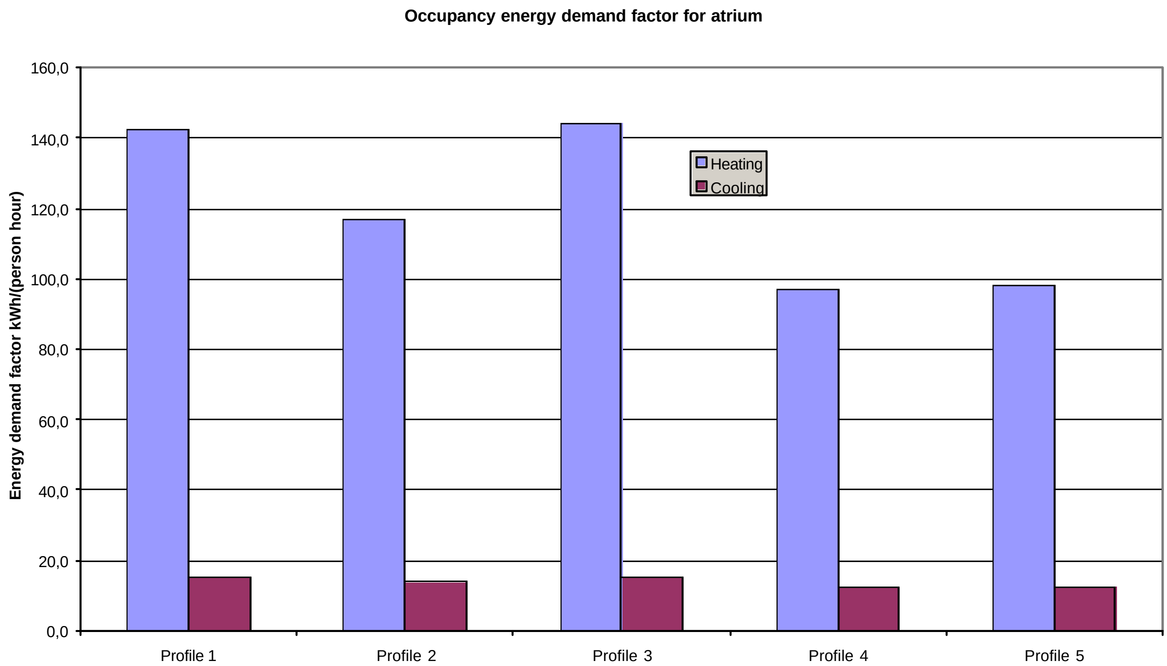


Figure 2. Demand factor for atrium

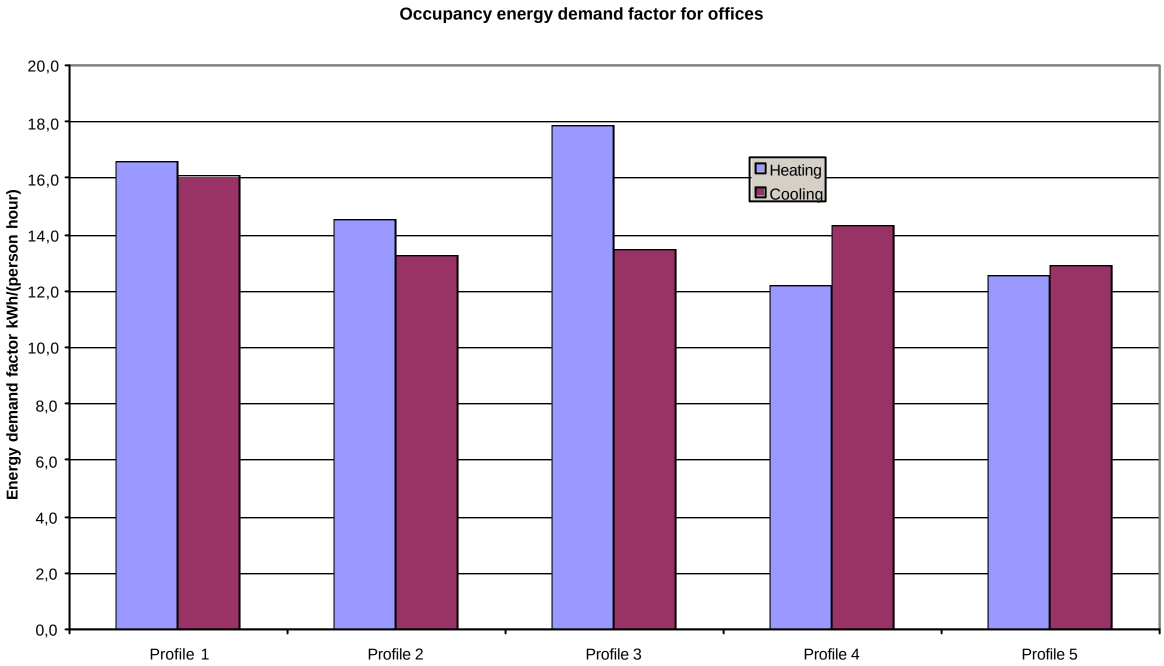


Figure 3. Demand factor for offices

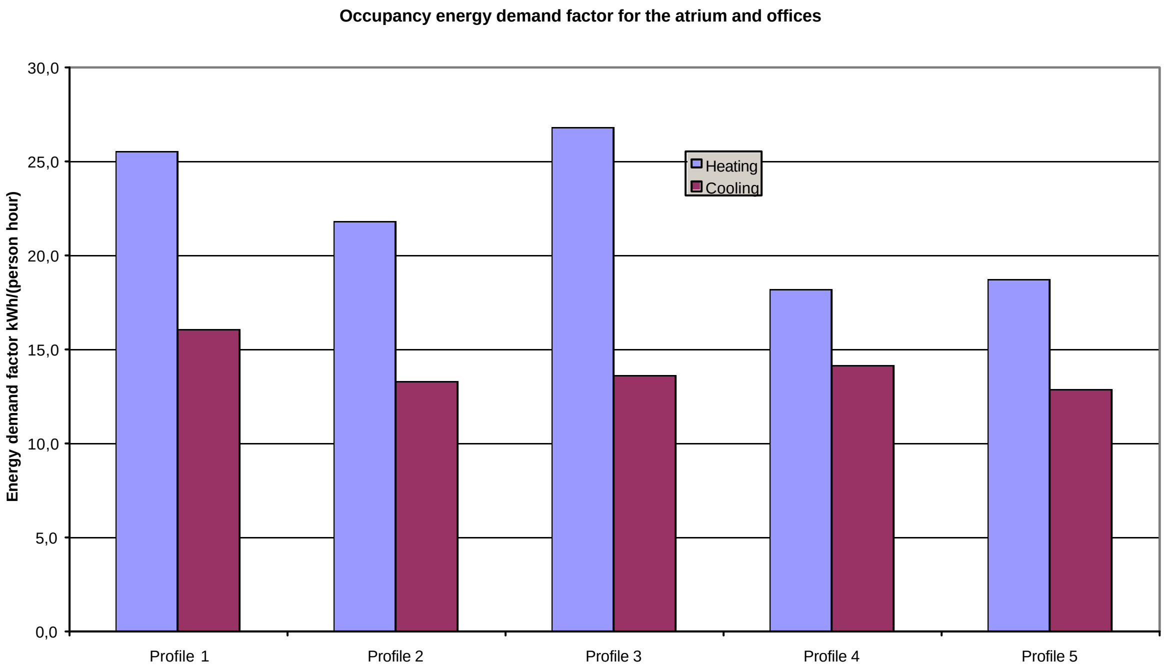


Figure 4. Demand factor for atrium and offices

6. Conclusions and future work

The numerical results of one-year analysis show considerable differences in cooling and slightly in heating energy demands. The heating and cooling energy is determined by additional internal heat gains and highly depends on the length of working day and number of employees. Any breaks during the day (for the same number of working hours) caused increasing heating and decreasing cooling demands.

Energy demands factors referenced to floor area show proportional, as expected, dependencies on energy demands. In the case of second demand factors, related to the density and hours of occupancy, some differences are reported. The highest factor was obtained for low density, gradual profile while the lowest for compact, long-term profile. Any breaks during the working day also increasing analysed factors. Therefore, the relationship between occupancy intensity and energy demands should be analysed in the future.

This study is the first step in the estimation of energy demands factor as a function of occupancy. Further, more detailed analysis about dependencies between usage profile and energy demands factor (related to time of occupancy) will be considered in the future. Finally, the new evaluation method based on the numerical results of energy efficiency for office building should be developed and validate.

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CO_2 REDUCTION IN POST-WAR HOUSING: COSTS, BENEFITS AND POLICY IMPLICATIONS

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1. Introduction

In the Kyoto Protocol, governments of the industrialised countries agreed to reduce the total 1990 level of CO_2 emissions by 5.2% between 2008 and 2012 thus increasing pressure on governments to establish CO_2-reducing strategies. New housing production in the EU is 1.9 million units per year, or approximately 1% of the building stock. Dwellings yet to be built will constitute 15% of the total housing stock in 2020 and 5-10% of the total housing stock in the Kyoto period 2008-2012 [1]. Consequently, the existing housing stock is an important sector in reducing green house gas emissions according to the Kyoto agreements. In the Netherlands, a 3.6 Mton CO_2 reduction could be achieved from existing housing if an average investment of € 2,300 per dwelling was made and the energy tax was increased 2.5 times to shorten the pay-back time [2]. The environment, however, continues to play a small part in renewal projects [3].

From an economic point of view, a firm or a household will invest in energy conservation up to the point where the costs no longer outweigh the financial benefits [4]. Costs were often seen as a main barrier for the adoption of CO_2 reduction measures in urban renewal, but this concern is related to impressions of costs at face value, rather than any consideration of the actual costs and benefits [5]. Advantages and disadvantages of different options received little attention, regardless of whether they were cost-effective or not. Economics can have a strong role in determining changes in energy consumption levels. Therefore, development of operation-focused and long-term policies that can support investing in energy improvements in the existing housing is in a key position in promoting sustainable urban renewal. Making adequate policies requires awareness of practical potential and barriers.

This paper has two aims. First, it presents a feasibility study of an energy efficient renovation in a post-war housing, focusing on costs. Second, it discusses policy instruments that could make use of this potential. This paper aims to answer to the research questions:

What is the energy saving potential of post-war housing renewal? What are the required expenditures and the expected receipts? Which policy developments make investments in energy efficiency more attractive in the near future?

2. Research approach and the field of study

Addressing sustainability problems becomes complicated in the urban context where the interaction between people, their social environment and their accommodation becomes complex [6]. The use of qualitative case studies as the main research method enables understanding the complexity of urban renewal and the identification of environmental problems of post-war housing areas in practice. The selected case study is a part of a wider research project on sustainable urban renewal where more case studies were examined and local housing associations commented on the research results [7]. The case study was selected according to two key criteria: it had to involve a post-war residential district because it is in districts of this type that most of the restructuring operations will be carried out, and it had to involve ambitions and objectives for sustainable building. This study focuses on the Netherlands, because it has a tradition in effective planning and consensual politics and it is using several approaches to environmental policy-making, also at the municipal and regional levels [8].

The selected case study is situated in Hoogvliet in the municipality of Rotterdam, in the Meeuwenplaat neighbourhood that consists of around 3,000 dwellings, located in similar five-storey buildings built in 1959. About 76% of the housing stock is social rental dwellings, mainly in the lowest rent categories. The studied building type has a cavity wall structure. Double-glazing and additional insulation, in some parts of the façade, have been installed in an earlier renovation. The concrete roof and the flat floor are not insulated. The energy demand is dominated by the use of natural gas for space heating. Natural gas is also used for warm water and cooking, and electricity is used for other energy services. The buildings have natural ventilation. The dwellings are heated with individual gas systems and tap water is heated with an instantaneous heater in the kitchen. The annual average indoor temperature was expected to be 15 degrees. One building contains 26 dwellings that have an average surface area of ± 60 m^2. There are two apartments in the ground floor, most of the ground floor space is unheated and used for storage. The interior staircase is unheated.

Figure 1. The case study, Hoogvliet, Rotterdam.

There are four main strategies to approach the problematic housing estates: demolition, renovation, maintenance, or not taking any action. In the Netherlands, demolition followed by new construction has become a common policy in renewal projects [9]. This research focuses on renovation because it can reduce energy costs and demand, forestall an increase in demand for new housing and improve the indoor air quality, without environmental problems of demolition, such as waste and new resources consumption. The study focuses on the dwelling-related energy consumption that means the energy consumption that is influenced by the technical condition of houses, involving natural-gas consumption and a part of electricity consumption and excluding the energy used for domestic appliances. Four cumulative energy efficient renovation solutions are examined in the case study, based on the National Package for Sustainable Management that is a generally used collection of standard environmental measures in the Netherlands [10]. The renovation measures have to be practical, economically and technically feasible with in five years. The life-cycle expectation for the constructions before the next intervention is 25 years. For the installations, the life-cycle expectancy before the next intervention is 15 years. Energy evaluations of the different renovation solutions are carried out with the Energy Performance Advice (EPA) -tool.

Clients and professional advisers often see investment cost more important than the revenue savings unless the payback time is very short, less than 5 years [11]. In this research, the commercial viability of a project is assessed with the Net Present Value (NPV) test. The calculations are based on an inflation rate of 2,9% and an interest rate of 6,5%. The investment level is set low as it is presumed that similar renovation measures are implemented in more than 50 dwellings. All costs are calculated without the Value Added Tax (VAT). Due to the elimination of governmental energy subsidies in the Netherlands in 2003, the investment costs are calculated without any subsidies. The gas price used is € 0,367, including the Regulatory Energy Tax (REB). The electricity price used is € 0,128, including the REB tax.

It is rare that what is deemed desirable is also feasible in terms of time and money as well. Although forecasting carries obvious risks, some aspects that will shape environmental attitudes and investments in sustainability can be speculated. Few energy price scenarios are used as background to test the conclusions from the case studies. An overview of the policy developments is based on a literature study [12, 13, 14, 15].

3. CO_2 reduction in the case study

Space heating is the largest end use category in the domestic sector. The thermal performance of a building can be improved with extra insulation in the outside walls, the roof and the floor. This is referred to as renovation solution 1 in the evaluation. In solution 2, in addition to extra insulation, the windows are replaced with new HR^{++} windows. In renovation solution 3, in addition to extra insulation and new windows, a HR107 kettle is installed for space heating and a WP boiler for tap water heating, with water saving water equipment. The ventilation is adjusted to demand and construction joints are sealed. In the solution 4, in addition to the measures of solution 3, a solar boiler is installed. The reference level presents the current situation, standard maintenance, without any renovation or environmental measures. The results of the energy evaluation in the case study, considering one apartment block, are presented in Table 1.

Table 1. Energy evaluation of the four different renovation solutions in the case study.

Options	**Reference**	**Solution 1**	**Solution 2**	**Solution 3**	**Solution 4**
	The existing situation	Insulation	Solution 1 + windows	Solution 2 + installations	Solution 3 + solar boiler
Energy-index	1,13	0,86	0,78	0,74	0,66
Space heating (m3 gas)	28,000	13,145	9,332	9,370	9,370
Tap water heating (m3 gas)	15,087	15,260	15,260	0	0
Total gas use (m3 gas)	43,887	28,405	24,592	9,370	9,370
Saving in gas use (m3 gas)	-	15,482	19,295	34,517	34,517
Tap water heating (kWh)	0	0	0	61,184	41,608
Help energy (kWh)	7,929	7,929	7,929	11,091	12,591
Lighting (kWh)	9,181	9,181	9,181	9,181	9,181
Total electricity use (kWh)	17,111	17,111	17,111	81,456	63,380
Saving in electricity (kWh)	-	0	0	-64,345	-46,270
Expenditure (excl. subsidies and VAT) (€)	-	108,179	168,235	322,404	368,046
Extra expenditure (excl. subsidies and VAT) (€)	-	85,263	119,654	258,519	304,161
Gas costs (excl. VAT) (€)	16,107	10,425	9,025	3,439	3,439
Electricity costs (excl. VAT) (€)	2,194	2,194	2,194	10,443	8,125
Annual receipts in energy costs (€)	-	5,682	7,082	4,419	6,737
CO_2 emissions reduction (kg)	-	31,641	40,327	39,562	48,177
Change in the reference energy index (%)	-	24%	31%	35%	42%

The evaluation shows that with the renovation solution 2 (additional insulation and new windows), the total gas use can be reduced with 44%. In total energy costs, € 7,082 saving could be achieved, accounting for € 272 per average dwelling. Solution 2 provides 40,327 kg CO_2 reduction. New energy efficient installations (HR107 kettle and a WP boiler) and the use of a solar boiler can reduce the gas consumption with 79% from the current level, although there is slight increase electricity consumption. They can result at annual € 6,737 cut in energy bills, accounting for € 259 per average dwelling. CO_2 emissions can be reduced with 48,177 kg. The results show, however, that the CO_2 reduction potential requires relatively high investments. The expenditure is € 168,235 for the solution 2 (€ 6,471 per average dwelling) and € 368,046 for the solution 4 (€ 14,156 per average dwelling). The results show that the installations increase the investment with 48% compared to the building technical improvements, the insulation of the thermal envelope and new windows, while the resulting savings in energy costs increase with 19%, and the CO_2 reduction with 2%.

When the results were discussed with the owning housing association, they proposed, to relate the costs to the extra investment required compared to a standard renovation, a "zero option", where building components and installations are replaced with similar measures as before the intervention, only necessary renovation actions are carried out without extra environmental measures. The results show that the extra expenditure is € 119,654 for the solution 2, and € 304,161 for the solution 4. The extra investment costs for the solution 3, new installations but no solar boiler, is € 258,519. The comparison shows that, compared to a standard renovation, the renovation solution 2 can result at 70% more CO_2 reduction, and save 38% more in total energy costs, with 29% extra investment costs. The renovation solution 4 with a solar boiler would result at 75% extra CO_2 reduction compared to the "zero option", with 17% more investment costs. See Table 2.

Table 2. Extra investment costs, receipts in life-cycle energy costs and the CO_2 reduction resulting from the different renovation solutions, in comparison to a standard renovation.

	Standard	**Solution 1**	**Solution 2**	**Solution 3**	**Solution 4**
	Standard renovation	Insulation	Solution 1 +windows	Solution 2 + installations	Solution 3 + solar boiler
Expenditure (%)	0	21%	29%	20%	17%
Receipts in LCC compared to a standard renovation (%)	-	30%	38%	23%	36%
CO_2 reduction compared to a standard renovation (%)	-	62%	70%	69%	75%

If we consider energy savings over 25 years, it appears that the solution 2 can result at € 135,267 extra saving in total energy costs compared to a standard renovation. This is illustrated in Figure 2. The lines present cumulative Life-Cycle Costs in energy, resulting from energy consumption of the different renovation options over 25 years, using the Net Present Value (NPV) with an inflation rate of 2,9% and interest rate of 6%. Life cycle costs mean only energy consumption, maintenance costs are not incorporated in the analysis. The difference between the lines illustrates the receipts, savings in energy costs.

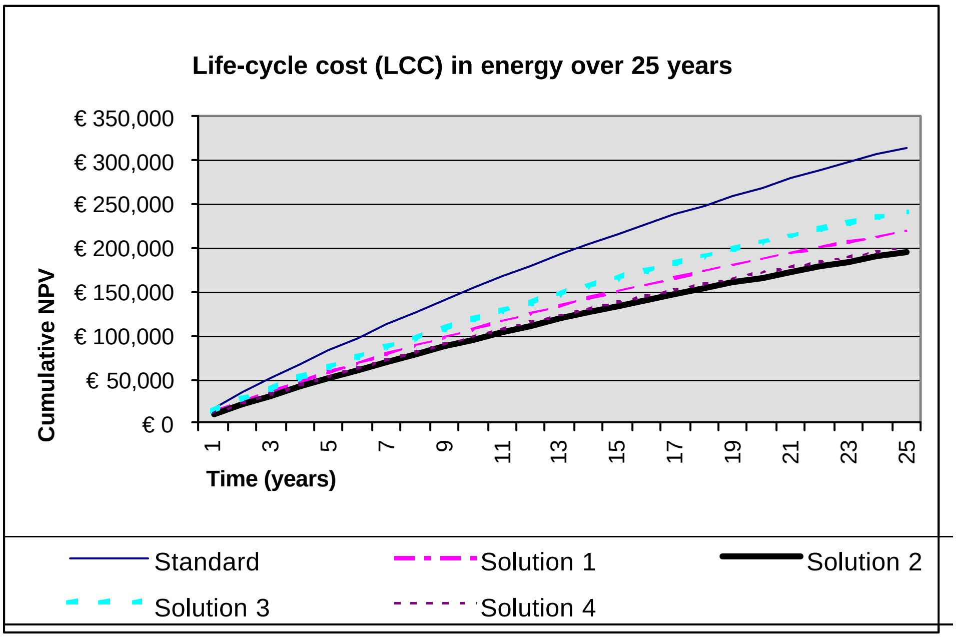

Figure 2. A comparison of LCC in energy of the different investment options over 25 years (NPV).

Despite a great CO_2 reduction potential, the general rule is that an investment has non-negative Net Present Value (NPV) then it should be taken, otherwise not. Cumulative savings of the different renovation solutions are related to the extra expenditures in Table 3.

Table 3. The NPV the solutions in 25 years regarding the extra expenditure, since the life cycle of installations is 15 years, the investment has to be done twice in 25 years.

	Solution 1	**Solution 2**	**Solution 3**	**Solution 4**
	Insulation	Solution 1 +windows	Solution 2 + installations	Solution 3 + solar boiler
Extra expenditure compared to standard renovation (€)	85,263	119,654	655,457	771,180
Cumulative receipts in energy costs over 25 years NPV (€)	98,802	123,146	76,840	117,147
NPV over 25 years (€)	13,539	3,492	-578,617	-654,033

The results show the renovation the solution 1 can be paid back in 21 years and the solution 2 in 24 years, but the NPV of the solutions 3 and 4 remain negative. Long payback scenarios and the negative NPV of the installations make energy investment unattractive to the owner in monetary terms. This, however, can change in the near future depending on policy developments like energy pricing, that are expected to rise because of regulatory measures, government action, implementation of the Kyoto treaty, a more dynamic energy market and the pressure to satisfy electricity demand with zero-emission technology, and taxes [15]. In the Netherlands, energy prices for gas and electricity have increased annually in 1999-2003, gas price for average households have increased from 29 to 40 Eurocents per m^3, including the VAT (annual increase 14%). On the basis of a policy overview, Table 4 presents the payback times of the renovation solutions with three different price scenarios, based on extra expenditure and the NPV of cumulative savings in energy costs over 25 years. Scenario A is based on the current energy price increase with a 2,9% inflation rate. Scenario B is based on the assumption that the energy prices will gradually rise with 30% in 2012, compared to the level in 2003, based on the assumption that the Kyoto Protocol will not be ratified. The scenario C is based on the prediction that the Kyoto Protocol will be implemented, meaning a rise of 60% in 2012 compared to the level in 2003.

Table 4. NPV of the solutions with A) the current energy price development, B) the expected 30% increase in 2012 compared to 2003, and C) the 60% increase in 2012 compared to 2003.

	Standard	**Solution 1**	**Solution 2**	**Solution 3**	**Solution 4**
	Standard renovation	Insulation	Solution 1 +windows	Solution 2 + installations	Solution 3 + solar boiler
Extra expenditure compared to standard renovation (€)	0	85,263	119,654	655,457*)	771,180*)
Annual receipts in energy costs (€)	160	5,682	7,082	4,419	6,737
A. Current energy price					
Cumulative receipts in energy costs over 25 years NPV (€)	2,782	98,802	123,146	76,840	117,147
NPV over 25 years (€)	-	13,539	3,492	-578,617	-654,033
B. +30% increase in 2012 (without Kyoto)					
Cumulative receipts in energy costs over 25 years NPV (€)	3,951	140,321	174,895	109,130	166,375
NPV over 25 years (€)	-	108,179	55,241	-546,327	-604,805
C. +60% increase in 2012 (without Kyoto)					
Cumulative receipts in energy costs over 25 years NPV (€)	5,790	205,600	256,258	159,899	243,774
NPV over 25 years (€)	-	120,337	136,604	-495,558	-527,406

The results show that if energy prices increase with 30% by 2012, the payback time for the renovation solution 1 is shortened from 21 years 16 years, and the payback time for the solution 2 from 24 years to 18 years. If the prices would increase with 60% in 2012, as anticipated with the Kyoto Protocol, the payback time for the solution 1 would shorten to 13 years and for the solution 2, to 14 years. The renovation solutions 3 and the solution 4 could still not be paid back.

4. Policy implications

At the operational level, the benefits of energy efficient renovation seem very clear. Yet housing associations still decide to demolish the existing housing and build new dwellings, also in this case study. The demolition is mainly due to the fact that current housing supply does not meet actual demand, is functionally outdated and has a poor energy performance.

The latter claim was responded to in this study that illustrated the CO_2 reduction potential that can be achieved in renovating the existing housing. This contradiction between this potential and practice, where measures are not taken, arises the question of factors that could influence decision-making towards energy efficient renovation, at the strategic level. The housing associations often name costs as the greatest barrier in the adaptation of sustainable housing management [16]. If the NPV of energy improvements remains negative despite the CO_2 potential available, a question arises which party is willing to take the investment if the receipts will be smaller than the expenditure. It seems that the CO_2 reduction will not be produced in sufficient quantity if the market is the sole allocative instrument in use. The market failure needs to be corrected in terms of policies.

Governments can improve sustainability and energy efficiency in the built environment in different terms. Political options for improving energy efficiency can be categorised as subsidies, regulations, measures to increase price of energy, actions to improve the operation of markets in energy efficiency by providing more information and actions to remove barriers to energy efficiency by establishing new institutions or by endowing existing institutions with new powers [11]. The use of policy instruments can be based on a further development, and combination, of the existing environmental policy instruments, on the introduction of sustainability to the existing policy instruments, or on the development of completely new kind of policy instruments.

In early 2003, the European Parliament accepted Directive 2002/91/EC on the Energy Performance of Buildings demanding that, by January 2006 energy certificates are issued for the existing building stock [17]. The Energy Performance Directive (EPD) will make energy saving in buildings more mandatory and help to collect data about energy consumption, but it leaves it open for each Member State to decide whether certain minimum energy criteria should be met and whether to combine the energy certificate with economic policy instruments or to use it only for communication purposes [18]. As one key policy instrument to promote CO_2 reductions in buildings at this moment, the Directive will certainly have implications on the construction sector in terms of labelling, consideration of energy efficiency as one factor in strategic asset management and making energy consumption of buildings more recognised in common terms. Experience from Denmark shows, however, that energy labelling of buildings should be used with sanctions. Despite the fact that the Danish energy certificate scheme is mandatory, only 50-60% of buildings are covered by the scheme, while there are great regional differences [19]. Furthermore, without a support from fiscal instruments, it can be expected that the energy improvements suggested in the labelling will not necessarily be implemented, especially in the rental and the social housing sector.

The case study shows that a tax in terms of energy price is an efficient existing policy measure in reducing the payback time of energy saving investments, if the rate is set high enough. Taxes can also support the Energy Performance Directive. Experience from the Netherlands shows that energy taxes require support from the communication instruments, information dissemination, to be effective. The Regulatory Energy Tax (REB) was applied to Dutch households in 2001 that had to pay a third more for their energy. A research shows, however, that only half of the population is aware of the Regulatory Energy Tax and 2% take it into account in the use of electricity [20]. Furthermore, the question remains as to how the taxation on energy can be increased without hitting low-income households that have less financial resources to invest in energy saving measures, especially in the social housing sector. As the prices increase, low-income households save energy whereas high-income households living in large dwellings seem not to react.

Sustainability can also be introduced in the existing policy instruments where they are not yet presented. Performance agreements for sustainable building, for example, are generally regarded as a suitable instrument for the realization of sustainability ambitions in the Netherlands. The conditions that need to be in place for the successful implementation and execution of performance agreements for sustainable building can be split into conditions for performance agreements in sustainable urban renewal, conditions for performance agreements in the planning process and conditions for the implementation and execution of performance agreements [7]. It should be considered, however, that general environmental agreements with third parties and action plans at all policy levels are easily weakened by their voluntary nature because, in the end, environmental objectives tend to be overshadowed by market benefits. On the other hand, regulatory measures are often considered as a cost-effective policy instrument, but they provide no incentives to go beyond the minimum level, and their implementation and control on the existing buildings remains problematic.

There are also new kind of fiscal instruments that can support energy efficient renovation. Preferential credit conditions can be allocated for sustainable renovation. Setting up specialised funds for sustainable building is already in the beginning for example in Germany and in the UK. Fiscal bonus or tax credits can be provided for sustainable renovation or a lower Value Added Tax (VAT) rate applied for energy efficient construction materials, such as in the UK. There has been a preliminary discussion about trade CO_2 certificates in buildings in Germany and in the UK. In high-density areas, developers could be awarded added density allocations for sustainable buildings [21]. Some Dutch housing associations have suggested that investments in energy efficiency could be compensated in land prices. Energy consumption could also be taken into account in an advisory capacity on the allowed rents, a system that exists for example in the Netherlands.

Compared to energy market prognoses, less data exists about the developments in waste policies and prices. In policies, waste management and recycling receives less attention than energy. Yet pricing construction and demolition waste and setting taxes can play an important role in encouraging renovation, and recycling in demolition. In the Netherlands, the landfill tax has reduced the amount of waste going to landfill from 49.7% in 1985 to 4.6% in 2000, and increased recycling from 49.5% in 1985 to 94.3% in 2000 [14]. The landfill tax has also contributed to the increase of crushing and recycling sites in the UK [12].

Furthermore, general subsidies should not support unsustainable development. Examples of this can also be seen in the housing sector; there is a need to reform home ownership assistance for housing projects where currently buyers of existing housing receive half of the bonus which is granted for new housing [22]. Long payback times also emphasise the importance of encouraging innovations that can radically change the energy saving scenario. Installations and energy efficient windows, for example, have been developing in large steps partly resulting from the sharpened building regulations and standards over the last decades. Supporting innovations is a challenge for the government and probably requires adjustments in current policies.

In the end, it is the inhabitant, or the owner, who consumes the energy and decides whether they want to make any investments in their housing. The case study presented the dilemma of investment and profit. The owner has to make the investment, while the tenant is the one profiting from in less expensive energy bills. This can be a main barrier in sustainable building unless it is considered in policies. Alternative strategies can be adopted to overcome this problem. If solar panels, for example, were installed in the case study, the energy provider could for example, manage them. In this option, the energy provider is responsible for the control and maintenance of the installation and receives the generated solar power, paying 20% to the homeowner at consumer rate. If the occupier invests in solar panels and is responsible for the maintenance, they also receive the electricity generated, and a small contribution if electricity is supplied to the grid, provided that the installation must remain for 10 years. If the housing association owns the solar panels, the tenant receives the generated electricity and the use of solar panels is included in the rent. Different ownership models in using solar energy have been tested in 1MW PV project in Nieuwland, Amersfoort [23]. Regarding extra insulation this is more complicated. Most likely the tenants will have to pay for it in higher rents, which can transfer the affordable housing to a higher category in rents making it unavailable for the current tenants. Although most people may seemingly have pro-environmental attitudes, in practice they engage in environmentally destructive behaviour. This 'attitude-behaviour'-puzzle is also related to the question of Willingness To Pay (WTP). The WTP of the inhabitants can radically differ from the authoritive estimates and in fact it has not often been studied. Linking the WTP to structural information, such as household income, could be of interest in planning sustainable urban renewal. The fact that CO_2 reduction is a very abstract measure that does not respect national borders makes its acceptance more complex and can limit the WTP. At the project level, construction technical measures in energy efficient renovation should be supported with educative material for the inhabitants and for example individual consumption measurement systems clarifying the impact of own behaviour on energy consumption.

5. **Conclusions**

This study was focused on the Netherlands. Generalisation of case study results should always be done with great restrictions. This is emphasised in housing renewal where every case differs by location, market demand or demolition pressure, and there are clearly also emotional, not only rational, factors involved in the decision-making. Therefore, an area-orientated approach is needed. Too much standardisation at higher policy levels can lead to sub-optimalisation so certain level of flexibility should be allowed. Standard solutions, whether renovation or demolition is the best strategy, cannot be set. Yet post-war housing production was based on standardisation and repetition, the neighbourhoods are characterised by identical housing types. Many European countries are facing similar developments like liberalisation of energy markets and trends in housing market. There is also recognition about the limitations of traditional policy instruments like regulation or subsidies. This enables some comparisons between cases that have similar housing typology and when the study is clearly limited on technical improvements or costs, also internationally.

The case study illustrates that there is great reduction CO_2 potential that can be achieved in the renovation of post-war housing. With additional insulation and the installation of HR^{++} windows, the gas use could be reduced with 44% in the case study. If energy efficient installations and a solar boiler are added, the gas use could be cut with 79%. This would mean a 48,177 kg CO_2 reduction in the case study. The feasibility of energy efficient renovation, however, is limited by costs. Extra insulation and new windows require an investment of € 6,500 per average dwelling, and if new installations and a solar boiler are added, this amounts up to € 14,200 per average dwelling in the case study. The lack of subsidies makes the payback times long for normal consumers, even if energy efficient renovation could also improve living comfort and indoor climate. Compared to a standard renovation, adding thermal insulation and new windows could result at 70% more CO_2 reduction than in a standard renovation, with 29% higher investment costs.

The results show that increase in energy prices is important in reducing the payback times. However, if the prices would increase with 60% in 2012 compared to the level in 2003, as anticipated with the Kyoto Protocol, the renovation solutions 3 and 4, with more effective installations, could still not be paid back. This is reinforced by the fact that most national energy subsidies were finished due to budgetary reasons and the free-rider effect in the Netherlands in 2003. Because it is still difficult to value the environment to correct this market failure between environmental and financial gains, sustainable renovation can be made more attractive in the further development of the existing environmental policy instruments, such as taxes and the Energy Performance Directive, and their combinations, by the development of new kind of policy instruments and by introducing sustainability in the existing policy instruments like performance agreements, while the dilemma of different parties making the investment and profiting from it, needs to be addressed.

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NEW URBAN DEVELOPMENT AND LIVING CONDITIONS PROBLEMS OF BALANCED DEVELOPMENT IN TOWN PLANNING

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Warsaw, Poland

1. Environmental protection and new investment

There are two clearly seen extreme tendencies in the discourse on new town developments in Poland:

The tendency of protection – understood as unconditional nature conservation in spite of the logic of land development

The tendency of investing – subordinated fully to economy understood narrowly and primitively, aimed against the existing local natural values and often dangerous for the landscape and environment in general

The effect of these two tendencies is constant struggle of the „protectionists" and „investors", so characteristic for the planning practice in Poland. The groups fight each other without much compromise. The victory of one of adversaries in this struggle can only be a hundred percent! It seems, that such a way of solving conflicts may lead us all and in every situation to defeat.

The „way" presented above, characteristic for newly developed urban areas is a contradiction of urban design (understood as form of discussion and social agreement).

2. Compromise as a method to solve the conflicts

Urban development is driven by mighty forces with huge financial background and is one of key elements of the country's economy.

The indispensable protection of natural landscape, as well as cultural heritage are perceived by most investors as a hindrance, an obstacle for urban growth and so stopping the economic growth, new jobs creation, etc.

The areas of potential urbanization are treated either as battle fields or in best cases - fields for the game, where one side has to loose. The looser is mostly the side fighting to protect the values of the environment.

It seems, that the best solution for urban development would be to work out the techniques leading to something that one would call reasonable compromise – finding the ways to solutions accepted by both sides of the conflict.

The main interest of the sides should be to solve the conflicts in urban planning through the rule of compromise. This compromise should not leave any losers. To work out the methods of compromise solutions the rule of compensation should prevail. It should promote to introduce certain qualities to natural and built environments which would strengthen, supplement and sometimes replace the existing values, which are touched by processes of urbanization.

The presented urban projects are examples of "compromise" solutions aimed at lessening the conflict between economy and cultural – natural values in urban processes.

The projects do not present any narrowly understood protection. Instead, the systems of natural and cultural landscape elements are proposed. They may be treated as added values or the enrichment of existing values.

3.1. New Belgrade – improving of the urban structure.

The first prize in the international competition of 1986 for the improvement of the New Belgrade urban structure (Krzysztof Domaradzki, Olgierd Dziekonski, Zbigniew Garbowski with the team).

The goal was to propose new guidelines for changes of the existing structure based on the Le Corbusier's town planning ideology. This ideology was foundation of the urban settlement New Belgrade, for approximately 200 thousand inhabitants. The urban development based on further increase of the number inhabitants had proved to be totally unsatisfactory in social and spatial terms. The first prize work proposed to "humanize" a large extent of urban tissue by lessening the domination of roads and by introducing natural elements - water and greenery into the cityscape. It was supported by the comeback to the traditional town elements. The idea was to free the new investment areas in such a way, that economy of space would become driving force for new urban development enriched both in nature and traditional concepts of urban composition.

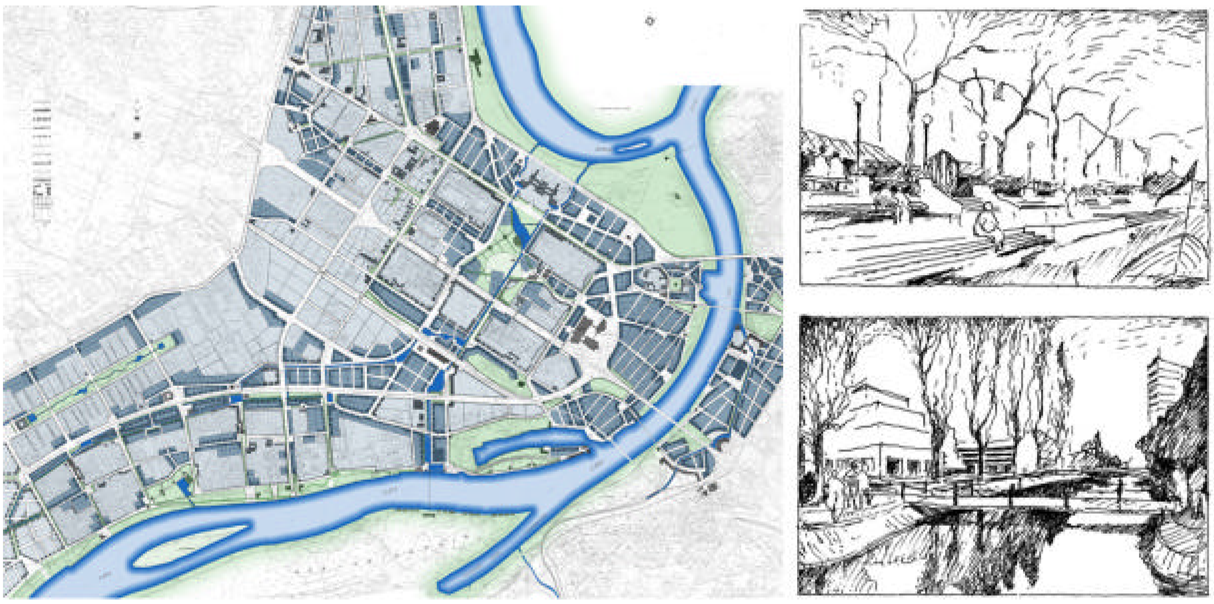

figure 1. New Belgrade – urban structure improvement.

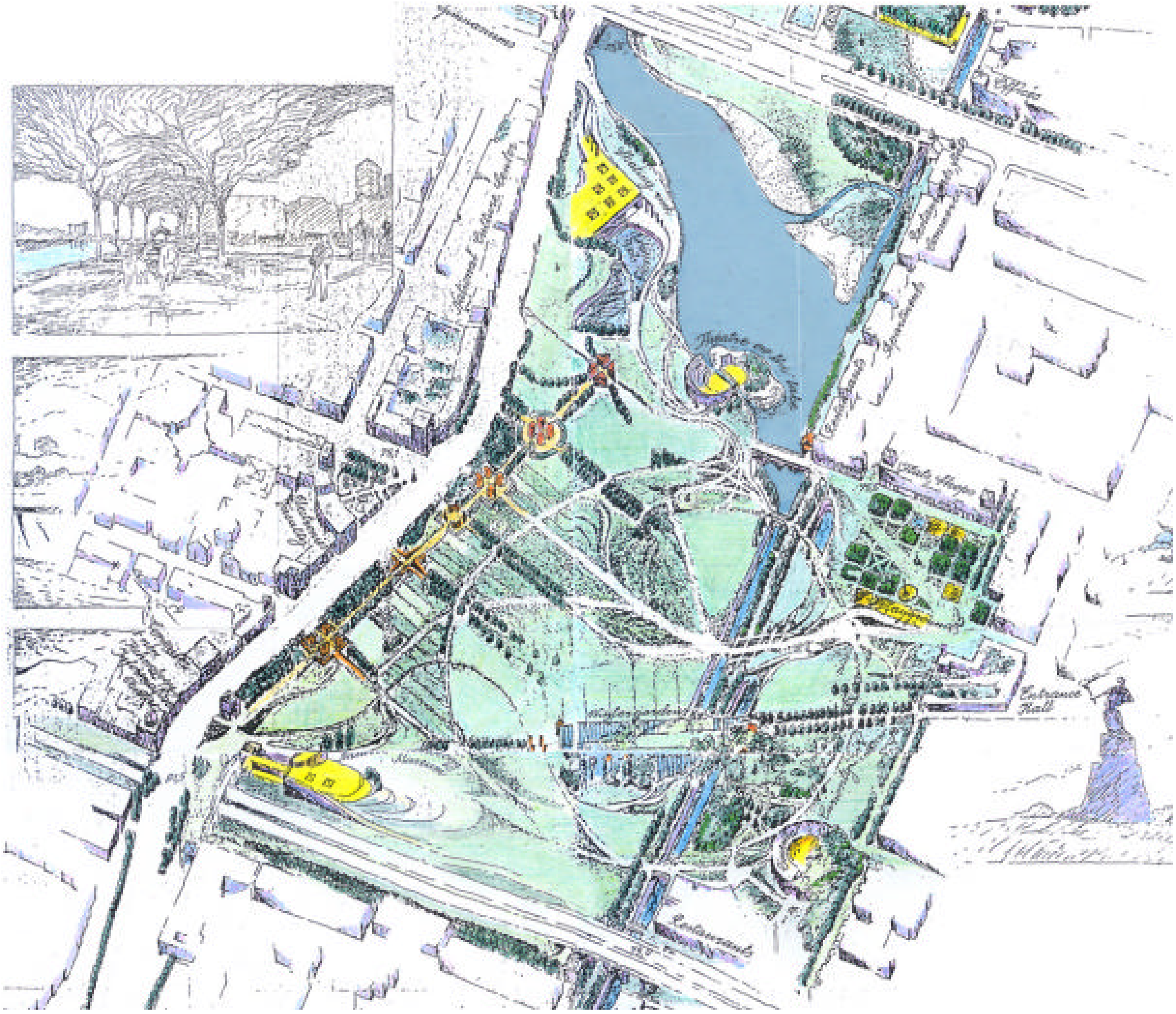

figure 2. New Belgrade – the park area layout.

3.2. The Garden – City Utrata and the settlement Nadarzyn Kolonia, years 1978 –1980.

Project proposals and realization work (authors: Krzysztof .Domaradzki, Olgierd Dziekonski with the team).

The authors tried to manage the urban sprawl processes in the western fringe of Warsaw suburban areas. The idea was to do it by realizing new chain of satellite towns, based on garden – cities' model and on new proposal for widening the network of the existing commuter train lines. This new group of settlements was called "Pruszków Stretch – bis" the project of the first one, the Garden – City Utrata was an interdisciplinary concept, containing the elements of the organization of urban development processes as well as introducing the elements of nature into design. It is important to notice, that this was done under the socialistic state conditions, which did not allow private sector (a form of a cooperative of institutions was proposed).

The urban solutions were to give a chance to create a living environment founded on the ideas of self-government (in the fields of investment organization and everyday life) and to build on the values of a garden – city (as the spatial organization was concerned).

The town was to be a contemporary interpretation of the garden – city ideal, made for the Polish conditions at that time. It was to give its inhabitants the possibility to be close to nature, allow for energy – conscious, infrastructure and social solutions as well as present the image of a cityscape bound with Polish tradition of town planning and architecture.

figure 3. Garden City Utrata – illustrative plan.

figure 4. Garden City Utrata – housing blocks detailed resolvements.

3.3. The Nadarzyn-Kolonia (Nadarzyn – Colony) settlement, 1984

The settlement Nadarzyn Kolonia is the only contemporary realized fragment of the garden – city idea in the suburban zone of Warsaw. The conflict that accompanied its realization was all about the need for more density (more flats and so – more multifamily houses) and at the same time, retaining the suburban settlement's character. The settlement's spatial organization was based on the rule of two - stage subdivisions (quarters and plots), with preserving of existing ditches and ponds as well as parts of greenery that were most valuable because of natural values and, at the same time, not fit to be built upon, because of high ground - water level. The settlement reached predestined density (115 persons per hectare), which allowed for getting bank - loans for the overall technical infractructure and helped to start building of the communal sewage treatment plant. As we said before, the condition was to introduce multi – family housing designed as rather small houses of six flats each (four of maisonettes with own entrances and direct access to own gardens and two apartments in the attic). Each of these buildings had its own plot in the whole structure and was similar to single - family homes in scale.

Unfortunatelly, the period of Polish transformation caused the slowdown of investment and only part of the designed green public spaces have been arranged according to the primary project. Looking at spatial solutions, the settlement relates to the period of Polish architecture and urban design from the time between the two world wars and has a rather urban, than rural character. It realizes the idea of looking for relations with natural landscape by opening vistas and by introducing public spaces in the form of parks and squares. One of the successes here is complete infrastructure realized together with the sewage treatment plant for the whole commune as well as local services. Unfortunately again, due to contemporary tendencies the entrance control has been introduced and so the settlement area is not open to public any more.

figure 5. Nadarzyn Kolonia settlement – illustrative plan.

figure 6. *Nadarzyn Kolonia settlement – implementation.*

3.4. A Garden – City in the suburban area – a new concept

The concept born in 2004 for the Poznan aglomeration (authors: Krzysztof Domaradzki,. Zbigniew Kaiser, Dorota Sawicka, Piotr Sawicki) is result of the up-till-now experiences coming from building in the suburbs.

This project goes quite far in the realization of an idea of introducing the elements of natural landscape into suburban settlements. The concept connects urban elements: main streets, boulevards, squares, plazas - forms of organized town structure with elements of „designed landscape", close to natural landscape, especially in areas where density is lowest. It includes rain water retention and reuse and local root-zone sewage treatment. In its spatial shape it is an attempt to connect urban and rural landscapes with open green areas surrounding the settlement. At the same time, the important element of the project is the market research, that would allow for commercialization of chosen solutions. The project is also directed to social programs included in urban structure as well as sports and recreation.

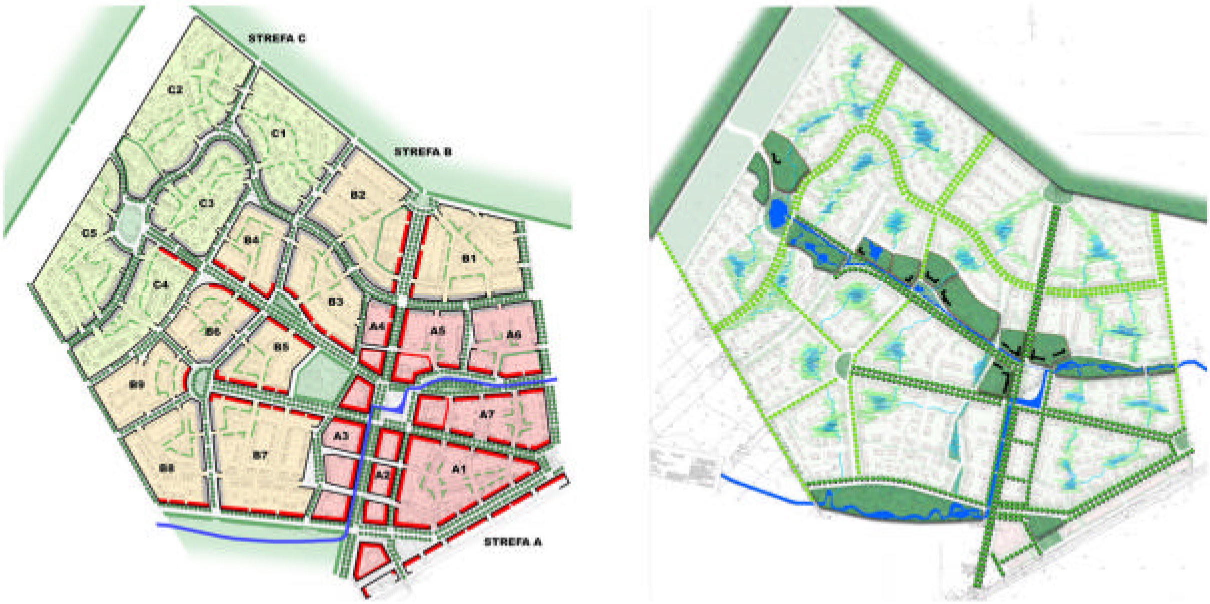

figure 7. *The new Garden City – development plan scheme and green areas structure.*

figure 8. The new Garden City – illustrative plan.

3.5. The project for the local plan for the Park pod Skocznia area

(Authors: Krzysztof .Domaradzki, Zbigniew Kaiser, Marek Sawicki)

The area is situated in Warsaw on the lower terrace of the Vistula river velley. In the former general plans of Warsaw (from 1982, 1992) this area was planned as a city park (some time ago, a new park of Polish – Soviet friendship was planned here), laid on the communalized grounds.

After 1990, courts began to give decisions of returning property to former owners. These were mostly single plots, elements of former rural land divisions. Up to now about 85 percent of land, which means the market value (if it was to be bought back) is about 85 million euros. The main problem for the area is how to retain its green character, with the cliff well seen and at the same time satisfy the owners of the plots, who want to build densely.

In the framework of this job some more extensive studies of natural conditions of the area were made. This resulted in three variants – scenarios of development of the area – from the park version, forcing the municipal authorities to buy all the land, to the variant allowing for low density housing with a balanced overall ratio of greenery.

In discussions with the authorities a fourth variant was developed. It was to „freeze” the northern part of the area as green space (now the allotment gardens are situated here) and allow for low density single – family detached houses on larger plots in the southern side. Part of the area in this sector would remain as a common green space, connected with the Sluzewiec stream valley and the designed water projects would receive excess rain water.

The project triggered discussions and became object to attacks both from conservationists and potential investors, who’s interest is only to gain the most of square meters of potential buildings.

It seems, that the weakest side is the „conservationists’” one, whose opinions are blocking the plan and paradoxically work for the good of the investors’ lobby.

figure 9. Park pod Skocznia area local development plan and its previous versions.

3.6. The proposal for the green areas system in the structure of public spaces of Warsaw.

(The Study ordered by the Chief Architect of Warsaw from the team of: Krzysztof Domaradzki, Dorota Sawicka, Marek Sawicki, Piotr Sawicki)

This is an attempt to find a model solution for the system of green spaces for the city of Warsaw. This system would comply with the network of main public spaces. Much attention has been put to research the existing state of Warsaw green spaces.

The special role is given to the Vistula river valley and the cliff.

It is worth to notice, that a part of green network, which is difficult to realize within the existing urban tissue (as causing conflicts) was proposed as the ones accompanying transportation routes. They have the potential of crystallizing the urban structure and help to make the city as one ecosystem.

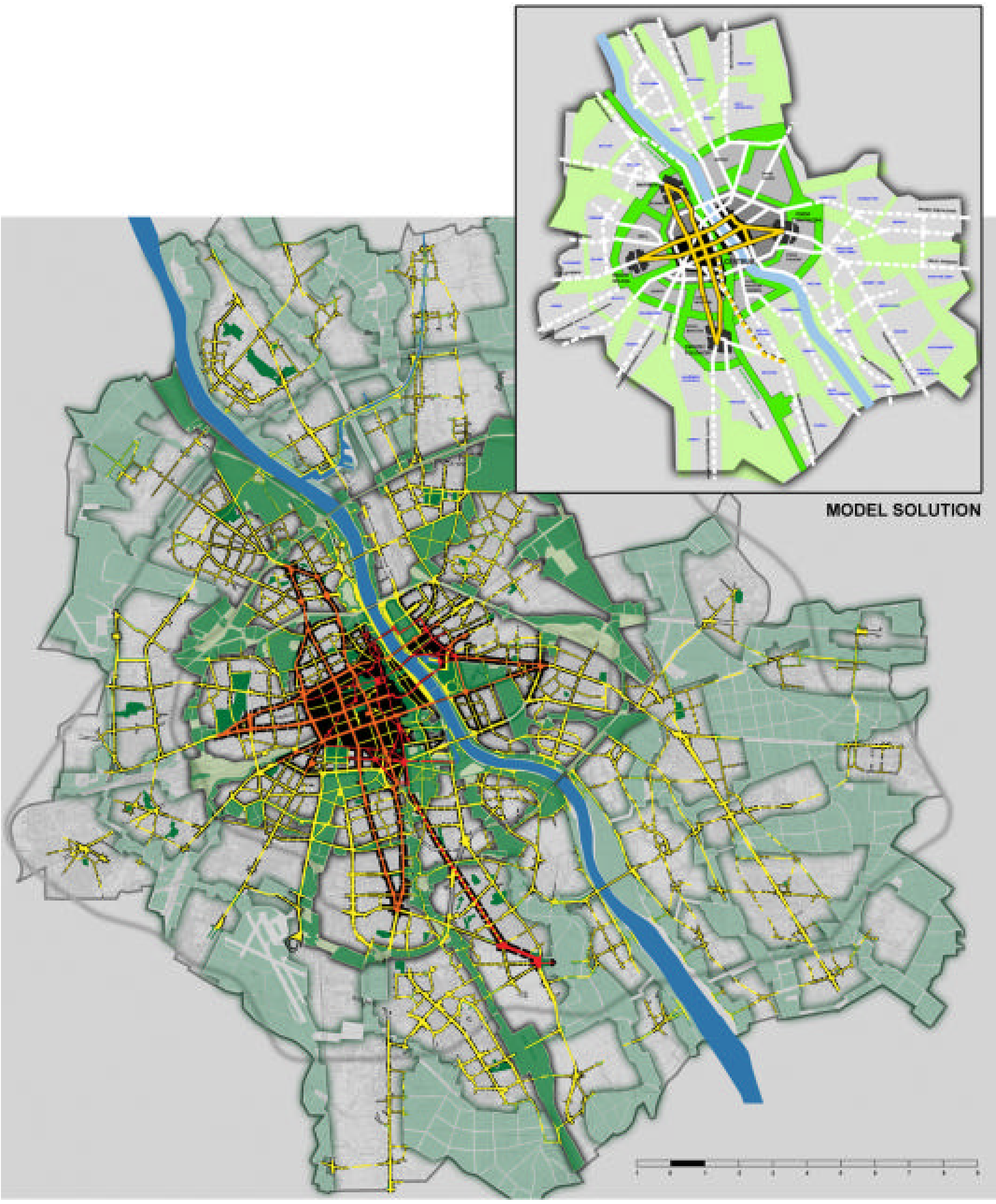

figure 10. Proposal for the green areas system within the public spaces structure in Warsaw.

4. Conclusions

It seems, that in urban planning, the slogans concerned with sustainable development should first of all lead to reaching the reasonable compromise between all kinds of lobby groups. This compromise should include the rule of compensation – reaching the certain standard to fulfill the needs of nature, the culture, landscape as well as functional and social needs.

Nature protection treated too dogmatically and stiffly makes the dialog with investors' lobbies impossible. At the end of the day, each new development brings the failure of the values, that would otherwise be achieved – if negotiated and based on compromise solutions.

Maria Stawicka-Walkowska *)
Bartosz Felski **)
Marek Ptaszynski ***)

ASPECTS OF SUSTAINABLE DEVELOPMENT IN SHAPING THE INFRASTRUCTURE OF INLAND WATERWAY TRANSPORTATION: THE CASE OF TORUN

1. Introduction

The increasing intensity of inland transportation, and in particular road transport, has led not only to surging environment pollution, but also to a significant decrease of Europe's motorway capacity. This has forced us to seek alternative solutions for transport and communication in Europe.

One of the possible solutions to this problem that is the idea currently being investigated by EU organizations of extending the existing inland waterways eastward. This aims at creating a system of inland waterways (see exhibit 1[1]) that would link the following destination points:

- the Baltic and Northern Sea harbors in the north with the Mediterranean and Black Sea harbors in the South,
- the Gdansk Bay Area with the system of European inland harbors,
- the System of European inland harbors with the existing waterway systems of Belarus, Ukraine, and Russia.

As far as Poland and its place in the general system of inland waterways is concerned, the Vistula river and its basin – despite its currently low transport capacity and need for technical modernization – plays an important role in this system.

The introduction of the Vistula into the system offers two important possibilities:

- a north to south connection of the Vistula waterway with the Danube (and in consequence, establishing an inland connection between the Baltic and the Black Sea)
- a west to east connection using the existing Warta channels, the Vistula, and the Bug river to establish a connection between existing western waterway systems and the eastern systems of the Dnieper and Prypec rivers.

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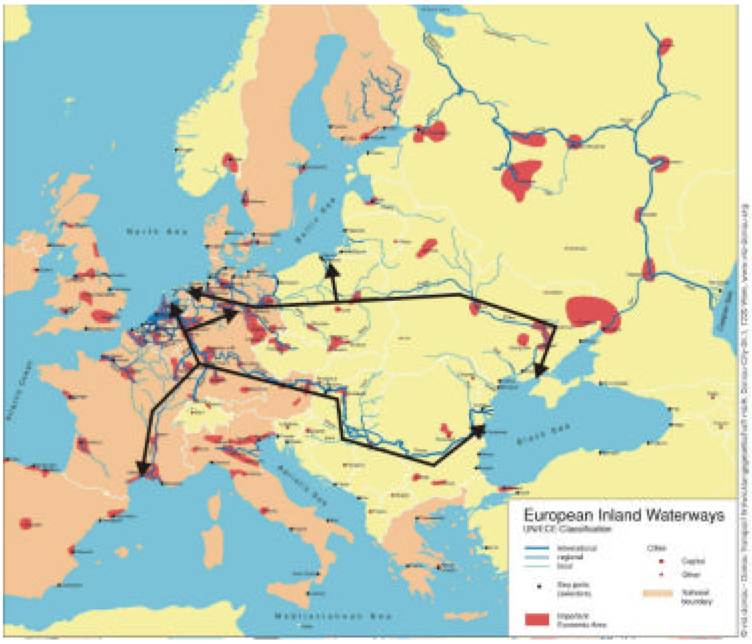

Fig. 1 European Inland Waterways (www.wia-donau.org)

The development of inland waterways is appealing because of its pro-ecological character, which entails its minimal degree of harm to the natural environment, and the low direct-costs of transport.

The fundamental limitation of said development of Poland's inland waters is that of the lack of appropriate transport means (ones conducive to managing a given route with regard to technical difficulties) and the unsatisfactory state of the infrastructure. For such infrastructure has to provide complete technical services, as well as the social and administrative requirements for vessels – all in accord with upholding the priority of ecological imperatives.

The complex proposals of the group of projects covering the selected problems related to this topic was undertaken by the Faculty of Ocean Engineering and Ship Technology of the Gdansk University of Technology [1].

One of the complex research proposals for the Baltic Sea transportation system, one that was elaborated and launched for research projects under the aegis of the EU's Eureka program, is: INCOWATRANS – A New Generation of Environment Friendly Inland and Coastal Ships for Polish East–West Waterways. Project Eureka E! 3065.

The main task of this project is to create technically advanced, environmentally friendly and cost-efficient ships, ones boasting low emissions and amounts of waste, that could be used not only for the transport of goods and products, but also for tourist purposes.

The cruising routes of passenger ships would include certain stages with stops at chosen destination points offering the necessary infrastructure for harboring (including facilities for the safe and environmentally friendly disposal of the ships' waste for further treatment outside the base), hotel accommodation, sport and recreation facilities for tourism, as well as the necessary infrastructure allowing the service and small repairs of the vessels[2]. The

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[1] Internal research projects and grants funded by KBN, as well as within the European Union's V-th Framework Programme.

[2] Project Eureka INCOWATRANS E! 3065, "A new … Waterways". Main premises for the modular inland tourist ship", elaborated by Prof. Krzysztof Rosochowicz, General Coordinator of the project.

proposal of the necessary measures to provide this will be covered in detail in a separate expert work that will be submitted by subcontracting teams of the Eureka project).

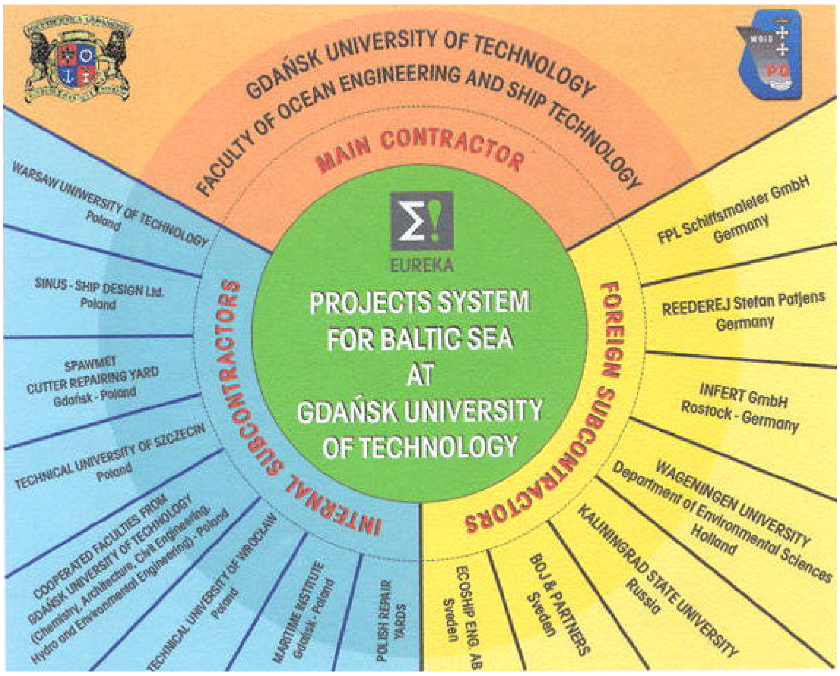


Fig. 2. [3] *The index of the Participants of the Projects System for the Baltic Sea under the aegis of the EU's Eureka program.*

This project is in an initial stage of elaboration. Thus, as yet we cannot present the concrete effects of its development. However, the objective of this brief paper is to but to call attention to the need of a thorough-going approach to the possibilities of taking-over roadway goods and passenger transport by inland waterways, in heed of the pro-ecological and economic aspects of this solution.

2. General premises pertaining to the lay of routes and the choice of stoppage places

The network of waterways as foreseen by the ICOWATRANS project runs through the riverside areas of the Warta, Notec, Vistula, and Bug rivers. The appropriate development of connections between the areas highly appraised for their cultural merits (the cities of Bygdoszcz, Torun, Wloclawek, Warsaw) and those of great value for their natural qualities (the National Park at the Warta's outlet, the Notec Forest, the Bydgoszcz Forest, the Kampinos National Park, the Bug River Scenic Park, the Biala Forest – areas which are rich bio-regions) is a matter which requires the utmost of far-sighted stewardship.

The introduction into these areas of new types of environmentally friendly river-going vessels will not disturb the present ecological conditions.

However, the danger of this type of threat does exist in regard to the stage stoppage bases for the communication centers as planned. For this requires the construction of riverside facilities, proper port infrastructure, and logistical needs.

[3] Eureka Projects Group. Baltic Sea Transportation System (BSTS); General coordinator: Prof. Krzysztof Rosochowicz.

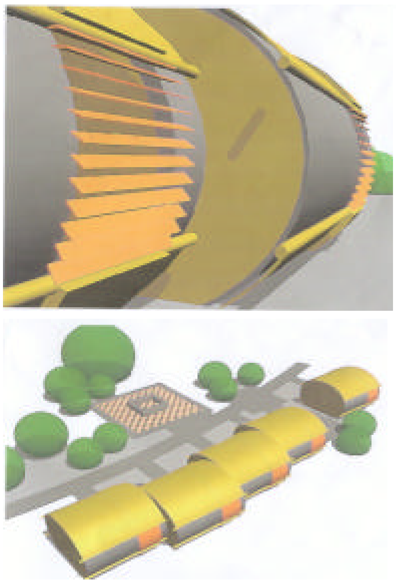
Riverfronts in urbanized areas generally developed in step with the expansion of ports or stoppages and entailed factors contributing to a city's growth and to that of local industry in the vicinity of rivers, being as they were until the Industrial Revolution, a driving force of development.

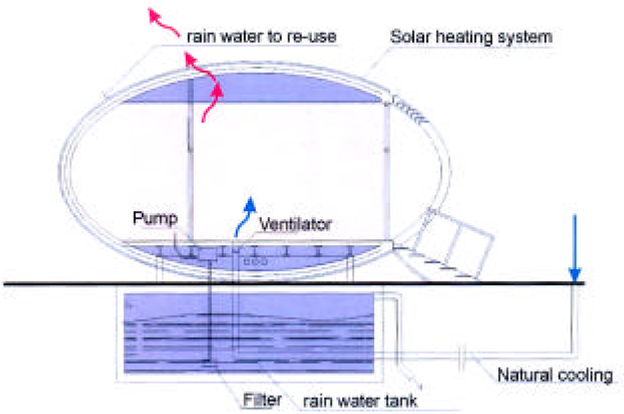
The ecological and economic aspects of waterway transport creates the need of formulating rules for the architecture of inland waterway fronts in close regard to the character of the place of investment (i.e, the zoning context, the social context, the economic context). This also involves the need to identify both the threats and the opportunities that arise from a new approach to shaping waterfronts and creating a veritable model network of places for tourist services on inland water routes. Much here can be drawn from analogous experience on roadways.

The emergence of such waterway facilities would ensure the creation of social, administrative, and service facilities that would bring about the development of a nexus between rivers and the land, between nature and people – and it would allow (in chosen stoppage points) an encounter not only with the wealth of Poland's scenic landscape, but also with the cultural and architectural riches of our country.

The tasks laid out by the INCOWARTRANS project for the creation of a modular solution of hotel-recreation complexes that could pose the relevant infrastructure for river-tourism stoppage bases wherever that might be – whether in urban and wild areas – requires appropriate technical solutions, ones that heed universal architectural standards, and construction material solutions that permit the desirable configuration of individual elements and utilize modern technologies that promote protection of the natural environment (i.e., solar power to aid in conventional heating). The initial concepts for this type of solutions are presented in Figure 3.

The initial requirement for the INCOWATRANS project is that of creating a universal coastal and inland vessel that in its tourist version would provide basic hotel accommodation for its passengers. Any longer periods of harboring for technical reasons (fueling, loading food stuffs, unloading waste and sewage for further neutralization and treatment) should be undertaken at a place attractive for tourists, and where disembarkation for land sightseeing routes and on-land hotel accommodation is provided.





Cross section – technical solutions of residental segments

Fig. 3. The concept of solutions for modular hotel facilities for stoppage points in waterway tourism.

Thus, this Project includes the investigation of the range of possible solutions for the:

- technical solutions allowing harboring (mooring) and the provision of supplies to the vessel, including the possibility of delivering the necessary products and technical materials via smaller delivery boats (water trams, etc.),
- hotel infrastructure of the vessel allowing for bed and breakfast accommodation, facilities offering a full range of amenities for tourists and the organization of entertainment, conferences, and meetings,
- sport and recreation infrastructure in the harboring base – including swimming pools,
- organization of cultural attractions and sightseeing routes within the range of a one-hour bus ride or water tram route (maximum 10-hour total routes for places available by water transport from the harboring base).

During the stay at the harboring base the tourists should have the possibility to organize private sightseeing routes by foot or using local transport, electric or traditional car rentals.

As the basic requirement of the program is to use the harboring base and its neighboring areas as natural parks for the recreation of the citizens of the city, its architectural conception should foresee the possibility of further gradual and modular development of the zone and its functions [2].

Generally, the localization of waterway tourist stoppage bases (and their categories) is dependent on the following conditions:

- technical and exploitational (with the periodic choice of vessels), the offloading of wastes for treatment, taking on food stuffs, technical examination of vessels;
- environmental (the possibility of using existing or creating new port infrastructure);
- cultural, landscape (in special regard to the merits of each given region);
- social and economic (i.e., the interests of local authorities, the organization of infrastructure that serves and stimulates the flow of material and non-material goods as an essential source of regional development.

An example of such a place that fulfills all the above localization conditions is the City of Torun.

For these reasons Torun is foreseen as the site of the modular base for the purpose of waterway tourism.

3. The City of Torun – characteristics of the location point for the first modular base

The city of Torun is located at the northern route of Poland's inland waterways. The route starting from Berlin goes first in the direction of the Odra river, and then further through the Warta and Notec rivers eastward, thereafter turning north through the Vistula to enter the Gdansk Bay Area with Elblag and Konigsberg right beyond it. The route then proceeds back west via Baltic Sea to Berlin.

Torun, a centuries-old city on the banks of the Vistula, is located at the crossing of the main communication routes from the Baltic Sea to the center and south of Poland, and from the western to the eastern regions of Poland.

Because of these attributes and the central location of Torun, this city has been chosen as the localization point of the modular harbor base. It is also a point at which part of the goods vessels could be disembarked to multimodal ships with destination points in Ukraine and Belarus.

As far as the tourist merits of the city are concerned, Torun is one of the most well-known cities in Poland. That is thanks to its rich history, its tradition connected to Mikolaj Kopernik (Nicolaus Copernicus, who was born in Torun) and the Old Town, which is one of the most beautiful in Europe and which, because of its preservation, is on the list of the World's Cultural and Natural Heritage of UNESCO.

The conscientiousness preservation of the natural and cultural values of the city, which includes around 340 items currently registered as artistic monuments[9)], makes this city an especially attractive point for tourism purposes.

The choice of Torun as a location point for a modular harbor base for the purpose of inland transport, as well as the development of both domestic and foreign river tourism, enjoys the full support of local authorities.

According to the description of the existing investment plans for the Vistula river[5)], the possibility for further development of harbor infrastructure on the Vistula River and the plans for the construction of new tourism and recreation centers near the river are all aimed at increasing the existing tourism merits of the city and its adjacent areas lying on the banks of the river. This development will allow the creation of a "green center" for the city whose "*value will systematically increase by locating within it the functions resulting from the constant monitoring of the citizens' needs… i.e., realizing the idea of creating an open recreation center, including bicycle paths, sight-seeing trails, recreation places for disabled people, inland harbor for water sport and tourism…*"[6)].

Given the fact that the rules for investment in water zones are practically non-existent (apart from the rules deriving from the "general aquatic law"), and given the fact that the development and preservation of river zones is generally not a primary concern in Poland, the initiative of the authorities of the City of Torun is an example of an enlightened understanding of inland waterways and their importance in balancing increasing social and civilization needs with the preservation of the natural environment.

Based on the local investment plan for the development of the City of Torun and its pro-ecological communication systems, the city's Winter Port neighboring zone was selected as the best location point for the modular base. (see illustration no. 4 – point 1).

This zone has very good communication routes along with major car routes and is located closely to the foremost tourist attraction of the city – Torun's Old Town. It also directly neighbors the harboring station, which is currently being used during winter season for harboring river barges, and could possibly be used as a harboring point for the newly designed hotel-vessels, i.e., for disembarkation and offloading sewage for further neutralization on land, as well as for undertaking all necessary maintenance repairs of vessels.

From the logistical point of view the selection of this base would simultaneously allow:

- mooring at the Vistula's existing embankment (Fig. 4 and 5 - see point no. 2) and disembarkation of passengers to the newly designed modular base,

Fig. 4. Functional diagram of the main architectural premises of the module stage base (connections with the neighborhood).

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5) The City Hall of Torun – materials regarding investment in the area of the Vistula and revitalization of the Old Town zone – response to INCOWATRANS Project (25.09.2003).

6) As above.

- entrance by the passengers wishing to use their cabins during their stay at the city to the Winter Port (see point no. 1), which neighbors the planned recreation base (see point no. 3)

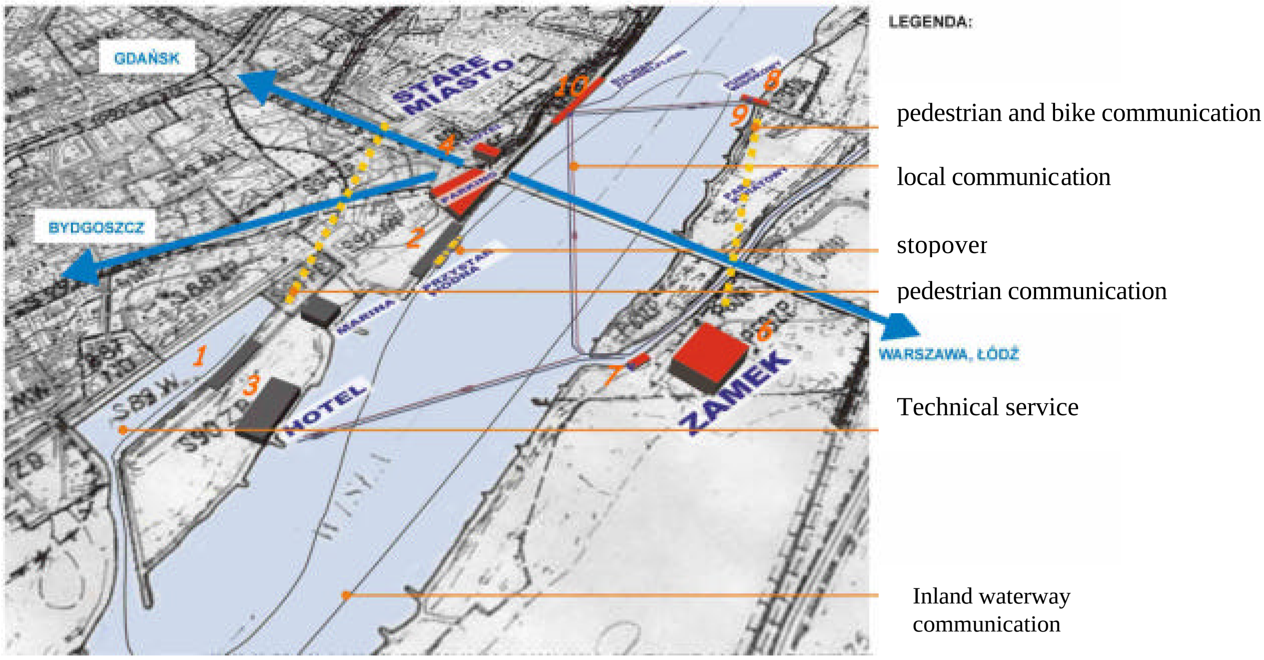

Fig. 3 Functional diagram of main architectural assumptions of module stage base(connections with the neighbourhood).

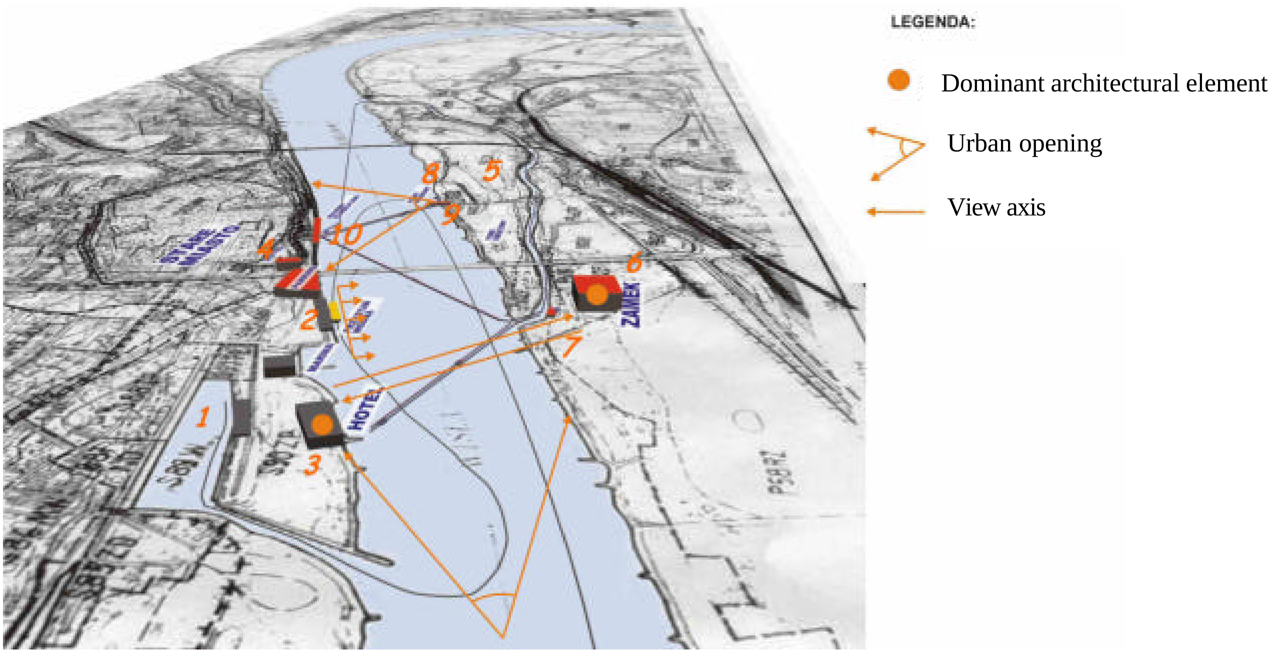

Fig. 4 Functional diagram of main architectural and urbanistic elements(localisation of module stage base and its viewpoints)

With this localization both groups of passengers would have the possibility to use hotel infrastructure and would be only a few minutes away by foot from the City's Old Town and the Higher Sea School hotel (see point no. 4), which is currently being modernized and could be used in the future as an alternative accommodation point for passengers. Further advantages of this localization include its wonderful view of the Natural History Park of Kepa Bazarowa (see point no. 5), of the XV century Royal Castle (also known as the Dybowski Castle – see point no. 6), and the nearby localization of the planned small sailing and small boat harbor at the mouth of Small Vistula river (see point no. 7).

This is harmonized with the Project for the revitalization of the Castle's ruins (approved by the City's Monuments Office), with a planned function not only as a museum, but also as a site for exclusive hotel rooms, restaurants, and panorama on the Old Town. Right next to it is a residential quarter boasting interesting examples of pre-WWII architecture and the remains of fisherman housing.

Looking further ahead, there is a planned construction of sight-seeing trails that would lead from the Dybowski Castle and leave the landscape of the Kepa Bazarowa untouched. The modernization of the Natural History Park and the trail over the Small's Vistula's foot-bridge to the existing viewpoint (see point no. 8) will allow a panoramic view of the City's Old Town.

The planned sailing, small boat and ferry harbor nearby (see point no. 9) will allow the joining of the left bank of the City with Philadelphia Boulevard (see point no. 10). This will provide an alternative for the city's road bridges and will bring closer the Podgórze city zone to the center of the city.

Based on the INCOWATRANS program and Torun's Town Hall investment plan for the city's Vistula River zone, the major goal of the project is to create a complex vision of water communication between the city's most alluring features, ones that join the past with the future, and to revitalize the precious recreation areas on the left bank of the river by introducing them as part of Torun's tourist attractions.

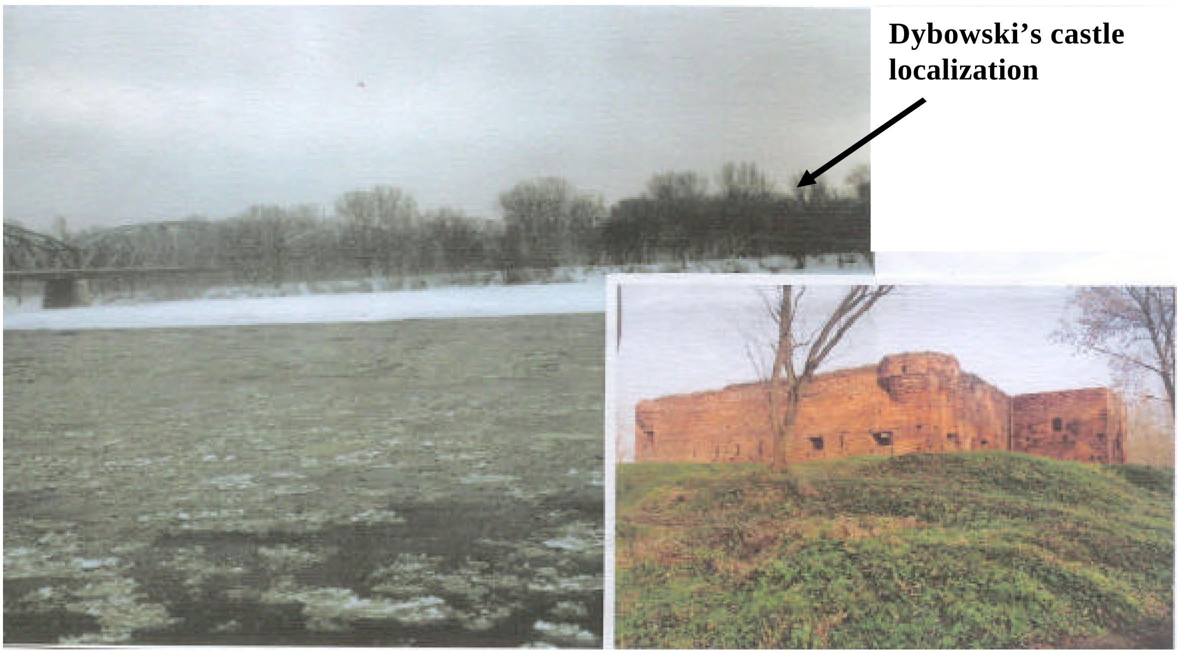

Fig. 6. View to the Natural History Park of Kepa Brzozowska and the localization of the Dybowski Castle (special thanks to M.Sc Archeology Ms Lidia Grzeszkiewicz-Kotlewska)

The creation of an alternative form of lodging – on land, in a complex of modular houses (fig. 7) that can be placed as desirable, is foreseen on the areas designated for the construction of the stage stoppage bases.

Fig. 7. Sample application of module solutions at the Water Tourism Stage Base in Torun – by the Winter Harbor

5. Summary

The development of transport systems using the connections between inland waterways is an alternative to roadways.

Introducing new types of inland and coastal ships that are technically advanced and environmentally friendly – including modern technical solutions having pro-ecological components and systems – to decrease the level of harmful emissions and the amount of waste further increases attractiveness of this type of communication, which (apart from its economy advantages) also has significant ecological merits.

Moreover, shifting car transport onto waterway routes shall relieve the burden on land roads on an international scale, increasing their flow capacity and safety and decreasing the level of atmospheric contamination and noise pollution in areas directly adjacent to them.

The development of water transport, both in goods and tourists, requires the creation of stage stoppage bases and river embankments. These bases are necessary for the reason of ship media intake, handing over waste and other materials for disposal, making small repairs, and acquiring food provisions.

The location of these bases, conditioned by 1) the maximum distance that a ship can make without technical stoppage, 2) the location of existing port infrastructure, and by 3) optimal construction conditions, is dependent upon cultural and landscape considerations, ones entirely essential from the point of view of tourism.

An important social aspect of constructing this type of base, especially one that expects to accommodate tourists and to organize an attractive stay for them, is the creation of additional jobs for local people in the organization and servicing of the necessary hotel and recreation infrastructure – something that can be used both during and after the tourist season.

Providing access to local tourism and sightseeing attractions, directing attention in particular to natural monuments, scenic parks, objects of material culture together with their history – this is a presentation of the cultural heritage of a given region. The care for its preservation is one of the elements of sustainable development – such as taking into account the environmental costs of the construction and exploitation of a stage base.

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DESIGNING THE "IMPROVED ARCHITECT"

Discussion paper on education by

Ronald Rovers (Wageningen University) and Jerzy A. Pogorzelski (BRI Warsaw)

1. Introduction

Experience in Poland and the Netherlands, and in many other countries as well, with education for architects regarding physical and environmental skills, is far from satisfactory, and the results are not sufficient for their professional life. This is also illustrated by international experience in the quest for design tools, that support the architect with decisions in physics and environmental questions, which in most cases fail to do so, or are neglected by architects.

The question is, how to bridge the gap between physics and environmental knowledge on the one side, and implementation in architectures practice on the other, and what can education contribute to this? This paper describes experiences and practice in Poland and Netherlands, and opens the discussion for further development and improvement of educating architects.

2. Problem statement

Traditionally departments and faculties for buildings physics have taken the role of providing Environmental input into the engineers and architects education. They had the possibilities to calculate heat loads, day-lighting and sound insulation, and from there developed tools for energy demand calculations, solar gains etc. Building physics this way had a scientific oriented approach: it was not setting conditions but providing information about any situation (construction) . This has been copied in the environmental approach as well: It was developed from a physical point of view: there were merely calculations provided from a physical point of view: You show us the design and we will tell you what it consumes (in energy for instance). Only later, when politics got interested in regulation, the development of setting targets and limits to energy performance of constructions started. But by then the daily practice was already established, of making a design first and then try to meet the standards.

Now the tasks for architects and engineers grow (for instance with implementation of Energy Performance Directive) and grows the level of difficulties with designing the buildings. We try to overcome the difficulties by feeding the architects and engineers with standards, formulae and PC programs. New European Standards (under preparation) for calculation of energy performance require good specialization in Thermal Physics.

The question arises: will good specialist in Building Physics be also a good architect?

3. Observations from The Netherlands

The Technical University in Eindhoven, Netherlands, has a major and internationally known department on Building Physics. It was established 30 years ago to educate architects from the parallel faculties with physical knowledge of building constructions. Now we can conclude that the cross fertilization has not taken place, architects are hardly interested in Building Physics. However, many building physics engineers have been educated, and have been accepted by the architects as advisors and consultants to architects: Architects hire the knowledge, in stead of integrating it. This can be called a success in so far that there has been established a more or less constant attention for building physics. Only: since it is hired, its seldom part of the initial design. And we all know the graphs showing the relation between decisions and project phase, in cost and effect.

Another aspect is that both architects and engineers in all disciplines always start the process from the product side view: There is a product and how to improve it, maybe make it a little bit more energy efficient, comfortable, spacey, cost efficient, etc. Same for cars, coffee machines and buildings: First there is the idea, the design, and then the question how can we improve a little bit in energy efficiency. But the clue is that the basic question should be: how can we provide interior space that meets human physical needs (and perhaps psychological needs) in an Environmental sound way. This way the design starts at its origins: providing shelter, and leveling climatic extremes.

In stead of: Physics follows form, it should be Form follows physics. And physics in a double meaning: physical well being, and with optimal use of physically limited available resources.

So far we always have tried to make the mathematical side of physics and environment understandable for architects. But we must conclude that architects hate calculations, that's why they started at the architecture department anyhow. And they regard themselves, the majority that is, as artists more then as masters of building and construction, as was in previous ages.

4. Observations from Poland

There is not any Technical University like Eindhoven with strong Department of Building Physics. Not on every faculty of Architecture or Construction, Building Physics is taught as an independent subject. When it is taught the scope of subject and dimension (number of hours) differ much, starting from 15 hrs of lectures (with no practical training) up to 30 hrs of lectures and 15 hrs of practical training in one semester.

It looks, that mostly the problems of Thermal Physics, Acoustics and Day Lighting are packed into the program, with e.g. 12, 12 and 6 hours respectively. Nobody mentions the problems of Fire Protection and Town Building Physics and environmental problems.

In common practice in Poland we meet following faults in design and construction of buildings:

- the application of too air-tight windows, with no notice paid to ensure the access of ventilating air to the rooms,
- wrong solutions of external envelope, causing thermal bridges,
- growth of moulds, as the result of two previous faults,
- too thin layers of thermal insulation, due to misunderstanding of economy,
- lack or misuse of vapor barriers and wind barriers in light weight walls and roofs.

On the photo below the first story of building is recessed, and upper stories are supported with naked concrete columns.

The result is growth of moulds on walls like in a flat above the columns (photo below).

Also in common practice in the architectural designs of buildings there is often lack of hygrothermal calculations, lack of identification of thermal insulation material, lack of specified thickness of thermal insulation.

With rising energy prices, when investors are interested in energy efficient buildings, we observe that architects are not prepared for design of buildings for predicted annual heat requirement.

Generally it is easier to find the design with right thickness of insulation, then with calculated heat transfer coefficient.

It also shows that knowledge transfer between countries of comparable climates can improve very much.

5. Discussion

It looks that nowadays architects are mainly visual oriented people, and that this could be the clue to raise their interest. This is supported by an experience from the end of the eighties in last century, when in the Netherlands a book was prepared with “Design guidelines” containing only Graphs: window surface versus inside daylight level, and such. This was very much used at that time among architects, and shows the force of visual information.

We could conclude that there is need for a different approach regarding architects, that concentrates around “viewing” . Starting the design process from a different point of view, and learn architects to look at their designs with different eyes: seeing the consequences of any drawing for energy consumption, solar contributions, materials use, maintenance etc. Not with calculations but imagining sun directions, rain pouring, amount of resources involved, possibilities for deconstruction and recycling of products, etc. This is matter of training in viewing, rather then scientifically calculating the effects.

We would discuss the possibility of developing an approach and/or a BSc/MSc looking at the building sector not from a building eye view (how can we improve the buildings environmental/sustainable performance) but from the question how can we translate a balanced resource management (and a sustainable human approach) into the building and architecture practice and education.

In a university setting this would mean that programmes, and trainings, should force students (and lecturers) to reflect on the origins of building, the reasons for construction as we did for ages. To discuss where we lost contact with materialisation from a natural, physical, sound and environmental approach , and from there show how to develop a new design, a new architectural/construction and develop a visual physical language from where the built environment can be (re-)constructed.

Physics should no longer be used to solve problems created by architectural freedom or developers profit hunt, but provide the basis for (guidelines for) design and development. Thus training and creating architects and MSc's that are fully equipped to lead the buildings sector next decades into a real shift and sustainable approach.

A practical training used in a Sustainable Building curriculum at Wageningen Universities MSc program recently is providing a photograph to all students at the end of the day, and discuss the building the day after: They have to analyze the building/construction/product from physical and Environmental point of view: and what can they conclude only by using their eyes: a simple example shows the illustration below.

A pedestrian walk and the connection to the road. A simple exercise in "viewing."

Maybe this is aesthetically a nice solution. But there is no need for calculations to see the consequences of this design in environmental load: tiles laid in concrete: It's a resource consuming design compared to loose laid tiles, and this way recycling, except as crushed waste, is hardly possible. You can see the problems when reparation occurs: Heavy drilling, many manhours and difficult repairs (are the same tiles and colors still available? And we see an endless gutter of iron: a gutter every twenty meters would have saved a lot of steel and provide the same function. The road could have been constructed from loose elements, to have more water stay in the neighborhood, to reduce decreasing the ground water level, and reduce sewer system size.

Of course building and construction is getting more and more complex, and its difficult to know all the facts about some material. But its conceptual rather then conditional: The decision about what kind of materials, and structural type, orientation, are more important then the actual materialization.

Architects still are at the basis of this and fulfill a crucial role in developing 'products' that meet modern needs from physical and environmental conditions: longevity, recyclability, energy efficiency, indoor quality. And there is urgent need to discuss how we can train and educate architects to address this role.

Perhaps the calculations and checking of meeting the requirements should be left for specialists: Building Physicicists like on the photo below

PROBLEMS OF SUSTAINABLE DEVELOPMENT IN BUILDING IN MINING AREAS

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1. Introduction

The building in mining areas encounters two following problems:

- constraints in land development,
- additional costs of protecting newly designed buildings and of removing damages in the existing ones.

The above problems pose a recurrent dilemma of overcoming the contradiction between unimpeded construction of building structures in view of their safety and the extraction of available mineral deposits. Adequate technical solutions must be adopted to secure that basic needs of the inhabitants of buildings located in mining areas are fulfilled. Such task involves the issues of sustainable development [1], [2], [3].

In Poland building in mining areas has a big economic and social importance. In 2003 underground coal extraction reached 100.5 millions tons, which was more than the total extraction figure in all other European countries. It approaches still over 30 millions tons of copper ores that are excavated yearly too. Building activity comprises about 2000 km^2 of mining and post-mining areas and applies to rational construction of all new structures there and the necessity of removing the damages that occur in about 10000 structures annually. These figures, if compared to any other European country, indicate an unprecedented scale of the occurrence of the problem.

2. The development of land subjected to mining influence

2.1 Mining areas

The impacts of underground mining on the land surface are characterized by the occurrence of the threats evoked by (Fig.1):

- continuous deformations of the land surface in the form of a subsidence trough,
- subsoil tremors caused by mining works,
- discontinuous land surface deformations,
- change in the water conditions in the subsoil, leading to foundations damping or local flood lands.

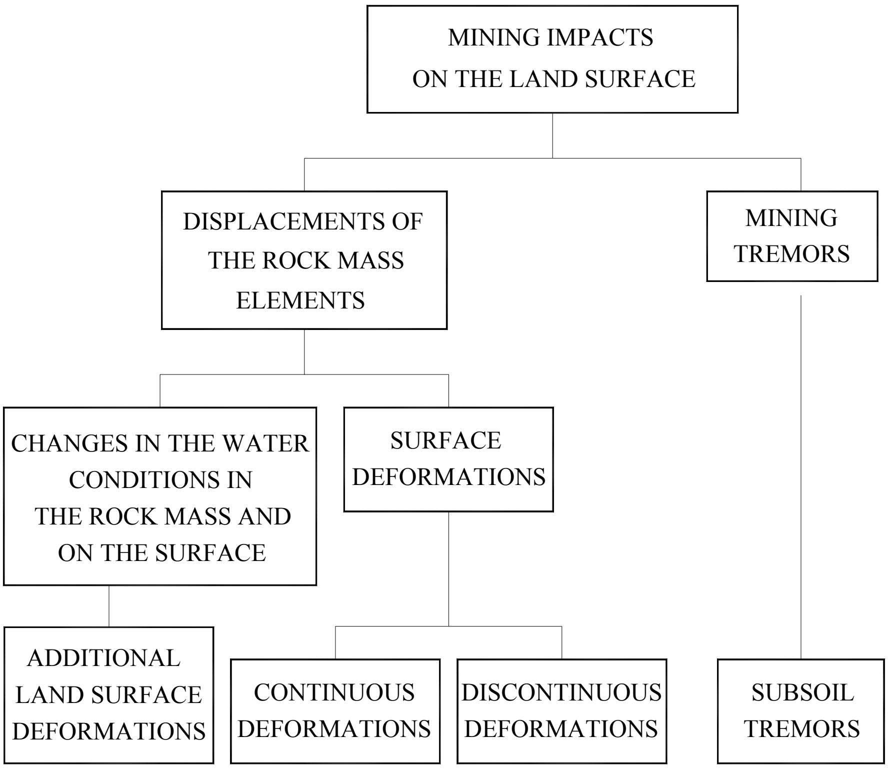


Fig. 1. Types of the impacts of mining exerted on the land surface

The most common symptoms of the mining impact are continuous deformations, occurring in the form of land subsidence, also referred to as subsidence troughs. Every point of a subsidence trough is subjected to vertical w (subsidence) and horizontal u displacements, which finally the deformations of the land surface evoke. The deformations are described by means of the following ratios:

- slope T,
- curvature K (or curvature radius $R= 1/K$),
- horizontal strains ε.

Depending on the intensity of deformation ratios: ε, $R=1/K$ and T, the lands exposed to the impact of regular subsidence troughs have been divided into six categories [4], in accordance with Table 1.

Table 1. Categories of mining area deformations

Category	Limit values of land deformation ratios		
	Slope T [‰]	Curvature radius R [km]	Horizontal strain ε [‰]
0	$T \le 0,5$	$\|R\| \ge 40$	$\|\varepsilon\| \le 0,3$
I	$0,5 < T \le 2,5$	$40 > \|R\| \ge 20$	$0,3 < \|\varepsilon\| \le 1,5$
II	$2,5 < T \le 5$	$20 > \|R\| \ge 12$	$1,5 < \|\varepsilon\| \le 3$
III	$5 < T \le 10$	$12 > \|R\| \ge 6$	$3 < \|\varepsilon\| \le 6$
IV	$10 < T \le 15$	$6 > \|R\| \ge 4$	$6 < \|\varepsilon\| \le 9$
V	$T > 15$	$\|R\| < 4$	$\|\varepsilon\| > 9$

The behavior of a building in any position on the subsidence trough is illustrated in Fig.2. Due to ground deformations, from its initial position of 1-2-3-4 the building is displaced to 1'2'3'4'. In the course of the process, assuming that the building is treated as a rigid solid body, its geometrical centre S undergoes vertical subsidence (w_b) and horizontal displacement (u_b) and the building itself a turn, determined by its tilt from position (T_b). There are two options in such position: convex (ε^+, R^+) or concave (ε^-, R^-) subsidence trough periphery.

As a result, internal forces evoked by horizontal strains (ε) and land curvature (up to curvature $K= 1/R$) are generated in the structure of the building [5].

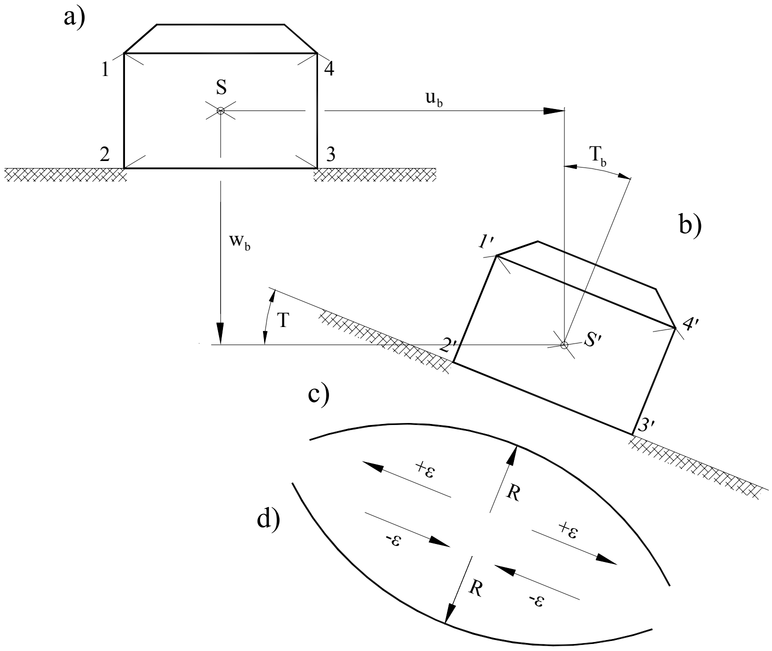
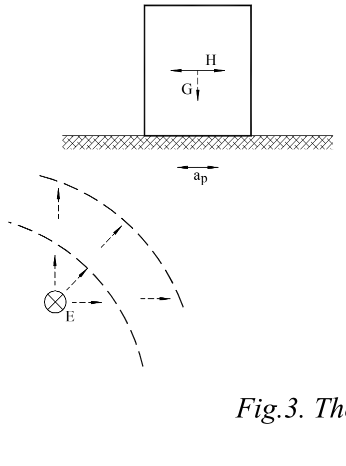


Fig.2. Building in any position on the subsidence trough
a) initial position b) position after the displacement c)convex subsidence trough periphery
d) concave subsidence trough periphery

Mining tremors are a dynamical phenomena resulting from rapid displacements, bursts or collapse of the rock mass layers and the generation of energy *E*.

The hazard to which a building is exposed may be designated from horizontal force *H* (Fig.3), which can be calculated if the weight of structure G and its geometrical features η are given, together with subsoil tremors maximal acceleration $a_{p, max}$ [5].



$$H = f(G, a_p, \eta)$$

Fig.3. The impacts from mining tremors

It is usually accepted that the lands exposed to the impacts of continuous deformations falling into categories 0-IV and to the impact of mining tremors with the acceleration up to 1000 m/s^2 are suitable for building developments, in accordance with general principles discussed in [6] and expanded in the form of design guidelines in [4].

The problem of selecting the right location for a building or making a rational choice as to the methods of adjustment to withstand potential hazards is applicable to areas where discontinuous land surface deformations or changes in the water conditions in the subsoil are forecasted.

Most commonly, the causes of the occurrence of discontinuous deformations include:

- disturbances in the state of equilibrium of the rock mass in the close-to-surface zone of post-mining voids,
- impacts from mining works resulting in the values of deformation ratios falling into category V,
- mining of close-to-surface seams with roof caving,
- mining works conducted in the zone of faults,
- mechanical or chemical suffusion.

The lands exposed to the hazard of discontinuous deformations offer very unfavorable conditions for building development [7]. Examples of the impact of discontinuous deformations on a building are shown in Fig.4.

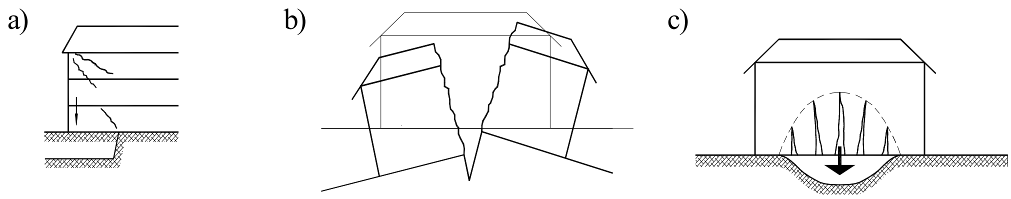


Fig.4. Exemplary damages of buildings caused by discontinuous deformations
a) cavity under the outside edge b) ground brace under the central part c) cavity under the central part.

The decision to locate a building in the area exposed to the hazard of discontinuous deformations calls for the preparation of specialist geological and mining expertise, often including the geophysical examination of the rock mass [5]. Likewise, a given strengthening method is also selected on the grounds of individually adopted solutions.

The most effective protection against discontinuous deformations is to remove the causes of their incidence. For example, in the case of shallow mine headings, the existing voids are rock-filled. However, such works are characterized by a different degree of complexity, and, sometimes, cannot be performed. The whole process of eliminating the causes of discontinuous deformations is a serious technical and financial venture.

If the decision on building development in the area exposed to the hazard of discontinuous deformations has been made on rational grounds, the financial calculation should prove that building adjustment method or the elimination of the deformation causes are cost-effective. Often the most rational solution involves the choice of locating a building elsewhere or building reclamation.

The impacts of land deformations on the water conditions can also be serious. For the building practice, the so called phenomenon of relative rise of the ground water level is of essential importance, because it may lead to the hazard of damping or flooding a given building, which occurs when $g<w+h$ (Fig.5). Any changes in the water conditions require an appropriate forecast.

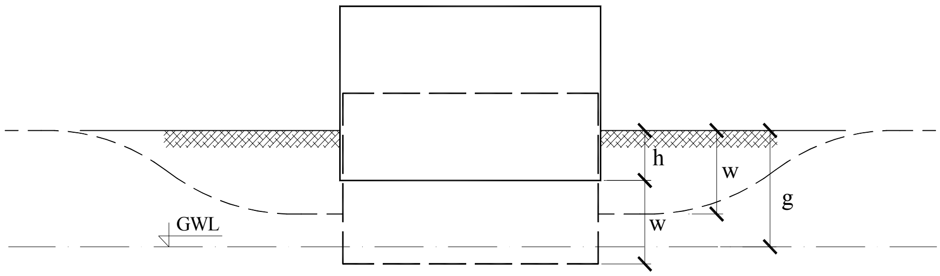


Fig.5. The building lowered below the ground water level (GWL)
h- depth of foundation, g- ground water level, w- land subsidence

In the case of the appearance of local water inundations or flood land, the area in question may be completely disqualified from building development or protective engineering solutions must be implemented, such as, for example, additional insulation or drainage.

2.2. Post-mining areas

Mining areas, once underground extraction of deposits is ceased and the operational permit expires, become post-mining areas, where building development is still subject to certain conditions. In view of liquidating coal mines, this issue is more and more common in the building practice. In comparison with mining areas, post- mining ones are exposed to the same hazards, yet in different aspects, and, in addition, to gas explosion hazard.

The requirements imposed on the reclamation of post-mining areas for building development as well as the hazards to which buildings are exposed were discussed in [8], with the specification of the categories of post-mining areas. The area exposed to the hazard of water inundation and flood lands are classified as unsuitable for land development. Furthermore, it is recommended that the zones of closed down shafts and shallow pits should be excluded. Likewise in mining areas, it is the financial calculation that should be decisive, including the process and costs of adjusting the land in question to the planned development.

3. Protection of new buildings and removal of damages in the existing buildings

3.1. General principles

The engineering costs of protecting buildings in mining areas may be described as a total of the costs incurred on making the designed protection solutions and the additional costs of maintenance due to the effects of mining. The latter costs include the costs of removing mining damages as well as the costs of extra repairs associated with poorer durability of the building. It is supposed that in the near future, there will be added costs of compensation for lowered market value of the damaged building due to mining damages that are beyond repair or that have not been repaired (for example, the tilt of a building).

On the bases of the studies on the economic efficiency of mining in consideration of surface protection and protection of building structures [9], Fig. 6a illustrates a general scheme of shaping the total costs of the protection of buildings (K), including the costs of protection against the forecasted mining impacts (K_p) and the costs of further maintenance of the buildings (K_m) as the function of their resistance to the mining impacts; whereas Fig. 6b presents a graph describing the forecasted effects of mining in buildings D, also in relation to their resistance R.

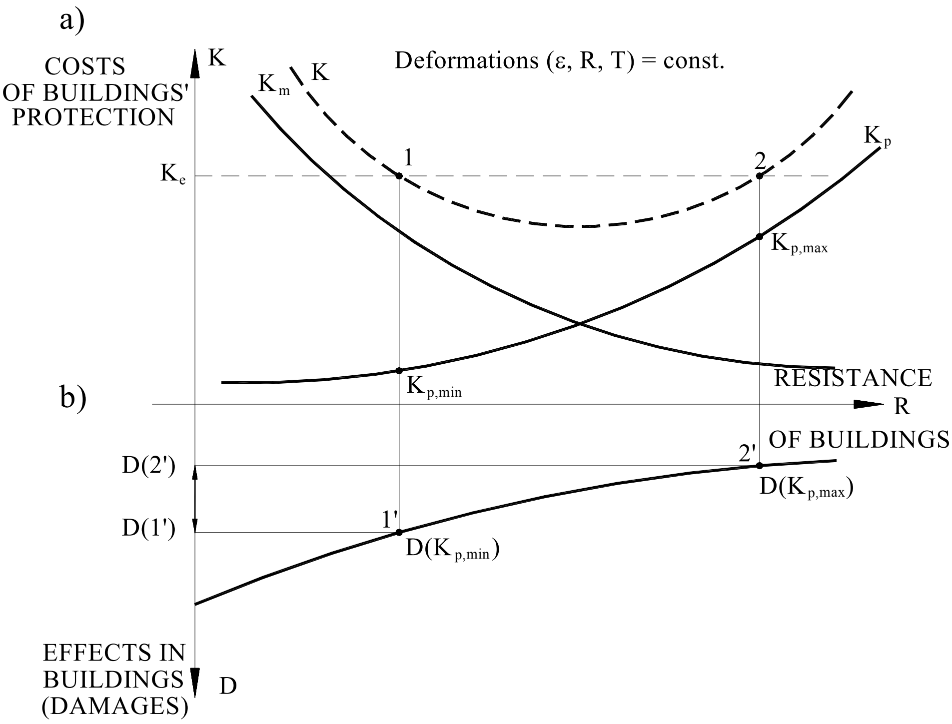


Fig.6. Scheme for cost analyses of protecting buildings in mining areas
a) component and sum costs of protection, b) effects of mining impacts in buildings
K - sum costs, K_p - costs of protection solutions, K_m - costs of maintenance,
K_e - economically feasible costs of protection

Both graphs should be related to explicitly specified mining impacts on the land surface, having assumed that deformations (*ε, R, T*) = constant, and different options of engineering methods of protection are possible. If economically feasible costs of protection K_e may be determined, the whole graph of the costs of protection and further maintenance is below value K_m only in the section between points 1-2. In accordance with Fig.6b, these points correspond to 1' and 2', designated by minimal ($K_{p,min}$) and maximal ($K_{p,max}$) protection costs. Points 1' and 2' designate a certain range of the mining effects resulting from the analysis of financial outlays for the protection of the building. The bottom level of these effects D(2') corresponds to a building "well" adjusted to withstand the forecasted land deformations with the associated investment outlays $K_{p,max}$;whereas the top limit D(1') refers to a building the protection of which is limited to the repair of the damages, with investment outlays $K_{p,min}$.

It should be emphasized that the bottom level of D(1') related to the acceptance of the most intense mining impacts made in the building and the resulting rectification of the damages also lead to increased social costs as well as intangible or even hard to quantify costs of the functional inconvenience of the damaged buildings to their inhabitants or users.

Furthermore, from the point of view of an investor, user and coal company, the consideration of only direct costs associated with the protection of buildings in mining areas leads to different "protection strategies". The choice of a compromise must take account of the above mentioned social costs with their basic indicator which is the possibility of using the building in accordance with its designed function, with acceptable inconveniences suffered by its inhabitants. As far as the construction of newly designed buildings in mining areas is concerned, the social costs should be eliminated or reduced. Thus, the design solutions should guarantee that possible mining effects correspond to the bottom level, designated in Fig. 6b as D(2').

3.2. Transient serviceability limit states (TSLS) of buildings in mining areas

The suitability of buildings to perform their design functions is checked by the boundary conditions of their load-bearing capacity and serviceability. The observations of buildings located in mining areas indicate that generally the limit values of their serviceability are exceeded. However, in the majority of cases the safety of their performance is not at risk, hence, the limit values of their load-bearing capacity are not exceeded. Accordingly, the building in question may perform in accordance with its designed function.

In view of the above conclusions, and in consideration of the inevitability of the occurrence of negative mining impacts upon buildings in mining areas, the concept of transient serviceability limit states (TSLS) was developed for buildings in mining areas [10]. The essence of this concept is to accept – on temporary or permanent bases - the lowered (mitigated) criteria of the serviceability of buildings located in mining areas in relation to the generally recommended requirements and design standards. Such exemption from the standards has been legitimized in the Minister's Ordinance [8].

Nevertheless, TSLS refer only to these effects that are direct results of the mining influence, including:

- tilt of buildings T_b induced by the land slope;
- width of single cracks a_w in the walls of brick or concrete buildings (without reinforcements – without the protection against the mining impacts);
- deflection of the structure walls Θ_b, induced by land surface curvature.

The condition of implementing TSLS to the building practice is the determination of the level of deformations and damages in the building that is acceptable to its inhabitants. To establish such level, the investigation of the inhabitants' reaction and their assessment of the damages were conducted on several housing structures [11]. On the grounds of the results from these studies, the intensity of the above mentioned mining impacts was classified in relation to the assumed level of inconvenience to their users. The acceptable values as implemented in the building practice [4], [5], are compiled in the Table 2.

Table 2.Inconvenience in the performance of buildings as perceived by their inhabitants

Effects in buildings		Degree of inconvenience			
		Imperceptible	Low	Medium	High
Tilt	T_b [$^o/_{oo}$]	≤ 10	10 - 15	15 - 20	20 - 25
Width of single cracks in walls	a_w [mm]	≤ 1	1 - 3	3 - 8	8 - 30
Deflection of the walls	$\Theta_b \cdot 10^3$	≤ 1	1 - 2	2 - 3	3 - 5

Depending on the degree of inconvenience, a certain level of building performance properties is selected. The grounds for the selection should be determined by the following factors:

- technical and economic consequences, differentiating between the existing and the designed structures;
- duration of the negative impacts, differentiating between temporary and permanent inconvenience;
- the need to assess the effects of mining damage at the design stage or after their occurrence.

In consideration of the above factors and technical, economic and functional considerations, the following principles were observed for designating the acceptable level of building performance:

- **As far as newly designed buildings are concerned**: temporarily, low level of inconvenience to the users is acceptable (excluding shaping the rigidity of the load bearing structure, i.e.: value Θ_b); whereas in the case of long-term deformations the imperceptible level of inconvenience should not be exceeded.

- **As far as the existing buildings are concerned**: temporarily medium level of inconvenience is acceptable; whereas in the case of long-term deformations the low level of inconvenience should not be exceeded.

If there is a possibility that the tilt of the building may exceed the limit values it should be rectified or the plan of constructing it at that site abandoned. Nonetheless, under special circumstances, depending on individual settlements, the investor (or future user) may agree for increased tilt in exchange for the compensation (see 3.3.) for using the building the standard of which is lowered.

The assessment of the state of damages evoked by the mining impacts in the existing buildings is important, especially in view of the consequences of the damages for the users and the coal company responsible for inflicting the damages. Pursuant to the Mining and Geology Law [12], the coal company is obliged to remove the damages. Unfortunately, applicable technical and implementation regulations are still missing.

Thus, the acceptable level of building performance should be understood as such intensity of the mining impacts exerted on the building, which, when exceeded, leads to the coal company being obliged to remove the damages as soon as possible. Otherwise, the user should be liable for appropriate financial compensation for such high level of inconvenience. Eventually, all the structural effects of the mining impact, connected with material and structural damages, must be repaired, and, in particular, cracks in the structural elements, irrespective of their intensity.

3.3. Compensation for using the buildings with excess level of inconvenience

Pursuant to the Polish Mining and Geology Law [12], a coal company is responsible only for the damages made by its operation. The repair of the damage should, first of all, lead to restore the previous state, thus, the building undergoes an overhaul. It is only when the overhaul is impossible, or when the costs of restoration would strikingly exceed the value of the damage, it may be compensated by financial reimbursement.

In view of the proposals of TSLS concerning the existing buildings, the range of a coal company's responsibility for mining damages should be assessed with a different attitude. Beside directly specified costs connected with the removal of damages, the owner (user) of a given building also incurs some additional costs- partly tangible (associated with the decreased durability of the building and increased investment outlays required to maintain it) and partly intangible (associated with inconvenience in the use of the building with lowered performance level).

In Germany research schemes on the methods of assessing the mining impacts on the decrease in the value of buildings have been conducted for a long time now. Pursuant to the results [13] only the tilt of a building is assumed as an objective measure of assessing the decrease in its value.

In Poland it is necessary to regulate the issue of compensations for using the buildings with excess tilt. In view of the discussion, the amount of the compensation should be determined by:

- the value of a given building in relation to which compensation is calculated;
- the assumed dependence between the compensation for the building and its tilt T_b.

The proposal how to calculate compensations was presented in [14]. Final settlement of the dependence between the amount of the compensation and the tilt of a building and the determination of minimal compensation for the inconvenience of using a flat (building) should be a subject of negotiations between coal companies and the users / inhabitants.

4. Conclusion

In view of the issues concerning the development of mining areas, designing new buildings and protecting the existing building structures, the current state of legal and technical regulations may be generally described as regulating most of the problems encountered in the building practice. It should be emphasized that applicable solutions have been adopted since 2000 in the process of amending previous regulations in the updated Ordinance [6] and guidelines [4] and [15].

The loops concern post-mining areas and modes of rectifying mining damages in buildings. However, works have been undertaken to address these issues. A proposal of determining the compensation for the conditions of using buildings that have been damaged by the mining impact was made. Unfortunately, in view of the present condition of the Polish coal mining industry it seems that any further progress in these matters needs more time. According to the data published by the Polish Supreme Mining Agency in 2003 the coal investment outlays made by the coal mining industry on removing mining damages totaled 190 million PLN, which, set against the total production output , amounts to 1.9 PLN for each ton of coal. In comparison, in the German coal mining industry in 1998 the relation of investment outlays to the total coal output was 13.46 DEM per ton [16]. Until these proportions change, there will be no further progress in the field of mining damage rectification and compensations payable to the users of buildings with lowered performance.

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PROBLEMS OF STRUCTURE PROTECTION IN MINING AND POST-MINING AREAS

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1. Introduction

The occurrence in Poland of big parts of deposits of useful minerals (hard coal, copper ores, zinc and lead ores, rock-salt) under developed areas, extracted in underground mines, creates essential problems concerning the protection of structures localized in these areas. In previous years, in view of social and economic factors, and particularly considering the great demand for these minerals, mining activities were directed towards the intensification of extraction. These tendencies have not always created conditions for appropriate surface protection. Currently this situation has changed and this protection gains its due place. On account of the perspective of further, although certainly less intensive, activities of the underground mining sector we should judge that the protection of structures against mining damages will create still during a long period of time essential economic, social, technical, and formal problems in our country. Thus it is worth to take up this issues from the viewpoint of research, however, having in mind their utilitarian aspect.

Underground extraction of deposits under developed areas and the aspiration to reduce mining damages in structures as well as nuisances connected with exploitation caused the development of knowledge regarding the protection of structures in mining areas. It is an interdisciplinary knowledge (mining, building engineering), where everyday experience has overtaken and in many cases still overtakes the theoretical justifications. A particular share in the development of the knowledge relating to the impact of underground mining operations on structures localized on the surface have Polish scientists and practitioners [9, 10]. The extraction of a considerable part of minerals from areas occurring under developed grounds, with mining damages that in general do not exceed the anticipated scope, has proved the usefulness of the possessed knowledge. However, the problems connected with the protection of structures in mining areas still exist. The issues that distinguish current questions of structure protection in mining areas constitute:

- greater than hitherto requirements with respect to the scope of structure protection and removal of effects of mining activities,
- the need to take into account to a greater extent than before the effects of extraction in decisions concerning the possibilities and conditions of mining exploitation, first of all in order to estimate the costs connected with structure protection on the surface.

This leads to a better than hitherto prediction of extraction effects in structures. It should be noticed that this problem does concern not only mining areas exposed to the impact of currently conducted mining operations, but also post-mining areas, coming into existence along with the closure of mines. The paper presents selected elements of these topics, essential for the Polish underground mining sector and areas exposed to the impact of mining.

2. Formal aspects of structure protection

Underground mining exploitation causes dislocations, inclinations, curvatures, and horizontal deformations of the rock mass layer localized close to the surface; this concerns also the foundations of structures. In some cases also vibrations of foundations take place, combined with tremors of mining origin. In connection with it, constructional elements of structures are subject to additional dislocations, deformations, and loadings in relation to non-mining grounds. The protection of structures against undesirable effects of mining operations consists in their appropriate designing and execution. In spite of the impact of mining exploitation there should be ensured the safe use of structures in conformity with their purpose, in conditions of socially accepted impediments connected with mining operations.

The requirements imposed in relation to structures regulates the building Law [12], while the protection of structures in mining areas ensure the provisions of the geological and mining Law [11]. Article 5 of the building Law decides that structures should be designed, built, used and maintained in accordance with regulations, including technical and building ones, compulsory Polish Standards and rules of the technical knowledge, in a manner ensuring among others: safety of construction, safety of use, protection against vibrations, and functional conditions consistent with the structure’s purpose. The principles of static and strength-related calculations that should ensure the safety of building constructions and the possibility of their use according to the purpose regulates the standard [7]. When calculating and designing building constructions according to the method of limiting states, this standard recommends to check the limiting states of load capacity and usability. Among the limiting states of load capacity we count the destruction of the entirety or part of the construction, and among the limiting states of usability we count:

- excessive deformations of the construction or foundation,
- excessive scratches of the construction,
- excessive vibrations of the construction.

Checking of meeting of limiting states of the load capacity in mining areas should be performed similarly to their checking in non-mining areas, taking into consideration the changes of impacts between the structures and the foundations caused by extraction, and classifying the connected influences among the appropriate type of loadings. In order to check the limiting state of usability it is necessary to determine the values of parameters characterizing the ability of structures to use according to the purpose. It should be noticed that the adaptation of parameters used in non-mining areas for application in mining areas would limit to a considerable degree the realization of profitable exploitation. Indispensable is the introduction of tempered conditions of use of structures in these areas [5, 10], and the degree of their tempering should correspond with the provisions of article 53 of the geological and mining Law [11] with respect to the guarantee of common safety and structure protection, as well as with the provisions of the standard [7], concerning the dependence of parameters characterizing the limiting states of usability on negative reactions of the users, taking into consideration the economic effects. The Ordinance [13] decides about the possibility relating to non-fulfilment of requirements corresponding with Polish Standards concerning the limiting states of usefulness of buildings for use in mining areas with respect to deformations, damages, and vibrations of their constructions, caused by mining operations. This resolves itself into the determination of the optimum, in given local social and economic conditions, nuisance connected with the use of structures in mining areas, which does not restrict excessively the extraction possibilities of mines, and does not create problems that are not accepted by the local society.

In order to observe appropriate requirements, the structures erected in mining areas should be constructed in conformity with the recommendations formulated in the instruction [4], and mining activities conducted under existing objects should meet the requirements formulated in the instruction [3]. Detailed data with respect to structure protection in mining areas are comprised among others in the monographs [6, 9, 10].

3. Mining area

In problems relating to the protection of structures subject to the impact of mining extraction an important role plays the mining area. The space in the limits of which the entrepreneur is entitled to extract the mineral covered by the concession is called the mining field. The impact on the surface of extraction conducted within the boundaries of the mining field goes beyond this field and comprises the so-called mining area. According to the act [11], the mining area constitute the space covered by the anticipated harmful impact of mining operations executed by a mine. The boundaries of the mining area are determined in the concession.

From the point of view of building engineering, the mining area isolates a fragment of the surface, on which the structures should have a considered need to use special protections against the harmful impact of mining activities, and possibly should have introduced protections according to the anticipated hazards. Essential is the determination of criteria to outline the boundaries of the mining area. In general we consider that in the case of continuous surface deformations, about the boundary of the mining area decides the absolute value of the horizontal deformation equal to 0.3 mm/m (possibly also the inclination 0.5 mm/m and radius of curvature 40 km), and in the case of surface vibrations the value of the amplitude of the resultant of horizontal components of acceleration equal to 120 mm/s^2 (according to some sources 200 or 250 mm/s^2), with vibration frequency up to 10 Hz. The determination of the boundaries of the mining area owing to the remaining factors that can decide about the harmful impact of extraction (change of water conditions, discontinuous deformations) requires to work out specialist opinions. The final boundary of the range of the harmful impact of extraction is the envelope of ranges of its partial influences. The boundaries of the mining area can be subject to changes according to possibly appearing mining damages beyond its boundaries.

4. Types of mining damages

Underground mining exploitation has an adverse impact on structures. In order to minimize possible damages of objects, called mining damages, mining prevention and building prevention are used. However, their range is limited first of all by economic factors, but also by technical reasons. In the end, the mining damages are almost always an inherent element of mining activities. The mining entrepreneur is obliged to repair the damages. The repair of damages should follow through the restoration of the previous state, and if this is not possible or the costs would glaringly exceed the value of the damage, then the repair of the damage follows through the payment of compensation [11]. Damages arosen in structures can cause:

- hazard relating to stability,
- hazard with respect to the safety of constructional elements,
- hazard regarding the safety of use,
- decrease of functional advantages,
- decrease of aesthetic advantages,
- accelerated technical wear.

The manner of damage repair depends on the type and scope of damages, as well as on anticipated further mining activities in the regions of impact on the structure or lack of such activities and recognition that the ground of the structure's location constitutes a post-mining area. In every case of execution of repair activities, the safety of use of the structure should be ensured, in conformity with the purpose. In the case of anticipation of further mining activities, the removal of damages should be combined with possibly necessary protection of the structure.

In general the effects of mining operations can be divided into removable and non-removable ones (Table 1). From among non-removable effects, depression of the surface and arosen on it overflow lands should be recognized as durable consequences of extraction; surface development should be adapted to these phenomena. The problem of flooded areas constituting a hazard for the foundations of structures can be solved by means of local lowering of the ground water level or appropriate protection of foundations. The decrease of the durability and value of structures, if this is justified, and the matter is difficult in view of lack of statistical data, should be squared by means of compensations. Removable effects should be removed in a range ensuring the safe use of the structure in conformity with its purpose, and its functional and aesthetic advantages should not be reduced in relation to the state from before the execution of mining operations. Repair work should be conducted on the basis of performed projects of repairs and should be suitably supervised. The manners of structure repair were described among others in the monograph [10].

Table 1. Removable and non-removable effects of mining operations

Site of occurrence of extraction effects	Effects	
	removable	non-removable
in the rock mass layer adjacent to the surface	- post-extraction voids occurring at low depths	- depressions, - overflow land and flooded grounds
in structures	- deviations from the perpendicular and from the horizon, - damages of constructional and finishing elements, - unsuitable drops of sewage systems, - insufficient dewatering of motorways and roads, - insufficient functioning of devices	- decrease of durability, - decrease of value

5. Nuisance of structure use

Every mining activity is inconvenient for the users of structures on the surface. The scope of nuisances, accepted by the society, depends on social and economic factors. From one side, the requirements imposed to structures in mining areas must be much more milder than the requirements imposed to structures in non-mining areas, because too strict ones could lead to an excessive increase of mineral mining costs and more than once to the desistance of planned extraction. From the other side one should take into consideration the increasing resistance of surface areas to the inconveniences connected with the extraction effects. This is a very essential social and economic aspect of conducting of mining operations. The fact of the matter is that the impact of extraction should not arouse anxiety with respect to safety preservation. The nuisances connected with mining activities should not exceed the optimum strenuousness in given conditions. The nuisance degrees of use of structures in mining areas, depending on disturbances of the normal use perceptibility relating to extraction effects as regards the inhabitants and needs in the field of damage repair [3] were presented in Table 2.

Table 2. Nuisance degrees of structure use

Nuisance	Disturbances of normal use	Human perceptibility with respect to extraction effects	Damage repair
not perceptible	practically do not occur	insignificant	effects requiring removal do not occur
low	inessential	observable	in the framework of periodical repairs
medium	hinder the use	inducing unfavourable reactions	after extraction termination
high	interruptions in use can occur	importunate	necessity of current interventions

Four nuisance degrees were introduced: not perceptible, low, medium, and high; it has been recommended to avoid exceeding of low nuisances. Effects in structures that can occur then should be practically not perceptible by their users or perceptible to an insignificant degree, and the use of structures in conformity with the purpose is not limited. However, the admission of nuisance higher than a low one is connected with essential troubles with respect to the use of structures, and generally it is not accepted by the society.

The possibility to use the descriptive, and in connection with this general definition of nuisance degrees as regards the adaptation to different types of structures is conditioned by the formulation of adequate criterial indices, characterizing the individual nuisance degrees. For example, for apartment buildings, farm structures and public buildings the nuisance of their use resulting from continuous surface deformations was made conditional on deviation from the perpendicular T_b, aperture of individual scratches d and angle of non-dilatational strain of building walls $?_k$. In order to avoid exceeding of a low nuisance, one has assumed: T_b = 15 mm/m, d = 3 mm and $?_k = 2 \cdot 10^{-3}$.

6. Resistance of structures

The basic notion determining the possibility to take over by the structure the impact of continuous deformations of the rock mass layer adjacent to the surface, caused by underground mining activities, is the structure's resistance to this impact. As the resistance of the structure to the impact of continuous deformations of the rock mass layer adjacent to the surface we understand the expressed by surface deformation indices adequate for the considered case (depressions, inclinations in the point for structures with compact horizontal projection, average inclinations on the structure's length for linear structures as well as structures with extensive horizontal projection, curvatures, horizontal deformations and others) ability of the structure to take over the impact of extraction under the following circumstances:

- maintenance of safe use of the structure in conformity with the purpose,
- occurrence of at least low nuisance of structure use.

In some cases the resistance of the structure depends not only on extreme values, but also on the velocity of increase of surface deformation indices, i.e. on the extraction velocity. In the case of lack of appropriate information we assume that the determined resistance does not depend on these velocities, and the structure is adapted to take over the impact of extraction conducted with high velocities.

The resistance used most often is the resistance to curvatures *K* and horizontal foundation deformations *e*, i.e. these surface deformation indices, which decide about the state of stress in the constructional elements of the structure. In particular it can be expressed – analogically to the category of the mining area – by the resistance category of the structure; this means resistance to extreme values of curvatures *K* and horizontal deformations *e*, corresponding with these categories.

In the case of structures subject to particular protection in view of historical, architectonic, or usable advantages, the nuisance of their use should be limited to not perceptible arduousness (if generally in the region of impact on these structures mining activities can be realized). However, sometimes the protection of structures on the level of low nuisance of use excessively restricts profitable extraction. Then it is possible – after obtaining social approval – to mitigate structure protection, considering medium or even high nuisance, however, under the assurance of safety of structure use. However, these cases cannot be considered on the basis of structure resistance determined according to the definition given above, and require a separate treatment [3]. It should be noted that the resistance of newly built structures, designed under the consideration of recommendations formulated in the instruction [4], corresponds with the given definition of resistance. The resistance of structures to the impact of mining operations is not a durable feature and can vary along with the change of their technical condition, caused particularly by the impact of executed mining operations. Therefore it should be revised before every planned mining activities, and present a possible increase of the value of surface deformation indices, essential for the considered structure in view to ensure safety maintenance and the assumed nuisance level of its use.

7. Mining surface deformations

The initial data concerning the design of protections of structures against the effects of continuous surface deformations and regarding the assessment of resistance of structures to these deformations constitute the values of surface deformation indices *D*, assumed for analysis. These are predicted values recognized as characteristic values. From the viewpoint of the probability calculus these are medium values *D*. A measure of dissipation of these indices are the coefficients of variation M_D, and the extreme values of indices determines the dependence:

$$D_{ekstr} = \eta \overline{D}, \quad \eta = 1 \pm nM_D \tag{1}$$

where:

? - coefficient dependent on the required probability of non-exceeding by the value of the considered index of its extreme values determined by the dependence (1).

Assuming this probability equal to 0.95 we obtain $n = 2$. In Table 3 the maximum values of the coefficient ? for horizontal deformations, curvatures and inclinations of the surface were presented, assuming $n = 2$ and the values M_D, obtained by *Popiolek* [8].

It results from the data specified in this Table that the dissipation of surface deformation indices, essential from the viewpoint of connected with them additional loadings of building construction, is high in comparison with other loadings, met in general. This concerns especially curvatures. In order to illustrate their dissipation, in Fig.1 the possible formation of surface curvatures was presented, with the probability 0.95 for cases of counting of the mining area among the adequate category.

Table 3. Dissipation of surface deformation indices

D	M_D	$?_{max}$
e > 0	0.20	1.40
e < 0	0.30	1.60
K	0.43	1.86
T	0.13	1.26

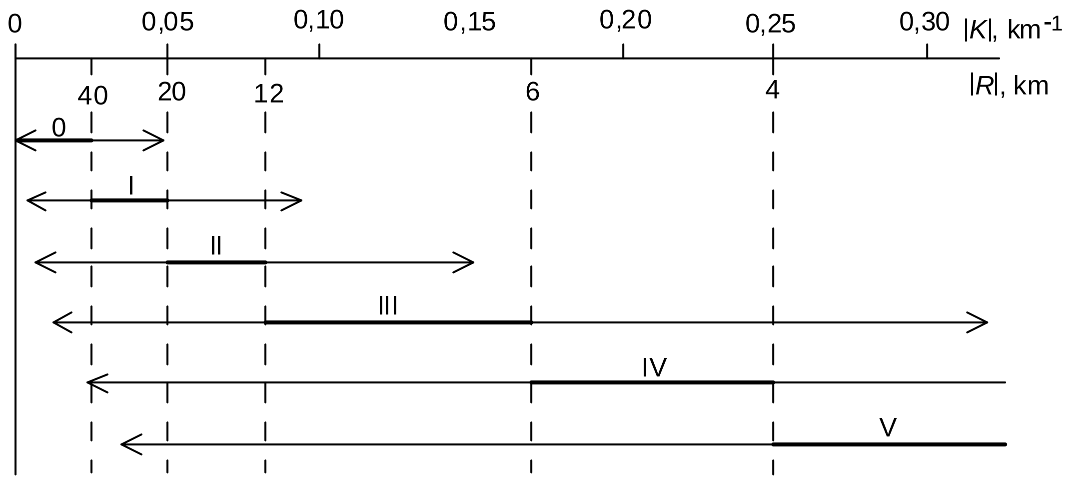

Fig.1. Possible curvatures of surface classified among the categories I – V of the mining area

High dissipation of surface deformation indices in mining areas should be taken into consideration in the analysis of extraction effects. It indicates also the inexpedience of imposing of too high requirements in relation to the prediction accuracy of surface deformation indices, especially for big time intervals, for instance for the anticipated period of structure existence. As completely sufficient in this case we should recognize the determination of the predicted extraction effects by means of categories of the mining area. Only in exceptional cases, when we can foresee the system of mining operations, and in the case of structures having particular significance we can postulate a more exact manner of determination of extraction effects on the surface than by means of categories of the mining area. High dissipation of surface deformation indices is another reason, for which the estimation of the impact of mining deformations of the foundation on structures should be performed in the probabilistic formulations [6].

8. High extraction velocity

Economic reasons cause the necessity of mineral output concentration, among others through the increase of the extraction velocity. Subject to decrease are then transient extreme surface deformations, what in view of protection of structures existing on the surface is a favourable phenomenon. In case of higher extraction velocities, extreme surface deformations occur in a shorter time, then in the case of low extraction conducting. This last circumstance is in view of structure protection in general an unfavourable phenomenon, because in some structures, according to the constructional materials used, the state of stress caused by mining operations depends not only on the value, but also on the velocity of mining deformation of their foundation. The final effect of increase of the extraction velocity in structure protection is thus an effect of overlapping of the factors mentioned above, and finally it can be for the structures both favourable and unfavourable.

The state of stress in constructional elements of some structures depends not only on the final values of their deformation, but also on the deformation velocity. A high deformation velocity is in such cases an unfavourable phenomenon. Then there is not sufficient time for the relaxation of partial stresses, which are the effect of partial deformations. There is not also sufficient time for the growth of deformations of constructional elements during their creep and partial adaptation of structure constructions to foundation deformations, and thus decrease of the effect of deformations in constructional elements of structures. However, not in every case a slow deformation of the foundation can be more favourable for structures in relation to fast deformation. In order that the deformation velocity of the foundation might have an impact on structures, the following conditions should be met, concerning their characteristics:

Static scheme – mining deformations of the foundation change the state of stress in structures with an indeterminable static scheme of construction and only then we can expect that the extraction velocity might have impact on their threat. In constructions statically determinable, realized in conformity with calculational assumptions, the deformations of the foundation do not change the state of stress and therefore the deformation velocity of the foundation has not essential significance in this case.

Rigidity of construction – the change of the state of stress caused by mining extraction causes construction deformations reducing the impact of foundation deformations. However, depending on the rigidity of construction, the role of these deformations can be considerable or omissible; along with the increase of rigidity, the adaptation of the construction to the foundation deformation is more and more lower, and in this case the extraction velocity has a more and more smaller significance.

Properties of the material – the elapsing time can have non-omissible significance for the state of stress in structure constructions in mining areas only then, when the constructional material is characterized by distinct rheological features. On the contrary, the extraction velocity does not influence to an essential degree the state of stress in structures in mining areas.

It results from the presented considerations that in some cases, in view of structure protection, right is the reduction of mining extraction velocity. However, it is not justified in the case of some structures. Among these structures we can count for example: many-storied buildings with box foundations (high construction rigidity), steel industrial halls (material with low rheological properties) and bridges constructed of free-supported plates based on proper bearings and having sufficient expansion gaps (structure statistically determinable). However, essential is the extraction velocity in case of buildings with traditional construction (brickwork).

In cases, when the impact of extraction velocity *v* on caused by it stress s in the constructions of structures is impossible to omit, this impact determines approximately the dependence

$$s = \beta s_s \qquad (2)$$

where:
ß - coefficient dependent on the rheological properties of the constructional material,
s_s - stress that might arise in the case of velocity $v_s \rightarrow 0$ [6].
Fig.2 presents the formation of the coefficient ß for concrete of brickwork, for selected extraction velocity *v*, and extraction depth *H.*

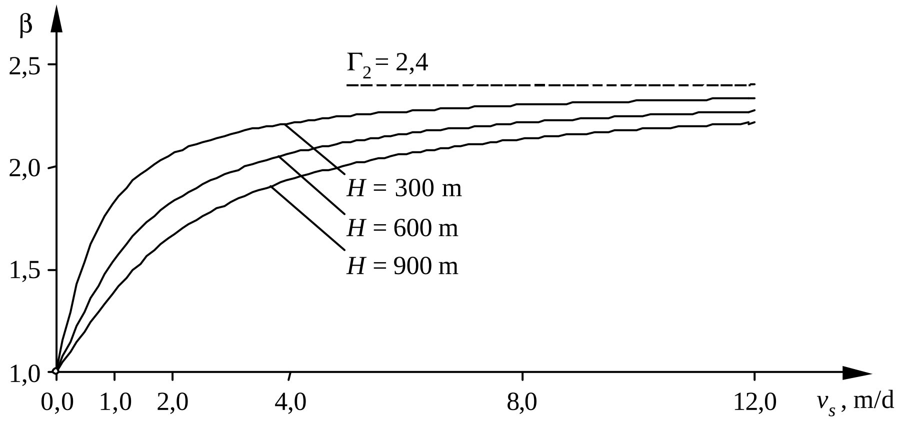

Fig.2. Coefficient ß for structures in case of different mining conditions

The analysis of diagrams obtained indicates an increase of stress values in some construction structures along with the growth of the extraction velocity. This proves the possibility of an unfavourable impact of the extraction velocity increase on these structures on the surface; at the same time the hazard growth diminishes along with the increase of the extraction velocity, and it is particularly high in the case of velocities up to 4 m/day. The hazard degree of structures together with the increase of the velocity of extraction depends also on its depth; the depth increase has favourable significance. Optimistic in view of the concentration of mineral mining is the statement that after exceeding the extraction velocity of about 4 m/day, the further growth of this velocity does not cause an essential increase of this hazard.

9. Mining tremors

In some cases of mining operations, when around mined workings occur rocks of high strength and possible are sudden rock mass destressings, originate the so-called mining tremors. Their effect is the appearance of elastic seismic waves, reaching the surface, and vibrations of the rock mass layer adjacent to the surface, which most often are characterized by acceleration amplitudes and frequency. The effect of these vibration can constitute damages and considerable nuisance of structure use. In the case of Polish coal basins, the origination of mining tremors is connected currently with executed mining operations in underground mines of the Upper Silesian Coal Basin and Legnica-Glogów Copper Region. In relation to other paraseismic vibrations, the vibrations of the rock mass layer adjacent to the surface connected with mining tremors are characterized by high intensity. However, in relation to earthquakes, these vibrations are considerably less intensive, and the time of duration of the basic vibration phase is shorter and amounts to several, rarely a dozen or so seconds. Hence results the necessity to adapt the existing assessment methods relating to the impact of vibrations of the rock mass layer adjacent to the surface on structures to the conditions of their occurrence in mining areas, having in mind not only the impact of vibrations on the constructional elements of structures, but also on their finishing and architectonic elements and on humans in the buildings. This last impact of vibrations constitutes an essential problem of resistance of building users to mining activities that can create tremors.

10. Post-mining areas

10.1. Post-mining areas hazards

As post-mining areas is considered the surface area within the boundaries of eliminated mining area. When determining the boundaries of a post-mining area one should, in the case of existence of neighbouring mines, to take into consideration the necessity to enlarge their existing hitherto mining areas. Thus the post-mining area of a closed mine may not be in line with its previous mining area. According to the geological and mining Law [11], the mining entrepreneur is obliged to take action in the case of mine closure in order to protect the individual environment elements on the surface; the Law determines the procedure of this obligation. However, when planning the development of a post-mining area, we should take into account the hazards connected with the consequences of executed mining operations. They result from:

- appearance of delayed continuous deformations of the rock mass layer adjacent to the surface,
- possibility of appearance of discontinuous deformations of the surface type as a result of activation of post-mining voids in the rock mass at low depths,
- possibility of occurrence of overflow lands and flooded grounds,
- gas hazards on the surface.

10.1.1. Delayed continuous surface deformations

The process of appearance pf continuous deformations on the surface is a long-lasting process. The increasing deformations within the period of several years from extraction termination should be predicted and the erected structures should be suitably protected. We consider that such a period does not exceed five years. However, this does not mean that after this period the post-mining area is stabilized. There can further occur additional continuous surface deformations of low intensity, without impact on the construction of structures, but influencing their finishing elements. In these elements can occur scratches and crackings. In order to minimize the possibilities of their occurrence, it is proved to consider the post-mining area as a ground of possible non-uniform foundation subsidence, even in the case when the appearance of considerable continuous deformations is not expected. In the framework of building prevention, constructional reinforcements of structures should be used.

10.1.2. Discontinuous surface deformations

Having in mind an essential increase of investment costs in the case of realization of structures on areas subject to discontinuous deformations, one should avoid the localization of structures in such areas. However, in the case of use of grounds subject to discontinuous deformations to erect there structures it is recommended, in justified cases, to fill in the voids and to strengthen suitably the construction of structures.

10.1.3. Overflow lands and flooded grounds

The state of water conditions in post-mining areas will depend on the fact, if the gobs of the closed mine will be still drained, or the drainage system will be eliminated and mine flooding will follow. In case of maintenance of the drainage system, extraction termination does not change the water conditions in the rock mass layer localized close to the surface. However, the elimination of the drainage system and mine flooding will cause effects on the surface dependent on the type of the rock mass.

10.1.4. Gas hazards on the surface

In post-mining areas of some closed mines we observe increased contents of mine gases (methane, carbon dioxide). The process of gas outflow can be intensified by mine flooding, when the water will cause the displacement of the mine atmosphere upwards. In view of the possibility to develop post-mining areas it should be noted that the gas hazard on the surface is a phenomenon limited in time.

10.2. Categories of usefulness of the post-mining area for development

Mining activities leave durable and disappearing effects on the surface, which may restrict its free development. In order to illustrate the usefulness of post-mining areas for development, the division of these areas into three categories (A, B, and C) [6] was introduced, which has been presented in Table 4.

Table 4. Categories of usefulness of the post-mining area for development

Specification*)		Type of hazard	Usefulness for development
A		does not occur	not restricted
B	B_1	continuous deformations	conditional
	B_2	discontinuous deformations	
	B_3	gas hazards	
C		overflow lands and flooded grounds	restricted to temporary and recreational structures

*) there is possible the co-occurrence of different hazards

Category A covers such areas, where no restrictions with respect to area development are predicted, however, it should be taken into account that the considered area was in the past subject of the impact of underground mining operations, and although the signs of this impact were recognized as finished, further inconsiderable and not predictable deformations of the rock mass layer localized close to the surface cannot be excluded. Therefore it is proposed to recognize the area of category A as an area of possible non-uniform subsidences, for which it is recommended to consider the necessity of the constructional reinforcement of structures in order to avoid the damages of finishing and architectonic elements.

Category B covers areas, the usefulness of which for development is temporarily and durably conditional. From this category, according to the type of hazard, were separated the following sub-categories: B_1 in view of continuous surface deformations, B_2 in view of discontinuous surface deformations, and B_3 in view of gas hazards. As restrictions elapsing together with the time we can consider the hazard connected with appearing delayed continuous surface deformations as well as the gas hazard. In general we consider that after five years from extraction termination follows the stabilization of continuous surface deformations and one can, in view of such deformations, count the area among the category A, however, the retreat of the gas hazard requires confirmation by means of appropriate measurements, executed in the framework of its monitoring. The hazard connected with the possibility of appearance of discontinuous deformations is a durable hazard as long as it will be eliminated by filling in of voids in the rock mass; it is recommended to exclude from grounds to be developed the areas of filled in shafts and galleries.

Category C covers areas useless for development as regards long-lasting structures in view of the hazard connected with overflow lands and flooded grounds. It is possible to erect in these areas provisional objects, planned to be eliminated before the hazard appearance. Possible is also ground development with respect to recreative buildings.
The basis to assess the usefulness of a post-mining area for development should constitute

a map presenting the classification of this usefulness. This map should be carried out in the framework of the plan of operation of its elimination. On the map should be presented the categories of the post-mining area according to the presented classification; moreover, there should be determined the impact of operating neighbouring mines. It should be noted that the categories of usefulness of the post-mining area for development, resulting from Table 4, have a general character. In individual cases they can be précised, according to local geological and mining factors.

11. Summary

The inevitability of the unfavourable impact of underground mining operations on the surface and structures causes social resistance to extraction. For the protection of structures against the effects of extraction suitably selected mining and building protection procedures are used, but these activities increase the costs of exploitation and can lead to unprofitableness of mining activities, with social effects in the form of closure of a part of the mine or the mine as a whole. The selection of the appropriate scope of mining and building prevention procedures is thus a difficult task with respect to the protection of structures and optimization of extraction costs, taking into consideration the costs of removal of extraction effects on the surface, considering the social resistance.

The problems presented in the paper constitute the elements of solution of this current and general issue of technical, economic, and social character, relating to structure protection on the surface.

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EVOLUTION OF VIEWS ON SUSTAINABLE BUILDINGS

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1. From Green Building Challenge to Sustainable Buildings

The Green Building Challeng initiative, undertaken by Natural Resources Canada from 1996, demonstrated the interest of researchers in the development of a common environmental assessment method for international comparisons. The first phase of GBC process concluded with two worldwide Conferences in Vancouver 1998 and in Maastricht 2000, and these events showed a necessity for formalisation of the process. The International Initiative for Sustainable Built Environment (iiSBE), a non governmental institution, was formed as a conseqience to manage the GBC process and to organize (with CIB) future conferences related to Sustainable Buildings. The Oslo Sustainable Building Conference 2002 was the first big event promoted by iiSBE, and was a proving ground for the third version of the framework and GBTool, the software used in the assessment process.

Poland has participated in the GBC process from the beginning and the author is presently serving in the iiSBE Board of Directors to work towards the development of further versions of the framework. This work encompasses testing of the GBTool and providing a national platform for information exchange on sustainable building issues. The method elaborated within the GBC supports international efforts of environmental assessment of buildings for the sake of international harmonisation and standardisation.

The GBC initiative, broadened over the years as a wide action program for the encouragement of sustainable development in the building sector, is still under the development and new countries are expressing interest in participation. The scope of the current work relies on modification of the assessment framework and evaluation criteria in order to include regionalities, and to identify the balance between indoor and outdoor environment.

An example of international acceptance of GBC is the recognition and support from the organisations as CIB, UNEP, IEA and ISO. The international SB conferences have attracted an increasing number of participants (600 in Vancouver, 850 in Maastricht, and 1100 in Oslo). The next one which will be held in Tokyo in 2005 is preceded by series of regional

conferences in – South America, Africa, Asia, and the Central and Eastern European summarising the regional circumstances of implementation of sustainable buildings idea (more about the regional Conferences on www.sbis.org).
The concept of organisation of regional conferences paraellels the emphasis on regional variation in the universal assessment system. It is expected that the regional aspects of the framework and criteria will form a mainstream of conference debates which hopefully will stimulate development of national assessment systems accounting for local conditions.

2. Expieriences of development of assessment methods

The 8 year period since the establishment of the GBC initiative, brought significant changes on views in the relationship between erected buildings and environment. Successive conferences in Vancouver, Maastricht and Oslo proved the concept maturation and increasing scale of interest in the subject. The experience of the recent period of development indicates that the following phenomena of interest:

- an exceptional increase of interest from local initiative to world wide movement,
- evolution of the methodology of assessment – from the variety of national systems and methods to harmonization efforts undertaken by ISO, and recent recognition of CEN,
- evolution of activities from an initial emphasis on attracting public opinion towards recent initiatives on policy coordination and education,
- establishment of iiSBE as a reflection of the need for co-ordination of activities.

The experiences gained are underlining the need to transform theory into action. How can we act locally to fulfil the global vision? How do we gain the attention of decision-makers ? An important role for this (Warsaw) conference is to search for specific regional actions and solutions towards sustainable buildings.
During the last 15 years considerable research has been focused on the development of systems to assess the environmental performance of buildings, based on different initial assumptions and prepared for different purposes. The best-known existing system is the Building Research Establishment Environmental Assessment Method (BREEAM), developed by BRE and private-sector researchers in the U.K. This system provides performance labels suitable for marketing purposes, and has captured increasing interest of the new office building market in the U.K. Similarly, the Leadership in Energy and Environmental Design (LEED) system is becoming very popular in the U.S.A. Many national systems have been developed by different countries world wide as HQE in France, Eco-profile in Norway, Ecoeffect in Sweden, LEED in US, CASBEE in Japan. There are few countries in Europe that have not not attempted to develop adaptations of existing or to develop entirely new systems. Several other systems (largely inspired by BREEAM and Green Building Challenge initiative) are in various stages of development in Europe and the World. Several of these systems have gone the next step, to result in a labeling system that indicates clearly the building's approximate performance to end users.
There are also more specialized systems of interest that are more closely tied to Life Cycle Assessment (LCA), including ECO QUANTUM (Netherlands), ECO-PRO (Germany), EQUER (France) and ATHENA (Canada).
Assessment methods that use LCA methodology to take into account the environmental impact of materials and used fuels, do not necessarily cover important issues as indoor envinronment, quality of management, functionality, and adaptability.
Inclusion of the economic assessment of environmental performance of building would be of great interest. However, the results of such evaluation can not be justfied as it is impossible today to economically validate degradation of natural resources or environmental pollutions connected with production of goods and services, as market prices do not account such

externalities. Economic environmental evaluation should answer the question about value of environmental savings due to implementation of specific environment positive measures.
Meanwhile, the today's assessment based on financial efficiency gives an answer on direct economic benefit which is of inwestors' interest and is not complying with environmental requirements and sustainable development. It does not matter how strong environmental consciousness of designers or buildings owners is, finally they want to know how big is the financial pressure of environmental measures on their budget.

3. Efforts for harmonisation of environmental requirements by ISO

3.1. Normalisation towards user performance requirements

Significant increase of interest into non technical aspects of buildings research can be noticed among the scientific society since approximately 50 years; especially CIB works [1] about definition of criteria for performance assessment of buildings (performance concept) inspired the ISO TC 59 to undertake works in this direction. The series of norms published between 1980-1992 under the common heading *Performance standards in building* are expressing environmental requirements from point of view of users (ISO 6240, ISO 7162, PN-ISO 6241). Concepts of building design that encompass user requirements related to indor environment can be found in works of TC 205 - Building environment design.
Work on development of the *Performance concept* are being further explored within an ongoing Vth Framework project *Performance Based Buildings* (PeBBu) co-ordinated by CIB with Polish participation under the leadership of Warsaw University of Technology.

3.2. Normalisation within environmental management

Demand for uniformity of action in environmental management caused establishment of Technical Committee 207 - E*nvironmental management.* Series of norms of 1400 familly, among them e.g. ISO 14020 – Environmental labels and declarations, ISO 14040 – Life Cycle Assessment, 14062 – Enviromenal design have been elaborated since 1996.
The comprehensive approach of the works undertaken by ISO in both mentioned directions and potential of practical implementation of agreed provisions situates ISO as a leading organisation in a scope of environmental cousciousness in both indoor and outdoor environment.

3.3. Normalisation of environmental impact of buildings

ISO TC 59 / SC 3 has called, in 1999, into being working group 12 (WG12), with secretariat managed by Norwegian Science Foundaton to start work on preparation of series of standards about *Sustainability in building construction.* Several projects of standards have been worked out by this group ISO/CD 21929, 21930, 21931, 21932), none reached the final form. Moreover, after three years the WG12 has been elevated to new Sub-Committee 17 *Sustainability in building construction* composed of four working groups and with secretariat moved to AFNOR:

WORKING GROUP 1: General Principles and Terminology

CD 21932 - Building Construction – Sustainability in Building Construction – *Terminology,* recommended for Committee Draft.

WD 15392 - Building Construction – Sustainability in Building Construction – *General Principles,* recommended for Technical Report.

WORKING GROUP 2: Sustainability Indicators

CD 21929 - Building Construction – Sustainability in Building Construction – *Sustainability Indicators – Part 1 – Framework for development of indicators for Buildings,* recommended for Technical Specification.

WORKING GROUP 3: Environmental Declarations of Building Products

CD 21930 - Building Construction – Sustainability in Building Construction – *Environmental Declarations of Building Products,* recommended for Draft International Standard.

WORKING GROUP 4: Environmental Performance of Buildings

CD 21931 - Building Construction – Sustainability in Building Construction – *Framework for Methods for Assessment of Environmental Performance of Construction Works – Part 1 – Buildings*, recommended for Technical Specification

The all listed above documents should be ready by the end of 2004.

The work of WG4 presents efforts of harmosnisation of the framework of assessment and elaboration of categorisation, which can be internationally agreed and widely accepted, in situation where many coutries have developed national assessment systems.

The assessment framework should be as general as it should take into account the local/country/regional environmental context related to climatic conditions, construction tradition and social-cultural aspects. Moreover, framework should allow comparision of at least chosen building's features if not the whole objects, and use a common method for evaluation of environmental impact.

The following definition provides very adequate description of the goal of environmental performance:

> *The environmental assessment of buildings aims to examine the buildings and/or its surroundings, and the use of the buildings, from an environmental and resource perspective.*

The above, general definition, determines scope of issues to be taken into account in a proces of elaboration of methods and tools for environmental assessment of buildings. According to the assessment's intention the following distinction is applied:

- assessment on planning and design stage as an example of environmental care and element of 14000 series of norm connected with environmental management
- assessment of existing buildings as constructed assets from environmental point of view – often used for laballing purposes;
- assessment of building management process for the sake of evaluation of exploition quality of building as management, monitoring and control

Assessment is designed for comparisions of buildings' environmental quality, therefore it is important to have a set of agreed, categorised and identical features of same scope and clearly presented results. For these purposes it is necessary to determine assessment intention, its elements (issues, categories etc.), necessary data, their quality, and the way of results presentation.

The scope of an assessment depends on its intention, underlying assumptions, and will define the range of results. Assessment can encompass a whole building and its surroundings, or part of a building or groups of buildings, but the actual scope should always should be clearly indicated.

Quality of input data (parameters) influence the result of assessments. The measured data should be used as a priority. Calculated data or benchmark should include references to the data sources.

Assessment systems should have hierarchical tree structures of relatively few levels (branches) where the higher level comes from the lower. These levels are usually called issues, categories, criteria, sub-criteria and parameters. Every level can have assigned weights which depend on local, regional and country's conditions. Assignments of weights should be reliable, documented and same for the group of compared – evaluated buildings. Results of assessment should be presented in a form of different types of figures in a way facilitating comparision.

The assessment has mandatory and optional elements. The hierarchy tree for environmental performance assessment is presented on figure 1, and it reflects such issues of concern as: environmental impact, environmental aspects and indoor environment.

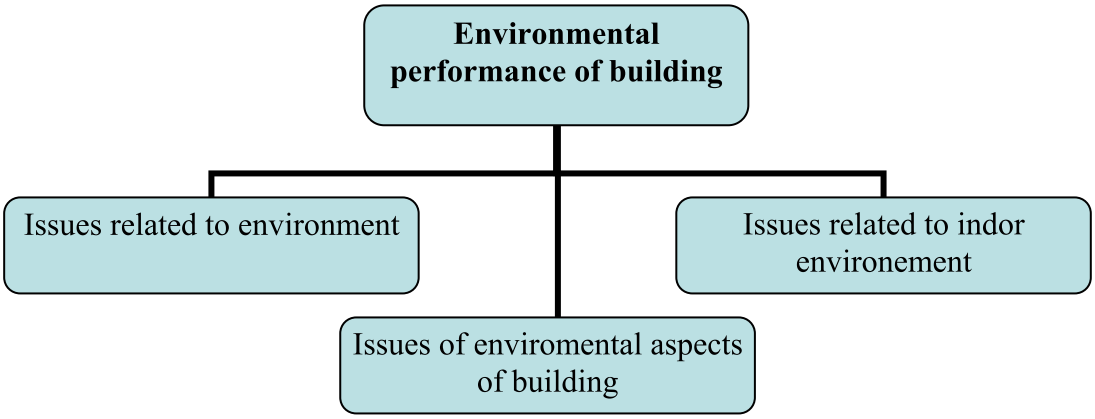

Fig.1 Main issues of environmental performance of buildings

Identified issues are issues related to environment (climate change, acidification, eutrophication etc.), issues of environmental aspects (energy and mass flow), and issues related to indoor environment (emissions, quality of light, water etc.). The proposed categorisation is similar to those taken in many national assessment systems, and in presented parts coincides with GBC 2002 method (worked out by experts from 20 countries and is a predecessor of internationally accepted method). The GBC 2005 system is silimar, but somewhat simplified and rationalised.

The issues referred above are mandatory, however the lower levels can contain optional, elements. The examples of optional elements of assessment are: economy of building, quality of building services, or management. Optional issues depend on local circumstances and construction tradition, and their assessment is biased by local subjectivity vs. international comparisons. Thus for local, national use the optional elements can be considered to be mandatory, as for example economical comparison of exploitation, capital and investment costs are locally well defined and objective.

The following description of development of issues of concern is only the one possible scenario, as they form the framework content of which can be adjusted to the designer of the system for specific purposes. The categorisation below is GBC driven.

Figure 2 presents the elements located under the **issue of environmental aspects of building**.

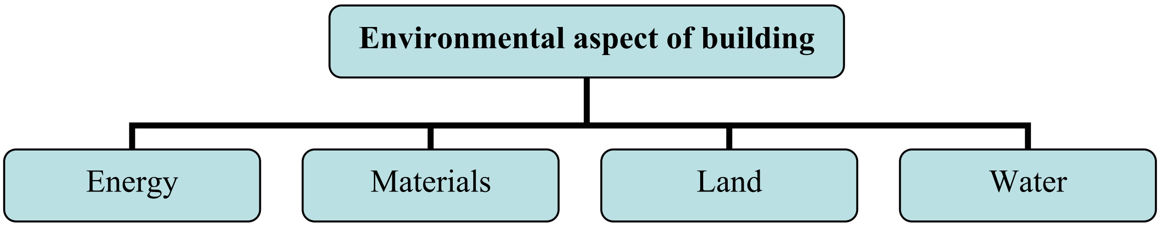

Fig. 2. Categories of issue related to environmental aspects of building

The environmental aspects of buildings are a well defined issue. The overall goal of its evaluation is estimation of amount natural resources taken from environment for erection, or

modernization of building (energy, materials, water and land). The use of resources is related to energy and mass flow provided to building and its surroundings distributed among the specific criteria of assessment.
Categories within this issue are (also in the GBC system) mandatory and can be divided in criteria, sub-criteria and parameters.

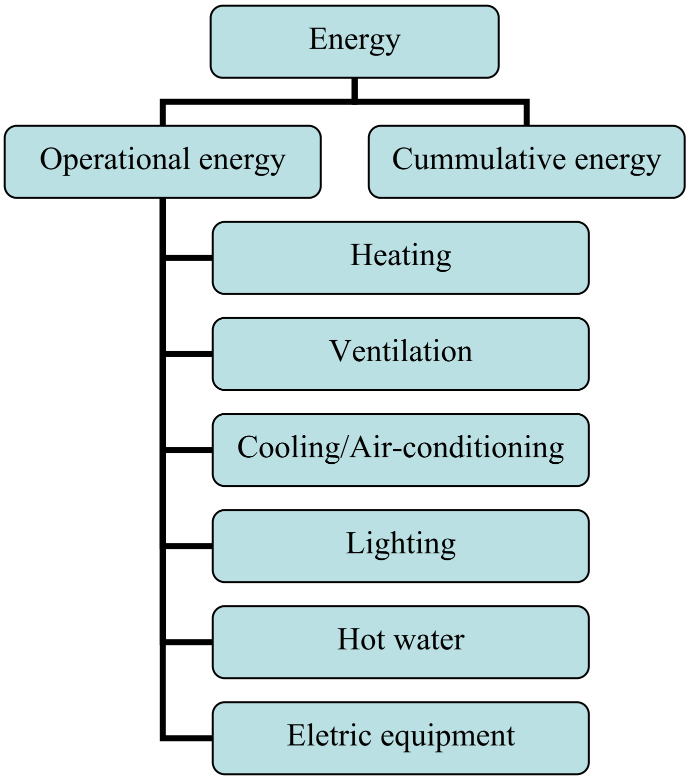

Fig 3. Proposal of criteria and sub-criteria for Energy category

Energy category is divided in two elements: Operational energy and Cumulative energy. The operational enegy develops to sub-criteria which depend on following parameters describing building features: characteristics of envelope (higro thermal and geometric); efficiency, type and kind of heating/cooling system; efficiency of ventilation; efficiency of heat recovery; efficiency and quality of lighting; efficiency of air-conditionig and control systems used by building and by the users; and finally the extent of renewable energy use.
Aviliabilty of data determines the ability of estimation of cumulative energy in materials used in building. Researches on energy use for materials production and on technological processes are the basis for construction of reliable databases in some countries. There are differences in statistical approaches which cause significant differences in results. There is not internationally agreed method of estimation of energy effectivity of products and thus this category is optional in many systems because of the lack of data.
Materials inhere are understood as materials used for production of construction products or building components such as for example clay, lime, sand, cement, steel and aluminium. The process of extraction of row materials should be supplemented by materials flow used for maintenance and overhaul of building elements. Thus, the evaluation of the category encompass efficiency of materials application and use, as well as their reuse, recycling or disposal after completion of technological service life of component or building itself.
Category *Materials* contains following criteria: materials reused, materials with recycled content, new materials, requirements for materials due to maintenance and overhauls.

Parameters describing the criteria could be use of hazardous substances for production of new materials, localisation of production site (to account environmental loadings related to transport), environmental declaration of building products, material outlays related to building operation.
The third indicated resource is category of *Water* developed into following criteria: collection and use of rain water, collection and use of grey water, tap water use. Parameters describing the criteria are: application of water saving devices, adequate construction of toilets, use of sensors, use of thermostatic batteries and hand dryers. *Water* is always mandatory category; however some of the referred criteria can be optional.
Land is considered as mandatory category and is not developed into lower levels. For evaluation of land the parameter describing flora, fauna and biodiversity is used.
The second environmental **issue of concern related to environment** contains following categories: *Impact on environment, Transport, Waste, External Environment*
Category *Impact on environment* is mandatory and is based on criteria related to air pollutions as emission of climate change gases (CO_2, CH_4, CO, N_2O,CFC); ozone layer depletion (CFC, HCFC and their derivatives), acidification of atmosphere (SO_2, NOx), photoxidants formation (VOC, NOx, CO), eutrophication (P andi N), eco and human toxicity and particulates formation (P10). In order to determinantion of above mentioned quantities the emissions of all types should be estimated based on analysis of all kinds of activity of building technical systems.
Category Transport, mandatory and is developing in following criteria: *Access to public transport, Frequency of local transportation, Existence of bicycles and walking paths*.
Category Waste depends on criteria: Number of fractions of sorting waste, *Content of not sorted waste, Application and avialiability of procedures related to hazardous waste*.
The last category of the issue is an External enviroment which deals with: *Exposition to noise, Outdoor air quality, and Electromagnetic pollution* e.g. from high voltage lines, etc.
The last, third mandatory **issue is related to indor environment** with following categories: *Thermal comfort, Indoor air quality, Noise, Lighting and Daylighting.* Thermal comfort could be assessed based on e.g. predicted percentage disappointed due to the temperature and air movement. Indoor air quality depends on emissions of bio-pollutants and emissions from building materials and furniture. Noise refers to internal sources (installation, motors, pumps etc.), transmission of nosie between building sections, ability for nosie damping in compartments, external noise. Lighting and Daylighting are referring to type of lighting, amount of day light and solar radiation.
Remaining issues as for example Building management, Quality of services and Economy (according to GBC [2] categorization) are considered as indirect in sense of environmental performance, and therefore are optional. This section has been somewhat reorganized in the GBTool for 2005.
The set of mentioned standards are under different stages of development. The Framework for the method of assessment of environmental performance of buildings deals with environmental issues, whereas groups WG1 and WG2 are working on sustainability principles, terminology and criteria. This discrepancy within SC17 indicates difficulties and challenges in extending environmental to sustainability performance. Some attempt towards assessing sustainability performance has been undertaken by SC3 before establishement of SC17.

4. Development of indices of environmnetal performance of buildings

Description of quantitive features related to building performance and quality of indoor environment is a subject of numerous scientific works and publications. The best examples of growing interest in the problem are cyclical conferences Healthly Buildings, Indoor Air etc.

attracting thousands of stakeholders from the whole world. In spite of the interest of scientific society, many problems remained usolved, as for example in case of non measurable building features there is no realiable satisfactory way of describing them in the quantitive terms. This diffuculty indicates a necessity for search a new ways of expressing requirements for assessment of indoor environment in buildings. Perhaps, in a similar way as in HDI (Human Development Index [3]) the predicted percentage of disappointed of indoor environment vs use of resources – defined by non dimensional indicator constructed with the same method as used for Enviromental Sustainability Index [4] can be used.
Discussions about the choice of adequate and realiable method of evaluation are the subject of research work and it is difficult to forecast today a common agreement. Would it be a development towards the aggregation of environmental features of building external and internal environment together? Or the comparison of outlays and effects within the environmental issues independently will be chosen in a future?
It is possible that the QEB (Qualité Environmentale du Bâtiment) French method, comparing two issues – conservation of environment (eco-construction and management) vs indoor environment (users health and comfort) is a step into the right direction?
Activity of ISOTC 205 constitutes the international forum for discussion about the agreement of rules within the best way of expressing non measurable environment related issues.

5. Actions for buildings sustainability in EU

The sustainable development paradigm initiated official statements presented by member states and by the European Union and mandated international organisations, research institutions, industial associations, local governments and other entities to undertake programmes addressing different issues of sustainability. Agenda 21 for Sustainable Construction published by CIB (1997), International Energy Agency Annex 31 of ECCBS Energy related environmental performance of buildings (2001-2003) is an example of sectorial approach towards such development.
Buildings and construction issues are subject of competence of Directorates General as TREN, Enterprise, Environment, Research and other agendas of EC.
The two directives form a basis for inclusion of sustaiablity into European legislation, and should stimulate researches supporting their provisions:

- Construction Product Directive (DG Enetrprise) referrs to six essential requirements, leads to product conformity. It does not provide a link between the performance base approached used in product specifications and a performance based approached for works. [5]. The works on new generation of CPD will explore this link.
- Energy Performance Directive (DG TREN) establishing new requirements of energy performance and creates a harmonised methods for calculation.

Surprisingly, the above official efforts did not get adequate attention for support from VIth Framework programme where construction and building researches took insignificant place within the work programme. Even at the information meeting, before the VIth Framework starting day, the representative of the EC stated that there no more research proposals are needed, and that priority will be given to demonstration projects. This is contradictory to the official statement from VIth Framework work programme itself:
The building sector is at present responsible for more than 40% of EU energy consumption. There are technologies under development, which could substantially improve (up to 30%) the energy performance of buildings, reducing the conventional energy demand in new and existing buildings and substantially contributing to reduce energy intensity, through combined measures of rational use of energy and integration of renewable energy technologies.(Priority 6.1 Sustainable Energy Systems, 6.1.3.1.2.1 Eco-buildings)

This situation is confusing and there is a need for co-ordination of actions undertaken by official bodies and stakeholders

The lack of integrated research in a dirction of sustainability in building sector can be illustrated by the recent process of harmonisation of methods establishing methodology of calculation of energy performance. The deadline introduced by EPD and amount of work to be completed by CEN and national bodies, showed the need for support from the research and scientific society, and fear about ability to follow the timeschedule. Moreover, it is now clear that the forthcoming technological decisions have wide influence on economies of member states, and there are researches needed to account these influences [6].

The Intelligent Energy for Europe the SAVE programmes managed by DG TREN partly addresses the researches for EPD e.g. ENPER project (Calculation tools used in European countries, 2001-2003) identifies state of the art and prepares some conclusions for designers of harmonised methods. The recent edition (2004) of SAVE promotes more actions related to EPD and details of accepted proposals will be announced soon, as they are now under the negotiation process.

To conclude short description of EC efforts the new initiative the Directive on environmental performance of buildings (planned by DG Enterprise) should be noticed. This idea is related to Energy Performance Directive, works of ISO and recent standarisation mandate to CEN (from DG Enterprise) about Development of horizontal standarised methods for the assessment of integrated environmental performance of buildings where the following standards and technical reports are proposed:

1. Framework standard for integrated environmental building performance. This framework standard is intended to provide the methodology for the assessment and the subsequent declaration of the integrated environmental performance of complete buildings and construction works.

2. Horizontal standard on the aggregation of LCA results of individual materials into the building, a standard that will provide the methodology for the aggregation of materials data or data on components to provide the overall integrated environmental performance of a building.

3. The Standard on LCA methodology for building products/materials will be based on the ISO TC 59 SC17 standard for the environmental declaration of building products, should provide an answer to the issues beyond the scope of ISO.

4. The Standard on the communication format/EPD should be based on the results of the standard for the LCA methodology for construction products/materials. The outcome of the LCA is one of the communication items of an Environmental Product Declaration.

5. Technical report on the assessment of the environmental performance of the construction process of a building, will provide LCA-based method for the assessment of the environmental impact of the construction process on relevant scenarios. It should identify which factors should be taken into account and which should not, what climate and what generalisations are acceptable regarding transport, etc. The results should be able to fit in the aggregation step for the integrated environmental performance of complete buildings and construction works.

6. Technical report on the assessment of the environmental performance of the end of life phase process (demolition, recycling, waste treatment processes) of a building and products. The deliverable will be a technical report that provides an LCA-based method for the assessment of the environmental impact of the end-of-life (demolition) process.

7. Technical report on the assessment of issues of building products related to the life time of the building (service life, durability, design, maintenance and replacement). The deliverable is a technical report that provides an LCA-based method for the assessment of the environmental impact of the maintenance and repair processes based on relevant scenarios.

The works foreseen on harmonised standards demand significant support from research institutions, as they have to be completed by December 2007, and require the co-ordination with the DG preparing Enviromental Performance Directive.
The taks related to mentioned directive, standarisation works and researches on buildings and construction requires integration of construction society to recover recognision at least proportional to its environmental impact.
Introduction of sustainability rules in economy requires special instruments, researches and additional funding. It for example could cause decrease of GDP, as is reported by UN Economic Commission of Europe in case of implementation of Kyoto protocol. It is because the GDP as a market factor does not account the external benefits whereas costs of implementation are real.

6. Towards sustainable buildings in Poland

6.1. Energy conservation a pace to sustainability?

In spite of the international recognition of building and construction environmental and sustainability issues, the idea of sustainable buildings is still under the initial development stage in Poland. Among the three options for building assessment: building - as an end use product and integrated assembly of products, building – as an active process and building – as a place to live; the first one, is commonly understood in Poland to be the subject of assessment.
The implementation of thermal protection of buildings in Poland has a form of regulation referring to maximum permissible heat losses (PN 02020) and requirements about maximum seasonal energy demand for heating for multiaoartment buildings only (PN 02025). There are other provisions related to energy, energy conservation and energy efficiency included in Constraction Law, Technical criteria to be met by buildings and Thermomdernisation Act in Poland. Many of existing provisions are rational and it this sense can be recognised as conforming with terms of sustainable development. But sustainable construction or sustainable buildings are not included in the regulation, as there are no requirements formulated for them.
Sustainable building in Poland is the subject of many discussions and papers, but there are no efforts leading to implementation of this way of thinking.
Therfeore, the dissemination of interantional achievements on creation of methodology of erection of buildings complying with sustainable development paradigm is not well supported by Polish technical society. The level of knowledge about future buildings is nearly same as number of demostration buildings existing in Poland – very limited. One of the examples of work dedicated to the change of such situation is the method of assessment of enviromental impact of buildings described in following section.

6.2. E-Audyt method

The E-Audyt method of environmental performance assessment of buildings (new and existing) has been created as a result of analysis of existing methods, and the work of GBC and ISO. It could be a prototype of official method for assessing environmental impact of buildings in the country scale. The method relies on building comparison in relation to the chosen standard. The standard is defined as a hypothetical building so called reference building, designed and erected according to existing norms and local best practices, which are characterised by the same shape, volume, number of rooms, their functions, number of users and location as the building assessed.
The assessment is a three stage hierarchical process. The lowest one is the sub-criteria, followed by criteria, and category which at the end forms the assessment of the issue. Features of the one level are the input to the higher level.

Detailed description of issues, categories and their components criteria and sub-criteria are provided in [7].
Sub-criteria are related to the assessment on the lowest level, and after normalisation and weighting their sum present the assessment of higher level – the criteria. Within the criteria the founding sub-criteria can have same units but sometimes it happens that they have a different units (like for Environmental Loadings different kind of emissions). The last case is a subject of normalisation in relation to some artificial scale.
The features not related to the assessed buildings, as for example energy demand for cooling, in case of non existence of air conditioning system, the criteria is not considered and marked as non applicable - N/A
Every component of assessment system has the value assigned from the relative scale, which allows objectivity and uniformity of the assessment at every level. Scale should have agreed graduation within the range containing recent demands for buildings and the demands beyond the existing norms and commonly used technologies. The scope of relative scale is from -2 to 5, where -2 represents building below the existing demands, and 5 reflects the best available solution.
All buildings are assessed in respect to 0 on relative scale, which represents the reference building. It should be noted that some of the features are simple to be assessed (such are called direct}. These, direct elements, as for example the composting organic wastes feature, are assessed based on their existence, for the cases assessment is a two value process where the -2 denotes non existence of the feature whereas 5 indicates its presence.
Assignment of values from the range of scale is performed on a level of sub-criteria or on a level of criteria for some simple features. The value assigned reflects the distance of the assessed building feature to the same feature of the reference building. For example, assessing seasonal heat demand, the reference building of some shape factor requires 283 MJ/m^3, and the case study building has 193 MJ/m^3, which is 32% less then the reference. The assigned value, from the scale is 4 which mean that case study requires 30% energy less then reference (0 on a scale). The resulting values are weighted (in order to reflect their internal importance) and summed. The definition of weights has been performed on a basis of analytical hierarchy method.
The framework of E-Audit system conforms to the framework of recent system being under the development by ISO TC59 SC17 WG4 and GBC, but for some of the features there are no reliable data in Poland. This includes for example the embodied energy in relation to materials and building components as it is required in Life Cycle Analysis. The E-Audit system is general and it can be applied to new and existing buildings of different types. Main issues of the framework are: Resources use, Environmental Loadings, Health and Indoor Environment, which are representing issues of environmetal impact.

6. 3. Local circumstances

The state of the art of implemention of sustainability issues in Poland is not only limited due to the lack of information about international and other countries achieviements or due to the underestimation of EU regulations.
The numerous presentations and publications are describing actual trends and experiences of leading research institutions, and activities of interantaional organisations during last years [19]. There are Polish versions of standards ISO-PN about expressing requirements in relation to indoor environment, environmental management and foundation of analysis according to life cycle. The existing Polish regulations have included basic essential requirements related to building product according to Directive 89/106/WE. The lack of knowledge about the environmental provisions of standards and essential requirements resulted in their general disrespect, as the adequate regulation did not include efficient control and monitoring

mechanisms. The common lack of interest of decision makers in the subject, lack of strategy for sustainable development, lack of funds supporting research and scientific works and no one demo building are only examples explanining the reasons. The result is that international commitments – as taken on cyclical Conferences of European Housing Ministries – where countries agreed on development of common research and development projects, and restructuring of administration to meet new challenges are not being fulfilled.

7. Conclusions

Initiators of GBC intended to create the platform for comparison of state of the art of the countries in construction of buildings environmentally friendly. The assumptions, methodology and categorisation of features, improved over the years, have been accepted by many countries as a basis for formulation and development of own assessment systems. The first experience of evaluating public, office, commercial, multiapartment and school buildings has been complemented by evaluation of modernised or existing buildings.

Commercially avialiable assessments are important elements of sustainable building policy in many countries. The necessity of respection of sustainable development rules in non questionable today and should introduce controlling mechanisms for the relation of fulfilling users requirements vs. enviromental burden related to them. The huge potential for improvement of environemtal quality of buildings, in situation where building and construction activities use 40% of fuels, indicates how wide the framework of future activities should be. There is a hope that the official declaration about sustainable development will be implemented and the environmental assessment of buildings will be an obligatory element of building project or modernisation in apredictable future.

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METHODS OF DETERMINATION OF CUMULATIVE ENVIRONMENTAL IMPACT IN PRODUCT MANUFACTURING

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1. Introduction

Applied to establish environmental profile of building, life cycle assessment encompasses the analysis and assessment of the environmental impact of building products, services and energy carriers throughout the entire building construction, use and demolition. The determination of the cumulative environmental loads are the obligatory element for the evaluation of industrial products in respect of their environmental impact. This resulted in the development of methods for determination of cumulative environmental loads of building products.

In references related to this subject, one can find a considerable number of publications devoted to the issue of cumulative energy consumption, which was the subject of interest in the 1970s and 80s [1,2,3]. However, more general problems related to cumulative environmental loads became topical at the end of the 80s and still continue to be a subject of interest. Definitions and methods applied in those problems also proved to be, to a great extent, useful when applied to determining cumulative environmental loads. Work [4] has brought a definition of cumulative pollution emission formulated in a similar way as in the case of cumulative energy consumption [4,99], although in considered application cumulative energy consumption is only one of environmental loads taken into consideration.

The need to determine the cumulative environmental loads, in particular in life cycle analysis, resulted in considerable increase of importance of process analysis method. For the use in LCAs analysis the principles of its practical use for products and services were standardized to a large extent in the ISO 14040 series of standards [5].

In the presentation an overview of the methods of cumulative environmental impact of industrial products has been done. Here environmental load is the quantity of substance put into the environment or quantity of resources taken from the environment. Environmental impact means the effect resulting from the load entered to the environment.

2. Cumulative environmental loads

Product manufacturing processes in different branches of economy are interrelated through a network of technological and energy relations. Demand for increased amount of specific products results in increased consumption of resources in all the processes related to the production of these products and on intensified generation of environmental loads of pollution and waste. In order to characterize a product, its environmental profile is determined, which is a set of environmental loads: consumption of non-renewable energy, non-energy and water resources, amount of pollution emitted and amount of generated waste.

Environmental load generated in the process of direct production of the given products does not encompass its total load, as they are generated also in many previous and simultaneous processes related to the production of this product. Resources necessary for the production of the given product as well as materials, semi-products and energy carriers also came into being in result of processes which generated specific environmental loads. These were done in the following processes [1]:

- acquisition of energy and non-energy resources,
- production of materials and semi-products,
- conversion of energy resources,
- transport of resources, materials, semi-products and energy carriers,
- construction of facilities and devices in which the given product is manufactured and the materials and semi-products are utilized,
- during manufacturing and distribution of products.

In consequence, environmental load of the given product is generated not only in the direct production process, but also in many earlier processes which are links in the production chain leading to a new product. Sum of environmental loads of a specified category generated at all stages of production and transport processes leading to the product in question are referred to as cumulative environmental load.

Cumulative environmental load characterizing industrial products is determined with the use of appropriate load indicators. Similarly, indicator of i-th cumulative environmental load per unit of product can be defined with the following formula

$$b_i = \frac{B_i}{P_k}, \tag{1}$$

where:
B_i – i-th environmental load generated in the chain of production and transport processes related to considered product,
P_k – net production of considered k-th product.

Environmental load with a given substance can be expressed as a vector **B** representing m loads of a given category. Each category can be determined on the basis of indicators of cumulative values of the respective loads and the amount of pollutants using the following formula:

$$\mathbf{B} = \mathbf{ß}_j \; G \tag{2}$$

where:
B – vector of environmental loads within the range of j-th impact category,
G – product quantity (mass of material, amount of energy),

ß*j* – column vector of product load indicators, e.g. quantities of different polluting substances per unit mass of material.

In order to determine environmental impact category, there is also need to determine cumulative equivalent environmental loads. Potential equivalent environmental load within the range of a given impact category for the whole product system equals to the sum of potential impacts generated by all the loads introduced into the environment during the product life cycle that contribute to the occurrence of the considered impact. Within the range of *j*-th category, potential environmental impact is determined by the following sum:

$$\Omega_j = \sum_{i=1}^{m} \mathbf{b}_{ij} B_i = \mathbf{b}_j^{\mathrm{T}} \mathbf{B}_j \tag{3}$$

where:
O_j – potential environmental impact within the range of *j*-th environmental impact category caused by *m* different loads,
b_{ij} – equivalent of *i*-th environmental load for *j*-th environmental impact category.
m – number of loads within the range of *j*-th category.

Taking into account formula (2), *j*-th equivalent cumulative environmental load (*j*-th impact category), determined by formula (3), generated in production of material of mass *G*, can be presented with the use of the formula:

$$\Omega_j = (\mathbf{b}_j^{\mathrm{T}} \mathbf{ß}_j)\, G \tag{4}$$

We may define the indicator of the cumulative equivalent environmental impact using the similar formula as for $ß_j$, that is

$$\hat{b}_j = \frac{\Omega_j}{G}, \tag{5}$$

where:
O_j – cumulative equivalent *j*-th environmental impact, whose components are generated in the chain of production and transport processes related to the production of product within the time period in question.
Using the formula (4) the indicator of *j*-th equivalent environmental impact category $\hat{b}_j$ is determined with formula [4,6] is

$$\hat{b}_j = \mathbf{b}_j^{\mathrm{T}} \mathbf{ß}_j \tag{6}$$

The indicator $\hat{b}_j$ of the equivalent environmental impact expresses potential environmental impact of *j*-th category caused by 1 kg of substance of reference per unit of product (e.g. for greenhouse effect measured in kg of CO_2). It is a value that characterizes products (construction materials, production processes, services, elements of products, energy carriers) manufactured according to specific production technologies.

Taking into account the formula (6), equivalent environmental load expressed with the amount of the substance of reference (load category) shall be expressed with the formula:

$$\Omega_j = \hat{b}_j G \tag{7}$$

It would be useful to characterize the building products with the use of the set of indicators of equivalent environmental impacts.

3. Methods of the determination of cumulative environmental loads

3.1. Introduction

Determination of the indicators of cumulative loads can be done with the use of methods similar to the ones already applied in calculations of cumulative energy consumption [1,3]. To determine the cumulative environmental loads it is possible to use the following methods:

- the process analysis method,
- balance equation system method for a single product,
- balance equation system method for a number of products.

The set of balance equations should be established for each environmental polluting subsance that enters the environment or for each equivalent environmental impact.

The method of process analysis to determine specific cumulative environmental impacts uses the analysis of networks of processes of product manufacture, that are analysed backwards, starting with the process considered, in which the final product is created, through consecutive ones, until the processes, which contribution in the environmental impacts are negligibly small. The need to determine the cumulative environmental loads, in particular in life cycle analyses, resulted in considerable increase of importance of process analysis methods and those of products and services were standardized to a large extent in the ISO 14040 series of standards.

Many works manufacture certain products, whose manufacturing processes are not interrelated. In such cases, the application of the graph theory allows to formulate a set of balance equations and to determine the cumulative environmental impacts of one product. The application of the method of a system of balance equations requires the knowledge of several basic notions from the graphs theory.

In case of simultaneous manufacture of several products in one company or products manufactured in the whole national economy, the method of a set of load balance equations based on application of the theory of inter-branch flows (based on input-output analysis) can be used to determine the cumulative environmental impacts.

3.2. Process analysis method

In the production processes of the given product, direct energy carriers are consumed as well as non-energy resources, air and water. These inputs introduce environmental loads that have been generated in their previous production processes before delivery of semi-products for the considered process. These loads are due to: consumption of energy and non-energy resources, water and emission of pollutants, waste and many others. There may occur loads generated directly in the given production process. Environmental loads introduced and generated in the given process participate entirely in the load of the stream of final products and semi-products created in the process in question.

The diagram shown in Fig.1 presents the course of process analysis used in determining the environmental load characteristics, giving a picture of the network of interrelations between the process of production the considered product and the processes of acquisition of resources and semi-finished products and of production machines and equipment [1,3]. The network of process interrelations has been divided into four levels. Calculation starts at level 1, at which loads are determined resulting directly from technological and transport processes for the product for which environmental load is searched for. Level 2, which covers loads related to acquisition, transport and stocking of energy and non-energy materials as well as with production of semi-products for level 1. At level 3, loads taken into account are generated during production of machines and equipment for level 1, as well as loads related to acquisition, transport and stocking of energy and non-energy materials and to production of semi-products for level 2. Possible feedbacks in the form of products a part of level 1 for production at levels 2, 3, 4, level 2 for production at levels 3 and 4 and level 3 for production at level 4. Flows of semi-products, energy carriers, machines and equipment transmit environmental loads. In practical applications, process analysis is usually completed at level 2, which according to [3] provides the value of cumulative loads at 90÷95% of the cumulative environmental load. When considering the cumulative energy consumption, omitting investment element that occurs at level 3 causes error not higher than 2.5% [3]. Similar errors can be expected when considering the emission of pollutants and other loads. Process analysis usually begins by drawing a diagram which presents the network of process interrelations between the final product of the process in question and raw materials and semi-products used in the considered process.

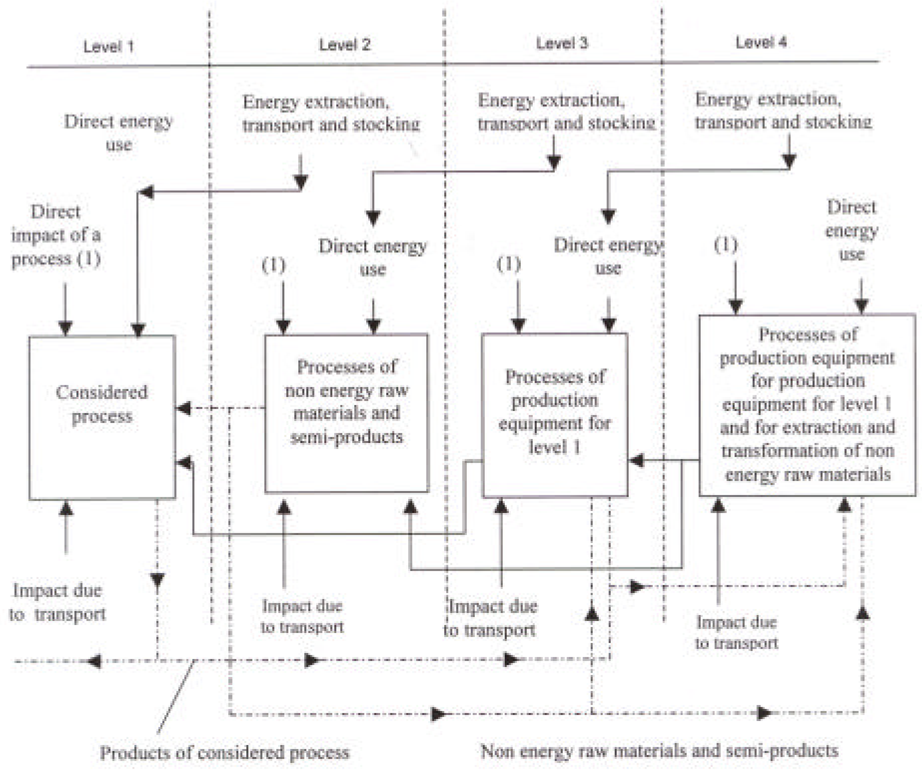

Fig 1. Diagram of process analysis to determine the cumulative impact on the environment of considered product: (1) – direct impact on the environment due to production process

Example

Example of applying process analysis method to the cumulative pollution emission of CO_2 for cement production is presented in fig. 2. Input data for the calculations are: values of energy and material streams delivered to the respective process links and cumulative pollution emission indicators for primary fuels and electrical energy and for non-energy materials, which are: limestone, gypsum, blast-furnace slag and possibly other additions. The important semi-product in cement production process is clinker, for which the process diagram is shown in fig. 2 to facilitate calculation of the cumulative emission of CO_2 or other substances.

In the example in question, transport processes have not been singled out. Both the transport of limestone and internal transport are powered with electrical energy, whose consumption was measured jointly with the consumption of this energy in other processes.

The diagram shown in fig. 3 [4,6] facilitates the calculation of cumulative emission also for many other pollutants which are generated in the cement production process. In particular, it is possible to determine cumulative equivalent environmental impact of different categories.

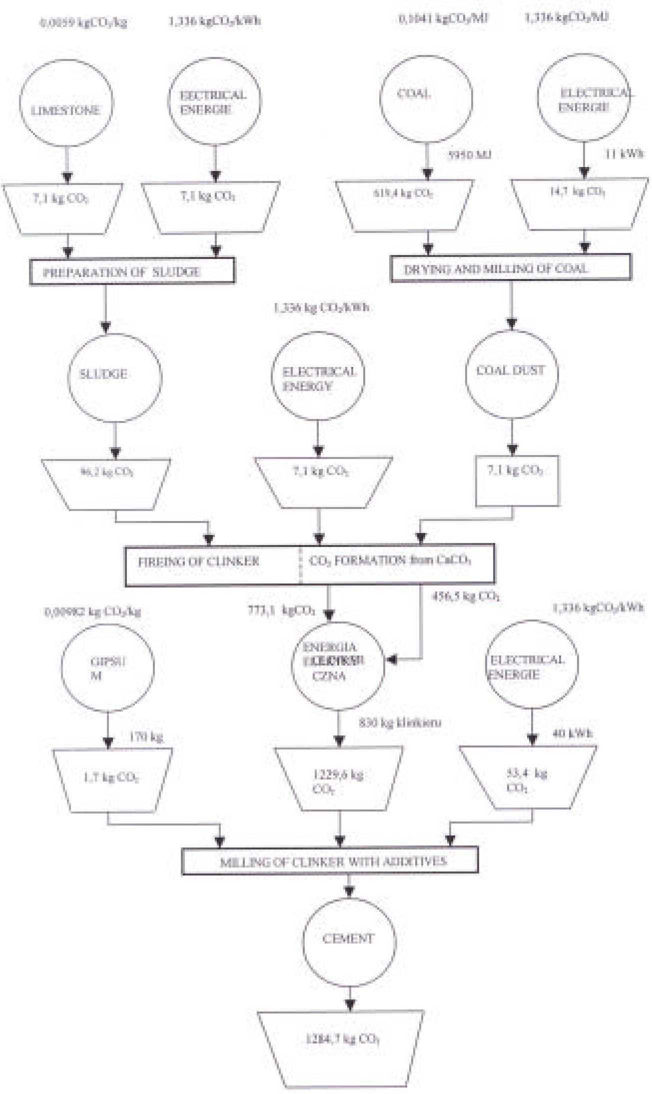

Fig. 2. Diagram of process analysis to determine the cumulative CO_2 emission for wet cement production process [4]

3.3. Balance equation system method for a single product

Application of the balance equation system method for determining cumulative environmental load indicators for single industrial products requires knowledge of a number of basic concepts of the graph theory [7,8].

Many works manufacture certain products, whose manufacture processes are not interrelated. In such cases, the application of the graph theory allows to formulate a set of load balance equations and to define the cumulative environmental loads.

In order to calculate the specific cumulative environmental load for any product in the considered company, a general chart of manufacture process should be prepared, including all technological operations of the process. A basic example of such chart has been shown in Fig.4.

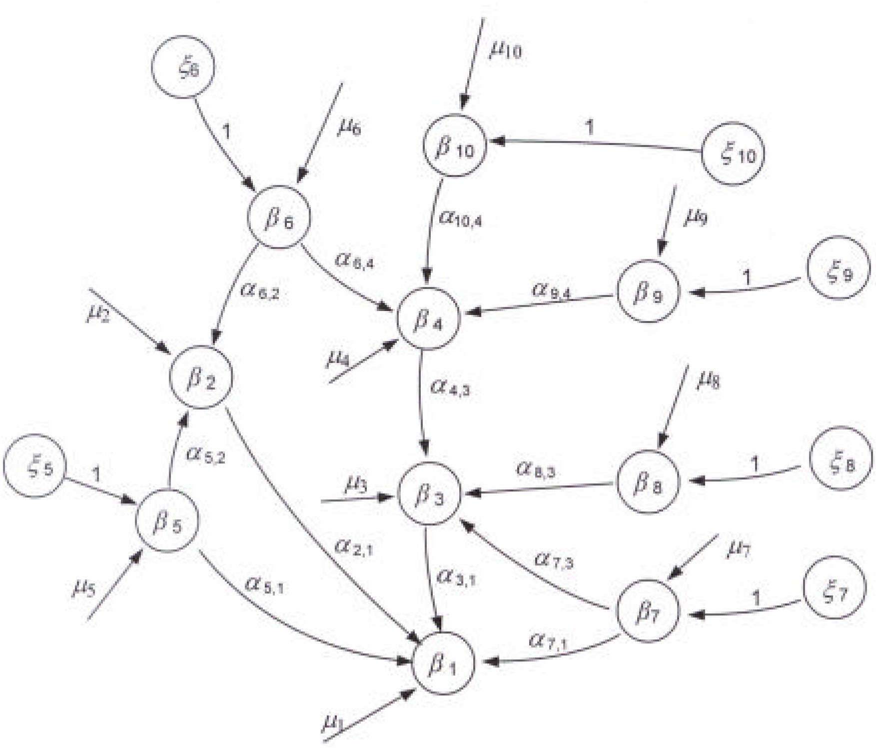

Fig. 3. Example of the graph indicating the environmental load transfer in the production process [4,6]

A graph node, with the label $ß_j$ variable, which is the value of cumulative load for a given semi-product, is assigned to semi-product manufactured in each operation. Then the following is supplied to individual nodes (technological operation): semi-product from previous nodes, raw materials and technological materials, as well as energy carriers in amounts necessary for manufacture of given amount of semi-product represented by given nodes. Furthermore, loads (emissions, waste) can be created in individual operations, which should as well be included in load transfer graph. The node labelled in Fig. 3 with $ß_1$ variable represents the final product.

Thus, in the load transfer graph, every node represents certain semi-product, which is distinguished by a label including the name of semi-product, as well as cumulative environmental load. The edge from $ß_i$ to $ß_j$ means, that carrying of loading $ß_j$ depends on node $ß_i$, not inversely. For each a_{ij} edge, a number is assigned, which defines the multiplication of load transferred from node $ß_i$ to $ß_j$. It means, that load transferred from node $ß_i$ to $ß_j$ is $a_{ij}ß_i$. The node representing variable x_i does not have incoming edges but only outgoing ones. x_i nodes represent all load input from outside into individual partial process. Moreover, the internal load m_j, is generated directly in the j-th process.

Each graph node $ß_j$ represents one equation of the load transfer graph, in which the symbol $ß_j$ is equal to the sum of products of the weights of all the input edges and initial node labels $ß_i$ of these edges increased by the load m_j, which is a result of the process j. For example, for the node $ß_3$ the load balance equation is the following:

$$a_{4,3}b_4 + a_{7,3}b_7 + a_{8,3}b_8 + m_3 = b_3. \quad (8)$$

Similarly, for the load *ß₆* which represent the semi-product supplied from outside, represented by the x_6 node, one gets the following equation:

$$x_6 + m_6 = b_6. \quad (9)$$

This way, for the network operations represented in the graph shown in the figure 4, one can write 10 equations of the form [4,6]:

$$\sum_{i \neq j} a_{ij} b_i + x_j + m_j = b_j, \quad (10)$$

where:
a_{ij} – weighting multipliers of burden transfer from semi-product *i* to semi-product *j*,
m_j – direct environmental burdens generated in *j*-th operation of process,
$ß_i$, $ß_j$ – environmental cumulative burdens of semi-products living the processes *i* and *j*,
x_j – environmental cumulative burdens due to exterior energy carriers, technological materials and semi-products.

In the equation (10), the sum refers to all the edges that represent the respective stream loads for the given node. Set of balance equation of cumulative environmental loads can be used to calculate the cumulative environmental load for semi-products in operations as well as for loads that occur directly in each of the process operation. The set of balance equations for the given load (10) using the matrix notation takes the form:

$$\mathbf{A}^T \mathbf{ß} + \mathbf{?} + \mathbf{\mu} = \mathbf{ß} \quad (11)$$

or

$$\mathbf{ß} = (\mathbf{I} - \mathbf{A}^T)^{-1}(\mathbf{?} + \mathbf{\mu}). \quad (12)$$

where:
I – unit diagonal matrix,
$\mathbf{A}^T$ – matrix of weighting multipliers a_{ij} of environmental load transfer,
ß – column vector of cumulative environmental load for all semi-products,
x **–** column vector of cumulative burdens to carry in the process as energy carriers, technological materials and products,
µ – column vector of direct burdens generated in each operation of production processes.

The unknown figures in the obtained set of equations (10) are cumulative loads for the respective semi-products manufactured in the process network, represented by the respective nodes $ß_j$. The a_{ij} element of weight matrix larger than zero (a_{ij}>0) means that the production of a single operation, energy carriers, technological materials described by the $ß_i$ variable is related to load bearing, while the a_{ij} elements equal to zero (a_{ij}=0) means that the creation of product $ß_j$ does not entail neither the semi-finished product $ß_i$ nor energy carrier nor technological material.

Equation (12) is formulated for semi-products, meaning the products that are consumed entirely or partly in other chain links of the given production process, and for the final product of this process, represented in fig. 3 by node $ß_j$. Energy carriers are also regarded as semi-products. Matrix $(\mathrm{I}-\mathbf{A}^T)^{-1}$ should take into account all the semi-product production process links in the whole chain of operations leading to the creation of the final product.

In order to find cumulative loads for a given product manufactured at a given company, one has to solve equation system (12) making into account the fact that all the all goods (semi-products) refers, for example, to specified mass or one unit of product. When calculating cumulative load of a product, first one needs to distinguish all the semi-products (energy carriers and secondary products as well as materials and typical components, subassemblies and assemblies) that are obtained from outside and make the final product. Specifying the number of semi-products incoming to the technological process from outside allows for determining column matrix x of cumulative loads introduced to the process by these semi-products. At the same time, one determines elements of weight multiplier matrix $\mathbf{A}^T$ of general load transmission graph which describes the analyzed production process.

By solving the algebraic linear equation system (12), we obtain cumulative loads characterizing the final product and all the semi-products made in intermediate (partial) process chain links that have impact on the cumulative load level of the final product. At the same time, one obtains information as to what factors have the highest impact on the cumulative loads characterizing the given final product.
It should be highlighted that for the process chain in question, the equation system (12) is written separately for each respective environmental impact category. In industrial practice, production processes for different products are usually interrelated, whereas correct separation of material and energy streams is often difficult. This can be done by making detailed analysis of all the production process chain links.

Example
On the basis of the data given in [8] on calculation of cumulative energy use in cast iron production process of mass 5,5 kg, it the indicator of cumulative CO_2 emission was evaluated. In the considered process 18 technological operations were distinguished: 1 – heat treatment of casting, 2 – removal of gating system, 3 – cleaning of casting, 4 – knocking out of casting, 5 – casting into moulds, 6 – metallurgical operations, 7 – smelting of cast iron, 8 – smelting of local scrap, 9 – mould assembly, 10 – fasten the core, 11 – preparation of core, 12 – preparation of core box, 13 – processing of core compound, 14 – fasten of semi-mould, 15 – preparation of semi-mould, 16 – preparation of model, 17 – processing of moulding sand, 18 – regeneration of moulding sand.

System of equations given In general form using the formula (11) is given below. According to [8] it was assumed, that cumulative emissions of CO_2 in operation 8,12 i 16 are negligibly small, so the obtained system of 15 equations is:

1. $a_{2,1}b_2 + m_1 - b_1 = 0$, 2. $a_{3,2}b_3 + x_2 - b_2 = 0$, 3. $a_{4,3}b_4 + x_3 - b_3 = 0$, 4. $a_{5,4}b_5 - b_4 = 0$

5. $a_{6,5}b_6 + a_{9,5}b_9 + x_5 - b_5 = 0$, 6. $a_{7,6}b_7 - b_6 = 0$, 7. $x_7 + m_7 - b_7 = 0$,

8. $a_{10,9}b_{10} + a_{14,9}b_{14} - b_9 = 0$, 9. $a_{11,10}b_{11} + x_{10} - b_{10} = 0$, 10. $a_{13,11}b_{13} + x_{11} - b_{11} = 0$

11. $x_{11} - g_{11} = 0$, 12. $a_{15,14}g_{15} - g_{14} = 0$, 13. $a_{17,15}g_{17} + x_{15} - g_{15} = 0$,

14. $a_{18,17}b_{18} + x_{17} - b_{17} = 0$, 15. $x_{18} - b_{18} = 0$

The values of the vector x for the considered operations:
x_2 = 0,1490 kg CO_2 , x_3 = 1,2675 kg CO_2 x_5 = 0,04254 kg CO_2 , x_7 = 1,4495 kg CO_2 , x_{10} = 0,6448 kg CO_2 , x_{11} = 0,1955 kg CO_2, x_{13} = 0,4524 kg CO_2 , x_{15} = 7,136 kg CO_2 x_{17} = 0,00866 kg CO_2 , x_{18} = 0,001062 kg CO_2 .

Weighting multipliers a_{ij} according to [8];
$a_{2,1}$ = 1,111, $a_{3,2}$ = 1,0, $a_{4,3}$ = 1,0, $a_{5,4}$ = 1,0, $a_{6,5}$ = 3,122, $a_{7,6}$ = 1,0, $a_{10,9}$ = 1,08, $a_{11,10}$ = 1,0, $a_{13,11}$ = 1,077, $a_{14,9}$ = 1,08, $a_{15,14}$ = 1,0, $a_{17,15}$ = 1,12, $a_{18,17}$ = 0,946.

Direct emissions of CO_2 take place only in processes 1 i 7 and are generated during the combustion process of fuel oil and coke, so we obtain: m_1 = 0,1522 kg CO_2 , m_7 = 0,3528 kg CO_2. Solution of the above system of equations gives the result: indicator of cumulative emission of CO_2 iron casting $ß_1$ = 3,308 kg CO_2/kg.

3.4. Balance equation system method for a number of products

The balance equation system method applied for determination of cumulative energy consumption for a number of products is presented in publications [1,3]. In this paper, the method has been modified for adaptation the system of equations formulated therein to the determination of cumulative environmental loads. Cumulative consumption of energy resources is one of considered environmental loads.

Balance equation system method applied for determination of cumulative environmental load is based on the assumption that cumulative environmental load burdening a product of the given process is the result of cumulative environmental loads burdening the process substrates and loads generated in the process as well as coming form other sources than energy consumption (dusting, chemical decomposition, chemical reactions).

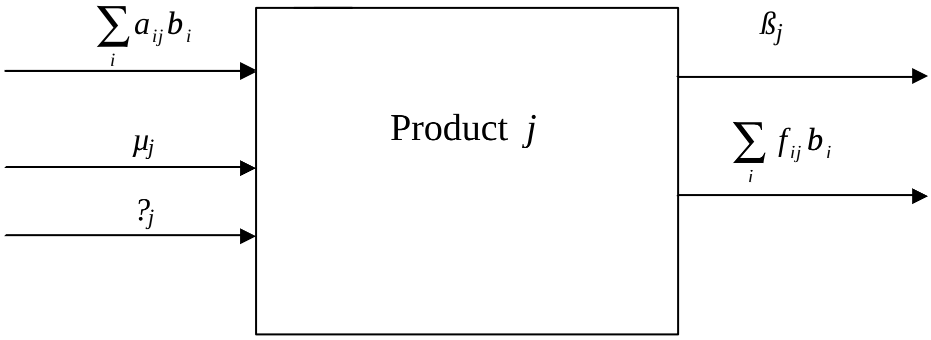

Fig. 4. Inputs and outputs in production process of j-th product

Inputs and outputs in the production process is presented in fig.4. The result of process j is the main product characterized with cumulative load g_j resulting from consumption of i-th semi-product and by-products with designated as $?_i$. Process j can directly generate environmental loads $µ_j$, whose origin is not related to energy consumption. Load $µ_j$ is considered as the system input, as shown in the diagram illustrating the production process of product j. Searched cumulative environmental load $ß_j$ resulting from transmission of loads of semi-products, supplied energy carriers and from direct consumption of energy carriers in process j, and also from load generated directly in j-th process, can also be written in the form of the following equation:

$$\sum_i a_{ij} b_i + x_j + m_j = b_j + \sum_i f_{ij} b_i , \qquad (13)$$

where:

$?_i$, $ß_j$ – cumulative loads of semi-products used for production of i-th or j-th product,

a_{ij} – share of direct consumption of i-th semi-product per j-th main product,

f_{ij} – multiplier of side production of product i in the technological process of production the main product j,

$?_j$ – load resulting from direct energy consumption in j-th process, $µ_j$ – load generated directly in j-th production process.

Equation (13) can be established for any given load, that is: for a single pollutant (such as CO_2, SO_2, NO_x), for solid waste or for equivalent emission (for example for substances that contribute to the greenhouse effect). It can also be stated for such environmental loads as energy, water or non-energy resource consumption.

In the matrix notation, equation system (13) will have the following form:

$$\mathbf{A}^{T}\mathbf{ß} + \mathbf{?} + \boldsymbol{\mu} = \mathbf{ß} + \mathbf{F}^{T}\mathbf{ß} \qquad (14)$$

or

$$\mathbf{ß} = (\mathbf{I} - \mathbf{A}^{T} + \mathbf{F}^{T})^{-1}(\mathbf{?} + \boldsymbol{\mu}). \qquad (15)$$

where:
$\mathbf{A}^T$ – matrix of semi-product share in j-th product,
$\mathbf{F}^T$ – matrix of secondary semi-finished product production rates,
ß – vector of cumulative loads for main products,
x **–** vector of environmental loads generated by direct consumption of energy carriers in main product processes,
µ – vector of loads generated directly in main product processes.

Equation (14) is formulated for semi-products, that is for the products that are consumed totally or in part in other production processes. Energy carriers can also be classified as semi-products. When considering overall national production, matrix $(\mathbf{I}\text{-}\mathbf{A}^T\text{+}\mathbf{F}^T)^{-1}$ should encompass all branches of semi-finished product production in the whole economy. Equations related to ready-made products not consumed in production processes are independent from other equations and can be considered after calculating $ß_i$ indexes for semi-finished products.

The balance equation method for the determination of cumulative environmental loads examined here is usually applied for the whole country. Equations written for all branches of economy, encompassing all product manufacturers, allow to determine the average load values for products manufactured over the considered area.

4. Overall environmental impact of building resulting from that of products

Building is an assembly of various products and not all environmental impacts are the simple set of those of building elements.

Design decisions as to building are made at a specific point in time – with implications that can extend for decades. The life cycle assessment embraces a sequence of events that precede and extend past that point of decision. It means that the life cycle of the material or product will consist of a portion of environmental impacts incurred up to that time and those which will be incurred during the future life of the material or product in the context of the building. Each of these includes events of varying degrees of certainty. For example, a designer will typically have full knowledge of the specific circumstances of a building project including the type, quantities and specific application of materials in the initial design but is faced with all the uncertainties associated with un unknown future.

Life cycle resource use and environmental impacts include all those incurred in the production, use and removal of building. For this reason, it is useful to distinguish between these distinct phases of a building's life cycle [10]:

- the resource use and environmental impacts to initially produce the building;
- the recurring embodied resource use and environmental impacts incurred over the effective life of the building, including both those:
  - associated with the refurbishment and maintenance of the building,
  - to operate the building: the energy required to condition (heating, cooling, ventilating) and to light the interior spaces and to power equipment and other services;
- the resource use and environmental impacts to demolish and dispose of the building et the end of its effective life.

Energy is one issue for which there are relatively complete and comprehensive data on wide range of common building materials and across all phases of the building life cycle. Data on resource use, airborne emissions, liquid effluents and solid wastes has been emerging for many material options.

In the figure 5 the progress of cumulative environment load is shown. At the moment t=0 the operation phase of a building life cycle begins. Just at t=0 the cumulative environmental burden equals to O_p: it is the end of the initial phase of the life cycle. During the period t=0 – t_1 we observe the linear increase in O due to the use of energy and water. At the moment t_1 the decrease in O takes place due to building maintenance and repairs. In the period $t_1 – t_2$ the curve progress is similar as in the first of operation period 0 – t_1 . However, due to refurbishment of building the energy required for heating decreases so the subsequent increase in cumulative burden is smaller than that in the first operation period. After the decision on building demolition at the moment t=t_n the increase of the cumulative environmental burden O is noted. At the end of demolition phase total cumulative environment burden of building takes the value O_C .

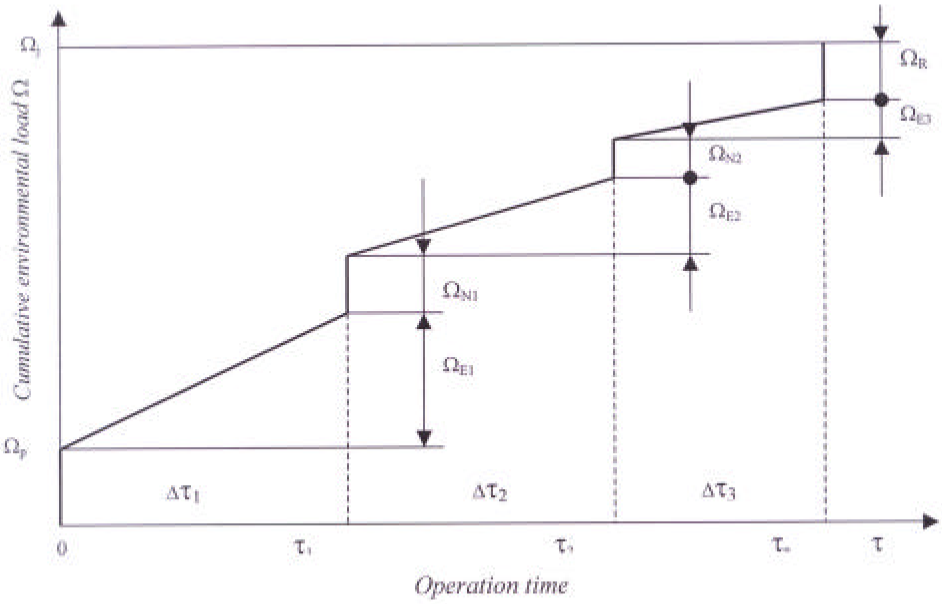

Fig.5. Cumulative environmental load of a building versus its operation time

According to figure 5 the cumulative resource use and environmental impacts (j-th cumulative environmental load) within the life cycle of a building may be written in the following way [6]:

$$\Omega_J = \Omega_P + \Omega_E + \Omega_N + \Omega_R, \qquad (16)$$

where the environmental load resulting from: Ω_P - initial production of a building, $\Omega_{E,n}$ - energy and water use to operate building, Ω_N - maintenance and repairs, Ω_R - building demolition and respective waste disposal.

According to figure 5 cumulative environmental load for the operating phase due to the energy and water use is the sum:

$$\Omega_{E,n} = \sum_{i=1}^{s+1} t_i \Omega_{Ei}, \qquad (17)$$

where:

O_{Ei} – cumulative environmental load for the period t_i,
t_i – operating time between the two subsequent renewals of building,
s – number of renewals during lifetime (fig.5).
Also cumulative load due to maintenance and repairs during the building lifetime is:

$$\Omega_N = \sum_{i=1}^{s} \Omega_{Ni}, \tag{18}$$

where:
O_{Ni} – cumulative environmental load for *i*-th renewal process during operation (fig.5).
Taking into account (17) and (18) the environmental load within the life cycle of a building takes the form

$$\Omega_j = \Omega_P + \sum_{i=1}^{s+1} t_i \Omega_{Ei} + \sum_{i=1}^{s} \Omega_{Ni} + \Omega_R \ . \tag{19}$$

The formula (19) may be particularly useful in case of cumulative energy consumption and cumulative emission of CO_2. In general not all environmental impacts are simple set of those of elements.

5. Conclusion

In life cycle analyses of building there is a need to determine the cumulative environmental loads of products, which are necessary element to evaluate its environmental impact. This resulted in the development of methods of the determination of specific cumulative environmental impacts (environmental impact indicators) which are described in the presentation.

In application to life cycle analysis of building considerable environmental conservation efforts must be made to understand and minimize the current and future environmental impacts of the consumption and production of building materials, components and assemblies as well as services and energy carriers.

An example of applying process analysis method to the cumulative pollution emission of CO_2 for cement production has been presented. Also an example of application of a set of balance equations in production of cast iron is done.

The equivalent environmental impact indicator has been introduced which expresses potential environmental impact caused by 1 kg of substance of reference per 1 kg of a given substance (e.g. for greenhouse gases – in kg of CO_2). The value of indicator characterizes the product (construction materials) manufactured according to specific production technologies.

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ENVIRONMENTAL PROFILE OF BUILDING ELEMENTS MADE FROM VARIOUS MATERIALS

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1. Introduction

Environmental profile of a product is a set of environmental impact category indicators that are referred to as equivalent environmental loads. The basis for determining energy-environmental characteristics are cumulative environmental load indicators set as inputs or outputs of many links in the production process chain.

Construction object is made up of many products and materials, whose environmental profile should be known before we start performing the object's evaluation. The building's environmental impact begins already at the stage of extraction of resources needed for producing materials necessary for constructing the object. Therefore, in order to perform environmental impact evaluation, it is necessary to trace the influence of this impact from the moment of intake of resources from the environment to the moment of completion of the elements utilization stage after the object has been demolished.

In the example of determining environmental profile of a one-family building presented in this study, one has used the methodology prepared at the Building Research Institute and presented in monography [1]. The discussed example of environmental profile evaluation of a detached house serves the purpose of presenting the method as well as its further development and discussion, similarly as it has been done for external partition wall of a building [2].

2. Environmental profile of a product

According to [5], environmental profile of a product is determined as a set of values of selected environmental impact category indicators characterizing the product in its full life cycle. This can be written in the form of column matrix **O**

$$\mathbf{O}^{\mathrm{T}} = \{\Omega_E, \Omega_M, \Omega_W, \Omega_{GWP}, \Omega_{ODP}, \Omega_{AP}, \Omega_{POCP}, \Omega_{HTA}, \Omega_{HTW}, \Omega_{ET}, \Omega_S\} \quad (1)$$

where:

Ω_J – index of *J*-th category of environmental impact generated in the product's full life cycle: $J \equiv E, M, W, GWP, ODP, AP, POCP, HTA, HTW, ET, S$ where the following have been marked:

E – energy consumption,
M – consumption of non-energy resources,
W – water consumption,
GWP – global warming potential,
ODP – ozone depletion potential,
AP – acidification potential,
HTA – human toxicity in air,
POCP – photochemical ozone creation potential,
HTW – human toxicity in water,
EP – eutrophication potential,
S – amount of waste.

Selection of environmental impact categories taken into account in environmental profile depends on the type of the examined problem and on the purpose and scope of the analysis.
Upon consideration of the respective stages of the object's life cycle in study [1], dependencies determining cumulative environmental loads have been formulated. Total cumulative environmental load of *J*–th category in construction object's full life cycle is the following sum [1]:

$$\Omega_J = \Omega_P + \Omega_E + \Omega_N + \Omega_R, \quad (2)$$

where indexes: *P* – erection stage, *E* – operational stage – usage, *N* – operational stage – operations, *R* – liquidation stage.

In formula (2), environmental load in the exploitation stage is considered as a sum of two components:

- environmental load during usage (by users and due to performing servicing actions),
- environmental load due to performing exploitation operations.

The course of cumulative environmental load in time can be determined on the basis of loads in the respective stages of the life cycle that is calculated on the basis of the object's known characteristics and of the known schedule of its exploitation. The object exploitation schedule should contain detailed scope of all the projected exploitation operations and the corresponding consumption of materials and energy carriers in the assumed period.
Cumulative environmental load in full life cycle of a construction object can be expressed with the following formula [3]

$$\begin{aligned}\Omega_C = {} & \Omega_{Puz} + \mathbf{x}_{Pm}^{\mathrm{T}}\mathbf{G}_{Pm} + \mathbf{x}_{Pw}^{\mathrm{T}}\mathbf{G}_{Pw} + \mathbf{p}_{Pw}^{\mathrm{T}}\mathbf{P}_{Pw} + \mathbf{L}_{Pt}^{\mathrm{T}}(\mathbf{G}_{Pt}^{\mathrm{D}}\mathbf{x}_{Pt}) + \\ & + \sum_{i=1}^{k+1} t_i \Omega_{Ei} + \sum_{i=1}^{k} \Omega_{Ni} + \mathbf{p}_{Rw}^{\mathrm{T}}\mathbf{P}_{Rw} + \mathbf{L}_{Rt}^{\mathrm{T}}(\mathbf{G}_{Rt}^{\mathrm{D}}\mathbf{x}_{Rt}) + \Omega_{Ru}.\end{aligned} \quad (3)$$

where the following have been marked:

G – product volume vector, **P** – work volume vector, **x**, **p** – vectors of environmental load indicator of construction products and works, **L** – vector of distance of transport of construction products or waste, indexes: *m* – product, *w* – auxiliary materials, *t* – transport.
O_{Puz} – cumulative load related to land development,
O_{Ru} – cumulative load related to utilization of waste.

Cumulative environmental load generated during the production and transmission of energy carriers consumed during the object's exploitation stage is expressed with the following formula [3]

$$\Omega_{Ei} = \frac{E_{co}}{h_{co}} m_{co} + \frac{E_k}{h_{el}} m_k + \frac{E_{cw}}{h_{cw}} m_{cw} + \frac{E_{el}}{h_{el}} m_{el} + \sum_{p=1}^{m} \frac{E_p}{h_p} m_p + \mathbf{m}_w^{\mathsf{T}} \mathbf{G}_w \qquad (4)$$

where:
E – consumption of energy carrier, $\mathbf{G_w}$, $\mathbf{m_w}$ – vectors of water consumption and its consumption rates, *m* - index characterizing the given load, *?* – cumulative efficiency of producing and delivering energy carriers, *s* – the number of fuels consumed; indexes: – *co* – central heating, *k* – air conditioning, *cw* – utility hot water, *el* – electrical power, *p* – fuel consumed directly, *w* – water.

When subject to consideration as environmental load is consumption of energy resources, indexes m_{co}, m_k, m_{cw}, m_{el}, m_p equal 1. In case of other environmental loads, one should insert indexes characterizing the respective loads.
Cumulative environmental load due to necessity of performing exploitation operations is expressed with the following formula [3]

$$\Omega_N = \mathbf{m}_{Nm}^{\mathsf{T}} \mathbf{G}_{Nm} + \mathbf{m}_{Nw}^{\mathsf{T}} \mathbf{G}_{Nw} + \mathbf{r}_{Nw}^{\mathsf{T}} \mathbf{P}_{Nw} + \mathbf{L}_{Nt}^{\mathsf{T}} (\mathbf{G}_{Nt}^{\mathbf{D}} \mathbf{m}_{Nt}) \qquad (5)$$

3. Object Description and assumption

The subject of evaluation is a detached house built in 1998 by private investors, shown in fig. 1. It is a 2-storey, 1-staircase building comprising 1 flat with the floor space of 120 m^2. The building is inhabited by 2 people.

Fig.1. Photograph of a detached house examined in this study

The building's technical data:

- heated cubic capacity $V = 400\ m^3$
- external partition area $A = 318\ m^2$

- shape factor $A/V = 0.80$ 1/m

Tables 1 and 2 contain a juxtaposition of the areas of the building's external partitions and the respective heat transfer coefficients.

Table 1. External walls

Cardinal points	Wall surface m^2	*U* $W/(m^2{\cdot}K)$
S	25	0,18
W	48,2	0,18
N	22	0,18
E	48,2	0,18
Roof	102	0,266

Table 2. Windows and doors

Cardinal points	Window surface m^2	*U* $W/(m^2{\cdot}K)$
S	7	1,2
W	3	1,2
N	10	1,2
E	3	1,2

Calculated ventilation air stream for the building's external partitions is 450 m^3/h. In terms of the building's heating, heat demand calculated in accordance with [5] is 3708.6 GJ/year, with seasonal heat consumption rate $E = 61.8$ $kW{\cdot}h/(m^2{\cdot}year)$.

The amounts of materials used in this study are the amounts specified in the price list of the construction works of the calculated construction object, for materials incorporated into the object during the erection stage. Regard has been taken of the transport of materials onto the construction site, of the removal of residual materials after the completion of construction and of the operation of machines in accordance with the National Standards For Construction Works - KNR [4].

The solutions of the building's laminar walls proposed below are characterized with identical heat resistance value of 5.55 m^2K/W.

The first examined solution of external building partition is a solution which utilizes laminar wall with insulation inside (fig. 2). The base (load-bearing) layer is made from MAX-220 brick of the thickness of 29 cm. Thermal insulation layer is made of one of insulating materials in accordance with Table 3. It has been assumed that the number of external layer paintings is 6 during the exploitation period. Due to the fact that the insulation is shielded with clinker bricks resistant to mechanical and atmospheric damage, the insulation will not be replaced in the examined solution within a 60-year utility stage cycle. Products forming the partition are shown in fig. 2. Table 2 is a statement of the volumes and properties of materials forming partition B.

Table 3. Technical data of elements of partition of the examined building

Component of external wall	Density kg/m^3	Thickness m	Heat cond. coef. $W/(m{\cdot}K)$	Multiplier of wastage	Mass kg/m^2
Clinker brick, size: 250·120·65	1800	0,12	1,1	1,1	173,91
Option A1 EPS 100, ETH-ESU data [10]	34	0,1	0,027	1,05	3,57
Option A2 mineral wool, ITB data [11]	35	0,12	0,040	1,05	4,41
Option A3 mineral wool, ETH-ESU data [10]	160	0,12	0,042	1,05	20,16
Option A3 min eral wool, Denmark data [12]	32	0,12	0,040	1,05	4,032
Hollow-brick MAX-220, sized: 288x188x220	900	0,24	0,21	1,1	278,3
Mortar	2800	0,02	0,13	1,05	5,25
Plaster	-	0,01	0,85	1,05	2,62
Paint on plaster	-	0,005	-	1,05	0,31

Fig.2. Cross-section by the wall A

Another partition wall solution is technologically more simple. This partition consists of a layer of gas concrete blocks of the thickness of 24 cm and the density of 500 kg/m^3, coated on the outside with insulating layer and external plaster (fig. 3). External layer is not as damage resistant as the clinker brick facades in the previous examples. It is assumed that in the 60-year exploitation cycle of partition B there will be: 6 paintings of external and internal plaster surfaces, 4 external plaster maintenance operations, 1 exchange of external insulating layer.

Table 4. Components of the external wall B

Component of B external wall	Density kg/m^3	Thickness m	Heat conduction coef. W/(m·K)	Multiplier of wastage %	Mass kg/m^2
Option B1 EPS 100, ETH-ESU data [10]	34	0,08	0,027	1,05	3,57
Option B2 mineral wool, ITB data [11]	35	0,12	0,040	1,05	4,41
Option B3 mineral wool, ETH-ESU data [10]	160	0,12	0,042	1,05	20,16
Option B4 mineral wool, Denmark data [12]	32	0,12	0,040	1,05	4,032
AAC brick: 240x240x490	500	0,24	0,11	1,10	137,5
Mortar	2800	0,02	0,13	1,05	3,15
Plaster	-	0,01	0,85	1,05	5,25
Paint	-	0,005	-	1,05	0,66

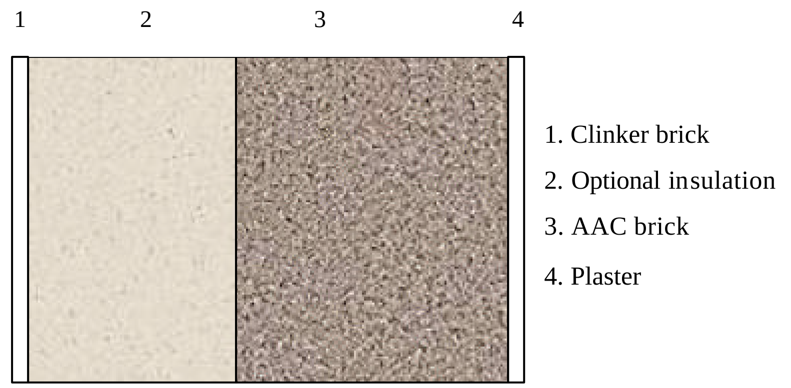

Fig.3. Cross-section by the external wall B

Solution C of the external building partition is a three-layer wall with load-bearing layer from gas concrete blocks, insulating layer made from mineral wool, ventilation gap and clinker brick facade. Three-layer walls with Three-layer walls with external clinker brick face layer are durable and aesthetic. Face wall must be joint with the load-bearing construction with the use of anchors from zinc-coated wire between 4 and 6 mm in diameter. The wall's protective layer is made from ceramic facade brick of the thickness of 12 cm, characterized with, apart from the obvious aesthetic values, very good parameters of resistance to mechanical actions and atmospheric factors such as rain, wind or frost. The load-bearing layer, made from gas concrete blocks of the thickness of 24 cm, has very good durability parameters. The thermal insulation layer, made from mineral wool, provides the possibility of flexible adaptation of the heat penetration coefficient U without significant increase of wall thickness (different types of wool as insulation options have been set together in Table 5). In the example, mineral wool layer of the thickness of 12 cm has been assumed (fig.4). The amount of paint for coating the plaster layer on the external side of the partition during 60-year cycle of partition's usage shall be multiplied by the number of maintenance paintings. Durability of other products forming this element within 60-year exploitation period does not require additional replacements or maintenance.

Table 5. Components of the external wall C

Component of external wall	**Thickness M**	**Density kg/m^3**	**Heat cond. coef. W/(m·K)**	**Multiplier of wastage %**	**Mass kg/m^2**
Clinker brick, size: 250x120x65	0,12	1800	1,1	10	173,91
Option C1, mineral wool 120, ETH-ESU data [10]	0,12	160	0,042	5	20,16
Option C2 mineral wool, ITB data [11]	35	0,12	0,040	5	4,41
Option C3 mineral wool, Denmark data [12]	32	0,12	0,040	5	4,032
AAC brick, size: 240·240·490	0,24	500	0,11	10	137,5
Mortar	0,02	2800	0,13	5	5,25
Plaster	0,01	-	0,85	5	2,62
Paint	0,005	-	-	5	0,31

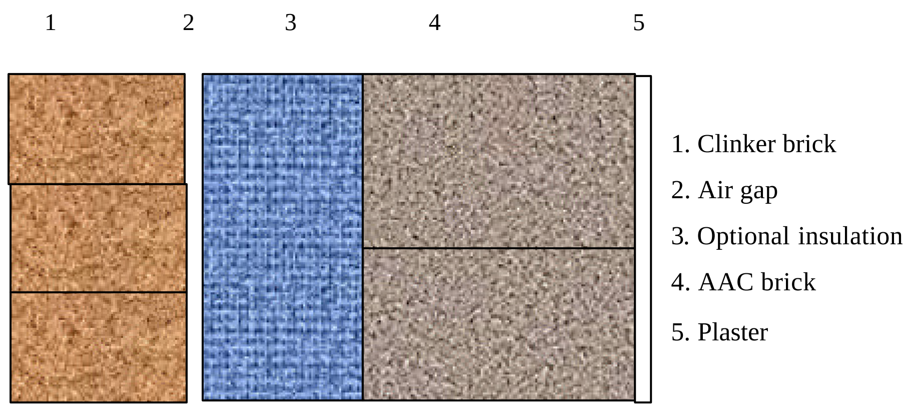

Fig.4. Cross-section by the external wall C

In the erection stage, the following have been taken into account: electrical power intake for the operation of mortar mixer, plastering machine and lighting from 4-8 MJ electrical power per one m^2 of external partition, depending on the option. Power consumption values in the erection stage have been borrowed from national construction works standards KNR [4].
Assumed length of window's life cycle is 30 years. Window area 2.102m^2, weight 71.16 kg. Amounts of basic component materials: zinc-coated steel ferrules 6.09 kg, window panel 26.53 kg, PVC frame (zinc-calcium stabilizer) 20.06 kg, steel reinforcement 17.48 kg.

Calculations were done with taking into account partition components, whose total mass fraction is at least 98% of windows' total mass, material losses included. Assumed technical parameters of component products are in accordance with average parameters of products applied in that technology. Taken into account in the calculations were environmental loads resulting from manufacturing and application of the following semi-finished products: glass, reinforcement steel, zinc-coated ferrules, aluminum, PVC frame, rubber gaskets, electrical power taken by the manufacturing company, emissions generated during putting the windows together, fuels used for transport, window packages, energy for window assembly at the facility, energy from gas furnace emitted during the heating season within a cycle of 20 years. Not taken into account were: maintenance, care operations, and post-usage disassembly and utilization. For the calculation of heat demand for heating purposes, the data for Warsaw have been assumed.

Low temperature gas heating boiler fired with natural gas, with smooth feed water adjustment, has been applied at the facility. The boiler's range of heating power is between 11 and 60 kW. Gas combustion in the boiler provides low emissions of nitric oxides and carbon monoxides: NO_x < 50 mg/kWh, CO < 10 mg/kWh. Average operating efficiency of the boiler is 90%. 6 heaters have been applied at the facility.

Evaluation of the building's power efficiency in the European Union based on Humme [5] classifies the examined object as a house with low energy demand. Main heat losses are due to ventilation needs. In accordance with the Ordinance of the Minister of Internal Affairs and Administration from September 30th, 1997 [8], the building and its heating, ventilation and air-conditioning installations have been designed and performed so that the amount of heat needed for heating the building in accordance with its purpose could be kept at reasonably low level.

4. Calculation results

Emitted substances in amounts M_i at the production of the respected materials has been classified into appropriate environmental impact categories. Environmental impact equivalency multipliers b_j, expressed in kg of substance/kg of the substance of reference, have been prepared at the Laiden Univeristy and included in the Dutch method CML92 [8]; they are commonly used in analyses performed according to the LCA method. Knowing these values for each material, sums of products of equivalents and emission volumes were converted to equivalent value Ω of the given criterion, in accordance with the following formula:

$$\Omega = \mathbf{b}^{T}\mathbf{M} \quad (6)$$

b – vector of impact equivalency multipliers,
M – vector of pollution emissions.

Emission data are taken from averaging industrial data accessible in such databases as BUWAL 250 [9], ETH-ESU96 [10], and from data gathered under scientific works of the Building Research. Environmental impacts of the optional insulations are listed in table 6.

Table 6. Comparison of the contribution to selected environmental impacts from 1 kg of different insulation material production based on various sources (from cradle to factory gate)

Impact Category	Units	ITB calculated mineral wool [11]	Average european min. wool [10]	Average european polystyren [10]	Denmark mineral wool [12]	Other source min. wool *
Total primary energy consumption Ω_E	MJ	5,51	14,064	82	20,8	8,92
Minerals Ω_M	kg	1,6	1,63	0,016	1,187	no data
Water consumption Ω_W	litr	51	10,6	175,5	3,3	3,9
Global warming Ω_{GWP}	kg CO_2 (100 y)	1,24	1,43	2,52	1,223	6,36
Ozone deplation Ω_{ODP}	kg CFC11	1E-6	4E-7	9E-7	no data	no data
Acidification Ω_{AP}	kg SO_2	0,007	0,009	0,019	0,012	0,001
Pollution to air: Low level ozone creation Ω_{POCP}	kg C_2H_4 (POCP)	0,0004	0,00023	0,002	0,003	0,0002
Nutrient enrichment Ω_{EP}	kg PO_4	0,001	0,0009	0,002	0,001	0,0001
Pollution to air: Human toxicity Ω_{HTA}	kg tox	0,029	0,018	0,026	no data	0,003
Pollution to water: Human toxicity Ω_{HTW}	kg tox	3E-3	1E-3	3,3E-5	no data	no data
Pollution to water: Ecotoxicity Ω_{ET}	m^3 tox	17,76	35,63	36,5	no data	no data
Generation of solid waste Ω_S	Kg	0,42	2	1,6	0,045	no data

* *not published data*

It has been assumed that emissions from products built into the object at the usage stage are negligibly low in the considering building.

In table 7, results of calculations have been given in accordance with formula (3) of environmental impact of a construction object during life cycle stages. The manufacturing stage covers impact related to raw materials extraction, processing, transport onto the construction site, building into the object and the processes of producing and supplying energy at that stage. Included into that stage are the amounts of materials necessary in the object maintenance operations. At the use stage, was the environmental impact, related to heat production for building heating purpose, taken into account in the calculations

Table 7 gives a collection of environmental impact category indicators at the object production stage for different external partition options and the impact resulting from the object usage stage.

Table 7. Environmental load category indicators at the construction object production stage and at the usage stage with different external partition options

Impact Category	unit	use stage	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3
Total primary energy consumption Ω_E	MJ	11801400	565825	534634	572352	543301	471261	404642	442360	413282	518944	481227	489894
Minerals Ω_M	kg	106800	550129	570150	568519	539714	699543	582120	580489	551679	564832	566464	536028
Water consumption Ω_W	litr	3588480	248929	250311	254066	249981	187746	188770	192525	188439	230665	226911	226580
Global warming Ω_{GWP}	kg CO_2 100 y.	309720	51046	51548	54947	51474	32770	31409	34808	31334	47173	43774	43700
Ozone deplation Ω_{ODP}	kg CFC11	0,06	0,020	0,020	0,021	no data	0,020	0,020	0,021	no data	0,021	0,020	no data
Acidification Ω_{AP}	kg SO_2	367	548	579	601	6676	452	440	462	6523	548	526	6623
Pollution to air: Low level ozone creation Ω_{POCP}	kg etylenu	63	93,8	96,0	96,4	98,1	69,6	68,1	68,5	70,1	86,0	85,6	87,7
Pollution to air: Human toxicity Ω_{HTA}	kg tox	809	677	692	726	no data	582	578	612	no data	675	641	no data
Pollution to water: Human toxicity Ω_{HTW}	kg tox	42	11531	11533	11534	no data	11530	11532	11533	no data	11534	11533	no data
Pollution to water: Ecotoxicity Ω_{ET}	m^3 tox	7545	7023490	7233985	7327102	no data	3166308	3146426	3239543	no data	6082364	5989247	no data
Nutrient enrichment Ω_{EU}	kg PO_4	65	143	144	146	144	98	97	99	97	129	127	127
Generation of solid waste Ω_S	kg	5340	1240	1545	7143	1302	1174	1429	7027	1186	7099	1502	1258

Presented below are graphs of environmental impact values in the respective load categories for the object usage stage and the object production stage with different external partition options.

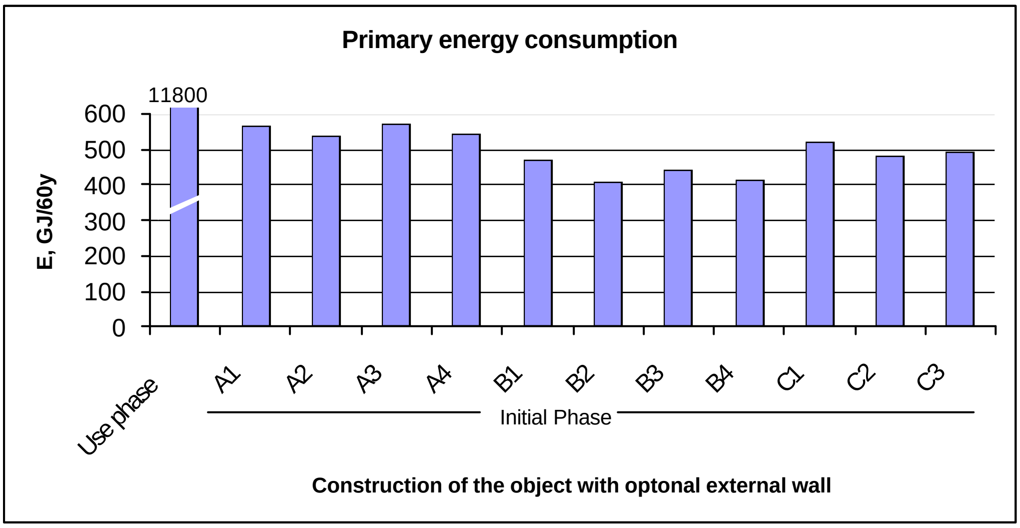

Fig. 5. Total primary energy consumption of the building with optional external walls

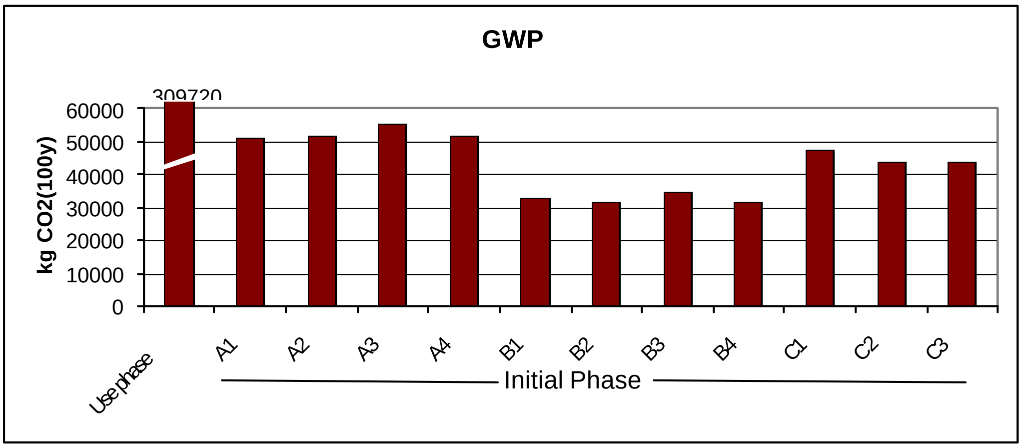

Fig. 6. GWP impact of the building with optional external wall

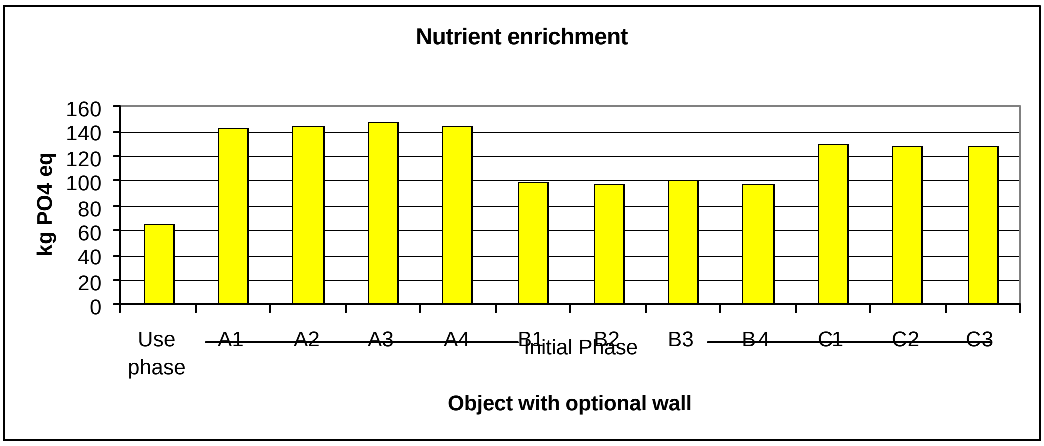

Fig 7. Nutrient enrichment impact of the building with optional external walls

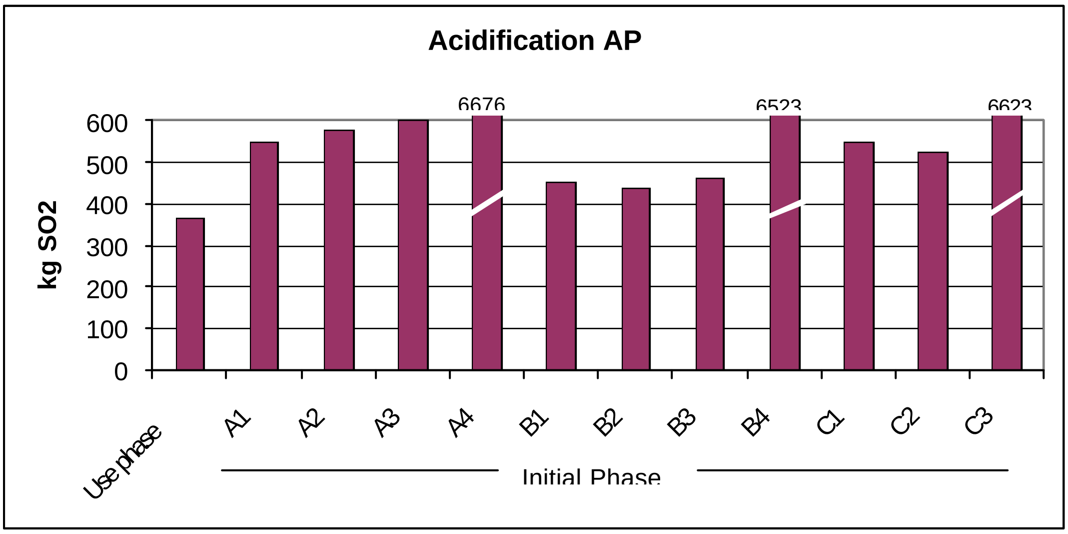

Fig. 8. Acidification impact of the building with optional external walls

The considered solutions of building obtain the same consumption of energy for heating in the usage stage. On this basis it is possible to compare the initial stage of the building. Example of the determination of cumulative environmental impact of a construction object with low heat demand for heating purposes has been considered. Different ways of using the object may influence its environmental profile.

External walls make for about 10% of the house building costs, and are decisive in approximately 40% on the total operation costs and in more than 50% of the generated cumulative environmental loads. Knowing heat conduction coefficients of different materials constituting external partitions, already at the designing stage one can influence the building's ecological properties expressed with indicators of environmental load categories.
Selection of materials with low values of environmental impact category indicators and of low heat penetration coefficients is a significant indicator of how friendly to the environment the construction object is. As implied by the costs of components, partitions of a construction object do not have to be expensive nor technologically complicated to provide good environmental profile.

Applying more and more modern construction technologies leads to decreasing the heating energy consumption at the building usage stage. In the presented example, achieved environmental profile shows that in certain case the production stage ofen causes, the higher environmental impact than the 60-year period energy supply for heating energy produced using natural gas. It is seen in fig.7 and 8.

The presented method can be used to consider the possibilities to decrease the consumption of energy and non-energy resources and of the emission of pollutants in new construction objects and in modernization the existing ones.

5. Conclusions

Directive of the European Union recommends performing evaluations of building from the point of view of environmental protection. For that purpose, environmental profile of building elements are being prepared on the basis of performed analyses consisting in estimating cumulative environmental loads (pollution) in full life cycle. Using the example of environmental profile of single-family house, we have presented the possibilities of complex evaluation of environmental impact of construction object in its full life cycle, which can be applied in comparative analyses of different building elements solutions.

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SUSTAINABLE CONSTRUCTION TOWARDS SUSTAINABLE DEVELOPMENT: STRATEGIES, POLICIES AND PLAYERS IN THE MEDITERRANEAN REGION

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1. INTRODUCTION

Built environment represents a major demand on energy resources and is consequently a primary contributor to global pollution. Despite a general improvement in the thermal performance of buildings, much energy is still inefficiently used. In Europe, roughly half of the energy consumed is used to run buildings. Large quantities of non-renewable fossil fuel are used to generate this energy. In general, more than 45% of energy used in a country goes to buildings, up to 26% of landfill waste comes from building construction, and 100% of energy used in buildings is lost to the environment [1]. Improvements to energy efficiency in buildings offer the single most significant method to reduce primary energy needs. Besides, the environmental impact of the built environment focusing on the urban form and the technology choice related impacts (urbanization, high urban densities, etc.) have been widely analyzed by various authors [2,3,4,5]. For instance, increased urban density reduces the ecological footprint components associated with housing type and urban transportation by 40 per cent [4]. Energy use (in buildings and transport) is reduced by density increases since the shared insulating effect means considerable reductions in space heating/cooling (far more than the small loss in embodied energy due to greater use of steel structures) and considerable transport energy reductions due to reduced automobile dependence. On the other hand, within the urban environment, urban climate phenomena (e.g. the heat island effect) affect dramatically energy consumption of buildings. Results from a European Commission research project show that because of the heat island effect the cooling load in a major Southern European city is about the double at the centre than in the surrounding city. High temperatures increase peak electricity loads, thus burdening local utilities. Double peak cooling loads have been calculated for the central city area compared with the surroundings. Finally, a very important decrease in the efficiency of conventional air conditioners, because of the temperature increase, is reported. In Southern Europe increased energy consumption mainly results from the use of conventional air conditioning systems in combination with compact urban form of Mediterranean cities. In the Mediterranean area, conventional air conditioning presents a very high penetration, especially during the last years, mainly because of the increasing living standards [6]. For instance, as regards the Athens metropolitan area results from a specific urban climate study [6] have shown clearly that except the high cooling loads and peak electricity problems, heat island effect reduces significantly (to about 25%), the efficiency of the air conditioning systems something that may lead designers to increase the size of the installed A/C systems and thus intensify peak electricity problems and energy consumption for cooling purposes.

2. SPECIFIC CONDITIONS OF THE MEDITERRANEAN BUILT ENVIRONMENT

2.1 A developing "air-conditioning" culture

Demand for artificial cooling has traditionally been very low in Europe. However, clear signs of a rapidly growing "air conditioning culture" have started to appear during the last decades. Reasons for this development include increasing thermal loads in buildings due to additional equipment, particularly office equipment, as well as cheaper and more widely available cooling technologies. Cooling has become a standard in cars, offices and commercial buildings which contributes to a demand for a "continuous" thermal comfort that is spreading also to households. This effect is much stronger in Southern European countries, where the climate and the rising living standards are creating a real "air conditioning culture". The situation becomes more severe in urban environments due to the so-called "urban heat island " effect that increases the air temperature and consequently increases the needs for cooling and the smog formation in summer. The explosion of room air conditioners (RAC) sales [7] confirms this trend. There is however a very large uncertainty in these projections due to the immaturity of the market.

2.2 The Athens urban micro-climate case study

In-depth measurements have been made in Athens (8, 9),where thirty automatic temperature and humidity stations have been installed giving hourly data during more than 3 years since 1996. The main objective of the project was to study various urban micro-climatic conditions. The following conclusions were drawn: a/. Cooling degree hours in the central area of the city is about 350% higher than in the suburban areas. B/. Maximum heat island intensity 2 in the very central area is close to 16 °C, while a mean value for the major central area of Athens is close to 12 °C.c./The Western Athens area, characterised by scarce vegetation, high building density and a high anthropogenic emission rate, presents twice as many cooling degree-days than the Northern or Southern Athens area. The heat island intensity in the central Park is close to 6.1 °C, compared to 10 °C in stations located nearly. The park further presents almost 40 % less cooling degree-hours than the other urban surrounding stations.d./Heating degree-hours in the very central area of Athens are about 40-60 %lower than in the surrounding suburban areas. These results indicate clearly the role of urban layout, existence of vegetation and the type of building materials used, on the potential energy demand for cooling urban buildings.

3. TECHNIQUES AND POLICIES REGARDING SYSTAINABILITY OF THE MEDITERRANEAN BUILT ENVIRONMENT

3.1. Urban and building design techniques

Strategies to mitigate the urban heat islands in the Mediterranean cities can result to large energy savings and delay investments in electricity infrastructures, pavements and roofing. They can also improve local environment conditions, i.e. less smog, increased thermal comfort, and, at the same time, contribute to aesthetics and general well being. Increased urban temperatures have a direct effect on the buildings energy consumption, especially during the summer period accompanied by carbon dioxide and other pollutants emissions. In order to limit the effect of heat islands on energy demand and summer comfort, various urban design measures can be taken including the use of more appropriate materials, increased plantation and use of cool sinks. According to the URBACOOL study project co-ordinated by the University of Athens [12] relevant action can rely on four main axes: a/Improvement of the urban microclimate: promote cool sinks, decrease the impact of anthropogenic heat, and reduce the influence of the urban ambient environment on the cooling demand, b/Buildings design: improve building design in urban areas in order to make the best possible use of passive techniques, as well as of new advanced building materials c/Active cooling systems from district cooling to individual air conditioning appliances d/Demand-Side Management actions to manage and control the cooling energy needs in urban areas. The project includes also the study of the existing legislative framework on the application of advanced and energy efficient cooling systems and techniques in urban environments, identifies possible barriers and contributes to the development of appropriate national and European codes and standards. The results are integrated into a set of guidelines for city planners, building designers, installers of cooling systems, energy companies, etc. A set of integrated strategies that make possible the adoption of these guidelines is also proposed. Besides, theoretical studies have shown that the application of advanced techniques for the improvement of thermal characteristics of buildings, use of urban oriented central cooling systems and of advanced air conditioning equipment, as well as of techniques aiming at improving the urban environment and the corresponding thermal conditions, may decrease the Mediterranean buildings cooling load up to 70 percent [6]. Consequently, major impact in the improvement of environmental conditions in Mediterranean cities can result from the integration of modern cooling strategies and energy efficiency measures in the rehabilitation of existing old building stock which would be a European priority [13,14] or in new constructions, accompanied by the improvement of the ambient urban microclimate involving the use of appropriate materials, green spaces, cool sinks for heat dissipation, appropriate layout of urban canopies etc., to counterbalance the effects of temperature increase.

3.2. Policy instruments

However, policy instruments are needed if the above mentioned techniques and strategies are to be implemented. They need to involve several actors: governments, energy companies, manufacturers, designers and installers. They have also to be adopted at various levels: European, National, local. Policy relevant recommendations to reduce cooling consumption in urban environments have already been implemented or are included in the Urbacool Handbook [8]:

3.2.1 General Policy measures

-Provide assistance to municipalities to adopt urban heat island attenuation measures. An interesting initiative is being taken by the International Council for Local Environmental

Initiatives (ICLEI, 2000). It consists in the preparation of a model ordinance to assist "cities, counties and other local governments in adopting a local government ordinance to mitigate the effects of urban heat island". It shows the possibilities of synergies between international co-operation and actions at local level.
-Adopt procurement rules for European, National or local public owned facilities based on life cycle cost analysis. This kind of approach has been proposed in the energy efficiency action plan presented by the European Commission.

3.2.2 Policy measures at European level

-Adopt energy labeling to equipment for both central and room air conditioners.-Adopt energy efficiency standards eliminating the worse products from the market. -Implement energy certification in buildings and extend it to include air conditioning systems (relevant is the directive SAVE 93/76/EEC).Extend inspection of boilers to air conditioning systems. The recent Directive 2002/91/EC for energy efficiency in buildings, based on the Construction Products Directive (Council Directive 89/106/CE) gives emphasis to strategies that improve thermal behavior of buildings, making specific reference to Southern European countries. It proposes techniques of passive cooling, improvement of indoor climate as well as improvement of urban microclimate.-Develop standard methods to calculate equivalent annual EER and COP of air conditioning equipment, including a method to take into account climatic regional differences. -Promote convergence between building regulations within the EU. Obviously, the requirements should not be the same but adapted to the Member States or regional situations, e.g.building codes have to be dependent on the climate and existing building materials available. -Promote training and certification for installation and maintenance companies.-Strengthen focus on equipment that are heavy contributors to cooling loads like office equipment (including energy management and stand-by issues)and lighting, thus reaching a "double dividend" to reduce the direct energy consumption and the indirect consumption resulting from air conditioning.

3.2.3 Measures at local level with municipalities acting as:

a. Planning actors : -Additional requirements respecting summer comfort and cooling needs, i.e guidelines for using roofs with a higher reflectivity and emissivity than usual, use of pavements with higher reflectivity in streets, sidewalks, parking lots etc. -Issue of ordinances addressing tree planting requirements as part of a tree management master plan. –Adoption of building certification programmes. -Use of spatial tools to evaluate energy conservation potentials, plan and verify the implementation of the measures required.-Use their role of licensing entity for electricity distribution and supply. Municipalities can collaborate with license holders or even establish demand-side management obligations. Electricity systems, in most Southern European cities, have to cope increasingly with the highest demand when it is more vulnerable and the losses are the highest. Cooling contributes particularly to these periods, resulting in very high costs. Activities to be developed include with energy companies rebates, financial solutions and create energy service provision that promote the adoption of passive and low energy cooling, high energy efficient equipment, advertising campaigns, training courses to installers and users, etc. b.Motivators :-Promote, in association with their local energy agencies, energy and environmentally friendly solutions, like planting of trees in ground gardens and roofs, cool materials for private pavements and roofs. This can be achieved by issuing product guides and supplier directories, contacting building owners, etc.c.Energy consumers :-Act as leader by example by adopting materials, technologies and practices that help contribute to attenuate the urban heat island effect and reduce consumption for cooling.

3.3. Enhancing transferability of existing techniques, tools, methods and mechanisms can play a crucial role

Besides the above mentioned techniques and policies, enhancing transferability of innovative techniques, tools, methods and mechanisms can play a crucial role for an effective regional implementation concerning "sustainable building" in the southern European or generally the Mediterranean region. A good example of such an initiative is a recent LIFE Project planned and coordinated by the Municipal Development Agency of Athens in the frame of the LIFE-Environment Programme. The project is aiming at creating a common consideration of the notion and practice of "sustainable building" in the Mediterranean region, enhancing transferability of ideas from Northern European countries that have already developed relevant expertise to the Mediterranean region. For this purpose, a specific use of buildings that has a high education and sensibilisation value has been chosen as demonstration case. Thus, the project is aiming, using the "school case", at exploring methodological bases, capacities and structures needed in order to achieve sustainability of school buildings in each participating country or region and support environmental excellency and diversity in different local conditions. The project is also aiming at generating environmental sensitisation actions and community involvement in sustainable design of school and lyceum buildings. The project will be oriented to the following actions:

a. the exchange of innovative methods and techniques concerning environmental quality in buildings
b. the transfer of knowledge to create regulatory and operational frameworks to implement sustainability in buildings using the 'school example" for demonstration and education purposes.
c. exploring regional characteristics necessary to the future elaboration of effective regional standards that can both contribute to a pragmatic differentiated approach in the Mediterranean region and to the replication of the project results regarding a large amount of school building stock.

It is structured around the following axes of action:

a.Pointing out common problems and specific conditions in the Mediterranean region.
b.Exploring school buildings situation and future needs.
c.Exploring existing innovative technical and policy tools concerning sustainable buildings and specifically sustainable school buildings in the Mediterranean region.
d.Developing and demonstrating urban and building design techniques focusing to environmental quality and eco-design of school buildings.
e.Developing policy tools in various administrative levels.
f.Promoting environmental education and community involvement actions.

The variety of actors participating in the project (Municipalities of Berlin, Athens and Volos, Regional Authorities (the PACA Region), Prefectural Authorities (Ileia Prefecture), NGOs and Associations of manufacturers, designers and installers (Greece, France), Research Centres etc) will be useful for the implementation and demonstration purposes and the dissemination of results at various levels (national, regional, local) since it has been proved that implementation of sustainability requires multi-level cooperation. The choice of a certain use of buildings (school or lyceum buildings) will also facilitate the implementation, demonstration and environmental education purposes. It is characteristic that France has given priority in implementing the methodology of HQE, (high environmental quality) in Lyceum buildings. These already realised examples will be extremely important for the exchange of knowledge (success stories, constraints, failures) between the participating cities and countries. As main project result is expected to be the acquisition of a common definition of “sustainable building” in the Mediterranean region and the drawing of methodological bases that are needed to implement “sustainable building” techniques and related policy tools and mechanisms. Specifically at a macro-regional scale (in this case the Mediterranean basin) methodological bases are of major importance in order to explore environmental excellency and diversity in different local conditions. These methodological bases have to respond to specific problems and needs and to help local actors to create their own systems adapted to the local conditions. A second result of the project will be the development and implementation of sustainable and ecological design in school buildings by means of community involvement actions and the exchange of relevant experience in each city or country for environmental sensitisation and education purposes. A third result is the replication value that will be produced regarding a large amount of school building stock in all countries. A fourth result of the project will be the establishment of an important educational and cultural exchange between Northern and Mediterranean cities on urban sustainability and environmental quality issues involving different groups (pupils, teachers, decision and policy makers etc). This result will be fully accomplished with the creation of a Network entitled “SB-MED Network” between relevant Mediterranean partners for further communication and promotion of the idea of “sustainable building” in the frame of the already expressed in the Johannesburg Summit initiative for the co-operation in sustainable development in the Mediterranean area involving existing forums (e.g UNEP/Mediterranean Action Plan)

4. IS AN EFFECTIVE STANDARDISATION FEASIBLE ?

Sustainable building or built environment is the logical outcome of building or built environment with quality. Nevertheless, sustainable building is not a new technique. It is more a frame of mind, taking into account the consequences of all building-related decisions. In most cases, the techniques or know-how already exists. Specifically in the Mediterranean area, local traditional architecture can provide numerous and very significant examples of environmental quality in building with emphasis to bio-climatic solutions and mainly passive solar design and systems.

In order to proceed to the elaboration of more effective macro-regional standards concerning sustainable built environment, we have to find a solution to the following contradiction: on the one hand create a common language, which will be necessary to exchange experiences and knowledge, and on the other hand promote specific ways to reach environmental performances according to the geographical, cultural and technical local contexts. How to make both universal and specific ? Standardization of sustainability is a new field where we have to seek for special solutions, not extremely heavy and significant at the same time.

As regards buildings, and specifically sustainable building, ISO and CEN are working on this approach for some years. The concepts used are making reference to diverse cultural values and on the adoption of a common language which is necessary in order to progress together. This is the direction followed by the work recently launched by ISO. Within the framework of a standardisation structure (ISO/TC59/SC3/WG12), undertaken by the Technical Committee TC59 « Building construction », whose scope includes urban planning and design, ISO launched in 2000 a standardisation programme on sustainable development within the building sector (sustainable building) under the aegis of Norway and USA. This work will be conducted under a French convenor (AFNOR) within an ISO subcommittee structure, number 17, gathering together a large number of European countries (EU + EFTA). Therefore, it is obvious that a large confrontation of ideas and techniques is currently taking place. In this framework the European approach, rich in diversity, but mainly convergent, merits being enhanced and supported. Moreover, this work will be carried out in relationship with Technical Committee ISO 207 on environmental management which shares very similar preoccupations (climate change, life cycle analysis, etc.) and many of the methods of which have already been adopted. During its 11th meeting, last June and July in Bali, the ISO technical committee 207 in charge of environmental management, has asked for a better coordination of works about sustainable building, held under the aegis of ISO/TC59/SC17. The work of ISO in the area of Environmental Management, described below, forms the background to that work. The standards are those under development or the ones that have already been finalized by ISO /TC 207 ”Environmental management”.

Standard number	Standard title
ISO 14001 (EN ISO 14001)	Environmental management systems – specification with guidance for use
ISO 14020 (EN ISO 14020)	Environmental labels and declarations – General principles .
ISO 14021 (EN ISO 14021)	Environmental Labels & Declarations - Environmental Labelling TYPE II – Self Declared Environmental Claims
ISO 14024 (EN ISO 14024)	Environmental Labels & Declarations - Environmental Labelling TYPE 1 – Guiding Principles and Procedures
ISO TR14025	Environmental labels and declarations - type III environmental declarations
ISO 14040 (EN ISO 4040)	Environmental management - Life Cycle assessment - Principles and Framework
ISO 14041 (EN ISO 14041)	Environmental management - Life Cycle assessment - Life cycle inventory analysis
ISO 14042 (EN ISO 14042)	Environmental management - Life Cycle assessment - Life cycle impacts assessment
ISO 14043 (EN ISO 14043)	Environmental management - Life Cycle assessment - Life cycle impacts assessment – Life cycle interpretation

All of above standards are also European Standards, except from ISO TR 14025.Furthermore, the CEN Construction Sector Network Project for Environment (CSNPE) has undertaken considerable work concerning interrelationships between standardisation work in the building and the environment sector as well. One of the major difficulties of this exercise is to take into account all parameters concerning the life cycles of buildings. The societal use which is made of these parameters, the latter being dependent on cultures and on economic or environmental parameters alike, and which the IPP concept translates (see green paper on integrated product policy), is just as relevant as purely physico-chemical or biological characterisations. The complexity of the approach, which only reflects that of life, leads to privileging pragmatic approaches, based on progressive approaches rather than on sets of universal indicators. Standardisation must strive towards stakeholder involvement by providing them with the tools required in order to fulfil this responsibility, and not by defining good and bad in an absolute manner – thereby withdrawing all responsibility –.

Standardisation must focus on the information to be provided to the decision-maker and on the methods, not on the products themselves, for which the conditions of use cannot a priori be known. This is the approach followed for the French standard XP P01-010 on information concerning the environmental characteristics of construction products. Generally speaking, standardisation relating to sustainable development runs the risk of being abundant and not easily exploitable, since there is a great number of parameters to be integrated since an analytical approach is used. Consequently, a pragmatic approach should be adopted, which integrates as early as its conception the use to which it will be put by the operators. Summing up we can say that standardisation concerning sustainable development within the building sector must satisfy operational objectives[16]. Failing this, it would be pious hopes without any true effect on the action, which must be the main objective. The first stage therefore consists in determining what we expect from standardisation concerning sustainable development in the building sector, the degree of adaptation as a function of the contexts, and the manner of using it. It is necessary, as it were, to draw up the « specification » for this quite specific standardisation.

Recommendations given by the CEN construction Network Workshop held in Malta, 2002-09-30 to 2002-10-01, are quite explicit : "CSNPE is requested to propose a strategy for consideration by stakeholders for practical development of standardisation in the field of sustainability, taking account of limitation of resources (space, ecology, labour, energy etc), accessibility to resources, optimisation of use of resources and adaptability in changing resources and needs, so as to meet the operational needs of construction". Taking into account local and regional specificities will only be possible if standardization deals rather with process and management of operations[17], than with the body itself. Standardization has to put the question : how do you take into account summer comfort, instead of giving technical standards about free cooling and any other way to create and keep comfortable environments. This kind of standardization has then to be completed locally by libraries of technical solutions, with the necessary environmental characteristics, in order to be able to support the decision-making process. Thus, we can see the settlement of a double system to satisfy a double demand, one the one hand being universal oriented to a standardization about the methods, and on the other hand regional and local with an access to solutions adapted to regional and local conditions. These libraries of regional solutions have to be settled with all the life time (life cycle and life cost) information. Co-operation between countries and technical institutes permits to go further and faster on that way. For instance, a Mediterranean cooperation will be able to provide the basis for a common climatic and urban complexity and diversity approach. The field of validity of the solutions has to be described precisely, in order to avoid possible mistaking. For instance, the cooling solutions in dry climates do not work with a high degree of humidity. Cultural and compartmental point of view has also to be taken into account. Air circulation and sensibility to noise problems have to be related. Furthermore, we should not forget cultural and local market criteria, which can add several modulations to technical solutions.

5. CONCLUSIONS

A general policy framework to achieve sustainability of the built environment at a macro-regional level like the Mediterranean basin should first of all include the establishment of a mechanism to elaborate the methodological bases needed to explore environmental excellency and diversity in different local conditions. These methodological bases have to comply with specific needs and problems and to guide local actors to create their own systems adapted to local conditions using existing potential. It is also crucial to streamline and improve the accessibility of existing knowledge on a European level. Although a lot of information is already available on different levels and on different topics, the terminology and the way it is documented are very different. This makes it quite difficult to access and compare the information. This can facilitate a common cross-border approach and cooperation on policy development and it can provide architects, industry and product manufacturers with a clear insight into how to adapt building and housing specifications with regard to sustainability. As mentioned in the NOVEM Synthesis Report on Sustainable Housing Policies in Europe elaborated for the Third EU Ministers' Conference on Sustainable Housing, held on 27 and 28 June 2002 in Genval, Belgium, the idea of establishing a European Knowledge Institute or Network would be an effective way of addressing this problem [13]. For the Mediterranean region, this mechanism, could have the form of a Sustainable Building Observation Network (e.g SBON-MED for the Mediterranean region) which would bring together all stakeholders and actors from both government, industry, energy companies and civil society and encourage their close partnership according to European and National strategies for improving the environmental performance of the building sector [18].This observatory could also constitute a framework to regularly monitor the environmental performance of the building sector, encourage greener public purchasing strategies for construction procurement and undertake ex-post evaluation of policy instruments [17]. In this policy context, standardization and libraries of technical solutions can have a crucial role. Nevertheless they cannot bring best solutions by themselves. They can only be tools for both the decision-makers, the architects and the engineers. The way to use those tools will continue to be a matter of human ability to create built environment, with sensibility, technical competence, sense of dialog, and experience.

This observatory could acquire a real strategic alliance role if established in the framework of existing fora (e.g the UNEP/ MAP forum, given that the Mediterranean Action Plan can trace a mediterranean strategy for sustainable development). In this way effective participation will be ensured of all the actors and players (international organizations states, local authorities, construction sector, and mainly NGO's, civil society) which is besides consistent with the French initiative expressed in Johannesburg about co-operation in the Mediterranean basin for sustainable development. Summing up, we can say that since sustainable construction is the expression of sustainable development principles in the construction sector, it can very well serve as an instrument for sustainable development and co-operation in sustainable development in the region, thus contributing to social cohesion, economic regeneration and environmental protection and conservation. Furthermore, broader objectives could be on the one hand the enhancement of cultural dialogue and economic solidarity in the " common sea" and on the other hand the creation of an intellectual solidarity network so that a new Mediterranean identity regarding sustainable urban environment asset itself during the XXIst century [19].

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APPLICATION OF THE IMPROVED FACTOR METHOD TO THE ENVIRONMENTAL IMPACT ASSESSMENT OF BUILDINGS

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1. Introduction

By defining the role of service life within a LCA and indicating what can be achieved by a sound service life prediction, the environmental assessment of buildings can be more accurate. Aspects that will be looked in this paper at are the fixed service life within the current assessments, the different phases within service life and the rate of replacement of components. A description is given of preliminary results of research undertaken to develop a life cycle assessment method specifically for "flexible" buildings. This paper describes different aspects of the way to execute such an environmental calculation. The link between environmental load and the building sector is elaborated and emphasis is placed on the differences between the environmental load in the building sector and other sectors. Certain aspects related to environmental calculations are important when determining the environmental load of a building are reviewed and further illustrated using three examples of LCA for a building. The use of the factor method is described when undertaking environmental calculations and additional information is given for enhanced calculations suggesting that the proposed changes make LCA calculations in the building sector more accurate.

2. Building and the environment

2.1. Environmental load

Every material has an effect on the environment. Extracting raw materials, transporting them to a factory, producing the product, assembling it in the project, dismounting, disposal and so on. If we know that building is an ongoing process and that this ongoing process will keep on putting a strain on the environment the current situation is evident. The goal for the building sector is to minimise the load on the environment caused by construction. This is one of the fields where the Kyoto protocol has had some influence on.

The Kyoto protocol however only mentions the exhaust of CO_2 equivalents. There are quite a few additional environmental aspects. Different methods are available and they discern different environmental aspects. Common aspects are ozone depletion, exhaustion of raw materials, human toxicity, eco-toxicity, global warming, acidification and so on. The literature

[1] provides descriptions of the various methods and the corresponding environmental aspects for environmental calculation. Every part of society causes an environmental load. Solutions for each of them are possible but the building sector has some aspects that are specific for this sector and need particular attention.

2.2. Environmental load and the building sector

The environmental load caused by building (construction) has some aspects that differ from environmental load in general. Klunder [2] mentions the three main environmental effects of building to be caused by material flow, energy and water. This study reached a conclusion that the aspect related to water to be less important; hence from this it follows that energy and materials are the most important. The average weight of a European building is about 100 ton. That is 100 ton of materials used in construction, but also (after the period is over) to be discarded. It is therefore not surprising to see that solid waste is responsible for a large part of the environmental load in building. As an example, in the Netherlands in 2001 a waste stream of 19550 kton was produced, compared to 12680 kton in 1990 representing an increase of 54% in 10 years [3]. The other effect is the energy use during the service life of the building, but this study is limited to the material aspects within environmental assessments. However the existing methods for calculating the environmental load (of the materials) are not developed for the building sector and cannot cope with the long total service life of a building.

2.3. Application of environmental load calculation

The environmental load can be calculated with the use of a Life Cycle Assessment (LCA) programmes. Examples of these programs are Sima Pro, Eco Quantum (NL), Envest (UK) and OGIP (CH). In this article some particular aspects of these calculations will be discussed. To get a better hold of the calculation the layout of LCA is given in Figure 1. This layout is according to the ISO 14000 standard [4]. A LCA consists of a goal and scope phase in which the aim is set. In the inventory analysis the building is looked at closely to determine the amount of materials. It is in this phase that the input for a LCA is retrieved. The third phase is the impact assessment. The materials from the inventory phase are calculated into the environmental load. In all these three phases the interpretation of the effects is of importance: how are these effects when compared to other situations.

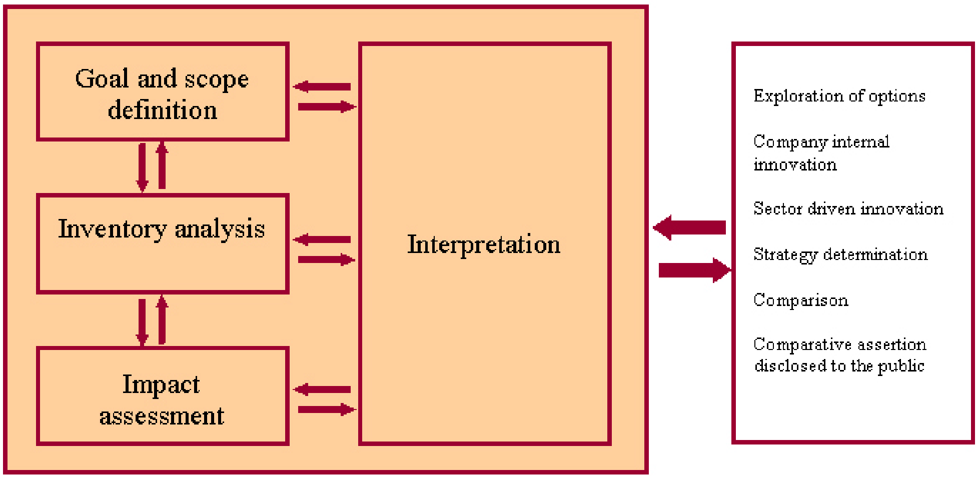

Figure 1. Layout of a Life Cycle Assessment according to the ISO 14000 standard

The way of using LCA can influence the interpretation. According to Guinée et al. [5] there are six different objectives to using LCA:

- Exploration of options
- Company internal innovation
- Sector driven innovation
- Strategy determination
- Comparison (i.e. legislation)
- Comparative assertion disclosed to the public (development)

Looking at the construction sector, the sector driven innovation, strategy determination and comparison are the most important reasons to conduct LCA. Special attention must be given to the possibility of comparison. This stands for comparison between products as well as the checking to legislation. Some countries are considering an obligatory environmental standard that for every (new) building has to be met. However at this moment the calculation according to such a standard will raise some problems because of a lack of consistency in its application (this will be discussed in section 4).

A calculated comparison between environmental loads makes it possible to vary in materials or design solutions and see the results of the variations. An optimisation of the load with the specific design is possible. The question is whether such an optimisation should be legislation, a kind of trademark or just a voluntary aspect? In case it becomes legislation, it has to be applicable for all buildings and no blanks or errors can be allowed in the method. This can be difficult because no general agreement has been reached on the calculation methods. When it is used as a trademark or even voluntary then some remarks or comments can be made. Then it can be used as a quality mark rather than an obligatory item.

3. The role of service life prediction in LCA

3.1. Characterisation

The common Life Cycle Assessment methodology is material based. The general thought is that when more materials are used in a building, the higher the strain on the environment will be. This is not completely true, the kind of material and the accompanying processes are of importance too. Each material (or process) has emissions to one (or more) environmental aspect(s), and each environmental aspect can be measured by an amount of equivalents. So for each emission there are factors to convert emissions into equivalents. An example: for the environmental effect of 'greenhouse' gases, the CO_2-equivalents are normative. CO_2 is chosen to be leading indicator and as a consequence 1 kg CO_2 has the equivalent of 1. Another substance, CFC-13 has a characterisation factor of 13000. This means that 1 kg CFC-13 causes 13000 times more pollution than 1 kg CO_2. Turning it the other way, 77 mg CFC-13 is as polluting as 1 kg CO_2. This step is called characterisation. This example shows that just a fraction of some material can cause a huge impact on the environmental load when performing an LCA. This is the reason why in a LCA, the inventory phase is crucial. Incorrect data about materials can cause a lack of information or a redundancy of information.

3.2. Replacements

In section 2.3 the structure of a LCA is explained. The inventory analysis is the phase in which data about the amount of materials is retrieved. Within the building sector the total service life of a building is often set at 75 years. In these 75 years materials have to be maintained and/or even replaced. The question is: what is the service life of a component? This is significant because this establishes how many replacements have to take place, and consequently the total quantity of materials used throughout the overall service life of the building. A building that is well maintained with limited use will last longer than a building with a lot of activity. An example: a simple interior door of a family dwelling has a Reference Service Life of Component (RSLC) of 25 years [6,7]. With a total service life of 75 years, the initial door and two replacements is the average situation. But imagine whether a family will use this door with two little children. The in-use conditions are much higher and the demands for replacements are larger as well. It is possible that the RSLC of 25 years will not be met and that 20 years is the maximum period (Estimated Service Life of Components, ESLC). More doors will be needed and the amount of materials used in the building is raised. Because the amount of materials is higher (inventory analysis) the impact assessment changes as well. Figure 2 shows the differences in output for a 20-year RSLC and a 25-year RSLC.The dark bars represent a service life of component of 20 years. The light bars represent a service life of a component of 25 year. The overall service life of the building is 75 years. Combined with the characterisation as mentioned in 3.1 the influence of the amount of materials and consequently the environmental strain becomes increasingly evident.

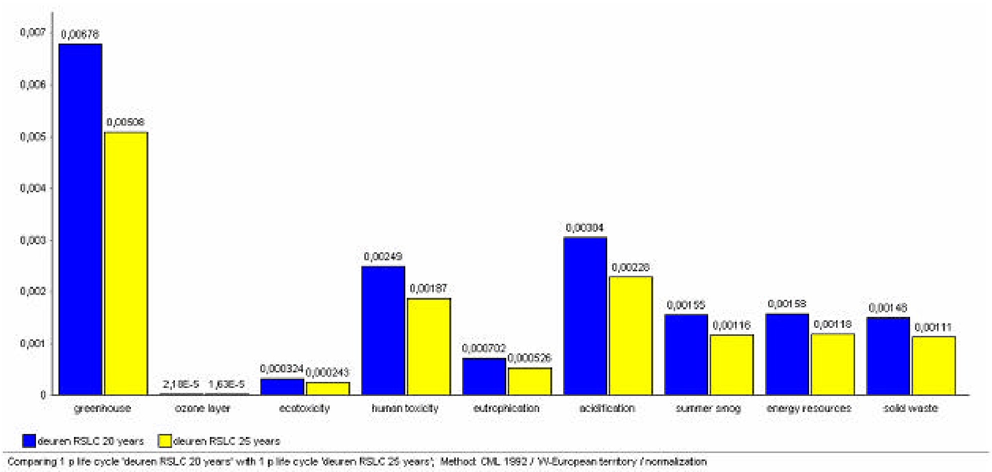

Figure 2. Example of LCA output of a comparison between two situations of using internal doors

3.3. Three kinds of service life

The service life of a product will end at the moment the product reaches its End Of Life (EOL).

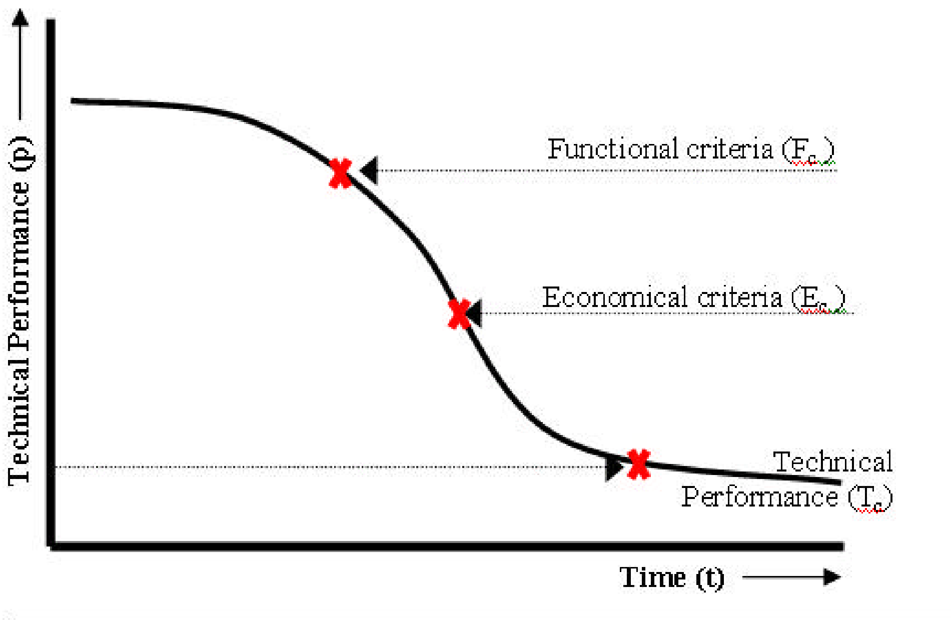

Figure 3. Different types of End Of Life (EOL)

There are many ways in which a product can reach its EOL. Van Nes et al. [8] mention up to six different ways of obsolescence for consumer products (technical, economical, ecological, esthetical, functional and psychological). In the ISO standards [9] three kind of EOL for the building sector are discerned. Concentrating on the building sector the following three EOL scenarios will be distinguished: technical, economical and functional EOL. The best-known type (and most easy to comprehend) is the technical service life. When looking at the reference service life published by SBR [6], it is the technical service life that is displayed. This is because for centuries this was the aspect that determined the replacement. However, looking at Figure 3 technical service life will in (most cases) last longer and be leading.

The technical service life is over when the component can no longer fulfil the performance it needs to (i.e. a leaking roof, a broken window). Another type of EOL is the economical EOL. This occurs when another component can fulfil the same (or better) function but with lesser costs. (i.e. central heating system, maintenance). In this case the economical criteria are indicative. The EOL that probably occurs first is the functional End Of Life. This occurs when the component does not fulfil the function people demand of the component. In this case the functional criteria can be a very wide range: the door doesn't open any more, the living room isn't large enough or the colour of the tiles does not please the user anymore. These three EOL's define the moment that a component will be replaced. Regarding the three EOL's the following can be concluded: at his moment it is no longer the product that indicates the end of (technical) service life of a product, but it is the occupant who decides that the (functional) service life of the product is over, so functional obsolescence is normative.

Usunieto:

3.4. Summary

The outcome of LCA depends highly on the reliability of the input. To obtain a LCA that is as accurate as possible the input must be close to the actual situation. The aspect that is most important in this case is the service life. At this moment most assessment methods that are carried out regard the service life as a fixed item. As a consequence the outcome of the LCA will differ from the actual situation. In the example of the interior door, used by a family with children, the average LCA will be based on a RSLC of 25 years, although it is known that the actual service life is 20 years (Figure 2). To calculate an accurate LCA the inventory phase is crucial. Key issue in LCA is service life prediction. If the ESLC is known, the exact amount of material used throughout the overall service life is known as well. With the amount of material known, the assessment is more correct than most LCA's, and a better judgement can be made.

4. Current problems in LCA

The previous section describes LCA and the importance of correct inventory analysis. Within LCA in the building sector there are some irregularities that can cause problems when performing calculations. In a previous paper [10] three problems are discussed:

1. Premature replacement; replacing products before it is a technical necessity;
2. Sequential use; replacement of (identical) products within the overall service life of the building;
3. Subdivision of environmental load; regarding environmental load as a linear process, instead of dividing it in different phases.

The first problem is already described in paragraph 3.4. In a LCA it is in most cases the technical service life that is normative for the calculations. Increasingly the economic and functional criteria are decisive for the replacement. Using only the technical service life in a LCA has a positive effect on the outcome of the LCA, because components in the calculation are supposed to have a longer service life than the actual situation. Calculating the full technical service life, fewer replacements will take place and the calculated results will be less than the actual environmental strain (figure 4).

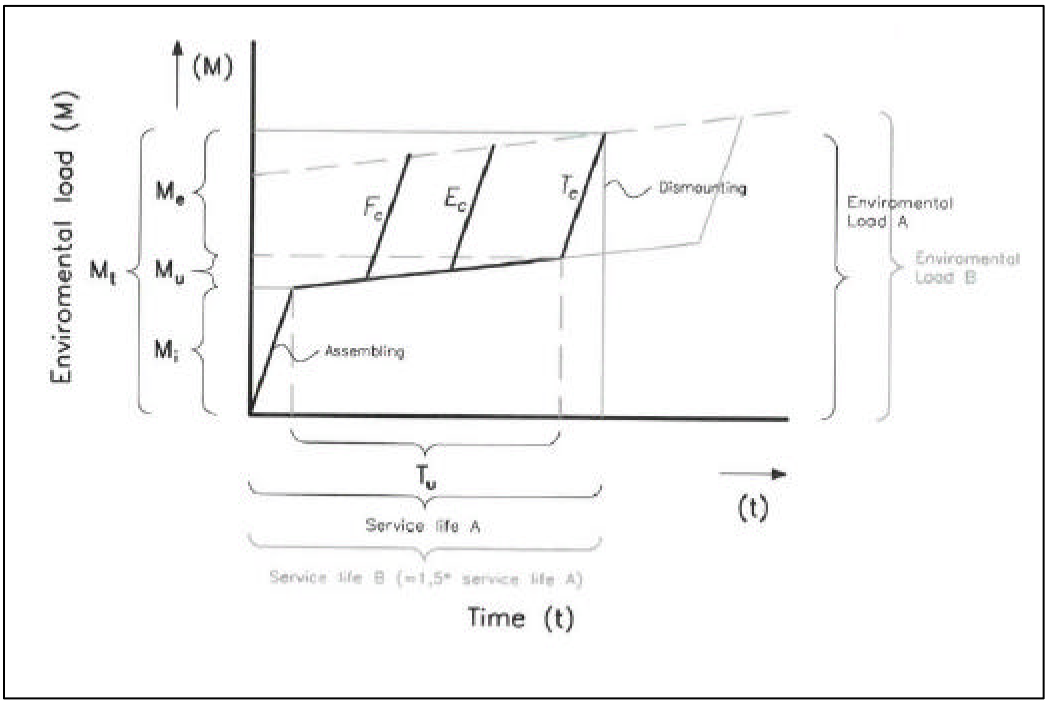

Figure 4. Environmental load divided in assembling use and dismounting.
The replacement criteria (Functional (Fc), Economical (Ec) and Technical (Tc)) are shown as well.

The figure shows that the total environmental load is hardly increased by a substantial increase of the service life.

Sequential use is the second problem and follows on the premature replacement. The LCA tool has not been designed for the building sector; it is more aimed at consumer goods. Looking at consumer goods replacements are not that big an issue and often not taken into account. Because of the long service life of a building, the replacement of components in a building is important. During the overall service life, several replacements have to take place. Given that the actual spread of service lives is not known, an assumption (as accurate as possible) has to be made in regard to a bandwidth, from which may vary the amount of material required.

The third aspect is the subdivision of the environmental load. There is a relation between the environmental load of a component and time [11]. Three different phases can be distinguished: assembling, use and dismounting. Assembling a building will have a relative high level of environmental load, partly because of the production of materials. In the use phase the environmental load will only slightly increase because of maintenance (energy consumption by habitants is not taken into account). The last phase is dismounting and there the waste creates the highest strain. In figure 5 this subdivision is illustrated. In the use phase the increase of environmental load is small compared to the prolonged service life. In the example this is shown by the light coloured graph. When prolonging the service life the average environmental load will decrease. However, in most current LCA programs the environmental load is regarded as a linear process (figure 5). If the environmental load is regarded to be linear, prolonging the service life will cause this process to continue. The environmental load will increase in time. In the actual situation, the environmental load during the period of use will rise slightly, perhaps some maintenance, the rest (dismounting) will not increase.

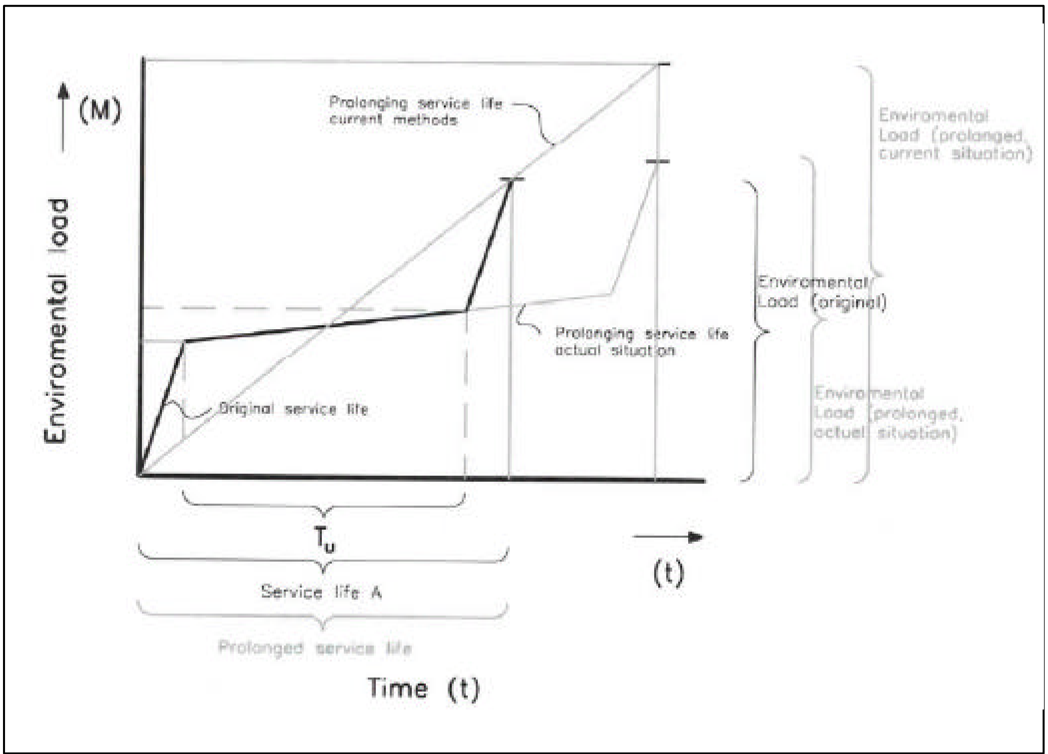

Figure5. Prolonging service life will only increase the environmental load to a limited extend.

The actual environmental bad will not increase as much as most programs calculate at this moment. As a consequence the calculated load (current methods) is higher than the actual load (prolonged actual situation). This is shown in figure 5.

5. Factor method

5.1 Goal within LCA

To get a better grip on LCA there has to be more information on the service life of products. Service life prediction originates in the 50's when the first experiments with cyclical loads were done. Later on these tests were elaborated. In the 90's service life prediction became an expertise and guides and standards were developed. Even now a combined task group (CIB W80/RILEM 175-SLM [12]) is studying service life prediction. Three different approaches are followed. First of all the research of the probabilistic design, second the so-called engineering methods and third the deterministic approach. The last approach is the simplest way to define the service life and therefore the deterministic methods are being studied. Defining the service life is an important part of LCA and an easy to use method must be available. Because buildings are not the same everywhere service life prediction varies from locations to location. In Japan a method to calculate a more specific method for service life planning was developed: The Factor Method [9].

5.2 Factor method

The factor method is a way to include several factors that influence the service life and come to a better estimated service life [13]. This method is described in an international standard ISO 15686 [9] At this moment parts 1, 2 and 3 are out, and parts 4 to 6 are to be published. The factor method consists of a RSLC and different factors (for different aspects mentioned below). The reference service life will be multiplied by the factors, some positive, others negative. The outcome is an ESLC, a specific service life for the given situation and product. The Factor Method uses seven factors to compensate for specific situations. The formula for the factor method is:

ESLC = RSLC * factor A * factor B * factor C * factor D * factor E * factor F * factor G

Where:
ESLC = Estimated Service Life of Components [year]
RSLC = Reference Service Life of Components [year]
A = Quality of the component [-]
B = Design level [-]
C = Work execution level [-]
D = Indoor environment [-]
E = Outdoor environment [-]
F = In-use conditions [-]
G = Maintenance level [-]

For each factor a value must be used whereas the mean is 1.0. An example: a product consists of high quality raw materials it will be more resistant to influences from the outside. In order to award the better quality, factor A (quality of the component) will be 1.2 instead of 1.0. Another example can be the location of the building. With a building near to the sea the outdoor environment (factor E) will be more severe than the average outdoor environment. Factor E will become lower than 1.0, for example 0.8. When these factors and the reference service life are all multiplied a specific service life, more accurate for the specific situation can be predicted:

ESLC = 25 * 1.2 * 1.0 * 1.0 * 1.0 * 0.8 * 1.0 * 1.0 = 25 * 0,96 = 24

The RSLC is 25 year, but when the quality (A) and the outdoor environment (E) are taken into account the ESLC is 24 year.

5.3 Adding factors

The Factor Method consists mainly of indicators for the technical service life. In section 3.4 two other criteria are mentioned: functional and economical criteria. To include these criteria Van Nunen et al. [14] propose to add two factors: Trends and Related components. With the Trend factor (T), the likelihood of a component to conduct changes not indicated by the designed service life is taken into account. The sensitivity to (fashion) trends will reduce the functional service life of the component. This indicates a replacement before the technical service life is over.

Looking at the Related components factor (R), two aspects are considered. The first one is the accessibility of a product to be replaced. When a wall panel can be replaced by just clicking four pins it will be done with much more ease than in a situation where a lot of nails and cement have to be removed. The first situation causes much less trouble and therefore will occur more often. As a consequence, the service life will be short. The second aspect is in combination with the replacement of components. When a single component has to be replaced, it sometimes is easier to replace a complete building part, although the service life is not yet completed. An example is a window frame. When the frame has to be replaced, in most cases the glass will be replaced as well, although it is not necessary in functional or technical way. Both factors trends and related components are not mentioned in the ISO standard. Adding these two factors will bring the ESLC closer to the actual service life and not only representative for the technical service life. Therefore it could be called the Improved Factor Method.

5.4 Distribution in the (Improved) Factor Method

To come to a service life prediction that is even more accurate the (Improved) Factor Method can be evaluated with a statistical approach. Aarseth and Hovde [15] use a statistical approach on the outcome of the multiplication (ESLC). In their approach the entire outcome is judged on its variation and the predicted service life is given with boundaries. Moser [16] uses a statistical distribution on every factor. The factors all have different distributions, because not all factors act in the same way. All these separate factors, with their boundaries are multiplied and the result is a mean (ESLC) with boundaries. This last approach, in which every factor gets its own distribution, is most suitable because deviations from the normal situation can be given a place in this method. The only difficulty is defining which distribution fits best to which factor. Moser [17] used a recursive Delphi method to obtain these figures. By using experts he defined percentiles and a mean and derived the statistical distributions for the factors. By adding two new factors to the Factor Method, creating the Improved Factor Method, new distributions have to be defined and in doing this, the existing distributions of factors can be reviewed. This is part of the current PhD research of Van Nunen.

6. Conclusions

This paper presents Life Cycle Assessment for the building sector. It is clear that although LCA for buildings is possible, most LCA tools are not specifically developed for the building sector. Typical problems between LCA and the building sector are discussed in this paper. One of the problems is that the most polluting aspects (waste and energy) are not taken into account in most of the existing LCA methods. Using these methods, a LCA will show a gap of important impact assessments. Another crucial problem for using LCA in the building sector is the service life of a component. A building has a long overall service life and replacements have to take place. But the service life used in a LCA is a fixed one, although we know the actual service life to be shorter. Without knowledge of the predicted service life it is also impossible to take sequential use into account, and as a consequence determine the exact environmental load.

In order to use LCA in the building sector it is necessary to define the service life. Only when the service life of components is estimated as close as possible, the effort to calculate the environmental load by means of a LCA has a value. To come to a method in which all the specific aspects of a situation are mentioned, the Improved Factor Method (with two new factors) can be used. To enhance the reliability of this method statistical distributions have to be added. This method calculates a better estimated service life without the need of huge data about deterioration of components.

Based on a service life that is as close as possible to the actual situation a LCA will also give results that are close to the actual situation. This is not the case in most current LCA calculations. It will be necessary to optimise the current methods in order to use LCA as a decision tool. Using the Improved Factor Method provides in this optimisation.

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SUSTAINABLE CONSTRUCTION IN THE COUNTRIES OF CENTRAL EUROPE – CONDITIONS OF DEVELOPMENT

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Introductory remarks

When considering the possibilities of dissipation of the sustainable construction, directed towards space, architectural, construction and material solutions friendly for environment, it is worth to define the status and financial conditions of the development of the sustainable construction in the Central European countries.

The countries of Central Europe are delayed in relation to the countries of Western Europe, members of EU, not only regarding to the economic development, but also in the range of civilisation progress, what determines the satisfying of their social and cultural needs and ensuring the achievement of the aims of the sustainable development.

Removing of those gaps in development requires the developing of the construction, which is or may be:

- a centre and tool for realisation of the strategy of the sustainable development,
- an economic process respecting the requirements of the sustainable development,
- an industry creating the building objects, using and maintaining of which should ensure the achievement of those aims.

Creating conditions and implementation of the programmes of the development of the sustainable construction causes arising of many questions and reflections, among others:

Should the programmes of the sustainable construction be implemented simultaneously in the whole range of the construction industry, or in selected areas and objects?

To which extent the implementation of that programme is dependent on the support of the public institutions and their means:

- in the form of new standards and regulations in the area of the architecture and construction,
- in the form of financing of its realisation?

Which countries have the bigger chance to achieve the aims of the strategy of the sustainable development – the poorer or the richer ones?

Will introduction of more restrictive construction standards and regulations bring the limitation of the investments and repairing jobs due to heightening of their costs? What will be the social impact of delaying in satisfying the current social needs, that would be the obvious effect of such limitation?

Does the civilisation delaying – the lower saturation by the building objects in the countries of Central and Eastern Europe – create the chance of avoiding the mistakes made by the highly developed countries, which have developed the construction in the way that was harmful for the environment and now have to carry out the expensive re-vitalisation actions?

What are the possibilities of financing the programmes of the sustainable construction in the countries of Central Europe? Are those countries able to propagate the construction of this kind in the whole area of the construction production, or only in the selected segments or objects?

Which strategy is more favourable for those countries: quick removing of the development gap – i.e. unsatisfied investment needs – by the development not always respecting the rules of the sustainable construction, or delaying that process until all rules, mechanisms and tools (including economic and fiscal regulations) will be developed and suitable conditions for effective achievement of the aims of the sustainable construction will be created?

What should be the standard for the sustainable construction according to the categories of the objects and buildings?

What are necessary expenses for financing of the sustainable construction, e.g. the costs of the housing construction with specified standard?

Can the countries of Central Europe afford the implementation of the strategy of the sustainable development in the construction industry and possibly where:

1. in the entire field of the construction industry,
2. in the selected areas,
3. in some types of the objects?

Implementation of the rules of the sustainable construction significantly restricts the liberty of the investors in realisation of the construction projects, imposing them suitable requirements and orders; this will limit the role and possibilities of realisation of the cheap construction! This is an issue that cannot be omitted! It is worth to consider, whether the construction realised in "self-made" way should be limited, because the keeping of the rules of the sustainable construction can be hardly controlled within such a type of activity. Another option is leaving this area outside the control and counting on the effectiveness of the indirect action – teaching and persuasion.

The financial conditions of the sustainable development of the construction are given by:

- Volume and economic structure of the construction production
- Intensity of construction per 1 inhabitants
- Systems of the construction realisation
- Structure of the construction acc. to type of construction

Construction market in the countries of Central Europe

1. The value of the construction market in four Central European countries in 2003 was equal to about 33.6 bln Euro. The dominating Polish construction market with the value of about 18.5 bln Euro was 55% of that group of the countries, and only 1.7% of the total value of the European construction (without the countries of the former Soviet Union) (see Table 1).

In the structure of the production according to the economic type of the job, the investment works predominate in the Central European countries – 75% in 2003 compared to 25% share of the repairing works (see Fig. 2).

In the countries of European Union the share of the investment works in the construction production was 56%, i.e. by 19 per cent points less than in the Central Europe, and the repairing works was 44%, i.e by 19 per cent more.

The share of the investment works in the construction production in the Central European countries during previous five years has been increased by 5 per cent points, contrary to the Western European countries, where this proportion is constant (the share of the investment works in 1998 was 56.5%).

Table 1. Total construction output in European countries in 2003

Rank	country	in millions euro at 2003 prices
1.	Germany	195 435
2.	France	153 176
3.	United Kingdom	133 941
4.	Italy	141 722
5.	Spain	127 525
6.	Netherlands	62 005
7.	Austria	27 202
8.	Belgium	22 740
9.	Portugal	21 016
10.	Ireland	23 288
11.	Finland	18 820
12.	Denmark	21 599
13.	Sweden	19 214
14.	Poland	18 470
15.	Greece	15 145
16.	Czech Republic	10 365
17.	Hungary	7 970
18.	Slovak Republic	2 400

Source: PAB- PCR&F, Euroconstruct

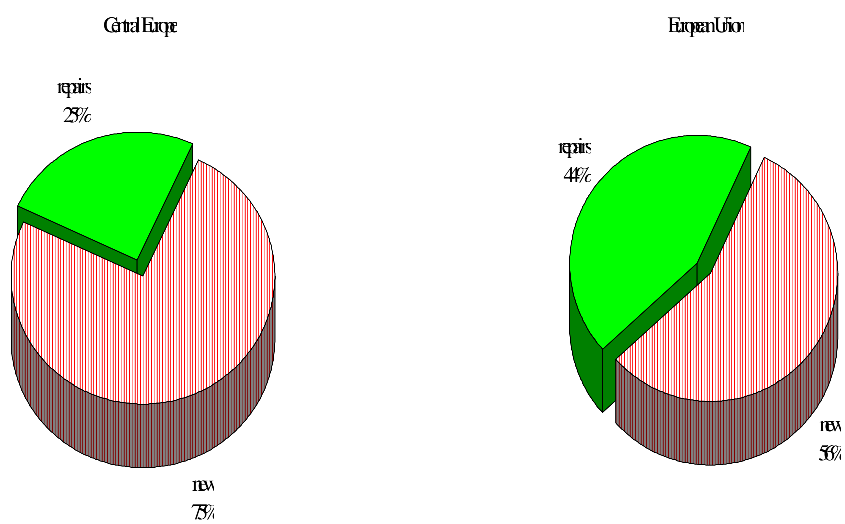

Fig. 1. Structure of the construction production according to the economic type of activity in the countries of the Central and EU-15 in 2003, in %

Source: PAB- PCR&F

The distance between the construction industry in the countries of the Central Europe and in the countries of so-called Old Union (further called UE-15), measured by the financial outlays in the present prices, is large.

This can be demonstrated by relation of the value of the realised construction production per 1 inhabitant.

The highest value of the construction production per inhabitant in the countries of the Central Europe in 2003 was achieved in Czech Republic – almost 1016 Euro per inhabitant, then in Hungary – 790 Euro, while average value in Western Europe is about 2667 Euro (see Fig. 2).

In Poland in 2003 the value of the construction production per inhabitant was only 483 Euro. The relation to the respective value in the Western Europe is 1 : 5.5, while in Czech Republic only 2.6 (see Fig. 2).

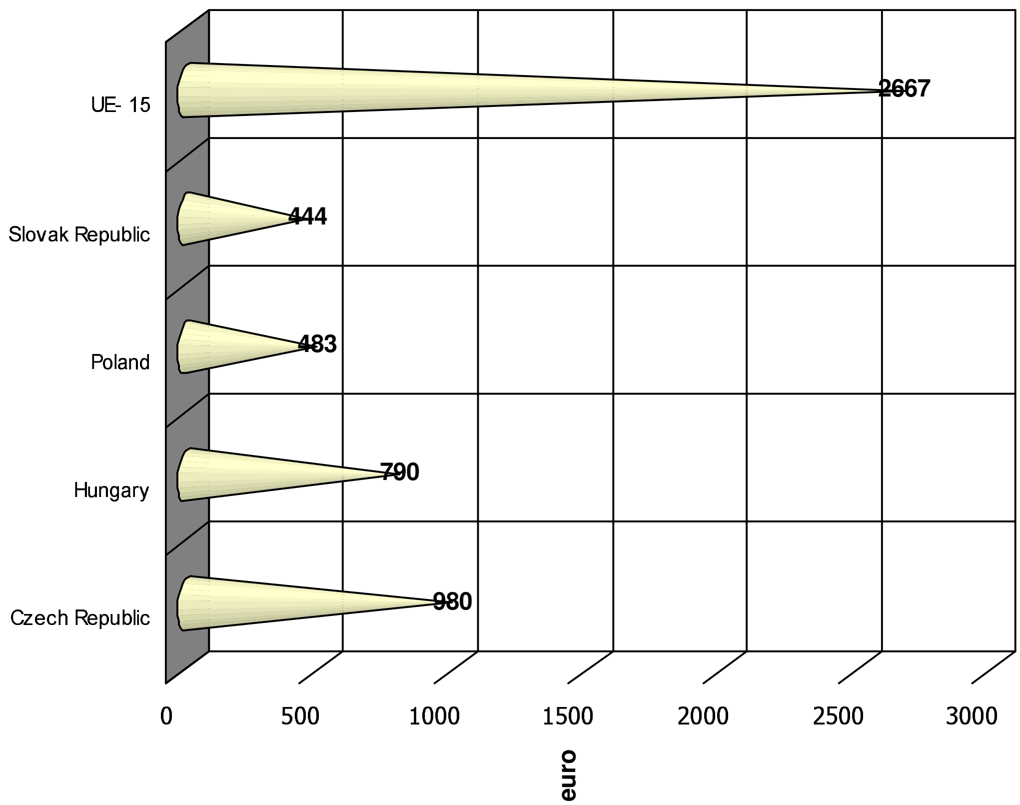

Fig. 2. Construction production per inhabitant in the countries of Central Europe and EU-15 in 2003, in Euro

Source: PAB- PCR&F

The research performed by Euroconstruct shows, however, that the distance counted by parity of the purchase power (PPPs) of the currencies is lower by more than a half (see Fig. 3).

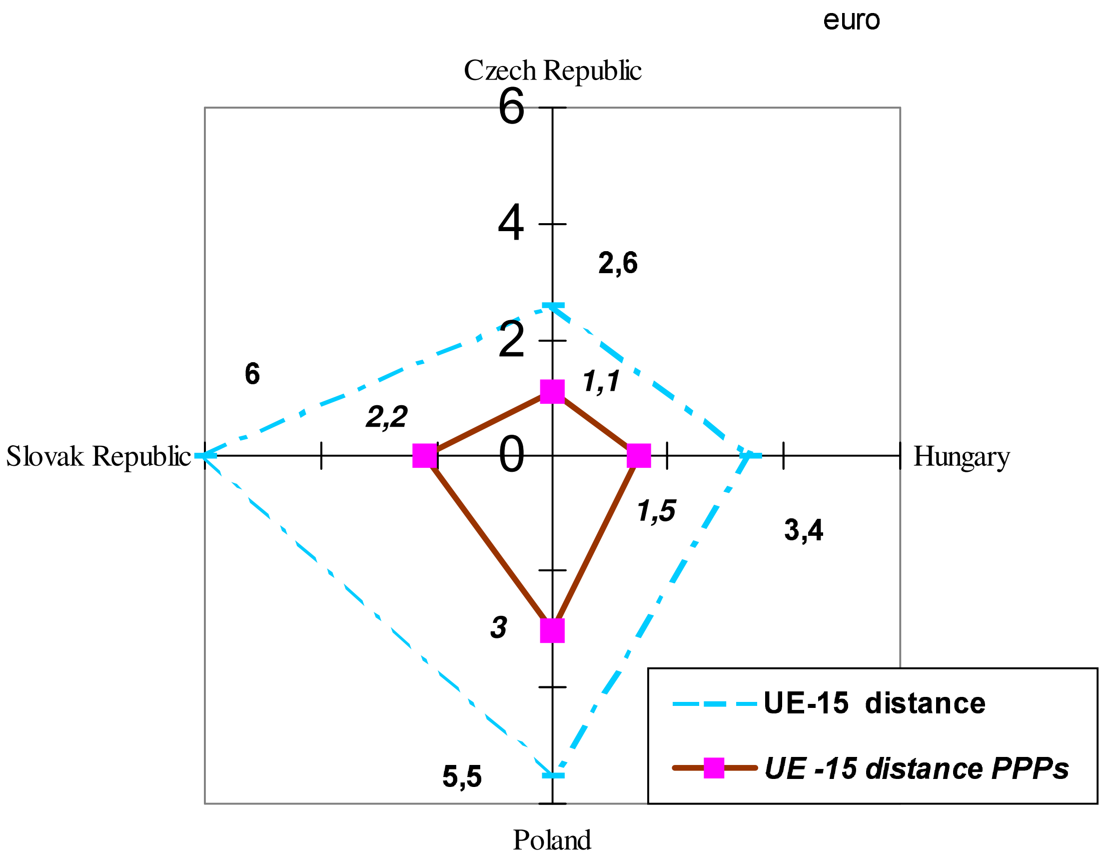

Fig. 3. Distance of the value of the realised construction production per inhabitant in the countries of Central Europe and EU-15 in 2003, acc. to the current rates and PPPs, in Euro
Source: PAB- PCR&F

The distance to EU-15 countries, measured by PPPs, is equal almost to zero in the case of Czech Republic, while the larger distance – about threefold – is observed for the Polish construction industry.

On the base of the researches and analyses carried out by PAB-PCR&F, it is possible to found out that in Poland the respective relations for the particular types of the construction, measured by the current rate in 2003, were as follows:

- in the housing construction in total 1 : 10.5
  including: new construction 1 : 9.95
  repairing jobs 1: 11
- in non-housing construction in total 1: 3.3
  including: new construction 1 : 2.8
  repairing jobs 1: 4.3
- in engineering construction 1: 3.4

including: new construction 1 : 3.5
repairing jobs 1: 3.2

The highest value of the construction production per inhabitant according to the types of construction in Poland in 2003 has been achieved in the non-housing construction – 222 Euro per inhabitant, in the engineering construction 149 Euro per inhabitant and the least in the housing construction – 112 Euro per inhabitant (see Fig. 4).

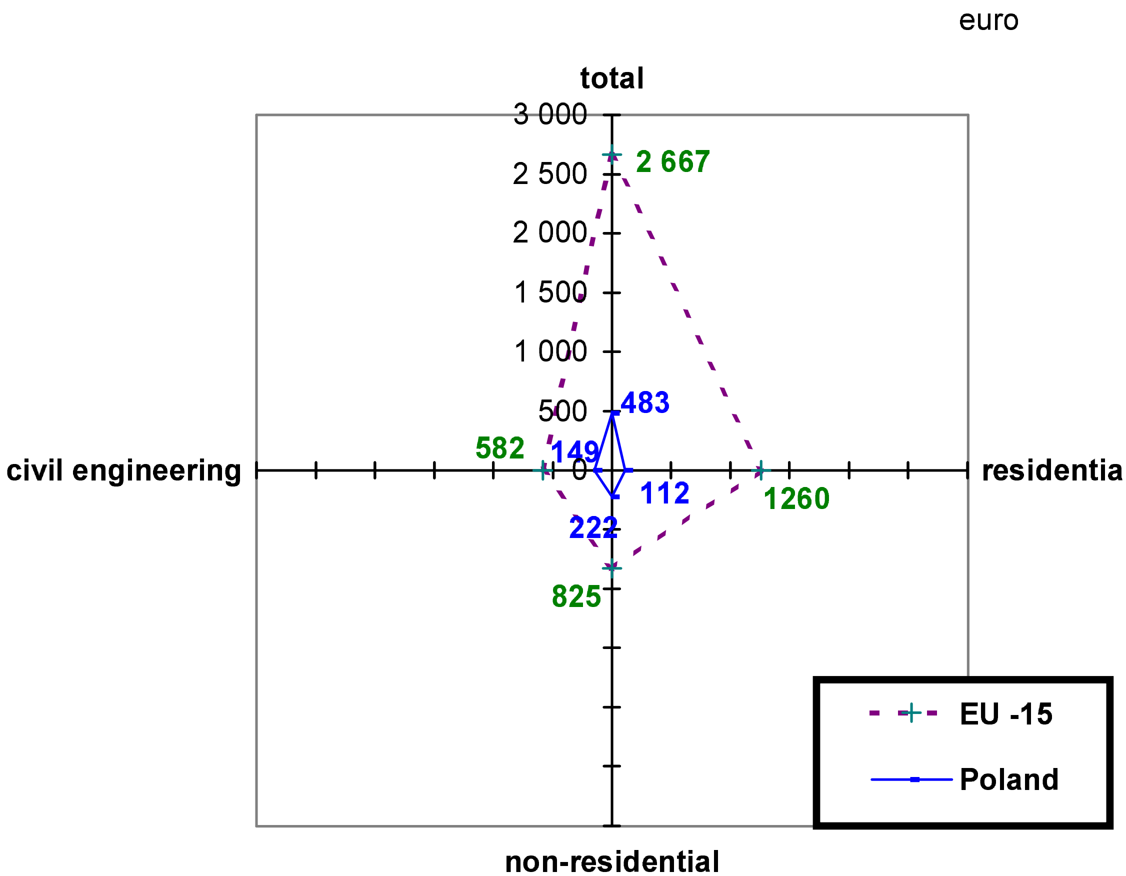

Fig. 4. Construction production per inhabitant acc. to the type types of construction in Poland and EU-15 countries and in Poland in 2003, in Euro

Source: PAB- PCR&F

2. The total value of the construction production realised in 2003 in four countries of Central Europe, associated in Euroconstruct organisation, was about 39.2 bln Euro.

From that, 81% has been realised by the order system, and 19% by so-called economic (self-made) system. The highest share of the latter type is noted in Czech Republic – 28.3%, followed by Slovak Republic – 27.4%, and the least one is observed in Poland – only 11% (see Table 2).

Table 2. Construction production in the countries of Central Europe in 2003 according to the types of system construction

Specification	Construction production in mln Euro	Own-account system		Contract system	
		mln Euro	%	mln Euro	%
Poland	18 470	2 050	11.1	16 420	88.9
Czech Republic	10 365	2 933	28.3	7 432	71.7
Hungary	7 970	1 658	20.8	6 312	79.2
Slovak Republic	2 400	658	27.4	1 742	72.6
ECC in total	39 205	7 299	18.6	31 906	81.4

Source: PAB- PCR&F

3. The biggest share in the structure of the production in the countries of Central Europe in 2003 had the non-housing construction – about 44%, followed by the engineering construction – 31%. The joint share of the housing construction and the repairing jobs was equal to about 25%.

The structure of the construction production in the countries of Western Europe was quite different. The share of the housing construction is twofold bigger, while the share of the private commercial construction is by 1/3 less.

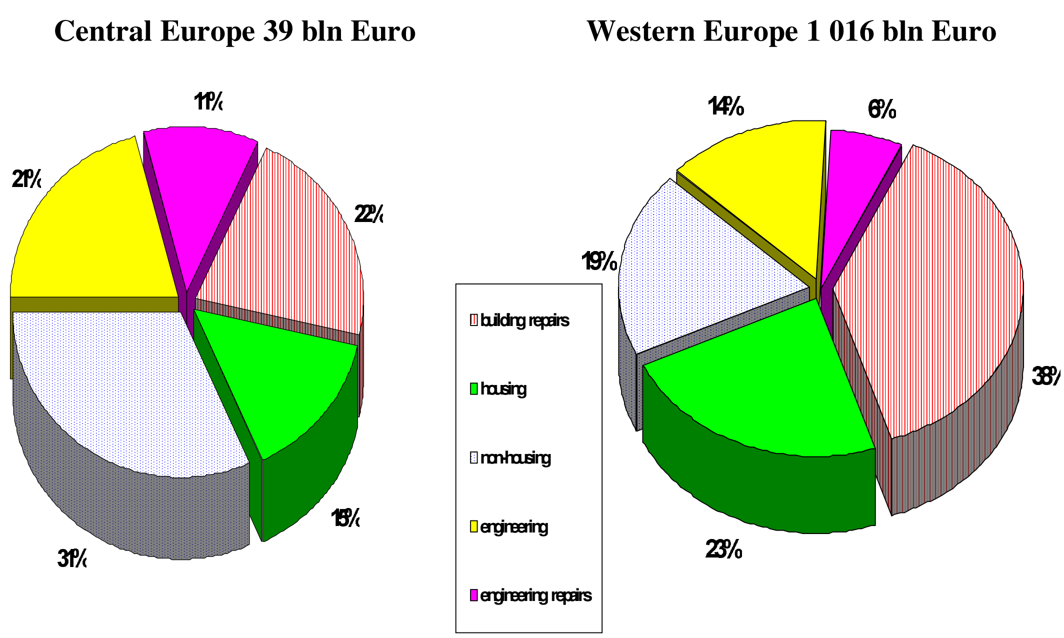

Fig. 4. The structure of the construction production acc. to the types of construction in the countries of Central and Western Europe in 2002, in %
Source: PAB- PCR&F

The big differences between the countries of the Central Europe and EU-15 manifest itself not only in the non-relative values of the realised engineering works, but also in the intensification of that construction measured by the volume of the works per 1 square km and one inhabitant (see Table 3).

Table 3. Total value of civil engineering in Central European countries and UE in 2003

Country	in bln Euro[1)]	Per capita in Euro	Works in Euro per 1 km^2 of the country area
Czech Republic	2.84	280	36 445
Hungary	1.91	190	20 850
Poland	5.70	150	17 385
Slovak Republic	0.58	110	14 965
ECC Total	*11.03*	*172*	*20 940*
EC-15	221.8	582	63 865

Source: PAB – PCR&F

CONCLUSIONS – Chances and limitations for the sustainable development of the construction industry in the Central European countries

1. The chances come from:
- urbanisation and saturation of the environment with the building objects less than in the highly developed countries, leading to the less needs of the improvement of the technical standard of the existing resources
- lower intensity of the realised construction in the countries of Central Europe, what makes the monitoring of the implementation of the rules of the sustainable construction easier,
- possibility of giving consideration to the requirements of the sustainable construction in the phase of programming and designing of investments, leading to avoiding the negative results for the environment and elimination of the high costs of its future adjustment,
- possibility of avoiding the mistakes during implementation of the rules of the sustainable development – using of experiences of highly urbanised countries.

2. The dangers come from:
- limited means for construction and implementation and monitoring of realisation of the sustainable construction,
- social and political pressure towards the rapid removing of the development gaps,
- possible high increase of the outlays for construction, which should be simultaneously adjusted to the rules of the sustainable development.

3. The present status and needs of development of construction in the countries of Central Europe allows to expect the rapid development of the construction in the next 2-3

years, in the range of new building objects. The particular attention should be paid to the preparation and implementation of the standards and rules of the sustainable construction on the introductory phases of designing of the construction processes.

4. The implementation of the rules of the sustainable construction is easier in the order system of construction, when the construction processes can be controlled on the particular phases and where many officially registered, professional contractors are involved.

This is more difficult in the economic (self-made) system of construction, where the construction processes organised and conducted by the object user are hardly controllable.

Sources:

[1]*"POLISH CONSTRUCTION YEARBOOK 2003* **-** *Vademecum of construction industry"* PAB-PCR&F, Warsaw 2004

[2] Sochacki M., „*Budownictwo w krajach Europy Środkowej*", PAB-PCR&F, Warsaw 2003

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SUSTAINABILITY AND PROTECTION AGAINST NOISE IN A BUILDING AND ITS SURROUNDINGS

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1. INTRODUCTION

Noise can be disturbing, annoying and harmful to our health. It causes sleep disorders and stress, increases the risk of heart attack, boosts drug use and affects society in other adverse ways, economic included. Among different global and local issues sustainability embraces problems associated with protection against noise. It also has an impact on land management and the construction industry. Environmental noise affects the quality of residential areas, public parks, recreation and other noise-sensitive sites. Excessive external noise brings down the value of buildings and their surroundings. It is important to assess properly in acoustic terms the land planned for further development taking into account its intended function. Legal requirements are not a perfect tool of assessment because limit and target values are determined in part by different interests, financial and practical reasons.

The acoustic performance of a building is one of the crucial factors which contribute to its quality. Sound insulation of partitions and noise levels inside rooms are becoming the main assessment criterion for users. New materials and new solutions resulting from the idea of sustainability in the construction industry should be assessed regarding acoustics. Some compromise should be obtained because of different contradictions, e.g. heavy materials with good acoustical properties are more energy-consuming in the process of production than lightweight structures. Building and its technical equipping generates noise emitted both to the environment, and into the rooms. The problem gains importance at implementing regeneration schemes, shortening distances between buildings, or changing functions of rooms in existing structures.

Sustainability ideas implemented in the construction industry and land management may worsen acoustic conditions if not analysed properly. Efficient protection against noise is impossible to achieve without a complex approach to the problem starting as early as in the preliminary planning stage.

2. NOISE AND HEALTH

Taking into consideration specific characteristic of different noise sources and the way of sound propagation, noise should be recognized as a local phenomenon but commonly occurring. In practice all human activities are accompanied by different noises with variable levels, which may seriously disturb occupational and living conditions. Acoustical problems also emerge in the construction sector considered as a branch of industry, spatial planning and land development, and also as a creation of human environment. Noise is one of the crucial factors affecting the assessment of environment's quality. It regards both acoustic conditions inside the building and in its surroundings.

The detrimental impact of noise on humans, their health and physical-mental state, is well known and confirmed by the results of numerous research. The problem does not consist only in partial or total loss of hearing which may be caused by high level impulse noise or long-term noise exposure which is quite common in the workplace. Depending on the place of exposure, our activity, type of noise source and its characteristics and sound pressure level, noise may be annoying, it may disturb relaxation, impair task performance, make difficult focusing attention, irritate, interfere with speech comprehension, make impossible effective handling of lecture or lesson in a classroom etc.. Excessive noise may disrupt sleep or cause falling asleep difficult. Neighbouring noise brakes intimacy and sense of privacy inside the apartment, or e.g. a hotel room. All adverse noise effects may worsen the health of exposed persons. Long exposure to noise may deregulate the physiological system, especially generating permanent release of stress hormones, adrenaline and cortisol, causing the increase of cholesterol and triglycerides level in the blood, which subsequently leads to higher risk of heart attack. The list of detrimental effects of exposure to noise is very long [1].

Environmental noise is a serious social issue. It is estimated to affect the health and quality of life of more than 90 million people throughout Europe [2]. So the European Commission deemed necessary to reduce noise and human exposure to its harmful impact [3]. Social exposure to noise has been also considered for a long time in Poland [4]. Surveys on noise's impact on peoples' mental and physical health in urban areas were conducted already in 1970-1975, jointly by the Acoustics Department of the Building Research Institute and the Social Medicine Institute in Warsaw [5]. The survey embraces over 2900 persons. As a result it demonstrates that noise at the place of residence may cause functional disorders, mainly neurosis [6]. The dependency between acoustic conditions and the frequency of cardio-neurosis symptoms suffered by inhabitants became evident, in addition to digestive ailments, state of permanent fatigue, exhaustion and headaches. Increase of drug consumption aimed to minimise stress and sleep disturbance and awakenings during the night was also observed. The symptoms have been confirmed much later by research carried out by the State Hygiene Institute (PZH) [7, 8]. Results shows that the consumption of sedatives and tranquillizers was about threefold higher in areas affected by noise in excess of 70 dB against the regions where noise level was below 57 dB.

Sleep disorders and awakenings, caused most often by noise, are currently very common and may cause various health problems. Research conducted in Germany indicated that about 20 million local inhabitants had problems with falling and staying asleep. Among them, 8.5 million need medical treatment, while 3,3 suffer from constant fatigue during the day [1]. Low sleep quality affect everyday life in many ways, e.g. road safety, where a large proportion of accidents is caused by drivers falling asleep at the wheel due to bad quality of their nigh-time sleep.

Noise also affects society altering the everyday behaviour of persons exposed to its long-lasting impact. Noise may increase aggression, unfriendly behaviour towards others, lack of activity, resignation, changes in mood, etc. [1]. The high level of external noise causes also changes in inhabitants behaviour aimed toward reducing detrimental impact of noise on living conditions [7]. Windows are opened less often or are not open at all. Frequently windows are additionally stripped or replaced by an air-tight type. These actions deteriorate the ventilation of rooms and reduce fresh air inlet which have also detrimental impact on health. Besides, people resign from staying on balconies and from walking around their place of residence, the effect is harmful to human psychophysical condition.

Sustainable development is designed, among other objectives, to promote health and human professional and social activity. The above just outlined adverse health effects of noise on particular persons and the whole population proves that acoustic issues should be considered seriously on implementing the ideas of sustainability in construction sector. Also the economic impact of excessive noise should be taken into account [9, 10].

3. ACOUSTICS IN THE CONSTRUCTION SECTOR

3.1 Spatial planning

The land as the object of spatial planning, occupied and shaped by new developments is limited as are the other natural resources. In this meaning space should be planed and used economically. In many cases noise caused by the functioning of different civil engineering structures and buildings with various noisy technical equipment exceeds the limits of created infrastructure. It can be said that noise „occupies the space” excluding it from proper use in an area which by far exceeds the structure’s outline. Transportation or industrial facilities are an example. The limitation of possible use of areas affected by noise determines the development of the whole surrounding of such noise sources.

Typical structures - sources of noise include engineering structures as highways and expressways, roads and streets in the city, airports, railway lines, industrial facilities, etc. Their environmental acoustic impact should be assessed in the preliminary planning phase. Such obligation exists in most of the European countries. In Poland environmental noise problems are subordinated to separate regulations. General principles are contained in the Environmental Protection Law [11] which in terms of noise is adjusted to the European Directive [12]. The permissible noise levels which should not be exceeded on the border of areas of different type listed as a terrain protected against noise are specified in the Ordinance of the Minister of Environment [13]. In Poland also threshold levels of noise are in force [14]. If exceeded a specific area is categorised as noise-threatened to be protected in the first place, in line with the Law [11].

Noise may be also emitted to the environment by buildings, namely by their technical equipment. For example noisy ventilating or cooling units are often situated on roofs devoid of any acoustic protection. They may affect inhabitants of adjacent buildings particularly if those are higher. The problem may be especially difficult to resolve in the case of densely developed urban areas if it is not considered already at the designing phase while determining the location of noisy installations. Depending on its type and functions, a particular structure may therefore protect users against noise and other external factors, however, it may also become a source of noise emitted to the environment. Buildings and another 3D structures may function as an acoustical barriers, possibly also reflecting sound waves. Adequate development planning may affect the external sound field. Also the functions of buildings designed should be considered, as well as the function and location of rooms inside.

3.2 Building

Three main issues should be taken into consideration while talking about protection against noise of the interior of a building:

- penetration of external noise and proper sound insulation of external partitions,
- noise produced by technical equipment and installations,
- proper sound insulation of internal partitions between rooms of different function.

The external noise level and spectrum, and also profile of changes during daytime determine the characteristics of noise penetrating into rooms inside the building. External noise depends on the location of a specific building, and is shaped by engineering facilities which are typical noise sources but also singular devices functioning nearby. Besides, noise associated with human noisy activities outdoor and inside the building may generate acoustic disturbance. In the recent period complaints regarding noisy functioning of playgrounds, summer restaurants, beer gardens, discotheques, music clubs etc., have been on the rise in Poland. Under current Polish regulations proper protection of a building against external noise requires use of external partitions with adequately high sound insulation. The minimum required value of airborne sound insulation index is determined by the noise zone in which the building is situated and function of rooms inside. Two different indicators are used depending on the noise spectrum according to EN [15].

Noise produced by technical equipment and installations is in general subjectively considered more irritating than transportation noise penetrating from outside. Polish regulations regarding that type of noise provide for separate required values, usually lower by 5 dB than those for noise originating from other sources. The building's technical equipment in most cases are situated either on the roof or in separate rooms designated for fans, lift devices, heating centres, electric power and transformer stations, generators, and increasingly used local boilers. Noise may be also produced by elevators, rubbish chutes, mechanism of garage doors, etc. Protection against noise from these sources consists not only in providing adequate sound insulation of partitions which separate them. Very important is also proper foundation of noisy and vibrating devices, as well as use of proper connectors, supporting elements, elastic suspenders etc. Otherwise, structural and impact noise transmitted along different members of building structure may be disturbing even in places very distant from source. Also, the problem of noise penetrating through installations should be dealt with, i.e. ventilating ducts and media-carrying pipes. Noise produced while using sanitary appliances such as wash basin, bathtub, shower, water-closet, washer etc., poses another problem. This type of noise is extremely annoying especially when penetrating from the neighbouring flat when our neighbour's daily lifestyle and rhythm differs from our own habits.

Partitions which separate noisy technical devices from rooms and areas designated for people should ensure adequate protection from mechanical or installation sounds. Other internal partitions are designed to protect against noise generated in the adjacent room by human presence and activity, household devices, TV and audio sets, plying children etc.. Walls and floors in residential buildings and hotels should provide necessary intimacy and privacy with internal partitions giving the possibility of focused and peaceful work, confidential conversation etc.. Proper sound insulation is also of crucial importance in another type of buildings enabling proper conditions in schools, for patients and personnel in hospitals, clinics, etc.

Internal partitions are assessed in relation to airborne noise (walls and floors) and impact noise (floors only). Airborne and impact noise are generated in various ways, they excite buildings elements in different manner and need different type of means necessary to achieve proper sound insulation. Requirements concerning minimum sound insulation of internal partition exist in all EU countries. They usually refers to the total sound insulation between rooms in particular building taking into consideration all paths of sound transmission, not separating partition only but also flanking transmission. Polish regulations provides minimum values of sound insulation indicators ($R'_{A1}=R'_w + C$) for walls and (R'_A and $L'_{n,w}$) for floors depending on building's purpose and the functions of adjacent rooms.

3.3 Building materials and products

The possibility to achieve proper acoustic quality of a building depends on applied materials and products, on the building's structural details, technical equipment used, installations and supporting elements etc.. Therefore precise estimation of acoustic performance of a building is possible when knowing the acoustic characteristics of construction elements. The estimation methods are given in EN 12354 standards which are also used in Poland. Sound insulation characteristics for different building products are measured in a laboratory and are used as an input data for calculations. Such laboratory tests are conducted while preparing approval opinion and certifying building materials and products. The results are presented as one of the basic technical characteristics of a specific product. In Poland acoustic tests are carried out in accordance with EN ISO 140 standards.

4. SUSTAINABILITY AND THE PROTECTION AGAINST NOISE

4.1 Spatial planning

In recent years there are some opinions among planners underlining absence of reasonable attitude to land management and planning of building development areas in Poland taking into account the principles of sustainable development. They indicate the rising number of new investments on agricultural lands instead of concentrating functions of urban areas. According to such opinions the sustainability in planning and in the construction business should favour completion of existing development areas, possibly leading to construct buildings in parks, green squares and green areas within the cities [17]. Such opinions brought forward thesis of frequent uselessness of insulation zones, suggesting that distance insulation should be replaced by the application of a proper partition, barrier, or another protective elements removing the possibility of detrimental impact of one premises or facilities on another [17].

From the acoustic point of view more dense development may increase the disturbing and annoying effect of noise associated with transportation, everyday life and neighbours' activities. Reduced distance between premises may increase the negative impact of building's technical equipment which emits noise to the outside, such as roof fans, ventilating units, air inlets and outlets, coolers, air-condition devices etc. Smaller distances will make more difficult the problems already apparent in patriarchal closed-type housing estate, where the conditions of noise propagation are much less favourable than in open free field.

Higher density of housing settlements if not properly planed may increase the inhabitants exposing to noise generated by rising traffic. Besides, the ideas of shortening distances may cause tendencies bringing transportation routes closer to residential areas or other premises which should be protected against noise. Also new noise-sensitive investments may be planed closer to existing noise sources. Very often planners and designers are not aware that the efficiency of applicable technical means of acoustical protection is limited. The effect of acoustic barriers is usually overestimated. The application of quiet road surface is effective only for vehicles moving with high speed and usually reduce tyre noise by not more than 3 dB against traditional asphalt [18]. On the other hand effective means of noise protection are usually very expensive. Therefore planning efforts at resolving transportation problems should be accompanied by a more detailed acoustic assessment.

Because of transportation noise local infrastructure should be developed in such a way to encourage pedestrian movement and promote bicycles as a means of individual transport. It is also essential to enhance the attractiveness of public transport, the underground in particular, and to follow a policy promoting family, group, monthly and school tickets, etc. Estimates indicate that among vehicles circulating in cities over 60% carry only one person - the driver. Attempts at creating special lanes for cars carrying at least two persons have been made both in Europe and the USA aimed to reduce traffic noise.

Increasingly intensive use of land will make the escape from urban noise at the place of residence more difficult. As was already mentioned there are some opinions point to the invasion of green areas by housing settlement prompted by implementation of sustainable development rules in the construction sector. Urban greenery is very attractive for developers and already under intense pressure from investors. An interest in direct development to green urban areas is apparent, as is the looming threat that sustainable development as a slogan may be used to carry out individual interests and build luxury housing estates at the expense of common green areas which the city needs. It is a serious problem especially in Poland, where multifamily block of flats dominate and urban greenery is important to provide respite from noise to inhabitants devoid of the gardens or greenery which accompanies single-family housing. On the other hand suggested by some planers needs for reduction of urban greenery may increase the pressure to use suburban areas for recreational purposes, additionally intensifying traffic noise on weekends.

Specific acoustic problems occurs in renovated post-industrial areas and modified former protective zones around existing industrial plants. Renovation schemes are one of the most important areas for sustainable development as well as problems associated with new living and commercial areas located in the direct vicinity of operating industrial facilities and other sources of noise.

4.2 Building

Acoustic quality of a building, residential in particular, should be assessed taking into consideration its surrounding. Not only building’s interior but also associated infrastructure, balconies and loggias creates an environment of living. In practice protection of rooms against noise penetrating from outside is often limited to applying windows with adequate sound insulation. However, location of residential and another kind of buildings in noisy zones providing high isolation of external walls causes isolation and “closing” the interior and may lead to the „aquarium” effect, when outside soundless traffic is observed through the glass pane. Complete acoustic assessment of a building should also include internal conditions when windows are fully or slightly open. It is especially relevant in Poland where most buildings are equipped with natural ventilation and have no air condition system so windows are opened commonly for a long time particularly in summer. Nevertheless, in accordance with Polish acoustic regulations maximum level of external noise penetrating into the room obliges for rooms with closed windows and doors.

Polish requirements also say that ventilation system should provide minimum air inflow when windows are fully closed. To fill that requirement in practice, windows are either unsealed or equipped with additional inlet devices. Both solutions usually reduce window’s sound insulation. It is very difficult to achieve good acoustic performance of a window with reduced air tightness [19].

Available and inexpensive housing is listed among the key needs included in sustainable development programmes. The drive to cut prices of flats should not, however, worsen their acoustic qualities. Residential buildings are likely to be increasingly more light structures constructed with light elements. Such buildings enable to apply less energy-consuming materials in production and to involve more small and medium enterprises in the process of construction. Light structure reduce the use of heavy equipment, enables application of latest technologies, and employ a highly professional workforce. All mentioned factors are favourable in terms of sustainable development. Light structural elements are already widely used in office and public buildings. However, in practice very often they are accompanied by a number of serious acoustic problems, difficult to accept in residential buildings.

The implementation of sustainability ideas in construction industry may also trigger the pursuit of new building materials and products along criteria of environmental friendliness, less energy consumption, possibility of recycling, etc. Nevertheless, the said efforts cannot ignore protection against noise. Even at presence many existing materials and technical solutions, acceptable from the structural point of view, are inapplicable because of poor acoustics.

Other acoustical issues emerge at modifying and modernizing existing buildings. Works aimed at improving their quality should take into consideration also acoustics. Noise protection is especially difficult in the case of an old but still existing buildings, completed in a time when acoustic requirements were not exist. Neither is it easy to alter the functions of rooms which originally did not require special protection against noise. Adaptation of loft to residential purposes is an example, or the transformation of dwellings on the ground floor of multifamily buildings into service outlets, such as retail or gastronomy.

5. TOWARDS UNIFORM ASSESSMENT CRITERIA

5.1 Land

The acoustic assessment of areas planned for development or already developed performed only on the basis of formally imposed legal limit values of permissible and threshold noise levels may be inexact. Obviously, on adopting legal requirements many factors are considered, economic impact included. Therefore permissible levels of environmental noise are neither universal nor clearly reflecting the subjective perception of noise by exposed person. Polish regulations on environmental noise protection are the example. Relationship between permissible noise levels adopted for different types of land may provoke questions, as do the relationship between permissible and threshold noise levels for specific category of land [20]. The differentiation of required noise level values depending on a specific type of source, i.e. industrial, transport and aircraft noise is also a controversial issue. Evidently, perception of noise having the same level but coming from different sources is different. Aircraft noise is considered more annoying than road traffic noise of the same level, while railway noise is tolerated better than road noise. However, introduced into Polish regulations differentiation not always reflects the subjective perception [20]. Hence the assessment of acoustic quality of development areas and their suitability for specific functions carried out on the basis of legal permissible and threshold levels only may be inaccurate. Issues associated with comfort, economic problems, technical matters and health-motivated protection against noise, should be separated from each other. The proposal to qualify building development areas in terms of acoustic on the basis of independent assessment criteria seems, therefore, worthy of consideration.

Such an independent criterion should take into account different level of annoyance caused by different noise source. Relationships between the L_{den} level of road, railway and aircraft noise, and the percentage of persons who perceive noise as „ annoying" [%A] or „highly annoying" [%HA] may be use for this purpose. Such dose response curves presented in [21] were developed based on the results of various studies, and are designed to be used for the assessment of social exposure to noise when amending attachment no. 3 of the Directive [12]. To a specific road noise level, e.g. L_{den} = 60 dB is attributed a specific value of indicator A=26%, while to the indicator A=26% is attributed the aircraft noise level L_{den} = 54 dB and railway noise level L_{den} = 66 dB. Therefore, aircraft noise (54 dB) road (60 dB) and railway noise (66 dB) will be assessed as similarly annoying. The analyse of dose response curves [21] shows that aircraft noise is perceived as more annoying by 5-6 dB than road traffic noise, while railway noise by 5-7 dB less annoying than road noise. On applying the criterion [%HA] for higher noise levels the relation is similar. (In the range of 45-50 dB the criterion [%HA] is not sensitive to changes in noise level because high annoyance is not the case at such low levels). After simplification the assessment of building development areas exposed to aircraft noise should be more severe by 5 dB than in the case of road traffic noise. Respectively railway noise should be assessed less strictly by 5 dB.

In order to unify the methods of environmental noise assessment the Directive [12] introduced new indicators and obliged EU member countries to apply them. Two mandatory basic indicators have been determined;

a) day-evening-night level, L_{den}, to assess general annoyance:

$$L_{den} = 10 \cdot \lg \frac{1}{24}\left(t_d \cdot 10^{\frac{L_{day}}{10}} + t_e \cdot 10^{\frac{L_{evening}+5}{10}} + t_n \cdot 10^{\frac{L_{night}+10}{10}} \right) \qquad (1)$$

b) night level L_{night}, to assess sleep disorders.

The introduction of a unified assessment criteria will be an important facilitation. However, the use of the indicator L_{den} in some cases may be unreasonable, e.g. for recreation areas used only in daytime. Residential areas are in turn used mainly in evening and night hours. Relations between assessment indicators currently used in various countries and the new EU indicators should be analysed. L_{den} indicator differs from the L_{Aeq16h} used presently in Poland for daytime in terms of transport noise as well as noise coming from other sources. Based on formula (1) differences (L_{den} - L_{Aeq16}) dB for different profile of noise were calculated [20]. Results sow that for local streets where traffic strongly falls during the night the difference (L_{den} - L_{Aeq16}) dB comprises between 0-1 dB. For city centre streets, motorways and railways carrying heavy traffic during the night it increases up to 3-7 dB. Thus the relation between assessment criteria may vary depending on specific situations. Relations which occur between different criteria should be taken into account also on classifying building development areas depending on their daily period of usage determined by function.

5.2 Building

Sound insulation of internal partitions determines the building's quality. Requirements in this respect are present in all European countries. Their level varies as do the criteria of assessment used in specific countries [22]. Sound insulation indices are defined by the EN ISO 717 standard which is adopted also in Poland. Although the standard allows several different indicators giving the option to adopt assessment criteria individually by particular countries. Such a freedom of choice makes difficult to compare different requirements in various countries because of different assessment criteria used. It is also difficult to introduce unified acoustic classification of buildings. As an example table 1 presents sound insulation indicators applied in several EU countries to assess acoustic performance of walls between flats in multi-family buildings and the required values.

Table 1. Sound insulation requirements for multifamily buildings

Country	Indicator	Minimum value dB
Poland	R'_w+C	50
Germany	R'_w	53
Austria	$D_{nT,w}$	55
UK	$D_{nT,w}+C_{tr}$	45
France	$D_{nA,T}$	53
Sweden	$R'_w+C_{50\text{-}3150}$	52

Different assessment criteria are also applied on determining required sound insulation of external partitions. Different indicators are used both to assess external noise level and the sound insulation of partition. It is particularly evident in the case of aircraft noise which in practice, depending on local regulations, may be assessed using the equivalent sound level, the maximum level, the long term average sound level, and the sound exposure level SEL. Besides, particular countries apply different sound insulation indicators of external wall which, in addition, may be selected depending on a specific assessed situation i.e. dominating source of noise. For example, in the case of criterion which includes the spectrum adaptation terms acc. to EN ISO 717 two different indicators are used for assessment of noise produced by jet and propeller planes.

Some problems also emerge on assessing noise produced by sanitary facilities and installation which penetrates into adjacent rooms. It is necessary to determine the cycle of operations adopted for assessment, e.g. for filling bathtub with water, flushing etc.. For this purpose new European standards are being developed, pr EN ISO 16032 and pr EN ISO 10052.

The presented difficulties point to the need of certain uniformity of acoustic assessment methods. However, the use of current regulations as a start point for such unification may be difficult due to diverse conditions and interests in various countries. It may be nevertheless possible to develop independent acoustic classification of buildings based on independent criteria. The acoustic class would be associated with acoustic quality and comfort and will affect the price of a premises. It is a solution providing potential customer or user with a possibility of conscious decision based on a compromise between expectations, sensitiveness to noise and financial possibilities. The dissemination of such a classification used as a tool for building quality assessment may lead to establishing uniform criteria adopted in different countries allowing to set requirements on different levels by determining the minimal class, depending on internal factors such as finances, culture, climate, lifestyle etc.

Summary

Contemporary noise is a growing threat. Its impact on health, society and the economy cannot be underestimated. The need of protection against noise concerns also the entire construction sector. The respective efforts carried out as a part of sustainable development require uniform independent assessment methods in order to be efficient. The development of acoustic classification principles for areas planned for development and of the guidelines of acoustic classification of residential buildings both seem necessary. Some trends resulting from implementation of sustainability ideas in the construction sector may generate detrimental acoustic consequences. It is another reason to seriously analyse the noise protection issues in the process of planning, designing and constructing.

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CONCRETE PRODUCTION IN THE ASPECT OF SUSTAINABLE DEVELOPMENT PRINCIPLES

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1. INTRODUCTION

It is expected, that construction industry in XXI century will satisfy of the society requirements for healthy and durable building works. However, from different reasons concrete structures can be considered as incompatible with the principles of sustainable development. In concrete production a large amounts of valuable, natural raw materials are used, and during cement production gas emission to the atmosphere takes place, contributing to the global greenhouse effect and in consequence – to the climatic changes [1].

2. CONCRETE PRODUCTION INCLUDING ENVIRONMENTAL PROTECTION ASPECTS

Three issues are widely discussed with regard to sustainable development: ecological production, changes of climate and reduction of natural resources.

The "clean production" is among elements of sustainable development strategy in the field of construction industry. It is defined as permanent protection of natural environment individual elements against consequences of production processes and against pollutions caused by products.

Clean Production Strategy assumes [2]:

- economical management of materials used in production process,
- energy economy,
- excluding of materials and products, which are harmful for environment and health of people,
- prevention measures against generation of waste materials.

In many parts of our globe the changes of climate took place. To the scientists [3] this phenomenon in mainly concerned with high degree of gas emission to the environment, in the

range of 280-370 ppm. Emission of greenhouse gases, mainly CO_2 , and its concentration in the environment is mainly associated with industrial transport and cement production. According to statistic data, cement production provides about 7 % of the world CO_2 emission [3,4].
The third aspect is the reduction of natural resources. Concrete industry consumes a large amounts of raw materials like sand, gravel, crushed aggregates and water. For production of portland cement and multi-component cement, 1 billion tons of materials is used every year. In addition, cement production uses a large amount of limestone and clay, with the involvement of high energy-consumption.
When technical conditions of building deteriorate or when building no longer perform the functions, before the assumed working life expired, then such big utilization of natural resources and energy can be considered as wastage.
There are the cases when nowadays built structures need repairs during guarantee period.
It specially concerns bridges, parkings, garages and marine-structures [5].
Mostly, the concrete structures are designed for the intended use of at least 50 years. From the time when HPC production has started, there is a chance that these structures would last about 100 years. The progress in reduction of using of natural raw materials by extending of building materials durability is rather long-time solution.
In the opinion of many persons, systematic actions to develop of ecological production in a large scale – is the solution of the new strategy. Similarly, water which is recover from the cement industry, may be substitute for water used in concrete mixes, after assessment of fitness for use [6].
The production of multi-component cements, which incorporate waste materials such as fly ash, slag and silica fume, are examples for ecological industrialization. In this way, cement industry provided the excellent materials and reduced the onerous effect on the environment.
In Polish construction industry, the concrete mixes incorporating 15-20 % of fly ash have been used for many years. The amount of fly ash utilized for this purpose is estimated as 700.000 tons yearly.

3. THE CURRENT STATE OF MANAGEMENT OF WASTES COMING FROM CONSTRUCTION INDUSTRY IN POLAND

The Act concerning waste, dated of 27.04.2001, imposed the obligation for waste management planning, which is the basis for preparation of plans in a lower levels. According to GUS data, as much as 139340.000 tons of wastes have been produced in 2000 in Poland. According to waste catalogue given in Decree of Ministry of Environment of 27.09.2001, construction wastes are qualified to the 17^{th} group. They are defined as wastes coming from construction sites, repairs and demolition of building works and road infrastructure. The amount of such wastes in 2000 was estimated as about 2186000 tons [8], it means about 1,8 % of total wastes.
Such wastes are derived from many scattered companies in the field of construction and repairs, in road and industry building, what makes the precise estimation very difficult. Above mentioned data include the group of large enterprises, producing more than 1000 tons of waste yearly.
The amount and type of wastes coming from small and medium firms were not the subject of investigation and they are not covered by statistic data. From the fragmentary information it may be concluded, that the amount of the latter wastes are estimated as 2-8 % of a total wastes generated in Poland.
Building wastes are formed both on the construction stage and during planned or emergency repairs and demolition works. Depending on the source, the qualitative characteristic of these

waste is very diversified. Wastes coming from building works, repairs and demolition works in industrial construction may be polluted by: heavy metals, petroleum products and impregnating substances. Wastes coming from railway building may be polluted by impregnating substances (sleepers), oil, grease, other dangerous substances, heavy metals (broken stone), as well as by soil and stones.

Depending on assortment and pollutions, including dangerous substances (asbestos), the wastes have been divided on the subgroups and marked by codes e.g. concrete wastes and concrete debris from demolition and repair are marked: 17 01 01.

3.1 Industrial production of aggregates from construction wastes

According to data for 2003 [9], 15 firms is involved in the recycling of construction wastes. Production of recycling aggregates includes the following stages:

1. Initial selection and segregation of road and construction debris,
2. Initial sieving and separation of oversize elements,
3. Shattering oversize elements,
4. Crushing and separation of material

Fig.1 Jaw crusher

Fig.2 Impact crusher

4. HIGH PERFORMANCE CONCRETE (HPC)

There are many definitions for HPC [10].ACI defines it as special engineering concrete, with one or more specific properties, which is improved by selected materials and by appropriate component proportions. This definition may not be adequate in relation to concrete, for which specific requirements was determined, such as good workability, high early compressive strength and high resistance to exposure conditions. Generally, the majority of critical opinions, with regard to ACI definition of HPC, did not accept this view, that durability is not obligatory but only optional parameter [1].

Statement, that combination of high strength and durability of concrete is unsuitable, resulted probably from many cases of cracks and premature deterioration of HPC in structures [11, 12]. But generally, the incorrect mix proportions, which were used to production of high strength concrete were the reason. Typical HPC mixes contain in 1 m^3 400-500 kg of portland cement or mixed cement, small amount of silica fume, fly ash or slag and they are designed with low w/c ratio. The superplasticizers and air entraining admixtures are used, when frost resistance of concrete is required.

Research works and practice indicated, that HPCs with high strength were mainly produced.

On the other hand, the massive structures are still executed with a large portland cement content, what results in a big shrinkage. Therefore, Aitcin [13] has proposed to complete HPC definition in this way: *HPC is the concrete with low w/c ratio and stabilized shrinkage, which receives adequate water to the shrinkage self-control.*

The research works carried out by Ho and Sheinna [14] have shown, that certain amount of cement in HPC may be replaced by other materials e.g. granite dust (by-product formed during granite aggregate production) which may be applied in new generation of SCC, instead of limestone powder. Replacement of certain amount of cement by dust not only decreases of cement consumption, but also reduces the energy needed for concrete vibration. Another example: to the very high performance concrete fly ash, slag and silica fume were used individually and in several combinations with cement. As high strength as 200 MPa was obtained together with w/c = 0,16, high density and high fluidity of mixes [15].

In concrete technology in Poland, as additions to concrete silica fume, slag and fly ash are used. In 1992 silica fume was applied in the first supervised by ITB structure, which was viaduct in Warsaw (fig.3).

Fig. 3 Viaduct on Hynka street in Warsaw –supervised by ITB (Concrete Department).

Above considerations, with regard to research works and practical applications of HPC, attract the attention to this type of concrete and answer the question: weather HPC is or it is not the choice satisfying the principles of sustainable development. The majority of conventional concretes may not be qualified as materials satisfying these principles, because they are not durable, contain a large amount of cement and small quantities of cement replacement materials.

5. HIGH VOLUME FLY ASH CONCRETE (HVFAC)

Fly ash - the main by-product of coal combustion may be used as compound of multi-component portland cement and also as pozzolanic addition to concrete. In common practice, fly ash is used in the amount of 15-20 % in relation to the cement mass. Normally, this quantity gives sufficient advantages in concrete workability an price, but in may be insufficient to improve durability of concrete to sulfate attack, alkali expansion and thermal cracking. For these reasons, the bigger quantities of fly ash – up to 35 % m.c. are used, but such composition still can not be qualified as HVFA system.

According to Malhotra and Mehta [16], the amount of fly ash in HVFA should be at least 50 % m.c.

From theoretical point of view, and on the basis of practical experience, the authors settled, that concrete incorporated 50 % of fly ash is possible to be produced in compliance with the assumptions of sustainable development. Such concrete mixes are characterized by high workability, high strength and durability.

The mechanism of cement hydration in the presence of pozzolanic materials is commonly known and described in bibliography. Improvement of concrete properties, as a result of their application, is connected with the ability of reactive SiO_2 to the reaction with $Ca(OH)_2$, and formation of C-S-H phase [17]. The only disadvantage of this system is too slow strength development, but workability of concrete mix is its virtue.

Several advantages, due to application of large quantity of fly ash in concrete are presented below [1]:

1. very good flow properties, better pumpability and better compactibility,
2. better finishing surface, quicker execution, without additional energy.
3. longer setting time, allowing to carry out the additional technological operations e.g. joining of the next layers.

6. OWN EXPERIENCE

ITB technical supervision on the building site of Warsaw`s tunnel takes into account of the investor requirements: economic effectiveness and maintenance of proper state of construction after execution of works. Typical technical specification was completed by several specific material, technological and logistic requirements, for various conditions of tunnel construction.

According to the regulations at that time, the decision regarding fly ash application has to be taken by the Minister.

In actual state of the art, when environmental conditions of future construction are properly defined, the technology of concrete execution and choice of materials may be precisely specified. To prevent asking the questions during implementation of this difficult construction, the rule has been adopted: to determine all potential hazards before the construction has started, and then to determine the procedures for specific situations.

The innovations in specification are given below:

1. essential components (concrete materials) were covered by the procedure of permanent delivery monitoring, according to European standards,
2. conformity procedures were defined and the Quality Plan was established,
3. the calculation of structure durability was determined on the basis of initial tests of concrete resistance to simulated deterioration, during ageing tests carried out in the conditions of simulated aggression,
4. according to ISO 9001, the procedure on the contact among investor, supervising body, management of construction and subcontractors has been determined,
5. the specific procedure in the range of quality has been applied for concrete suppliers.

According to the requirements the following materials were used: cement CEM I 42,5, aggregates in grit form and natural sand. Silicate fly ash was admitted by special, formal procedure. For such cement-fly ash combination, the appropriate chemical admixture (on the basis of polycarboxyethers) were selected.

All materials satisfied the requirements of specifications and standards, and their deliveries were controlled and supervised according to the principles of ISO 9001.

The various concrete mix proportions were used, including fly ash variations. The fly ash/cement ratio was in the limits from 0,15 to 0,42. Applying bigger quantities of fly ash and keeping the same mix consistence, the amount of water and w/c ratio was reduced. Concrete 1 was characterized by w/s = 0,39, and concrete 2 – w/s=0,32. Concretes were frost resistant and watertight. The results obtained on samples taken from 5 randomly chosen concrete

batches fulfilled the requirements of PN-88/B-06250 for concrete F150 and W8. According to EN 206-1 these concretes have been qualified to exposure class XF4.
During the structure execution, about 300 mix proportions have been made, since the concrete composition was verified before every concrete placing, and it took into account all technological aspects: type of structure, the way of moulding, curing, weather conditions etc. Fig.4 presents the results of strength for 210 concretes.

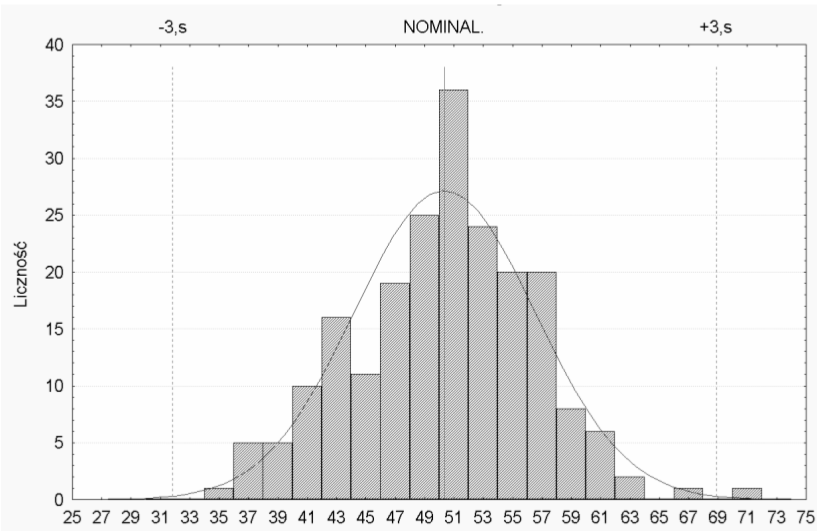

Fig.4 Statistic analysis of 210 series of 28-days compressive strength results of concrete built in the tunnel construction, $R_{mean\ value}$ = 50.3 MPa.

After 2 years curing of randomly chosen samples of concretes in the climatic chamber, the compressive strength was tested and compared with 28-days results. On fig.5 and 6 the results of strength are presented.

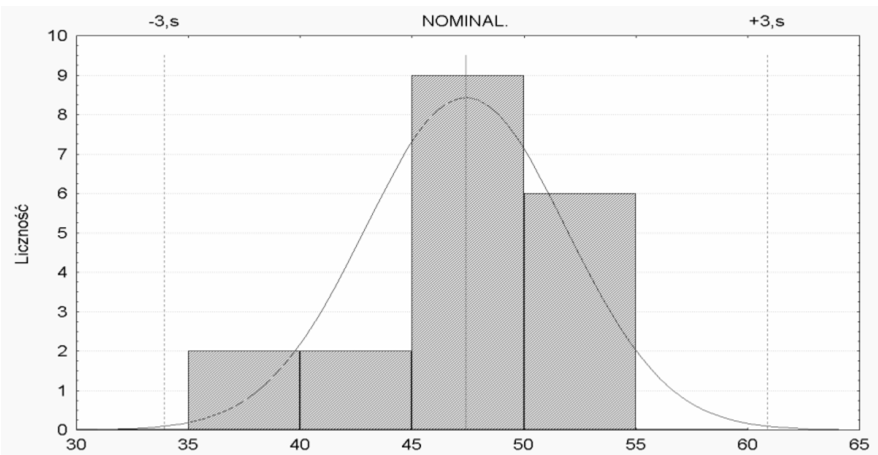

Fig.5 Statistic analysis of 28-days compressive strength of concrete built in the tunnel structure, $R_{mean\ value}$ = 47.4 MPa.

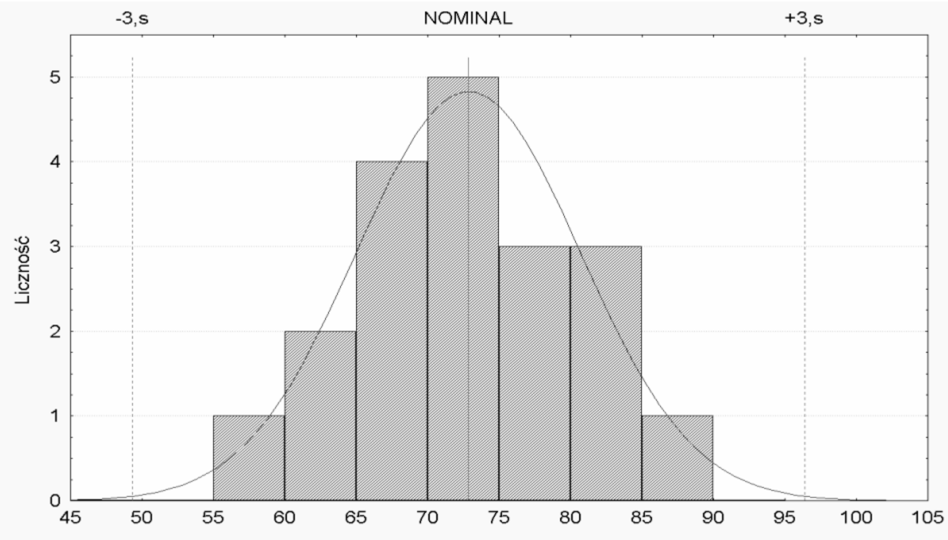

Fig.6 Statistic analysis of 28-days compressive strength of concrete built in the tunnel structure, $R_{mean\ value}$ = 72,8 MPa.

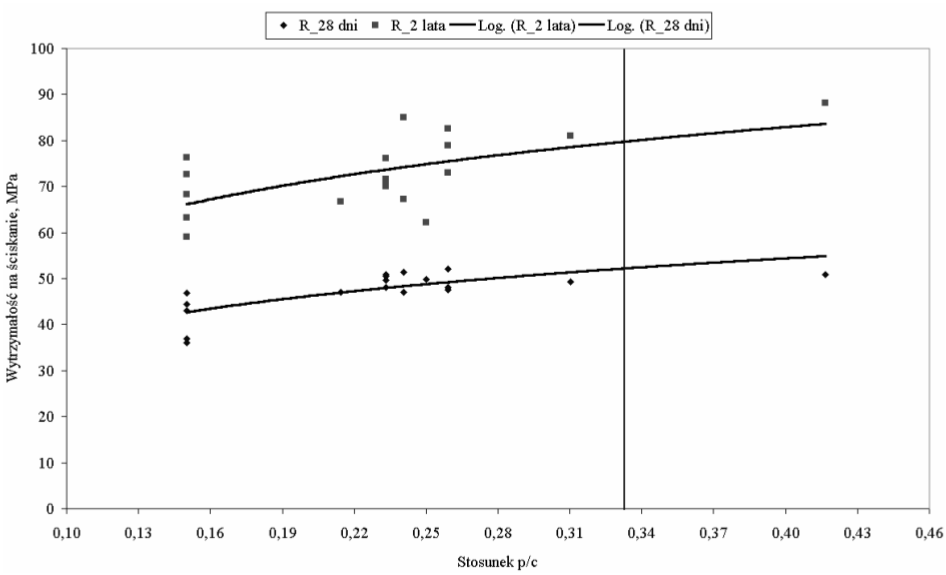

Fig.7 Compressive strength of concrete after 28-days and 2 years. (maximal p/c ratio permissible by EN 206-1 is 0,33).

Fig.7 indicated, that the concrete strength is on the increase with the increase of fly ash content in binder. Independent on p/c proportion in binder, after 2 years, about 50 % increase of strength is observed.

Two concrete compositions, with the extreme fly ash quantities, marked as concrete 1 and 2 are given in table 1.

Table 1. Mix proportions

	Composition of concrete (1) p/c = 0,15		Composition of concrete (2) p/c = 0,42	
	kg/m³	l/m³	kg/m³	l/m³
Cement	300	95	240	76
Fly ash	45	20	100	45
Water	136	136	110	110
Chemical admixture	1,2	1,4	1,4	1,5
Coarse aggregate	1205	456	1206	455
Fine aggregate	771	291	804	304
Total	2458,2	999,4	2461,4	991,5
w/s	0,39	---	0,32	---
Paste volume	---	252	---	232
Paste percentage	---	25,2	---	23,4

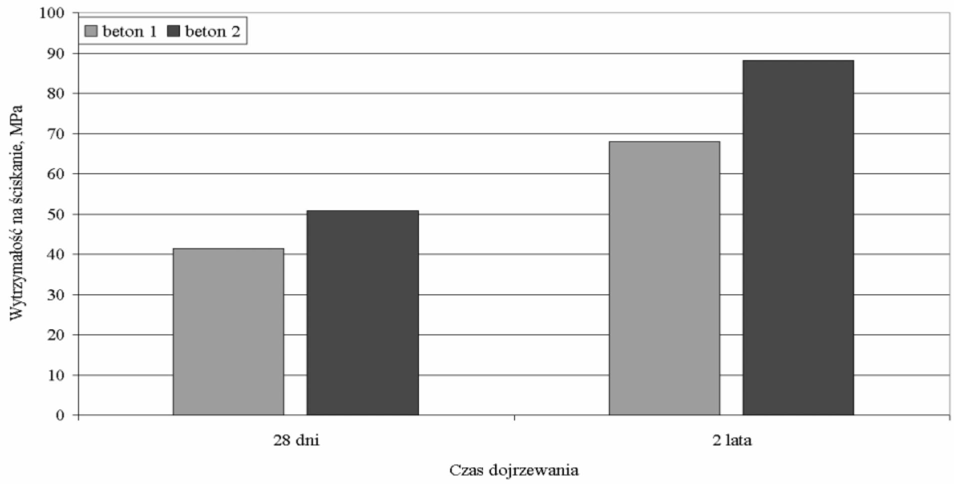

Fig.8 Compressive strength of concrete 1 and 2, after 28 days and 2 years hardening.

7. SUMMARY

In last decades, the development and the range of HPC application in Europe gradually increased. The application of HPC was so far limited mainly to the buildings and bridge structures such as: elements subjected to high compressive loads, walls, pavements, and beams with the small cross-section (slim structures) etc. Obtained results and practical experience should be formulated in the form of rules.

Present practical experience on the application of HPC, based on many research works can be transferred also to the underground construction and can be effective in development of a new technologies, specific for this type of structures. The specific requirements concerning underground construction force also certain conventional technologies to the further development.

The costs of removal of waste materials are increased all over the world. At the same time it was recognize, that fly ash is the cheap and easy available by-product, which can be applied in concrete industry.

HVFA system, to a large extent, allows to overcome the problems of thermal cracks, alkaline expansion or sulfate aggression. As an effect of w/c reduction and taking the advantage of fluidization due to superplasticizers, as well as by reasonable dosage of aggregate, concrete which is properly cured, indicates homogenous microstructure and high strength without cracks.

Summing up- in respect of the increase of requirements in relation to future concrete, HVFA technology provide the optimal, sustainable solution. It reduces the production costs and contributes to decreasing of wastes materials, which are created by two large industrial branches – cement industry and coal mining. In that situation, the link between low production costs and environmental protection seems to be suitable solution and development of HFVA may be recognized as conforming to the principles of Sustainable Development.
Application of such high fly ash content is difficult for acceptance, because of slow development of concrete durability in the early stage of hardening. The results of own research works presented here certify the chance for safe application of fly ash in the proportion p/c = 0,42.

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SUSTAINABLE REHABILITATION OF MONUMENT PROTECTED BUILDINGS
LIVING STARTS ON THE STREET

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1. City Expansion towards the Interior

Future-oriented and sustainable city development is the foundation for the revitalization of inner cities with historical building substance.
In 2000, the world conference on the future of cities - Urban 21- took place in Berlin. The, then, Federal Minister for Traffic, Construction and Housing, Reinhard Klimmt described in his inaugural speech to the world conference the quality of life and social peace in the cities as a priority goal.
The preservation of the inner cities is equivalent to the responsibility for tradition, history and culture. Inner cities are the political and cultural centres of the towns. Giving them up would mean irretrievable destruction.
He, who visits a European city has the direction to the old town described to him first. There one expects cultural and architectural highlights as well as lively variety.
The old towns are characterised by their old historical buildings, squares, and lanes etc. These historic buildings which are mostly listed delight with their flair, their beautifully structured ornamented facades, high rooms, staircases, and inner courtyards. However, under the requirements of climate protection and energy savings, old buildings are no longer competitive. With today´ s technology every new house can be erected as a passive house (minmal energy demand).

Buildings are responsible for a 1/3 of the energy consumption in Germany.[1]

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[1] Klimmt, Reinhard, Regierungserklärung zu Urban 21 vom 8.Juni 2000

However, what happens if the energy costs increase rapidly? Do the old towns become depopulated because the energy costs exceed the rents? This would be an extremely sad idea. Therefore, energy-saving modernization in the context of sustainable rehabilitation of buildings is for that reason of great importance, particularly in old towns and indoor Cultural Heritage.
Of course, sustainable construction within an existing building stock does not only mean the rehabilitation of a building or a group of buildings according to energy efficiency aspects. Glance in the quarter, in the close vicinity, in the street and you are already faced with more exciting tasks. Is it not possible that further development, reorganisation or restoration of formerly existing structures could enhance the site further?
Project steering in dialogue with all involved leads to optimal solutions without increasing costs and without decreasing quality.
Here project developers, town developers, architects, engineers, construction physicists, landscape planners, and curators of historical monuments, i.e. private and community partners have to create a team. Together, they have to create common general conditions for effective detail planning. A clean green environment is friendly and welcoming, conveys peace and cosiness. Living literally begins on the street.

The house entrances, staircases, as well as the inner courtyards are the visiting cards of the houses. Concrete deserts or small gardens as communicative places, the choice is actually not difficult. The quarter as the smallest constituent in the structure of a town bears the greatest responsibility towards its image and preservation.

You live, work and breathe in the quarter. We spend the greatest part of our lives in closed rooms, but put paradoxically most people place more value on comfort in the car than in their flats. The car, it is taken for granted that it may only consume a low amount of fuel and we are seldom satisfied unless we have all the extras, it has now cost a little more but we have treated ourselves. It does not interest us in the least that newly-purchased it will have lost half its value after two years. Unless it is a vintage car, which is cared for, cherished, kept in working order and continually increasing in value. Because it represents something very individual that cannot be built again.
You do not scrap an oldtimer! Unfortunately, one allows old houses to become dilapidated. The insight that long-lasting value and a value increase can be achieved through sustainable rehabilitation is only slowly catching on.

Many private investors who might invest their capital in the revitalization and maintenance of listed buildings are exercising restraint due to the present economic situation.
Most banks regard energy-based rehabilitation sceptically, since the ratio of rental yield to additional expenditure does not produce any immediate return, in other words does not yield a short-term profit.
The opportunity of long-term letting or the future lower expenditure is not at all included in the rating. On the contrary, the idea of short-term return is still decisive for the provision of funds. Owner-occupiers do not fare any better.

The household budget situation of the towns and municipalities is precarious. The federal states and the government argue about sharing the costs. In the old federal states no real subsidies have been foreseen supporting meaningful and energy-based modernization of old buildings since the reunification.
However, financial aid can be obtained from the "Kreditanstalt für Wiederaufbau" (bank, owend by the federal states and the governement) through certain partial loans at favourable

interest rates and by certain income tax breaks. The basic legal framework for this is established in the German income tax laws. Unfortunately, these advantages are partly offset by other taxes and levies. The owner of a rehabilitated property has to pay higher property taxes and insurances since a lot of these costs are levied according to the rateable value of the property. After rehabilitation, from the point of view of the tax authorities, this value has been increased and it forms the basis for further legal taxation. Here energy-based construction turns out to be more of a punishment rather than a reward.
At municipal level a lot of small efforts could be initiated to promote the acceptance of energy-saving modernization or generate incentives for it.

2. Living space old town

Regrettably in keeping with the facts, if there were not any civil commitment for the conservation of monuments and the commitment of the foundation – Cultural Hertiage in Germany, a lot of historical buildings would not exist anymore. Architects and town planners alike have approved the redevelopment of large areas and have allowed the construction of tower block flats distant from the work places.

left: unrealizied plan in the sixties /right: location 2002

Such planning also existed for the old town of Ludwigshafen; but, fortunately there was a committed building director who had other plans in mind and regardless of the changing political landscape could pursue his objective target for almost 20 years. Here one is speaking about the oldest and at the time of its designation in 1972, the largest coherent redevelopment site in Germany, named Hemshof.

The choice of working and residential locations is determined by the image of a city. Therefore every town district needs a future vision to promote the attractiveness of the whole town. The awareness for the positive development of the city is kindled in dialogue with its citizens. Only the identification of the citizens with their city can increase its attractiveness beyond the borders of the region.

Here is a small dialogue in this form which one frequently experiences:
"Ludwigshafen, where on earth is that, never heard of it" " It is in the Rhine-Neckar-Triangle in the immediate vicinity of Mannheim, just a few kilometres away from Heidelberg." "Oh, Heidelberg, the castle, the old town, we have seen it on our trip around Europe. It was beautiful there."
"Ludwigshafen is the seat of one of the largest chemical companies in the world, the BASF"
BASF, Styropor, Indigo, music cassettes, yes, yes we know and does one live well there?"

One lives here today better than ever, since the rigorous implementation of measures e.g. in the Hemshof redevelopment area, has immensely improved the quality of the residents´ lives. Besides the exhaustive displacement of the producing trade, the removal of the inside blocks, and the de-sealing of the areas and the greening of all streets, squares and inside zones, a large park with a childrens´ paradise was incorporated.

After the war the Hemshof was, unlike the town centre, not completely destroyed.
Due to the housing shortage, large apartments in the houses dating from the founder´ s period were quickly turned into two to three residential units. This type of living was very uncomfortable, the rooms were small and cramped and most of the residents on a floor had to share the toilet facilities, and bathrooms were extremely rare.
New buildings were then erected on the edges of the town and in the gaps between the existing buildings. Those who earned a little more moved away and the old and impoverished remained. In the sixties, the residents of the converted houses from the founder´ s period became the homes of the foreign workers who could only afford small rents.

The old town was neglected, the houses were in a dire state, the inner courtyards were obstructed and the streets and squares were sealed.
Living in the town or even in an old building was not "in".
In 1972 the old town was declared a redevelopment area by statute and the measures and the intended goals started to take effect.

Hemshof 1970

Hemshof 2000

Today we are again faced with a challenge to retain a manifold and vivid town in view of the demographic development.
Today, in spite of mobility, residences in the vicinity of the workplace are being sought after.
The town offers short distances and an extensive choice of public transportation, a good infrastructure, with schools and kindergartens, day nurseries, cultural and gastronomic facilities, quarters with a large amount of greenery and tree stock. All these attributes can be found in the Hemshof in Ludwigshafen.

We could build on this basis and were able to raise private capital to advance the rehabilitation of the properties in the old town.

examples for sustainable buidlings realized from Osika Ltd. in 1994 and 1997

3. Interior Insulation - an innovative solution for historical buildings.

There is a gigantic energy savings potential in the sustainable rehabilitation of old buildings. Not only, that built architecture represents a stored material resource, with the technical possibilities available today, it is possible to transform a non-refurbished old building with a heating energy requirement between 300 and 400 $kWh/m^2/a$ into a low energy house with a heating energy requirement of 30 -70 $kWh/m^2/a$.[2]
With our pilot project in Limburgstr.19/21 we have tried to reduce the heating energy requirements for these two listed buildings by over 75% and lower the CO_2 -emissions. [3]


Limburgstr. 19 /21

The sustainable rehabilitation of the houses has been awarded the KfW-Award 2004 "European Life, European Living, Property with Future - Modernization and Energy Saving" by the Kreditanstalt für Wiederaufbau in Berlin. Here is a quotation on the criterion from the brochure " Die Preisträger" (the winners).

"A decisive factor for the jury for awarding this building, was the exemplary solution for the integration of the neighbourhood regarding the technical equipment. Thus, the rehabilitation of Limburgstr.19 was completed at the same time as Limburgstr.21. The new gas central heating with calorific value technology installed in the basement of Limburgstr.19 also supplies the neighbouring house with thermal energy. There was sufficient space on the roof of Limburgstr. 21 for a solar energy device for service water heating which also supplies both houses. Thus by sharing this heating system, one system could be eliminated and correspondingly the CO_2 emission could be reduced. On the other hand this solution is not only exemplary from the energy point of view but also from a socio-political aspect since here two adjacent houses were beautifully refurbished for the condominium association. The dwellers of both houses have agreed, by the way, not to build a dividing wall in the garden between the two houses."
This high carbon dioxide reduction cannot be achieved by one single measure, only the bundling of different measures led to this result.

The rehabilitation was essentially related to the rearranging of the ground layout plan to more spaciously laid-out flexible units, the complete renewal of the supply and disposal facilities, the restoration of the monument protected street facades, and the enhancement of the sound insulation.

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[2] Prof. Dr. Ing. Karl Gertis „*Vom Niedrigenergiehaus zum Nullheizenergiehaus*“ Vortrag 1997
[3] Gutachten v. Dipl.- Ing. E. Baffia, Sachverständige für Niedrigenergie- und Passivhäuser 2002

The energy-based rehabilitation included:

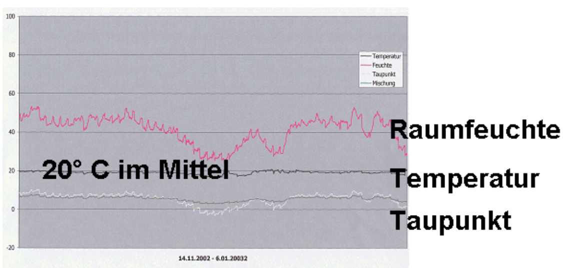
- installation of new wooden windows in historical partition with heat protection glass with U 1.1
- installation of central heating with calorific value technology with water heating
- installation of a solar energy device for service water
- installation of a decentralized ventilation system per unit with heat recovery
- insulation of the roofs, the ceilings of the basement, the neighbouring walls and the ceilings of the flats (material: Isover thermal conductivity 0.35, 240mm in the roof)
- insulation of the courtyard facades with an external thermal insulation composite system (material: Neopor 0.35, 160mm)
- insulation of the street facade from inside (material: Neopor 0.35 and Isover 0.35, every 80mm, for the study).

The detailed planning before the beginning of the measures covered stock-taking of the suitability of the wall construction, the thermal bridges, - and moisture proofing calculations for all critical components, mainly for the wooden beam ceilings.
In order to measure the suitability of the interior insulation, sensors were installed on neuralgic points of the street facade to provide information about eventual dew point shifts. This work was conducted under the supervision of and in cooperation with Dr. Feist, Passivhausinstitut Darmstadt.

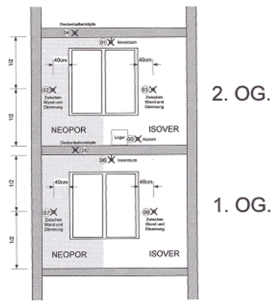
Combined sensors were fixed on the boundary layer between the old inner surface of the wall and the insulation and air temperature and humidity was recorded in each room and compared with the outside temperature and outside humidity.
The air tightness was reached by means of a climate-regulating membrane placed over the insulation material. The extremely careful workmanship of the membrane on all joints and connections was mandatory.
The air tightness was checked by a Blow-Door method, for all rooms one by one in order to specify the tightness.

Highly insulated houses have to be equipped with a controlled ventilation system, preferably with heat recovery.

The recorded data were read by EDP via a network system in the house and submitted to the Passivhausinstitut for evaluation.



Measuring record showing humidity, temperature and dew point shifts



Scheme for built-in the sensors and the two different materials of insulation for the study

This measuring programme has been running for two years now and covers two heating periods. These results are already available. All results are perfectly fine, internal insulation in combination with the ventilation system reduces the heating energy consumption by an additional 25%.

The expertise which was drawn up before the rehabilitation revealed a realistic starting point. However, the savings potential could vary depending on the utilization behaviour.

Therefore taking care of the properties and advising of the residents is of major importance. The residents have to find a competent contact person e.g. during the commissioning of the ventilation system and its programming according to personal behaviour patterns.

The exchange of experience amongst each other and the permanent possibility of receiving free advice, has freed the residents of the initial shyness of the new house technology.

And here we have come full circle, i.e. developing self-dynamic concerning the climate- and environmental protection. The people develop a new sense of responsibility and translate it into practice within their own four walls, on the street, in their quarter, in their town and region.

4. Sustainable revitalisation of a former barracks area

Another project is being realized in the town of Speyer. We started in spring with the first part of the revitalisation of a former barracks area. Erected in 1889, the 12 ha area was militarily used until 1997 mostly by French Armed Forces and was closed to civilians. This area is now to be integrated in the urban framework. In doing this, an important aspect is to go easy on resources. The Quartier Normand is situated right in the centre of the more than 2000 years old city.
The area is framed by historic buildings while in the interior small plain plaster buildings have been torn down.
The concept intends to realize the energy efficient redevelopment of the old building stock, supply the complete area with nearby generated heat from regenerative energy sources (biomass and solar energy), abstain from parcelling out of the area and erect a park in which the new houses will be placed. The historical buildings are under monument protection and can only be equipped with insulating measures in their interior.

Internal insulation in combination with heat recovery will lead to an energy conservation of more than 80% for this project as well.

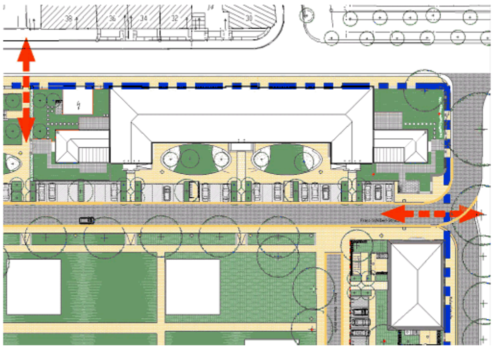
Innovative detail solutions for various structural elements, e.g. thermal bridge free connections of appended filigree balconies give the impression of an open facade and do not impair the character of the building.

Preserving the character, up to date equipping of the buildings allows new patterns of use and in doing this saves resources, which is roughly the aim for the revitalization of these former barracks.

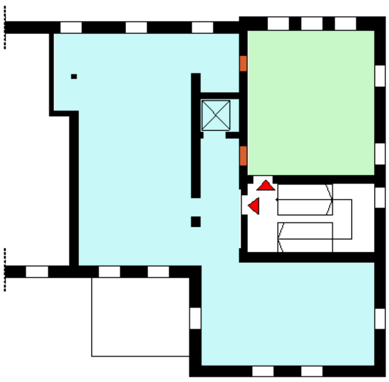
The new quarter is to provide living-quality by a variety of utilisation. Living and working for all age brackets near to the town centre but nevertheless quiet in a green environment containing high trees will be greatly appreciated. The Quartier Normand will appear, almost as if it had always existed, naturally-grown, in contrast to the many newly-developed estates on the periphery.

Here a listing of the various uses in the quarter:
<u>New Houses:</u>
Nursing home for the elderly operated by the Diakonie
Looked after housing for the elderly
Living in multi-storey town villas
Health Centre
<u>Historical Buildings:</u>
Leisure time provision for the young
Offices and Surgeries
Living in annexes with the character of a single family home with private garden
Living in lofts
Hotel providing service for the entire quarter

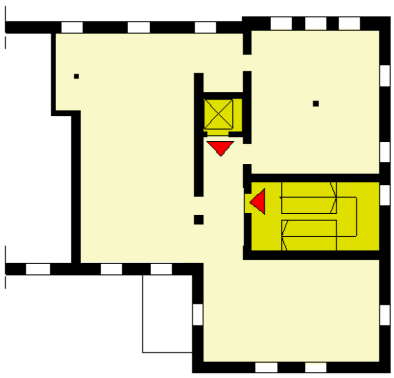
Quarter Normand



Plan of details, the green shows the park



Flexibility of the ground plan: two flats



or a spacious loft with only two operations

The few roads existing in the quarter will be tree-lined playstreets and subterranean garages will largely absorb stationary traffic.
Cross generation living will be appreciated by an ever more "single-living" society. Tolerance and cooperativeness are self-evident here. Having access to service features when required, provides a sense of security not only for the elderly.

5. Summary

Parallel to this conference, the International Trade Fair for Conservation, Restoration and Urban Renewal is taking place in Leipzig.

German monument curators are aware that a large number of buildings worthy to be listed as monuments have been destroyed by the improper and the uncontrolled application of interior insulation as well as by the misbehaviour of the users. The implication of this has been irreparable damage on load bearing structural elements.

The sustainable redevelopment of monument protected urban fragments in Ludwigshafen and Speyer makes a contribution to monument curators, town planners, project developers and persons willing to redevelop by offering solution methods based on field tested innovative and commensurable measures.

Shortly a publication will appear containing the principles, the detailed execution and the results of the measured data of the interior insulation measures in the buildings on Limburgstr. 19/21. The responsible authors are Klemens Osika and Dr Feist, Passivhausinstitut Darmstadt.

We follow the call "Join the action", "The time for talking is over- time for action is now." on the homepage of UNEP (United Nations Environment Programme). We hope that we are able to contribute to this programme with our work.

THE SUSTAINABLE OFFICE BUILDING

Eugeniusz Rylewski
Member of the board of directors
Masa Therm Polska
Warsaw – Poland

The passive building, built in Warsaw in 1998, proves that autonomous structures in Poland's climatic conditions are viable - at least from the energy point of view.
Initial technical criteria set for the project are compared with actual results, recorded during the last 3 year period of usage.

BASIC IDEAS BEHIND THE PROJECT:

- Present innovative technologies aimed at indoor microclimate without risking of Sick Building Syndrome
- Prove, that heating, cooling and heat - recovery ventilation are possible without conventional air - conditioning systems
- Prove that passive design is possible for office buildings in this part of Europe
- Prove the possibility of constructing autonomous buildings

PROJECT DESCRIPTION:

THE SITE:
It was chosen on account of a modest land price and good a access to both road and public transport systems as well as to services.
Initially the plot was free, among some built-up ones. The architectural form of the new building was meant to get in dialogue with forms existing in the neighborhood.
The building occupies a minimal portion of the plot area. New greenery was carefully planned. Its total green mass is much more important than it used to be, when the site was undeveloped. Path and parking areas are gravel. There is a green roof over the main volume of the building.

The access to direct solar gain was one of the main factors of site selection. Both the way the structure is situated and the landscaping support the idea of a passive building.

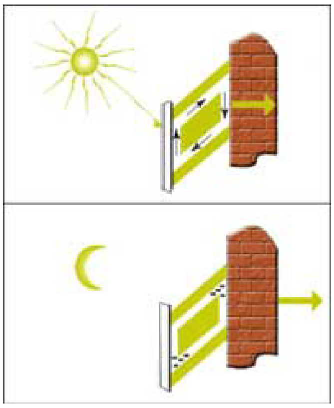
THE PROGRAM:
The whole structure contains two semi-detached double–floor units of 120 m^2 usable floor area each and the single-floor buffer zone attached to the north. Units are of four rooms each, in two different layouts, eight work places per unit. The buffer is two garage or storage spaces and entrance porches. The building was first meant to be of mixed use: apartments with some office room space(two flats making one single family house). Now it is more office space, with some guest room possibilities.

At present, it serves as an example of office space with human and environmental friendly creative working conditions. It is close to the city center but with direct access to the gardens and terraces. The shaded terrace on top of the buffer zone and the green roof serve as additional recreation possibilities.
Centered on peaceful mood and excellent indoor air quality this office space is an alternative to prevailing unhealthy commercial tower models.

THE BUILDING ENVELOPE, HEATING AND COOLING:

1. Each segment of 120 m2 is separately insulated (the border between them is a cavity wall filled with insulating material)
2. The south façade is the largest. The main double – floor volume is compact. The buffer zone is unheated. All the rooms have windows to the south. The southern wall is massive and, apart from windows, is covered with RymSol solar heating panels. The other walls are also massive and well insulated
3. Eaves and balconies serve both as reflecting and shading surfaces
4. Terraces also reflect sunlight towards south facade
5. As the building is a model solution (that can be used for other types of structures: row - buildings and multi – story ones), western and eastern walls of the whole volume are extra insulated – both on the outside and inside - to simulate the potentially neighboring units
6. The foundations and roofs are insulated almost to the same extent as the walls
7. The windows are low emission ones and have frames insulated from the outside. They are equipped with RymSol shutters and RymSol curtains of transparent insulation

Solar heating with RymSol insulating panels. The principle of operation of RymSol natural convection panels is as follows:

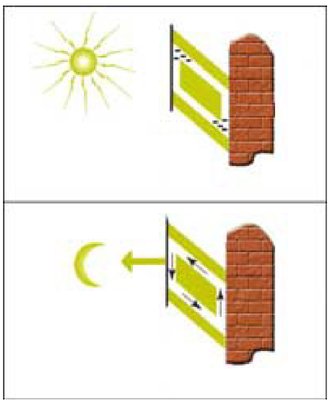


By day, when the pane is heated by solar radiation, natural air circulation is generated and heat is transferred by convection from the pane to the wall.

By night, when in the absence of sunshine the pane is at a lower temperature than the wall, there is a stratification of the air in the inclined ducts. The panel becomes a good thermal insulation.

Figure 1 RymSol – function of heating

Cooling with RymSol insulating panels – natural convection.



By day, an important part of solar energy is reflected by the white metal sheet and does not penetrate. In addition there is a stratification of the air in the inclined ducts. The device becomes a thermal insulation.

By night, when the wall is warmer then the pane, natural air circulation is generated which evacuates the heat from the wall to the outside. Thus the house is cooled.

Figure 2 RymSol – function of cooling.

Advantages of RymSol cooling

1. RymSol removes the heat from the outside skin of the outside walls which gives a time lag for the cooling of the building. This is a precious complement to the night cooling by ventilation the latter cooling the interior of the building.
2. Contrary to the cooling by ventilation in which the circulation of the outside air in the building necessitates the control of the air purity here the air circulates inside the insulation in closed space with no effect on the quality of the inside air.
3. In naturally ventilated RymSol there is no noise and in fan accelerated minimum noise is contained inside the insulation.

The solar absorption can exceed 50 % depending on the construction. The cooling can exceed 5 W/m^2K and insulation of the order of 0,2 W/m^2K and lower is already achieved.

RymSol insulating panels for cooling and solar heating with forced convection.

Fan accelerated convection in this double U shaped panels achieves cooling and heating at will by switching on a fan which allows the transfer of energy from an outside surface to the wall. Switching off the fan transforms the panel into a good insulation of 0,2 W/m^2K. Cooling and heating effects depend on the rotational speed of the fan. This characteristic is important particularly for cooling intensification. For the details see the book of the same author "Personal Energy".

AIR QUALITY CONTROL – VENTILATION WITH HEAT RECOVERY USING RylkAir UNITS

The ventilation system has been solved as a number of individual RylkAir ventilation units with heat recovery. The units supply clean, hygienic fresh air, preheated when necessary with the recovered energy (it is possible to use the units solely as ventilation, when heat exchange is not necessary). They are easy to regulate and maintain (cleaning, washing). The ducts (through external walls) are the shortest possible and accessible for inspection. Every user has the possibility to set the parameters according to needs. While using individual units it is possible to equalize energy savings all over the whole building.
It is possible to realize the system part by part. The whole system is cheaper, as long ducts are not necessary.
The RylkAir units are easy to incorporate in the interior design concept of rooms.
Summer performance: thermal mass, cooling system (RymSol), night ventilation (RylkAir)
Winter performance: thermal mass, heating system (RymSol), heat recovery ventilation (RylkAir)

TECHNICAL INFRASTRUCTURE:
The city infrastructure is available, so there was no use for personal sources of water, electricity or sewage treatment.
Each segment has its autonomous infrastructural connections (electricity, water). So it is easy to control energy and water bills for each.
From the beginning, there were no plans to use gas, neither for cooking, nor for heating (gas installation was projected only for simulation purposes – to state what approximate investment budget would have been for conventional space heating if it were realized)
Internal piping has been designed so, that connections are the shortest possible. All pipes are insulated.

Rain water: there is some retention (one cistern for both segments). The water comes from the roofs to the cistern and excess water is drained under planting.
The common green roof (extensive vegetation) serves, amongst other purposes, as rain water filter with some retaining capacity.
Domestic hot water and gray water: each office unit is equipped with separate sewage mains: “gray water” and fecal sewage. The plan is to use energy recovered from gray water to preheat the domestic water. The heat recovery system is already prepared to operate and will be placed in .

FEEDBACK AFTER SIX YEARS OF PERFORMANCE – CHANGES MADE AND POSTULATED:

As a result of user observations and research, some changes have been made, as well as remarks on the similar future construction.
Some changes have been introduced already:

- window glazing changed (U = 1,3)
- window and door frames insulated and formed to let more Sun energy and natural light
- the glazed entrance porch added
- internal RymSol window shutters added

Three years ago an extension to the neighboring house was made, shading some of the solar façade. It was not possible to intervene, during the planning phase (to change the shape or height of the obstructing structure). Anyway, it is important to say, that it was not a crucial loss of insolation though it proves legal problems of solar buildings shaded by the others.
Some more energy - economy potential solutions have been found:

- walls may be still better insulated (now 15 cm polystyrene, could be up to 20 cm)
- other types of foundations and better perimeter insulation are possible
- first floor may be better insulated (now 10 cm polystyrene, could be up to 20 cm)
- windows can still be better (now U 1,3)
- the RymSol system may still be improved towards more performance flexibility (solar gain in winter; just insulation - when necessary; cooling in summer)
- some RymSol solar heating panels may be equipped with a domestic hot water collector
- electricity, at least to run the ventilators, may be produced with PV panels

CONCLUSIONS

A CONVENTIONAL BUILDING belongs, in fact, to the past. Conventional, as it comes to a building, means a kind of conservative, even if this conservatism is paradoxically hidden behind so called modern forms.
Conventional – today’s standard - means wasteful, when building performance is concerned. Wasteful, when it comes to non-renewable energy consumption.
A conventional building today draws from the capital of the future generations. It used to be “modern” in the turn of nineteenth and twentieth centuries, it might have been called “modern” through the 20th Century, but it is non-relevant today.

THE NEEDED SHIFT IN CONTEMPORARY APPROACHES TO BUILDING

To build in a sustainable way does not mean to save some trees or to wrap the facades in wooden cladding. It means much more. Much more means paradoxically less: minimal impact on the outdoor and indoor environments, low-impact architecture. Environmental protection becomes non-relevant either, architecture, by itself, must enhance and create better environments – both outdoors and indoors.

A PASSIVE BUILDING IS A LEAP FORWARD, a jump over conventional and low-energy ones. It means to resign from conventional heating or cooling systems. It requires the use of renewable energy sources for heating, cooling and domestic hot water. Especially effective insulation and controlled ventilation with heat recovery are needed.
The idea of a passive building is quite well understood, but in practice only some private passive single family houses are more commonly built, rather than larger structures.

AN AUTONOMOUS BUILDING is aimed at the future.
Contemporary technologies and broad experience allow the buildings to be constructed in such a way. Autonomous buildings are the really sustainable ones.
Whatever the name is, there are more inspirations for new designs, when autonomous buildings are concerned: unique phenomena of a site, features and tradition of the place, careful functional analysis, and what is very essential: **gaining, whatever can be gained and saving whatever can be saved.**
In this way, creativity is not restricted to mere reproduction of forms we have been used to, but introducing new “responsible” structures. If energy bills are cut and costs of building envelopes drop, the time and money may be found: to create interiors mirroring individual needs and gardens mirroring natural ecosystem.

HEALTHY BUILDINGS – To build in a healthy way means to consider some factors that are more or less omitted everyday. These are for example radioactive pollution or electromagnetic smog. But it is also important to remember, that solar radiation in healthy doses is necessary – especially for children and especially, when grey and cold months come. Healthy means economic also, as good health means as few doctor visits as possible.
Healthy buildings are well lit and well aerated ones, keeping stable temperatures, built with friendly materials.

GOOD INDOOR ENVIRONMENT – AIR QUALITY
Scientific research proves, that air is always “fresher” outside than inside so it is important to change the used air into fresh. But, what does “fresh” mean? – it keeps it’s “freshness” only when it comes from outside the shortest way.
Comfortable living conditions depend on preferred temperatures and humidity levels. There are questions today on air – conditioning, use of gas cookers, fire-places and wood – stoves, centralized ventilation with heat exchangers – polluted ducts, problems of mould and legionella.

CAN WE AFFORD CONVENTIONAL BUILDINGS?
In the face of basic human and environmental needs, it seems that any new - built structure should be energy-efficient and environment-friendly. It is already obvious in theory but still not much in practice.
Passive and autonomous buildings are attractive possibilities today, although it still seems to need almost a shift in the approaches to building as well as in human conscience.
Considering, that any new construction must compensate for the losses to the environment and be user – friendly, any new buildings should be extremely carefully designed to be sustainable.

When autonomy is looked for, passive solutions should be explored and the right architectural solutions are important. It cannot be done for any price though – the sustainable architecture should not be luxurious although it should be of the best quality.
It is important to work according to the budget, proving that new solutions may be achieved for the price of the old, conventional ones.

BASIC, EASY - TO - USE ELEMENTS OF TECHNICAL INFRASTRUCTURE:
There is no sense today to put too much technical infrastructure into buildings. One should think on what is really needed and how it can be easily maintained. Otherwise man is overtaken by technology and is "controlled" by infrastructure instead of controlling it himself.

HOW TO GO AUTONOMOUS, BOTH FOR THE NEW AND EXISTING BUILDINGS?
The fastest and most economically spectacular results would flow from new constructions. Although new buildings consume new land and new materials it is much easier to build a "wise building" from the beginning, according to a wise project.

It seems to be easier, but it is even more demanding as it is taking land!
Let us imagine that all buildings from now on are wise. In general, one may say, that the best results are there, where they are obtained fastest.
Starting from the ground seems to be cheaper and faster, but some existing structures might also be interesting and possible to change into more sustainable ones. Many existing buildings – especially the older ones – occupy nice localities, have history and spirit if one likes and are worth redevelopment without financial loss.

ILLUSTRATIONS AND TABLES:

The exemplary building in Warsaw.

The solar façade is open to direct and indirect gain during the heating season and shaded for the summer. Architectural solutions used in most contemporary buildings (eaves, balconies, terraces) have been employed consciously, serving as reflective and/or shading devices. All rooms have access to natural light, and heated or cooled by southern wall surfaces. All other building envelope elements balance the microclimatic conditions (thermal mass is mainly concrete of high heat transfer capacity, relative humidity and internal wall temperature control is mostly gypsum plaster). Window frames are additionally insulated and window openings are shaped so as to reflect more light/energy towards interior.

The North façade of the building is partly buffered by garages and porches. The heated volume is individually insulated all over - balconies and buffers are detached from the main volume.

COSTS OF TYPICAL HEATING SYSTEMS IN COMPARISON WITH SOLAR PANELS.

For this building careful economic analysis was made for the non-conventional solutions. The basis was to simulate a conventional gas heating system investment cost (such system is used in all neighboring buildings). Then, the solar heating/cooling, ventilation with heat recovery and additional insulation for windows was planned "instead" – that means for almost the same cost.

Energy balance for 120 m^2 office building.

Let us make a projection of what will be the behavior of a 120 m^2 office.
The thermal characteristic is assumed to be 78 W/K. The total surface of RymSol panels 35 m^2.
In the attached table 1 we give metrological data for Warsaw Poland i.e. minimum, maximum and arithmetical average temperatures and solar insolation on south oriented surface for each month of the year.

In heat losses we include:

- losses of the envelope of the building for assumed inside temperature. This inside temperature can be lower during the night.
- Ventilation losses with 70 % heat recovery during the coldest month. In summer night direct ventilation is assumed with no heat recovery while during the day there is a possibility to switch to exchange during particularly hot days
- RymSol losses during cold months and RymSol operation in cooling configuration during the summer period

In heat gains we list:

- internal gains of 31,4 kWh per day for all months. This can vary as during the hottest months of July and August some people can leave on vacation. These internal gains can vary considerably depending on equipment and lighting used.
- Solar gains through windows are assumed to be full south during the coldest months and full north during the summer as is practiced if appropriate shading is installed
- RymSol gains during the winter period. For very precise calculation some solar gains should be added during the summer period but this was assumed that this small part is included in RymSol heat losses mentioned above.

On figure 3 we show in graphical form the content of Table 1. It can be seen that a good balance can be achieved throughout the year. It should be stressed that the total area of RymSol panels for cooling can be considerably higher that the 35 m^2 assumed. Since the panels for cooling do not need to be exposed to sunny orientation the entire north wall can be equipped with some additional 50 m^2.
This increase of RymSol panels is particularly interesting in polluted environment since in that case the rate of night ventilation can be reduced to avoid problems with air quality.
RymSol natural convection panels do not require any energy and RylkAir only a few Watts. This should be put in parallel with the real cost of 1 kWh of cold which is estimated at 0,27 € (Fraicheur sans clime – T.Salomon and others – Terre vivante France 2004)

Thermal behavior of the building.

Presently		Economically feasible	
Walls 107m^2 x 0,22 W/m^2K	23,5 W/K	x0,14	15,0 W/K
Roof 70m^2 x 0,15 W/m^2K	10,5 W/K	idem	10,5 W/K
Basement floor 70m^2 x 0,35 W/m^2K	24,5 W/K	x0,2	14,0 W/K
RymSol 28m^2 x 0,25 W/m^2K	7,0 W/K	idem	7,0 W/K
Windows * 15 m^2 x 1,1 W/m^2K	16,5 W/K	idem	16,5 W/K
Ventilation 150m^3/h x 0,33 x 0,3	14,9 W/K	idem	14,9 W/K
Total	96,9 W/K		77,9 W/K

* Only glass – frames insulated

Warsaw climatic conditions are not very favorable for solar heating in winter. Prolonged periods of overcast sky lower the average insolation for $1m^2$ of south oriental surface to about 0,8 kWh/m^2 day for the coldest month of January.

Internal gains

Occupants 8 x 100 W (+40 latent load)	= 800 W
Appliances 8 x 250 W	= 1760 W
Lighting 8 x 200 W	= 1360 W
	3920 W

Daily gains 3,92 kW x 8h = 31,4 kWh / day

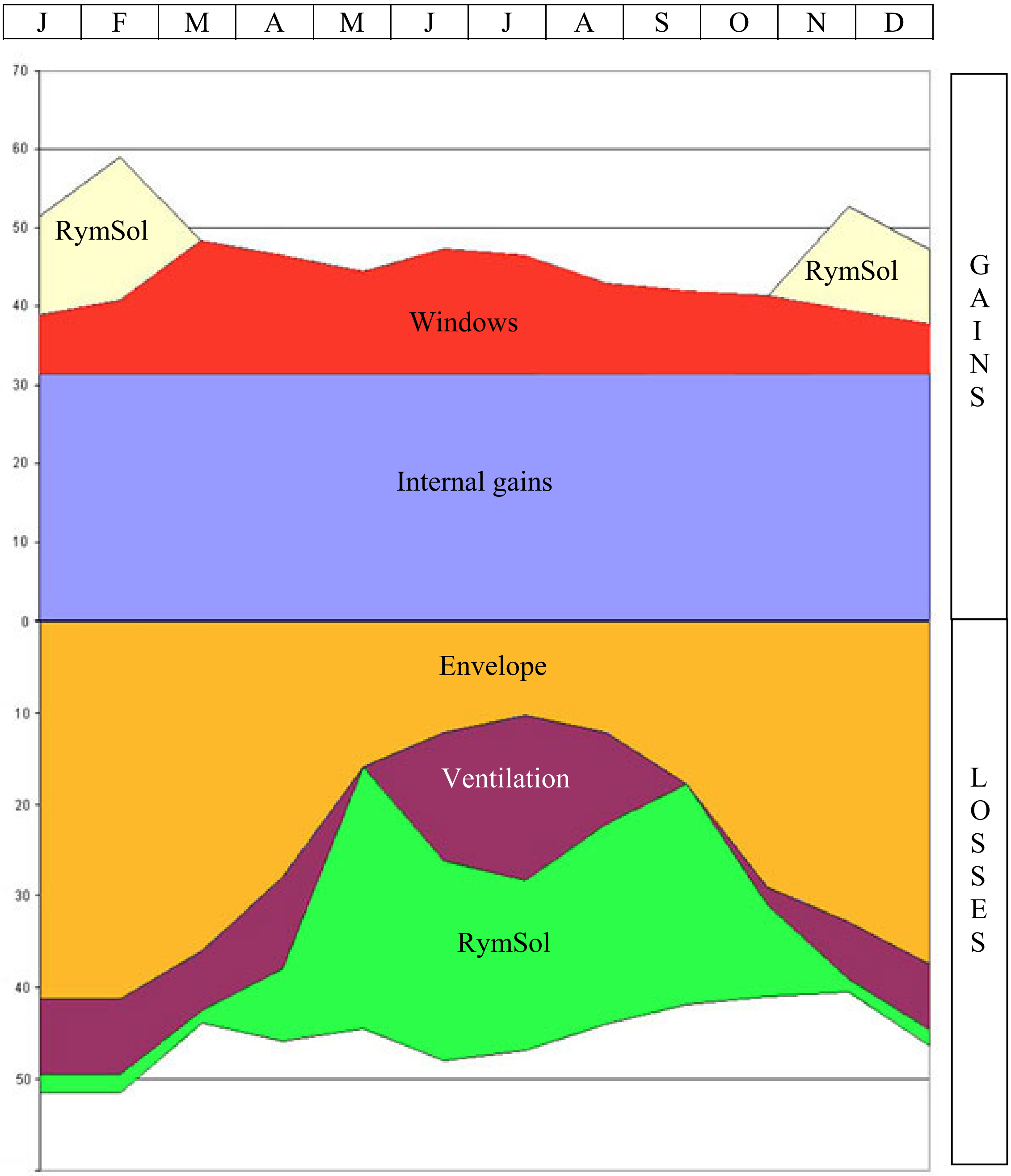


Figure 3 – Gains and losses in kWh/day

	J	F	M	A	M	J	J	A	S	O	N	D
Temperatures [C]												
max	0	0	6	12	20	23	24	23	19	10	6	2
min	-6	-6	-2	3	9	12	15	14	10	5	1	-2
mean	-3	-3	2	7,5	14,5	17,5	19,5	18,5	14,5	7,5	3,5	0
inside	20	20	22	23	23	24	25	25	24	23	21	20
solar energy [kWh/day South surface]	0,8	1,16	2,36	2,46	2,74	2,88	2,88	3,27	2,68	1,75	0,85	0,59
Heat losses in kWh												
envelope	41,2	41,2	36,0	27,9	15,9	12,2	10,3	12,2	17,8	29,0	32,8	37,4
ventilation	8,3	8,3	6,5	10,0		14,0	18,0	10,0		2,0	6,3	7,2
RymSol	2,0	2,0	1,4	8,0	28,6	21,8	18,5	21,8	24,0	10,0	1,3	1,8
Total	51,5	51,5	43,9	45,9	44,5	48,0	46,8	44,0	41,8	41,0	40,4	46,4
Heat gains in kWh												
internal gains	31,4	31,4	31,4	31,4	31,4	31,4	31,4	31,4	31,4	31,4	31,4	31,4
windows	7,5	9,4	17	15	13	16	15	11,5	10,5	10	8	6,3
RymSol	12,6	18,3									13,4	9,5
Total	51,5	59,1	48,4	46,4	44,4	47,4	46,4	42,9	41,9	41,4	52,8	47,2

Table 1

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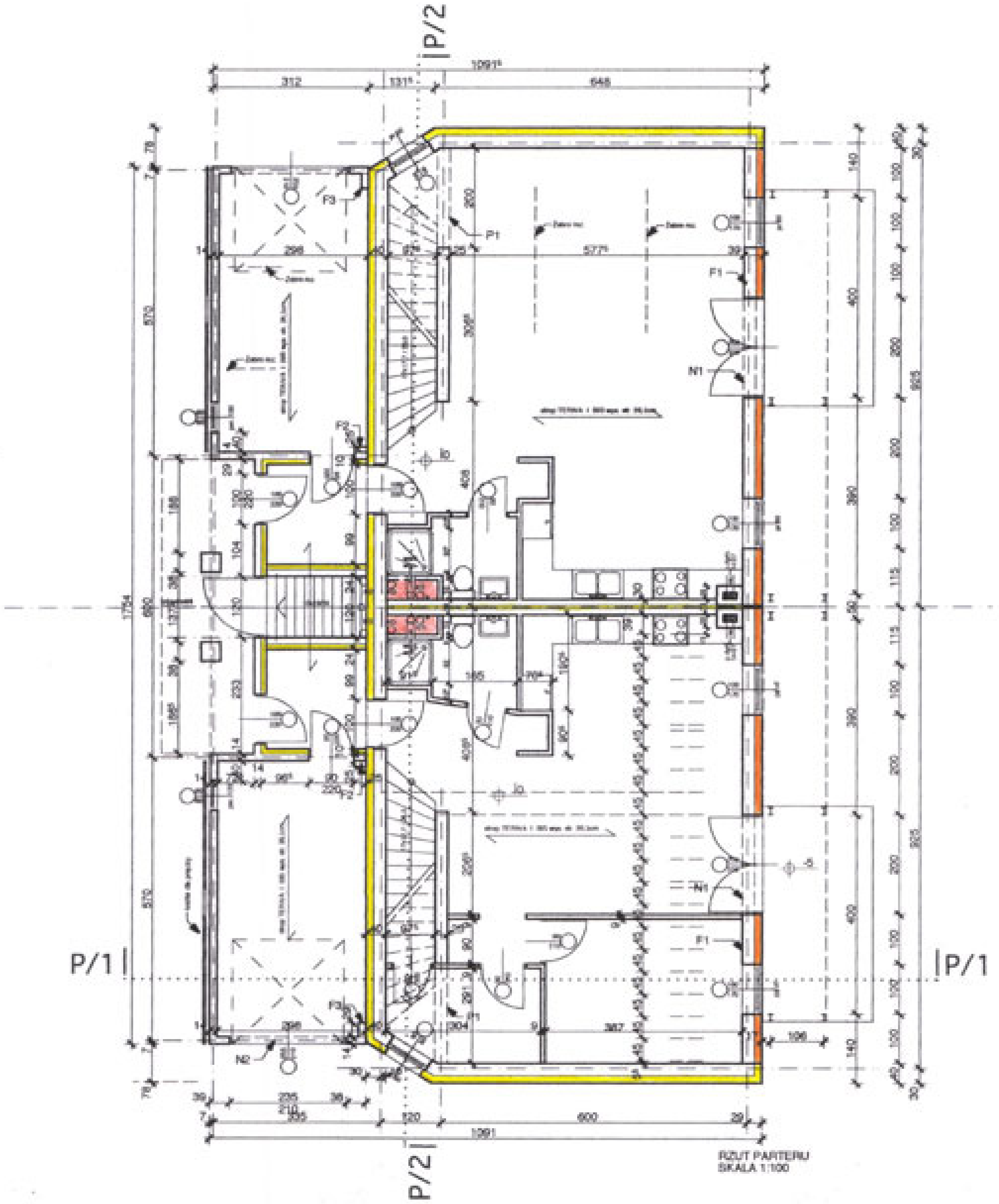
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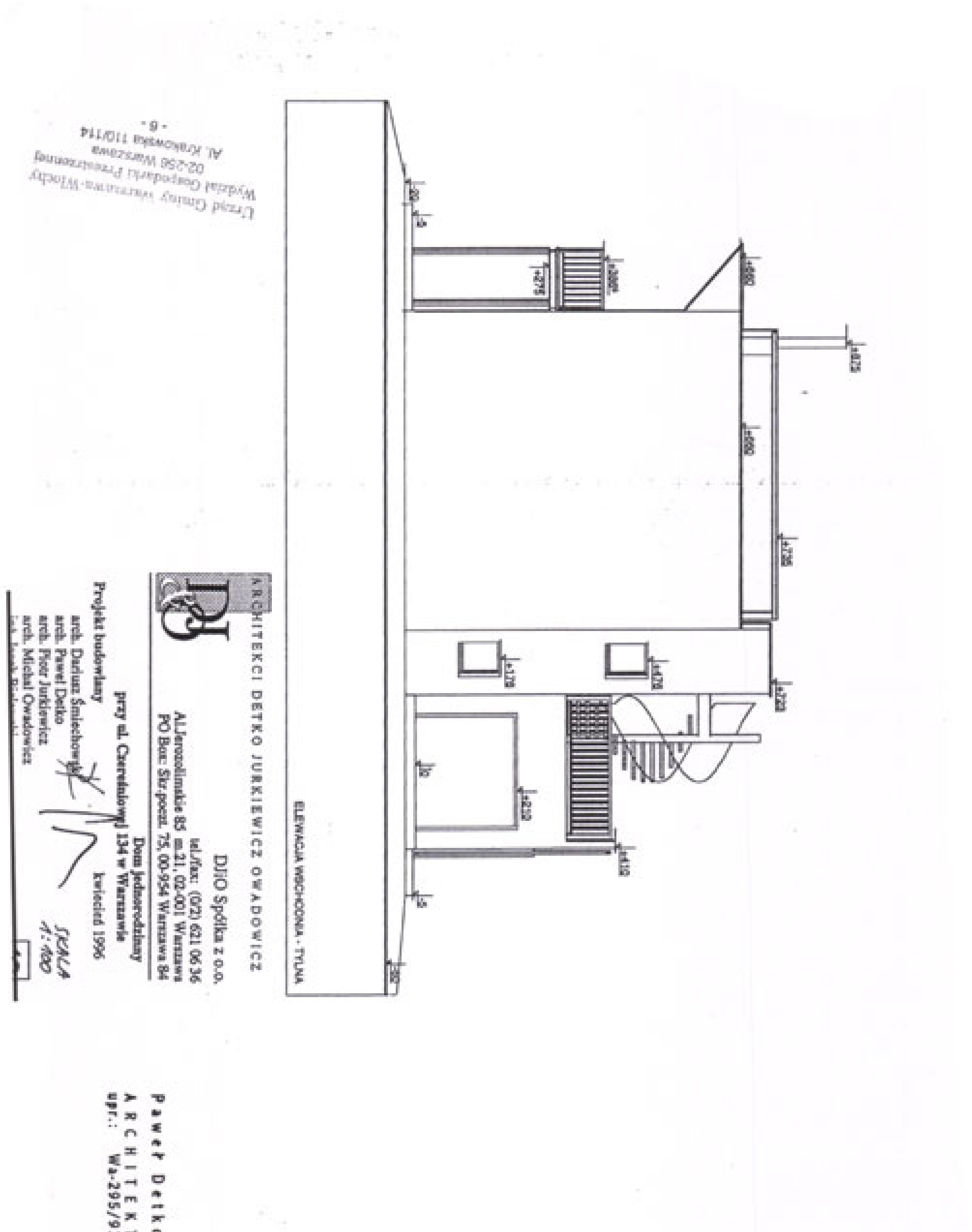
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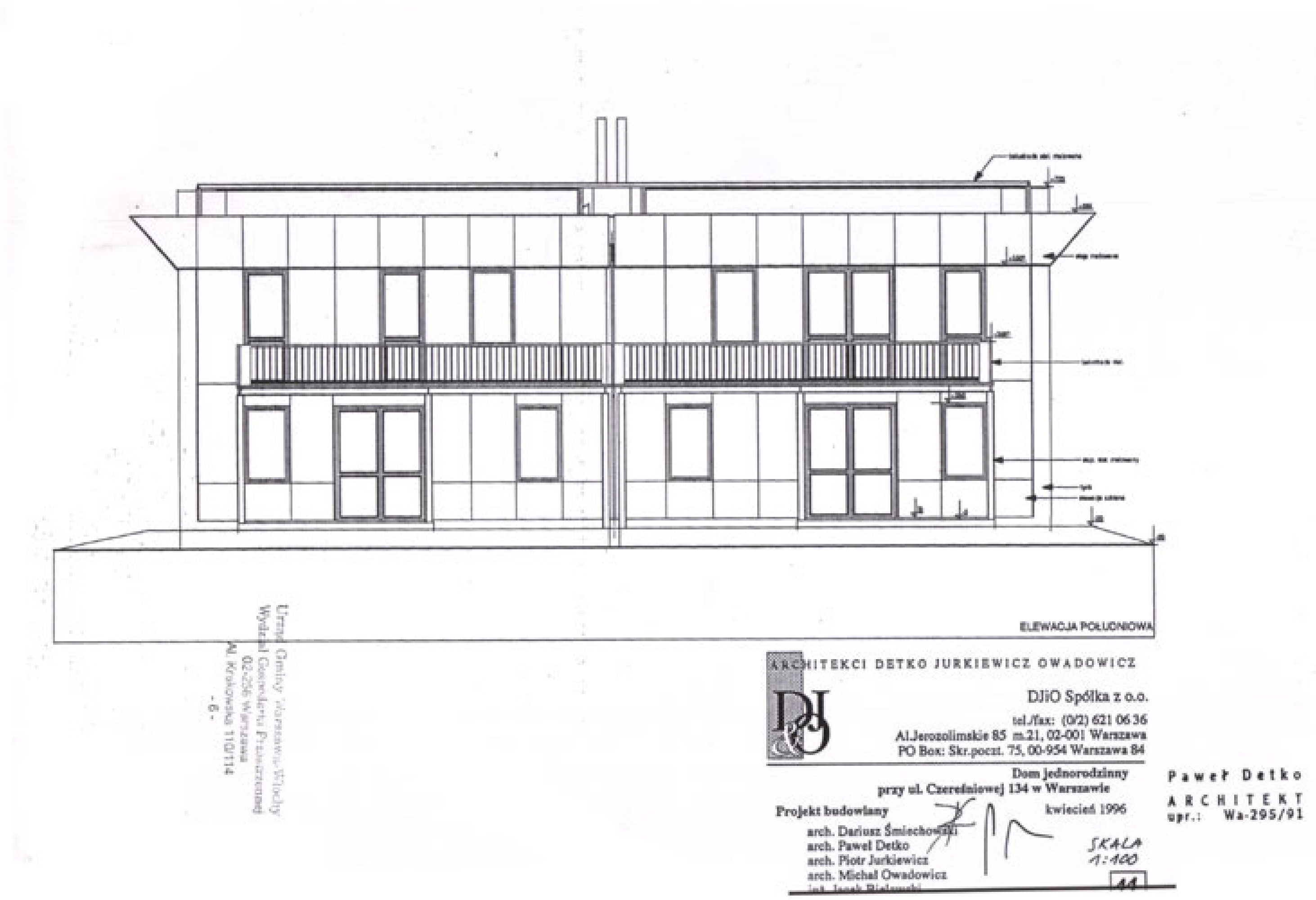

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MODERNIZATION AND EXTENSION OF DWELLINGS AS A SOURCE OF FULL VALUE DWELLING SPACE IN THE ASPECT OF SUSTAINABLE MANAGEMENT OF DWELLING RESOURCES IN GDANSK

1. Introduction

The current state of housing construction consists in saturating the real estate market with dwellings offered by developers and looking for inexpensive dwelling space. The existing council buildings can constitute an important source of such space. However, the technical condition of many buildings and their elasticity limits raise doubts whether individual investing in the said buildings is well-founded, which occurred frequently in the case of converting attics into dwellings. The unique attractiveness of the location of council buildings, often in the city center and their particular historical values indicate that such areas shall be revitalized extensively. At the same time, the issue of dwelling modernization is extremely urgent in a situation when consecutive suburban areas, attractive in terms of nature and landscape, are becoming the reserves for the housing construction. Therefore, it is important that *gminas* look for land reserves in the city among decapitalised and degraded buildings and in the areas where investments are carried out without any control.

2. Council buildings as a source of dwelling space reserves

Within the area of Gdansk agglomeration, the housing construction problem, beside the constant need for inexpensive dwelling space, is related to the problem of a dramatic ageing of the existing dwellings. It refers mainly to council buildings which up to now have been the only source of inexpensive dwelling space inhabited by a substantial percentage of Gdansk population.

Today, the number of people waiting to be allotted a flat out of the reserves of the Municipal Council in Gdansk totals over 5800 most needful families.

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In the meantime, council buildings have not been the source of new units for years. The last 14 new units had been put into use in 1987-1997. The situation was not solved by TBS[1] buildings either, as it was assumed, since their principles turned out to be unacceptable for those of the lowest income.

Dwelling Department data indicate that the list of buildings designated for demolition is getting increasingly longer due to their technical condition (over 600) as well as the number of buildings threatened with a construction disaster which demolition should be carried out in the nearest future (273 buildings).

At the current state of gmina's financial resources, the main source of dwelling space constitutes the investments carried out in the existing buildings. The type of those investments varies depending on the location within the city.

In buildings of historical value and conservation sites, attics are converted into dwelling space with a minimum interference in the building architecture or space of other purpose is converted into dwelling space. In the regions where the historical value is not of prime importance, superstructure and extension of the existing buildings is acceptable as well as attic conversion, allowing substantial changes in the construction and architecture limited by the type of building, proportions, construction quality assessment and building load capacity.

When we analyse possibilities of gaining land reserves in the town center, one shall pay attention to the land obtained after removing structures built in the act of lawlessness or temporary structures like e.g. a garage, an outbuilding and other.

As a result of demolition of decapitalised buildings new areas emerge which shall be developed first. Otherwise the area is threatened with degradation in terms of social aspects but also in terms of wasting the existing infrastructure. Photo 1 shows an example.

Photo 1. Gdansk, Malczewskiego Street, not-used land after demolition works

[1] TBS: Social Housing Association, which financial principles were to allow people of average income obtain a flat; the town was to guarantee loans for building construction whereas dwellers were to pay rent for living in those flats without any possibility to buy them.

3. Former holiday houses ("settlements") as a source of extra dwelling space.

The second sources of additional dwelling space are holiday houses typical of Gdansk, which formed settlements and were located outside the town center in easily accessible areas in terms of transport (graph 1). Their quality and type of developing the adjacent area does not comply with the existing standards. Despite their location in the cities, investment works are carried out in theses areas in uncontrolled and uncoordinated manner. Small holiday and recreation houses, which had existed there since the interwar period, were built without any proper plan the area density increased as new dwelling houses and outbuildings appeared.
The areas which used to be the enclaves of quietness in the city became the location of garages, noisy services, wholesale stores etc. which are unacceptable in those areas. Settlements located in the vicinity of dwelling houses are also treated as a source of auxiliary and supportive facility in multi-family housings. Frequently, garages are built there without permission. Such a situation occurred in several settlements located near a typical housing estate (photo 2 and 3).

Photo 2 Gdansk Sródmiescie Kolonia Zreby, scale of the existing dwelling space

In settlement areas gminas' actions can be carried out very effectively due to the form of ownership. The investments should focus on proper arrangement of infrastructure and buildings and shall comprise demolition of houses built in the act of lawlessness, illegally or houses which are a threat to the inhabitants and the city. Nowadays the existing network does not allow access to natural gas and city heating system which results in no control in terms of sources of heat, waste treatment as well as implementing and enforcing rational management in those areas which shall retain the character of border between the city and a garden area. On one side it will improve the environment in this area on the other provide full value areas for dwelling space.

Photo 3 Gdansk Sródmiescie, vicinity of Kolonia Zreby and Suchanino housing estate

4. Allotments[2]

Gdansk has been on of the most "green" cities in Poland and can be regarded as a unique city in this respect in the world. Rare number and area of allotments located in the town center and in the suburbs are legally recognized recreation areas of a certain type of buildings. As a result of this such large green areas can be treated only as the land reserves for housing construction.

At the same time, with a huge demand for inexpensive plots and dwelling space in the city, heavy investments are observed in those areas. For already dozens of years it has been difficult to call them gardens and recreation plots. New dwelling houses are built as well as extra outbuildings. Those investments are illegal due to other purpose of the area and principles of locating buildings in that area. In the said situation it is difficult to talk about development plans and its basic elements like: building line, standard distance from plot borders; distances between buildings and the area of plots frequently excludes developing land in compliance with the construction law (photo 4 and 5).

[2] Set of gardens of a limited area (300m2) subject to local authorities, treated mainly as places for cultivating vegetable sand fruit and recreation sites.

Photo 4 Gdansk Kartuska Street, dwelling houses in allotment area

Photo 5 Gdansk Jasien, dwelling houses in allotment area

Infrastructure of the heavily invested allotment areas does not comply with proper standards or is insufficient for the inhabitants. Parameters of the existing roads and driveways does not allow easy access for public utility service e.g. fire brigade, rescue vehicles, ambulances and sewage treatment service. The width of the existing roads allows only narrow traffic and pedestrian routes without any possibility to park a car. (photo 6).

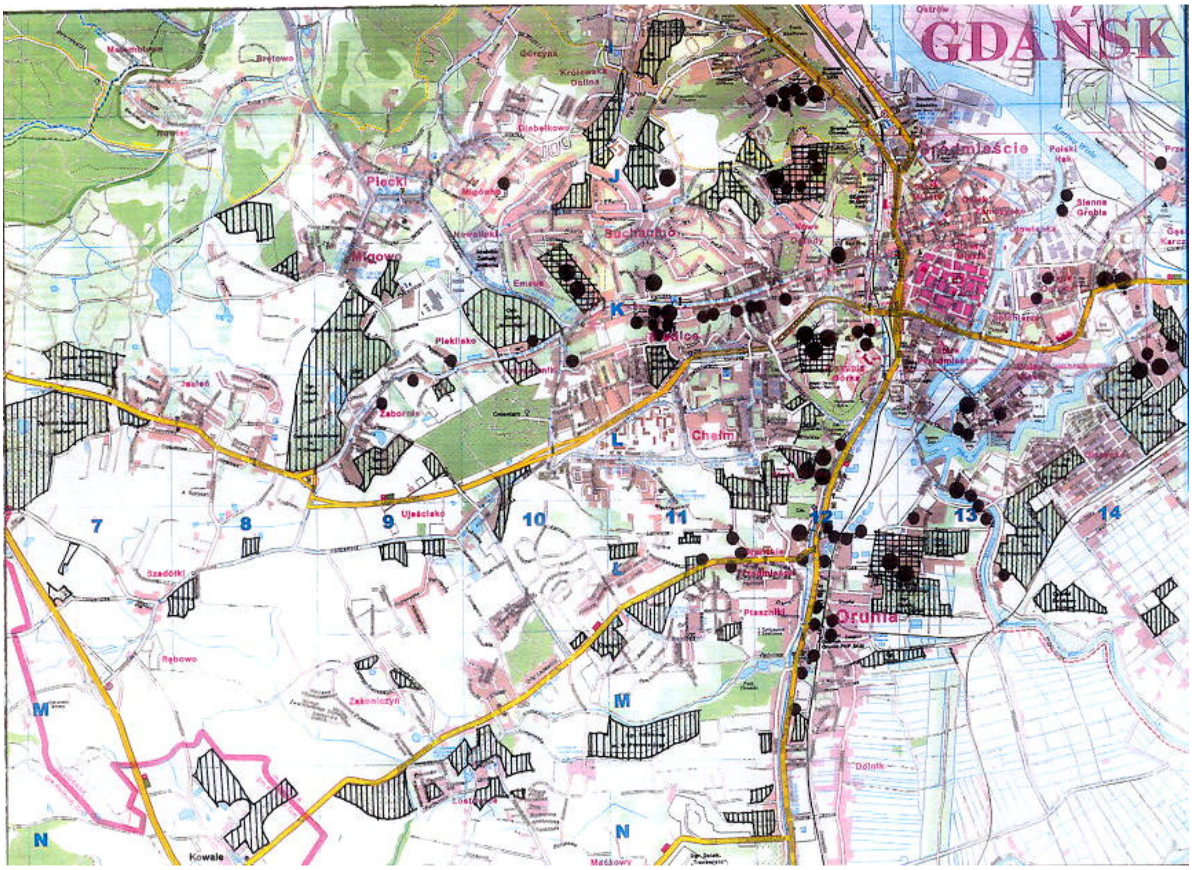
Photo 6. Gdansk-Jasien inner road in allotment area

The existing territorial development of the allotment settlements is insufficient when compared with the current purpose. Indeed, there is a power system, telecommunication network and cable TV in the said area but taking into consideration proper functions of the dwelling space they do not have adequate parameters. This refers also to water-pipe network. Allotment area is equipped neither with sewerage system nor a storm drain system. Despite the fact that sewage is carried to tight containers, it is a temporary solution and deadline for building a sanitary sewage system in the city shall be defined.

The current situation is even worsened by the fact that old construction and housing law binding from 1994 did not allow garden plot inhabitants to obtain a permanent residency in this area. When those areas will change their legal status, and plans related to converting allotment areas into dwelling space will be implemented, it will be necessary to provide substitute accommodation for the current inhabitants of these areas. Therefore, taking into consideration the scale of the problem (graph 1) the only real solution is to sanction the status quo of the settlements and change the existing status of allotments for dwelling areas and make them comply with the requirements of the construction law which despite forced situation complies with the strategy and development orientation for Gdansk.

As a result of establishing control over investments, social problems can be solved and rational area management principles can be implemented.

The control and orientation of investments should consist in the rational use of the construction area and definition of permissible parameters of buildings, building density and the volume of cubic capacity. The investments should also comprise modernization and construction of transport network and infrastructure indispensable for proper functioning of dwelling houses and raising the inhabitants' standard of living so that the area can function as a biologically active area, even in a lower scope.



Graph 1 Location of potential municipal areas constituting land reserves in Gdansk Centrum and Gdansk Poludnie.

Allotment area

Former holiday houses – settlement

● Units designated for demolition / Obiekty przeznaczone do rozbiórki

5. Conclusions on development orientation of the city

When we observe the current situation on the construction market, which in this case in Gdansk refers on one side to degradation of council building areas and their demolition, on the other intensive uncontrolled development of green areas within the city, we shall state clearly that the status quo requires consequent legal regulations.

First of all, as there is a necessity to manage dwelling areas rationally it is unacceptable to leave town center areas with complete underground infrastructure left after council buildings unused and tolerate the expansion of newly built houses and settlements to biologically active areas.

The analysis of Gdansk development plans and intensive taking up of suburban areas for the Tricity ring road makes us start analyzing costs of these investments related to environmental costs and possible consequence for the inhabitants of the city and the environment. Housing estates are located within a certain distance form the city center and those built by real estate developers do not constitute the source of inexpensive dwelling space, which is proved by decreasing number of flats sold in these housing estates.

At the same time, intensive development of suburban areas and negative impact on natural environment causing transferring financial resources from the city to neighbouring gminas is related to constant and increasing process of converting agricultural land into building plots.

Cost analysis of taking up consecutive land for housing construction taking into account costs of land reclassification, territorial development, building infrastructure and indispensable transport routes shall also take into consideration costs of future use of dwelling houses (heating, waste and sewage treatment and other) and costs of daily journeys which future inhabitants do not think of as they are not aware of the problem.

Building housing estates far from the city centers has a negative effect as the investors are taken away from the city center where many areas of historical and architectural value buildings require immediate intervention. It is the source of additional floor area and generally of valuable urban location and protected as an example of cultural heritage.

The observed process of degradation in urban areas equipped with infrastructure and expensive investments in suburban not developed areas is uneconomical in terms of functioning of the city and harmful in terms of environmental costs.

Only planned coordinated activities of gminas can change the investment orientation and solve the most important problems of the inhabitants and take into account a broad issue of natural environment protection.

Writings:

[1] Act of 22 August 1997 on the change of the act - Construction law, Act on spatial development and some acts (Dz. U. no. 111, p/726).

[2] Act of 2 July 1994 on rental of dwelling houses and housing facilities (Dz. U. no.195, p.509).

[3] Development strategy and orientation of Gdansk – Uchwala Rady Miasta 20.12.2001.

The PRESCO Guidelines for Sustainable Buildings

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Abstract
PRESCO, the European Thematic Network on Practical Recommendations for Sustainable Construction, is already running for four years and started with a series of objectives. The project was built around two main work items: The first was the realisation of a set of PRESCO guidelines for sustainable construction; the other was defining recommendations leading to a more harmonized approach for environmental assessment tools for buildings. This paper only deals with the first work package. The work done in the second work package, on the environmental assessment tools, is presented in another paper (Inter-comparison and benchmarking of LCA-based environmental assessment and design tools).

Guidelines for Sustainable Construction: Something new?
At the time the PRESCO network was established, two European examples of recommendations for sustainable construction were identified. The first was the set of Dutch National Packages (residential buildings, building stock management and office buildings) [1]. Each 'package' incorporates a set of practical recommendations, which have been discussed with and accepted by the different stakeholders of the Dutch construction industry. The Dutch government supported the initiative by giving financial advantages and/or tax benefits to those respecting a minimum number of recommendations.

Another inspiring example was the BSRIA Environmental Code of Practice for Buildings and Their Services [2]. This Code, realised under the guidance of a project steering group drawn from industry representatives, provides a strategy to assist all stakeholders to minimize the environmental impact of buildings over the building's entire life cycle. The BSRIA Code was developed to assist clients, architects, project managers, building services engineers, and facilities staff to design, construct and maintain environmentally friendly buildings. Whereas the Dutch packages are stimulated to be used by the local government, the BSRIA Code serves as an aid, but remains completely in the voluntary atmosphere.

The PRESCO partnership was convinced that other similar guiding documents on sustainable construction had been published in other countries. One of the first actions undertaken was therefore to identify and compile such documents, both in Europe and elsewhere. For most European countries, this process was realised with the help of the 28 PRESCO network members, representing 16 European countries. A problem with many of these interesting documents is that they are published in a local language only accessible to those who read and speak that particular language. To overcome this problem, network members were asked to propose a set of recommendations based upon the national experiences.

For non-European documents, an extensive search revealed the existence of a series of interesting publications with regard to guidelines for sustainable or 'green' construction. Most of these publications appeared either to be realized by government agencies or local authorities or by so-called ‘green’ publicists or (non-profit) organisations. The aim of most of these publications seems to be to stimulate authorities, builders or clients towards green or environmentally friendly architecture and construction. Whether these publications are supported by a broad basis of stakeholders or not, remains often an open question. However, it is clear that the guidelines published by government agencies or authorities may have an important impact on the local market, certainly if they serve for instance as a basis for green procurement.

Just to illustrate the type of documents found, three are cited here:

- “*The Sustainable Building Technical Manual*” produced by Public Technology Inc. and the U.S. Green Building Council [3]. Its goal is quite similar to that of PRESCO, as it aims to provide clear, easily applicable guidelines and useful practices.
- “*The High Performance Building Guidelines*” of the City of New York [4] show how a city can try to integrate green building objectives into high performance design principles and into policy and technical strategies.
- “*The Santa Monica Green Building Design and Construction Guidelines*” [5] are interesting as this municipality distinguishes between recommended and required practices. This has of course an impact on the environmental performance of buildings. Through the Municipal Code ordinances, builders and building projects are forced to comply with these required practices.

Besides these 3 examples from the United States, other interesting documents were found in Canada, Australia, New Zealand and Hong Kong.

The PRESCO Approach: Towards a Common Ground

The next step was to combine all the collected information into one package in order to start up discussions with the different stakeholders of the European construction industry. The aim of PRESCO was to come to widely accepted and scientifically supported guidance for the design, construction and operation of sustainable buildings. Whereas sustainable construction may now be considered as a mainstream principle – everybody recognises that buildings should be energy efficient for instance – it is far less clear how this objective should be realised in practice. The different societal groups, varying from industrial parties to non-profit (often called “green”) organisations, often have completely opposite views on the sustainability of certain technical interventions or product choices.

The aim of PRESCO was to define some kind of common ground by coming to a set of practical guidelines acceptable to all stakeholders. At the same time, PRESCO hoped to be able to go beyond what is already required by law or regulations. To realise these objectives, PRESCO established a working procedure in which stakeholders were invited to participate, and this not only once, but at several points in time:

- At the moment the project was introduced for financial support at DG Research, a series of organisations representing the range of stakeholders were invited to participate in the project. A well-balanced partnership of 28 members from 16 European countries was established this way.
- In the work program, it was provided to inform organisations and construction professionals about PRESCO and its objectives through different communication and dissemination channels. The PRESCO newsletter, 7 issues have been published actually, has played a key role in this regard. The newsletter is distributed to almost 4000 European contacts.

- PRESCO organised two workshops, one open and one limited to a range of experts. The first one was organized in 2002 together with another European network, i.e. the CRISP network, and took place in Ostend, Belgium. The second expert workshop was held at the BRE premises in October 2003.
- The PRESCO members organised local workshops or meetings in which they presented and discussed the set of guidelines.
- Finally, users or readers of the PRESCO guidelines will be invited to give their views and comments. If required, a new final version or a corrigendum will be published within the year.

Although the PRESCO project is reaching its end, the work is certainly not finished. After all, sustainable construction is a complex process involving a range of actors, products and techniques. Being complete was therefore never the issue; the goal was to define a set of 200 to 250 practical recommendations. The PRESCO set of guidelines must be considered as general principles, which need further detailing at the local or national scale. Indeed, each country or region is confronted with other circumstances, for instance climatic or with regard to natural resources. The general principles should however be acceptable for all. Finally, as scientific knowledge increases and societal opinions change, the PRESCO guidelines will become obsolete in the course of time. A continual updating will thus be necessary.

The PRESCO approach may be inspiring; most builders do need objective, scientifically supported guidance. They are, however, confronted with "coloured" opinions, for instance from those who want to sell a product or approach, or from those who have strong, in most cases, negative opinions about particular products or techniques. A question which has to be raised in this context is whether such discussions are fruitful and useful towards the final objective of sustainable development. Instead of setting organisations or companies against each other by comparing products or interventions, more can probably be reached by stimulating all parties towards a more sustainable production method.

This is particularly true in the construction world, where each building project is unique in its design and its combination of products, techniques and appliances. Comparing the environmental performance of building elements without considering the overall environmental performance of the building doesn't seem to be a sensible approach. This explains why the second main objective of PRESCO was to contribute to the development of environmental assessment tools and methodologies on the level of the building project.

The PRESCO Guidelines: More than the Environment.

Most of the guidelines developed worldwide consider in essence global and local environmental issues, such as energy use, waste, natural resources use, global warming, etc. Indoor environmental quality and comfort are also covered in most of these publications. However, sustainability incorporates more than environmental issues; it also looks for social and economic progress. PRESCO therefore not only had environmental objectives, but also tried to deal with the other elements of sustainability.

First of all, it devoted attention to the <u>economic costs</u> of each of the guidelines. Whenever possible, information with regard to the life cycle costs of applying the guideline was included. The project showed however that a lot of information is currently not yet available. LCC-methodologies are still under development; reliable data are hard to find. Experiences such as Green Building Challenge in which tools and methodologies are developed to assess the overall performance of a building (and not only the environmental loadings), show that it is currently difficult to cover all criteria.

Another element covered by PRESCO and on the cross-line of all sustainability aspects, is cultural heritage. Historic buildings, both those which are protected because of their historic significance as the unprotected buildings determining the view of most of our cities, have proven to be durable. Assessing and improving the sustainability of such buildings, are however complex issues. Due to their aesthetics and cultural value, a building may be very valuable; improving its energetic performance may however be difficult. From an energetic and/or economic point of view, it could be sensible to demolish old dwellings or buildings, replacing them by new constructions. Demolishing results however in more waste, and has an important impact on the urban and social sustainability. Understanding the cultural and historical significance of a building and its surroundings is thus essential whenever decisions about renovation or demolition have to be taken.

PRESCO also dealt with security, as it is a determinant factor for the urban sustainability. The feeling of security indoors and in the urban environment is an important element for the well being of people. To realise security, one can focus on protection against burglary and intruders and one can look for appropriate measures limiting the opportunity of committing offences. The organisation and management of the built environment thus has a direct impact on the security level.

Finally, PRESCO worked on recommendations with regard to the accessibility of buildings. An accessible built environment is without doubt a key element of a society based on equal rights [5]. In practice, however, the European built environment is far from being barrier-free. Building an accessible environment is not only relevant for disabled, although this would be many people's firs reaction people. On the contrary, it is relevant for all members of our society. Indeed, accessibility results in comfort and safety for all, certainly when taking into account the increase of the ageing population, the group of parents with prams or the people who are temporarily disabled due to an accident.

Realising an accessible or barrier free built environment is clearly a work of many years, and this not only because of the cost it may represent. Awareness with regard to accessibility and knowledge about barrier-free design are for instance not well spread. Many European countries have building regulations forcing public buildings to be accessible. However, most of the regulations only provide minimum standards of access and, probably even more important, regulatory control is often inadequate. Anti-discrimination legislation may in the near future improve this situation, but experiences in countries with such legislation illustrate that not all problems are resolved. Disabled people, and organisations representing them, may however be able to use them as legal and moral means of influence [6].

An important problem with regard to accessibility is the lack of uniform standards. In many countries guidance documents, and even building regulations, have been published. Comparing these documents and regulations immediately shows that the design rules are far from being uniform. Accessibility labels have also been developed in quite some countries, for instant with regard to tourist accommodation. A disabled person travelling through Europe will immediately experience that the criteria vary between countries, and in some cases, even within the country.

PRESCO clearly didn't aim to solve all these issues. Rather it wanted to contribute by raising awareness and providing some guiding principles. As such, it considers the concepts of adaptability, the principles of universal design (also known as 'design for all' or 'inclusive design') and the opportunities for innovative and more comfortable designs and buildings. Users of the PRESCO guidelines will find 10, mostly quite generally stated, recommendations on these subjects. More important, however, is the fact that the issue of accessibility is brought to a new, in general environmentally-oriented, public and this not only through the set of guidelines, but also through the different communication and dissemination channels of PRESCO.

The PRESCO Scope: Focused on Buildings

Sustainable construction is a term which encloses a whole range of issues. As defining the term leads most certainly to a never-ending discussion, the PRESCO network didn't lose itself in that discussion, but immediately started to develop a database structure and its content.

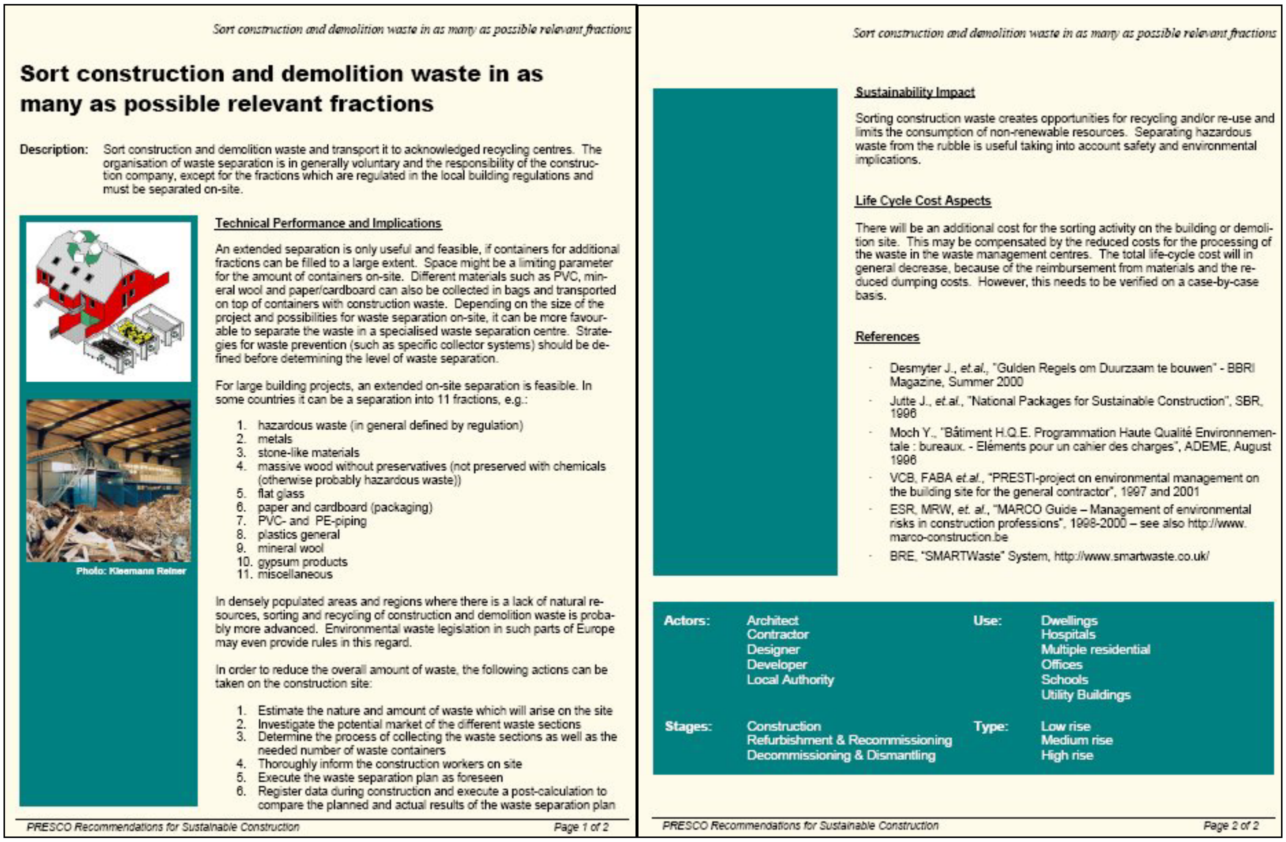
However, it was necessary to define the scope of the project. Indeed, the built environment is composed of many elements, buildings only being one of them. The network focused from the start, i.e. the proposal stage, on the sustainability of the building and its immediate environment.

Urban development and land use aspects were not dealt with, not because they were considered less important, but simply because of the need for focus. Moreover, at the proposal and contract negotiation phase, other research and working groups were already working on these issues.

PRESCO linked each guideline with the relevant stages in the construction process, such as the pre-design, design, construction, use, maintenance and demolition stage. The aim was to enable a particle actor to select those guidelines which are really relevant for his specific activities. The PRESCO guidelines are therefore not oriented towards the environmental or sustainability performance of only one of the actors of the building process. Their activities or working process were only considered if they had a direct impact on the sustainable quality of the final product, i.e. the building. As such, contractors are for instance encouraged to prevent and manage waste or to employ environmental management policies at the construction site. Designers on the other hand are stimulated to improve the quality of their design by considering items such as adaptability, accessibility, environmental product declarations or environmental assessment tools and methodologies.

Using the PRESCO Guidelines and System

The PRESCO Guidelines will be published on paper in a book format, in a layout as illustrated in the following figure. As such, the contractual obligation with regard to the PRESCO project will be fulfilled. As the guidelines deal with a whole range of issues requiring all a different kind of expertise, the guidelines were written in an easy-to-understand language to make them accessible to the broadest public possible. Besides a short description, a typical guideline contains more specific technical guidance and some information on the sustainability impact and the life cycle costs. Sources and references are always mentioned allowing the user to find more specialized literature if required.



Sort construction and demolition waste in as many as possible relevant fractions

Sort construction and demolition waste in as many as possible relevant fractions

Description: Sort construction and demolition waste and transport it to acknowledged recycling centres. The organisation of waste separation is in generally voluntary and the responsibility of the construction company, except for the fractions which are regulated in the local building regulations and must be separated on-site.

Technical Performance and Implications

An extended separation is only useful and feasible, if containers for additional fractions can be filled to a large extent. Space might be a limiting parameter for the amount of containers on-site. Different materials such as PVC, mineral wool and paper/cardboard can also be collected in bags and transported on top of containers with construction waste. Depending on the size of the project and possibilities for waste separation on-site, it can be more favourable to separate the waste in a specialised waste separation centre. Strategies for waste prevention (such as specific collector systems) should be defined before determining the level of waste separation.

For large building projects, an extended on-site separation is feasible. In some countries it can be a separation into 11 fractions, e.g.:

1. hazardous waste (in general defined by regulation)
2. metals
3. stone-like materials
4. massive wood without preservatives (not preserved with chemicals (otherwise probably hazardous waste))
5. flat glass
6. paper and cardboard (packaging)
7. PVC- and PE-piping
8. plastics general
9. mineral wool
10. gypsum products
11. miscellaneous

Photo: Kleemann Reiner

In densely populated areas and regions where there is a lack of natural resources, sorting and recycling of construction and demolition waste is probably more advanced. Environmental waste legislation in such parts of Europe may even provide rules in this regard.

In order to reduce the overall amount of waste, the following actions can be taken on the construction site:

1. Estimate the nature and amount of waste which will arise on the site
2. Investigate the potential market of the different waste sections
3. Determine the process of collecting the waste sections as well as the needed number of waste containers
4. Thoroughly inform the construction workers on site
5. Execute the waste separation plan as foreseen
6. Register data during construction and execute a post-calculation to compare the planned and actual results of the waste separation plan

PRESCO Recommendations for Sustainable Construction *Page 1 of 2*

Sort construction and demolition waste in as many as possible relevant fractions

Sustainability Impact

Sorting construction waste creates opportunities for recycling and/or re-use and limits the consumption of non-renewable resources. Separating hazardous waste from the rubble is useful taking into account safety and environmental implications.

Life Cycle Cost Aspects

There will be an additional cost for the sorting activity on the building or demolition site. This may be compensated by the reduced costs for the processing of the waste in the waste management centres. The total life-cycle cost will in general decrease, because of the reimbursement from materials and the reduced dumping costs. However, this needs to be verified on a case-by-case basis.

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Actors:	Architect Contractor Designer Developer Local Authority	**Use:**	Dwellings Hospitals Multiple residential Offices Schools Utility Buildings
Stages:	Construction Refurbishment & Recommissioning Decommissioning & Dismantling	**Type:**	Low rise Medium rise High rise

PRESCO Recommendations for Sustainable Construction *Page 2 of 2*

Figure 1: Example of one of the PRESCO guidelines

Since the information is readily available in a database, the network is evaluating if and how the guidelines can be distributed electronically. The current browser, which was originally developed for internal purposes, should however be redefined in order to make it fit for distribution. At least 2 options will be added to the browser. First of all, an output module that formats the print-out in the PRESCO style will be written. Secondly, an option will be added which allows the user to add notes and/or features. This way, users will be able to add information that is particularly relevant for their country or situation. A view of the current version of the browser is given in the figure below.

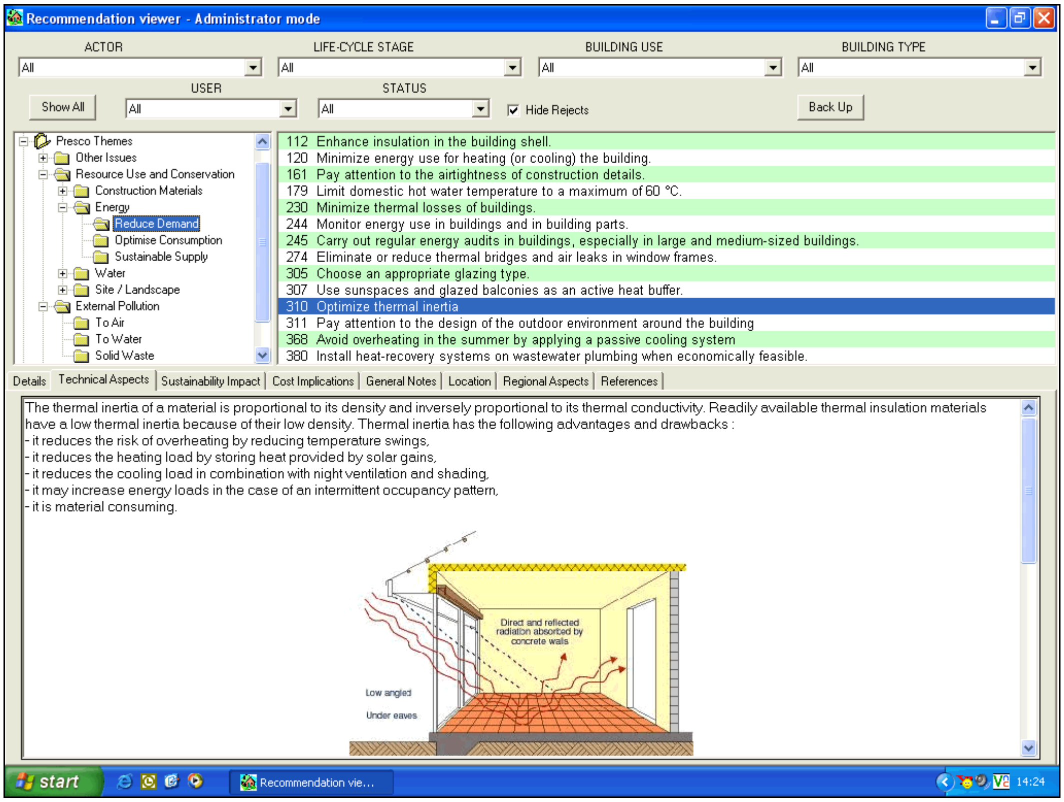

Figure 2: Current version of the browser for the PRESCO guidelines

Not only may the guidelines themselves be of interest, also the browser system may prove to be useful. For many countries the fact that the PRESCO Guidelines are only available in English, limits the potential use. However, the PRESCO members or any other organisation may use (and/or upgrade) the system to develop a local version of the PRESCO guidelines[1]. "Local" refers in fact not only to language, but also to the local particularities. As such, the recommendations or guidelines could be translated to the local level, by adding information about local regulations and examples, by proposing target figures, etc. If the local context allows it, it is even possible to add recommendations valid for the local situation. Interested to note is that the PRESCO guidelines could even be used as a basis for policy making, by stimulating people or organizations to respect a minimum number of guidelines by giving them financial or fiscal support.

Conclusion

It is hoped that the PRESCO approach, guidelines and software system will be used, updated, upgraded and translated to the local level. One of the objectives of the project was to define a set of basic principles for sustainable construction. The result is a set of more than 200 guidelines. Applying all the guidelines in a single building project is not realistic, nor is it the objective. However, by respecting a number of them one will certainly come to a more sustainable and comfortable building.

[1] The PRESCO Technological Implementation Plan includes issues such as the intellectual property rights, and serves as the basis for defining the licensing fees.

Stakeholders have been given at several occasions the opportunity to express their views on the different guidelines. Indeed, the aim was to come to a balanced and scientifically supported set of guidelines, acceptable to all parties active in the building world. The purpose was not to put a particular party or product in a negative light. Rather, PRESCO aimed to stimulate all stakeholders in the sustainable direction. As such, the network believes its final result can indeed form a kind of European common ground.

Finally, the PRESCO project was interesting to all its members. Indeed, most of the members are specialized in particular areas, such as materials sciences, design, energy use, ventilation, recycling, accessibility, etc. Through PRESCO, members were given the opportunity to place their daily activities in a broader perspective. Experts became generalists in a way.

Acknowledgements
The PRESCO project was supported by DG Research within the EESD thematic program of the 5^{th} Framework Program, more in particular in the context of the key action City of Tomorrow. More information about PRESCO and its membership can be found at http://www.etn-presco.net.

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Inter-comparison and benchmarking of LCA-based environmental assessment and design tools

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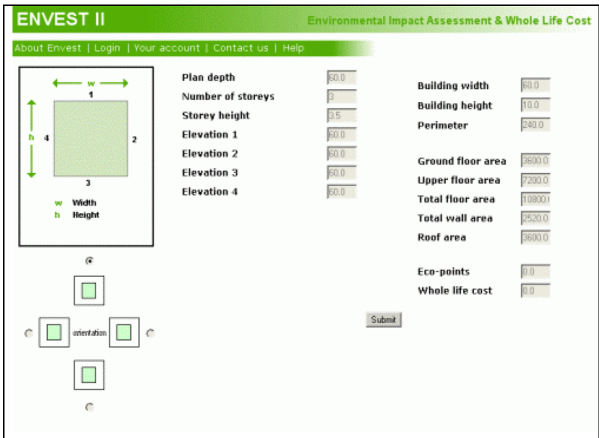
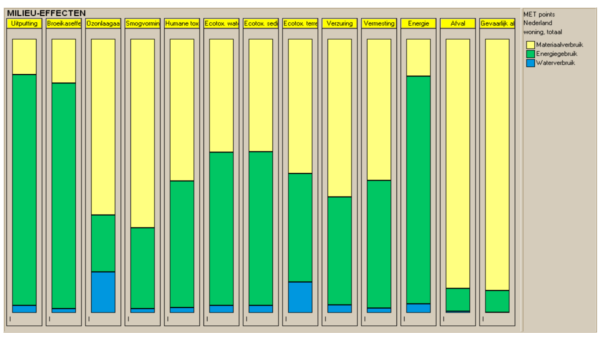
Various methods are proposed to evaluate the environmental quality of buildings. In general, these methods integrate issues of concern like the protection of the human health and eco-system (e.g. protection of the climate, fauna and flora), and the efficient use of resources (energy, water, materials). Life cycle assessment (LCA) allows a quantification of indicators related to these issues and is widely used among industrials as well as academics. This method has been applied in the building sector and several tools have been developed. The precision of these tools and their relevance as a design aid is often questioned. The aim of the work presented here is to have a clearer view upon these questions, and to propose some harmonisation regarding LCA based assessment of buildings. This work has been performed in the frame of the European thematic network PRESCO (Practical Recommendations for Sustainable Construction).

Previous inter-comparison exercises had been performed in the European project REGENER and in a working group of the International Energy Agency. But the hypotheses and results of the different tools had not been analysed in detail. The experience gained in these first activities allowed to plan a more precise protocol for the present inter-comparison. In a first step, the tools were compared in the case of a very simple "cube" building, and the main hypotheses were listed and analysed. A real case study has then been considered in a second phase : a single family house with a rather simple geometry. This exchange should help the participating tool developers to identify some good practice and to improve their tools.

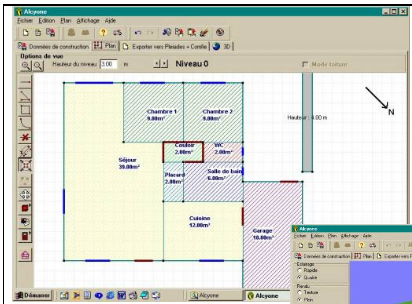
The tools considered are : ECO-QUANTUM (W/E Sustainable Building, The Netherlands), LEGEP (ASCONA, Germany), OGIP (EMPA, Switzerland), EQUER (ARMINES, France), ENVEST (BRE, United Kingdom), Eco-Soft (IBO, Austria), BeCost (VTT, Finland), SIMA-PRO (BDA Milieu, The Netherlands), ESCALE (CSTB, France). In general, the input data include a description of the studied building (geometry, techniques…) and its context (e.g. electricity production mix). The output is a multi-indicator comparison of design alternatives, supporting decision making.

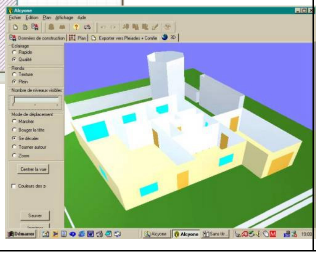


Example input window in ENVEST

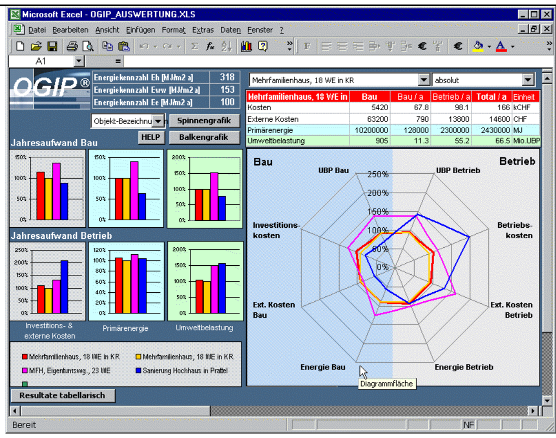


Example output window in ECO-QUANTUM





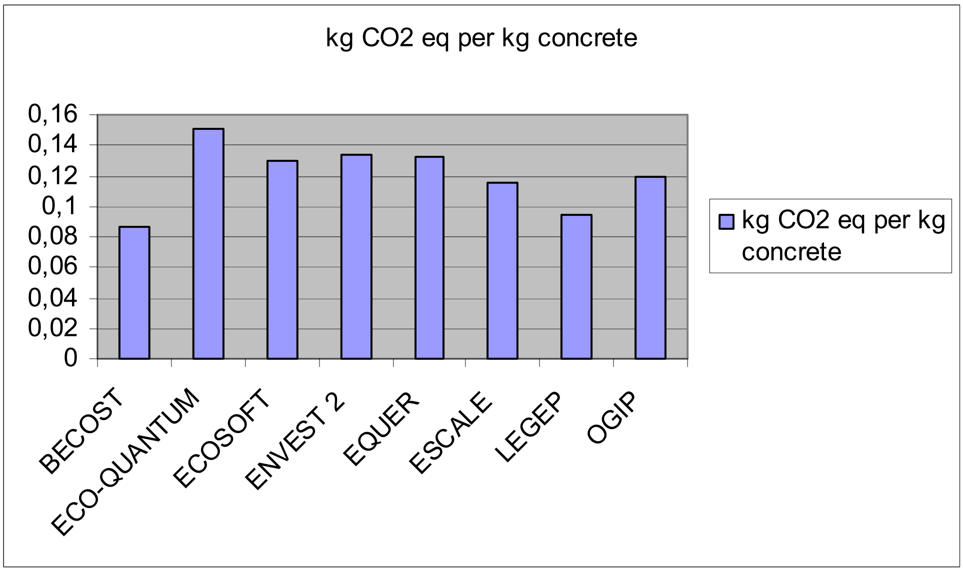
Example input window
In EQUER



Example output window in OGIP

The first activity consisted in defining the 5 case studies considered in the inter-comparison. The first case study corresponds to a very simple concrete parallelepiped with an electric heating (considering a European electricity production mix), assuming a 50 years duration. The objective is to exchange on the main assumptions of the tools (fabrication of the steel reinforced concrete, transport of the material to the building site, building process and waste, demolition process and possible recycling,…), on the data (LCI of the concrete and electricity production, waste treatment, transport) and on the results (impact indicators).

We present hereunder a few examples of the results obtained by the group.

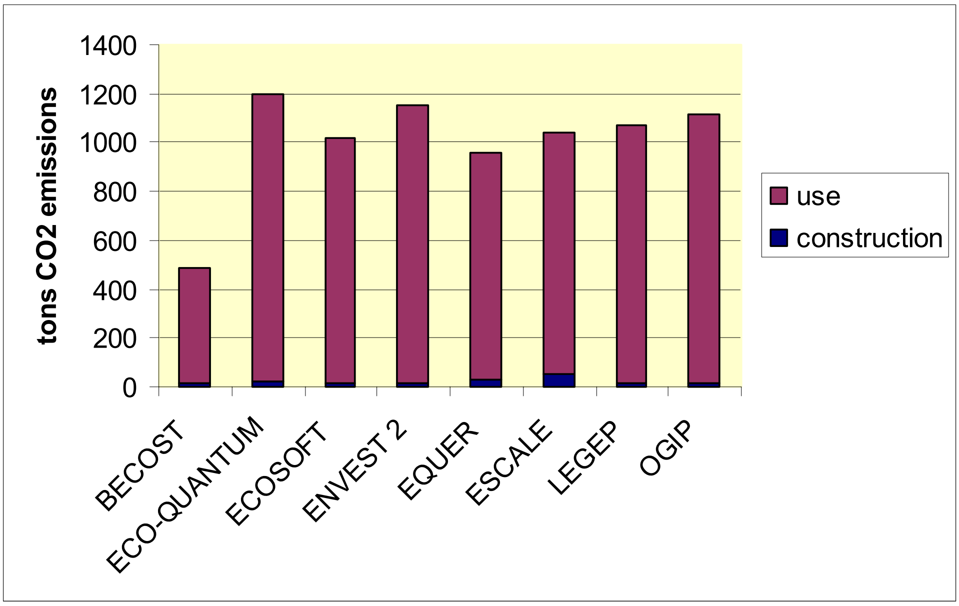


Example 1 : Material data, contribution in global warming by the production of 1 kg concrete

The difference between tools may be related to :

- different cement content in the concrete,
- different production processes (national or European data bases),
- different global warming potential indicators (IPCC, CML…).

The following graph shows the greenhouse gases emissions corresponding to the construction and operation phases of the "cube". In two of the tools (BeCost and Envest), only a national electricity mix can be considered which partly explains the differing results. If we except BeCost (the Finnish electricity mix being very far from the European mix which was to consider), the overall discrepancy is +/- 10%.



Example 2 : building life cycle, contribution in global warming by the cube over 50 years

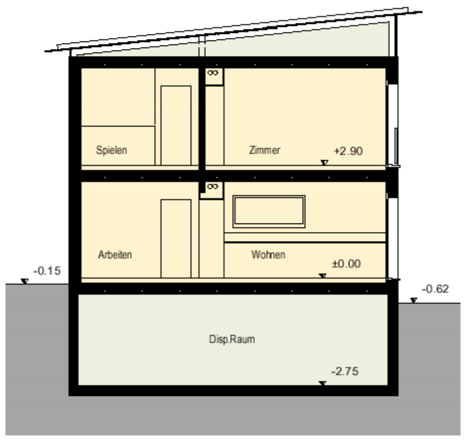
Among the other causes for discrepancy are assumptions concerning :

- the material quantities (exact calculation or value derived from simplified geometric input),
- the material surplus or waste during construction,
- different steel content in the reinforced concrete,
- different assumption concerning the use of recycled steel,
- the transport of materials (construction and end of life),
- the life span of building components,
- end of life processes.

The 3 next case studies correspond to a green building in Switzerland, the FUTURA prefabricated house, considering 3 alternatives : wooden, brick and concrete structure. The last case study is defined by applying PRESCO recommendations to the FUTURA house. These case studies will allow to compare the sensitivity of the tools to some building characteristics.

The FUTURA house is a single family house with two levels (210 m^2 heated area), well insulated, with a high solar aperture. The energy for space heating and domestic hot water is gas, and the heating demand corresponds to a Swiss climate. The European electricity mix is considered. A detailed description of the building has been provided to all tools developers, who performed a life cycle assessment considering an 80 years operation period.

The Swiss “FUTURA” house considered in the exercise



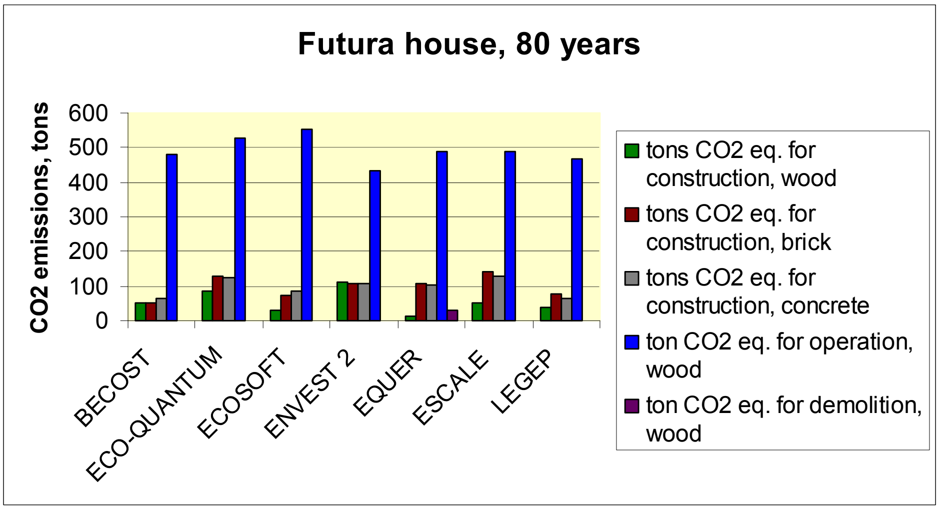
In a first step, inventory data has been compared for materials and gas heating. This comparison has been performed on the basis of the greenhouse gases emissions, which is the only common indicator between all tools (except OGIP), expressed as a weight of equivalent CO_2 emission. The results are summarised in the table below.

In the case of wood, some tools consider a CO_2 storage in the forest related to photosynthesis (and a CO_2 release at the end of the life cycle), while other tools consider a global zero emission process. The total CO_2 balance for the whole life cycle should be the same, but the carbon stored in the wooden structure during 80 years is not in the atmosphere, and this contributes to protect the climate.

For the whole life cycle of the house, the results are similar to the first case of the cube : there is a +/- 10% discrepancy between the tools, cf. the table below.

Functional unit	Mean eq. CO_2 emissions	Relative difference for the lowest value (%)	Relative difference for the highest value (%)
1 kg brick	0.255 kg	-15%	+25%
1 TJ gas (end energy)	64 400 kg	-15%	+15%
Whole house, wood structure, 80 years	550 tons	-10%	+10%

Concerning the comparison between wood, brick and concrete structures, the global warming indicator is lower for wood in all tool except Envest. But the results may be different when comparing brick and concrete, cf. the figure below. The emissions during the operation phase are very similar for the three alternatives, so only the case of wood is included in the figure. Some tools account for CO_2 emissions at the end of life of wood, therefore demolition is also represented on the graph for the wooden alternative. In all tools, the highest CO_2 emissions correspond to the operation phase.



The other indicators considered in the tools are differing. The tools may consider acidification, smog, waste (possibly indicating also radioactive waste), primary energy consumption, water consumption, exhaust of resources, eutrophication, ozone depletion, toxicity, eco-toxicity, cost, and global indicators like eco-points or eco-scarcity. Therefore it is difficult to compare the ranking of the three alternatives considered (wood, brick and concrete).

The last case study corresponds to the same house, but considering alternative designs which were derived by applying recommendations elaborated within the PRESCO network. Environmental quality is only a part of sustainability, therefore the LCA tools can deal with only a part of the PRESCO recommendations. Each tool developer has selected a set of 3 to 5 recommendations. The indicators have been compared considering the concrete structure with and without applying each recommendation. All concerned tools have obtained reduced impacts applying recommendations n°305 (selecting appropriate glazing, i.e. triple glazing in the considered case), n°325 (water saving), n°77 (reduce material transport) and n°107 (using renewable energy, solar domestic hot water). The results are more contrasted for n°324 (use rain water) where some impacts increase due to the installation, for n°107 (using renewable energy, wood fuel) because pollutants are emitted during the combustion, and n°134 (use renewable materials) according to the materials considered. The effect of recommendation 12 (use materials with an environmental declaration) is difficult to assess. In general, all tools are in good agreement to show that each recommendation individually has a limited influence on the global life cycle indicators : eco-design should include many aspects in order to improve the quality of a project in a significant way.

This exercise allowed to improve the software and aims at increasing the confidence in the tools. Its added value is also to clarify the main assumptions in each tool and to identify good practice from the discussion regarding :
- life cycle inventories (allocation, transport, recycling, infrastructure, representativeness, data age, cut-off rules, validation…),
- building and process model (construction site, renovation, maintenance, life span…),
- indicators (e.g. is renewable and feedstock energy included in the energy consumption indicator, is photosynthesis included in the global warming indicator etc.).

Some good practice is proposed by the group, for instance :

- account both for the use of recycled materials in construction and for recycling at the end of life, at each phase with 50% of the total possible avoided impacts compared to no recycling,
- include water consumption in the analysis,
- use product specific data when available with a consistent methodology, recent data being preferable,
- propose default values for transport distances to site and for each type of waste treatment process (incineration, landfill, recycling, ...).

As a conclusion of this exercise, some work is still needed to harmonise the methods and to facilitate the interpretation of the results by the building practitioners. Some tools are already used in practice, and educational material exist to train professionals. Therefore, impact reduction objectives could be integrated in the design briefs for green buildings. If we are to achieve a 75% reduction of greenhouse gases emissions by 2050, it is needed to integrate this objective in new buildings because they are likely to remain part of the building stock for a long time.

IMPLICATIONS IN ARCHITECTURAL DESIGN OF DOWNTOWN BLOCKS REVITALIZATION ACCORDING TO SUSTAINABLE DEVELOPMENT

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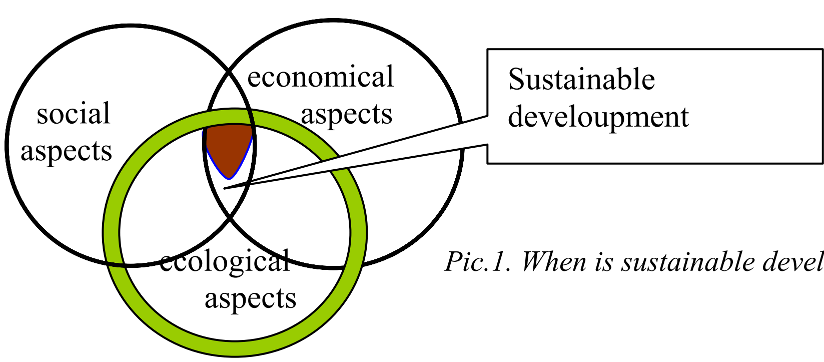
1.Introduction

Downtown XIX th c. blocks still remain major architectural structures in many cities, which of course has some good and bad implications. In Poland, we have about 11,3 mln flats, of which 1,5 mln were build before yr. 1918. Most of them are in downtown of big cities. The best part required to be overhauled, but about 300 thousand is need to be demolished The downtown block from XIX and beginning of XX c. ought to be revitalized, not only renovated. Revitalization – is meant as holistic changes in social, economycal and technical aspects. It is a permanent process, which constantly adapts historical structures to modern expectations. In the revitalization we have the same aspects like in the sustainable developing, so these activities are related. In sustainable developing three targets are similar to revitalization: - social equity between generations and with each generation; - economic development; - ecological sustainability.



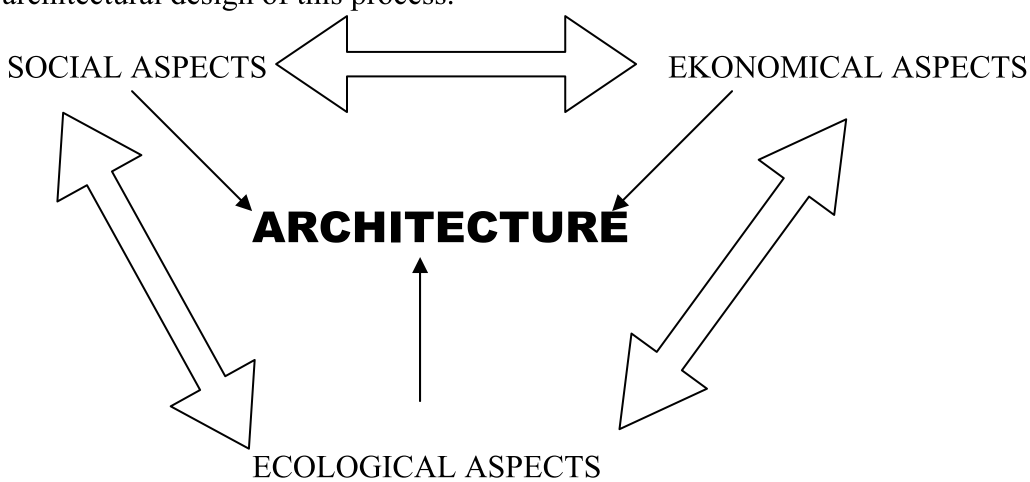
Pic.1. When is sustainable development?

The main target is to study, how the sustainable development theory changes the methods of revitalization proces? If the revitalization process is changed, so architectural design process should be changed to.

2. The characteristic of downtown block from XIX and beginning of XX c. in the sustainable development theory context.

In the second half of XIX c. whole Europe had emerged sudden economic development. The cities have grown very fast and mainly tenement buildings were constructed. The flats located in a front part of tenement house were better and more expensive than the flats in the out-building. Buildings were erected in high density and usually had from 3 to 5 floors. From the beginning of 20-s in XX c we observe postulates of change the standard of living conditions. The architects from modern movements suggest demolishing of all those constructions and to replace them with modern houses among the trees. In the eighties, the postmodern movement and ecophilosophy proposed new way of thinking about improvement of old structures. Tenement buildings are of great value in context of culture, sociology and ecology, and because they have absorbed large quantities of energy and pollution (emissions), we must protect and revitalize this structures.

The revitalization process, when based on the sustainable development theory, must solve not only technical problems but also take a deeper look in sociology, economy and ecology. Main ecological aspects concerns: energy, buildings materials and building structures with their life cycle assessment, space and are connected with eco-economy and sociology aspects, vary revitalization process and architectural design of this process.



Pic.2. *How the main aspects in sustainable development influencing on architecture (authors pic.)*

The quarters with tenement buildings are the multi family living area where the sociology and economy problems are stronger then somewhere else. This is existing structure, so architect cannot possibly design the new one, instead he tries to implicate changes and eliminate unwanted old elements. His decisions must be discussed with inhabitants or their representation. Learning from my experience and sourcing the literature[1] I have prepared the table with analysis how the theory of sustainable development can effect revitalization.

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[1] Author was a lider in research group in international demonstration project: "Ecology revitalization of Szczecin – Turzyn area" 1994 – 1998y. Autor was a main designer of projects: "Revitalization of quarter in downtown of

Tab. 1. How the theory of sustainable development effect revitalization proces. (Authors tab.)

a s p e c t s	main targets	effect on revitalization
Sociology and cultural	- proecology education; - social ties; - satisfaction and the social activity as the result of suitably designed space; - inhabitants participation in revitalization process;	- proecology education of inhabitants; - architectural spaces for community spirit; - looking for acceptance and homeliness of designed space; - inhabitants participation in design process; - inhabitants are real masters of the house;
Ecology	- ecology ethics; - proecology thinking; - life cycle analyzes for structures and building material; - space and existing structures as the exhausted goods;	- permanent revitalization of the existing structures; - redesign of flats and leaving spaces; - “gently revitalization” - multidisciplinary design teem; - designing of fool life cycle of building’s;
economy	- environmentally costs economy; - environmentally friendly technology; - pollutant pays;	- environmentally costs in business plan; - comprehensive economy costs of materials and structures life cycle including environmentally costs; - sustainable technology, local technology;

The effect of revitalization regarding chosen method can be verified after few years by simply asking questions like:

- how the social life is going?
- are inhabitants felling good in this spaces and are they real masters of the house?
- how easy is to keep it in good condition?
- how easy was to adopt to the new function?
- how much costs the ordinary exploitation? et ceterra.

New systems like: BREEM (Building Research Establishment Environmental Assessment Method), LEED or Green Building Challenge (GBC) for estimation environmental impact can be helpful.

3. Architectural designing process of revitalization

In Poland and in other Western countries similar methods of architectural design can be observed.[2] We can distinguish them into few phases (stages). First - initiating decision regarding solely subject and localization – called *inception.* Then goes first design, study concerning program of investigation and contextual situation – *preliminary studies*. Next step is architectural conception – *sketch studies* or *scheme design*. Further comes first complete architectural design with some

Szczecin between the streets: Małkowskiego, Bogusława, Boh. Getta Warszawskiego” and “Revitalization of quarter in Szczecin – Dąbie str. Dziennikarska”;
also in - A. Baranowski: „Projektowanie zrównoważone ” Gdańsk Teh. University 1998y.

2 „A Green Vitruvius – Principles and practice of sustainable architectural design” , James & James, London 1999r p. 8 and B. Edwards – „Sustainable Architecture – European directives and building design” Architectural Press, Oxford 1999r. p. 260, 261.

technical and economy data – *pre – project*. The next phase is the multidisciplinary technical design – *basic project* or *detail design*. The last stage with more details and economy costs calculation, and materials specifications – *execution of project*.

Tab.1 has listed detailed new aspects of building revitalizations which should be involved in architectural design process. Question is: how will they effect and change design process specially when rebuilding XIX c. tenement houses (tab.2)?

Tab.2. *Changes in architectural design process for revitalization the quarters of tenement houses from XIX c. New and expanded environmental responsibilities at different stages of architectural design: + new, +- partly new. (Authors tab.)*

Number of stage	**+, +-**	**Stage and issues**
I		INCEPTION
	+ +- +	1. Agree theory of sustainable development for the investment. 2. Prefer revitalization than new construction. 3. Advise on appointment of "green" consultants
II		PRELIMINARY STUDIES
	+- +- +- + +	1. Inhabitants postulate. 2. Directions from maser plan. 3. Social and economy directions from city developing strategy. 4. Ecology and energy audits. 5. Research the building type and analyze good practice examples. 6. Multidisciplinary teem for designing with sociologist, green consultants etc. 7. Election of tenant representation. 8. Analysis of sites and existing situation.
III		SKETCH STUDIES
	+ +- + +	1. Develop sustainable strategies in design. 2. Made few variants of sketch designs meeting theory of sustainable development. 3. Discus the sketch designs with tenant representation. 4. Check which one has environmental parameters better design.
IV		PRE – PROJECT
	+ +	1. Optimize the choosen design considering sustainable/environmental consequences. 2. Calculate predicted building performances and assess against targets. 3. Calculate the economy and ecology costs of whole life cycle.
V		BASICT PROJECT and construction
	+- + + + +	1. Specify design criteria for services. 2. Select materials and construction methods having regard on life-cycle assessment. 3. Prefer local production and materials. 4. Design the construction process with environmental duties. 5. Explain the requirements of environmentally friendly design to tendering contractors.

4. Conclusions

According to above analyzes (tab.2), the architectural design process for revitalization does not change in main stages. There are changes of the design targets and within criteria, when making a design, decisions and assessment of design. Today it is necessary, to add new sustainable (green) elements to design processes and to design of revitalization old structures, too. In my research I found, that the more we change the criteria and target, the more we effect on the final result of our work. There is a great necessity to research deeper into the subject of "Revitalization in aspect of sustainable development".

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SUMMARY

XIX th c. tenement buildings are still main downtown structure in many cities with its pros and cons. Among 11.3 mio apartments in Poland, nearly 1.5 mio were build before 1918, most of them can be found in major cities, where there remain as downtown living areas. It is essential to revitalize those buildings instead of just renovating them, with care of their inhabitants and present environment. Revitalization made in accordance to theory of sustainable development will concern not only technical but also social, economical and ecological aspects.

Author, based on performed studies and projects, researches the subject of: how will the architectural design change when processing revitalization of tenement buildings?

As a result of analyses, the designing process alone will not transform, its stages remain unchanged. What will change is the target of design, criteria of taken design decisions and also the criteria of project rating. It is essential to understand the number of people, which can take the decision about the project, will increase by inhabitants and non builder's specialists.

Today it is necessary, to add new sustainable (green) elements to design processes and to design of revitalization old structures, too.

Modern Earth Building for Promoting Regional Development under the Action Programme Leonardo da Vinci

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Talking about sustainable building, in order to avoid a technocrats point of view we shouldn't focus on building materials, energy gadgets and construction technologies only. The problem with rules of sustainable development implementation is not in technological part of our life but in mental resistance, in a human factor and acceptance level to change our habits and behaviors. Therefore we have to remember about living community as a part of sustainable building and how to create vital relations between all members to achieve regional development in context of factor 4 or factor 10. Interactions between material part of building (which seems to be a kind of hardware) and its user, a community member with his customs and preferences (which seems to be a kind of software) seems to be a crucial issue in sustainable development. Involvement of community in participation process of design and construction is an aim of successful project.

photo 1. Process of participatory design involves different partners from local community

Consequence of factor 4 approach should be an idea of de-materialisation. To reduce amount of material part of product or to reduce its negative, environmental impact, local natural building materials should be considered. The best example of such material is earth with its symbolic relation to humans.

Looking for a local building culture, a kind of local building materials inventory should be proceeded. It could be done with help of computer data base programs, as a part of Informative Society distributed in a web. It is necessary to stress, that collecting of information is the first stage to understand the world and local environment. The next stage is knowledge about selection and implementation of collected bits of information and the next one is wisdom, transforming know-how into appropriate choices. Dynamic architecture, open for processes initiation, self-regulating as an organism in symbiosis with its environment is a challenge for next generations of architects and designers. In order to measure a quality of human-nature relations, development of adaptative architecture could be used as an indicator of information society transformation into knowledge society and society of wisdom. Again, the earth seems to be a very good example of building material which meets mentioned above requirements.

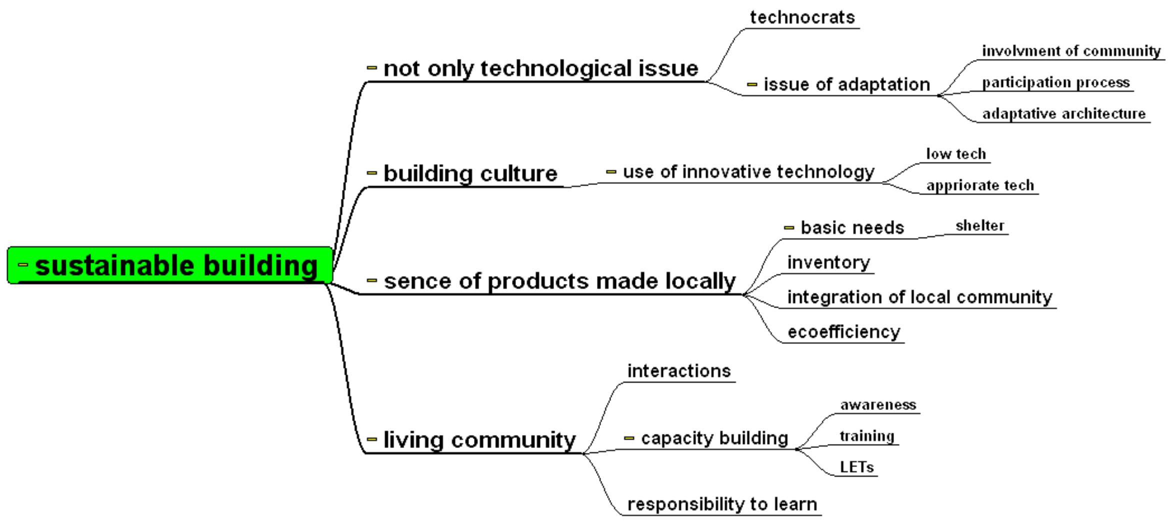

Fig. 1 Sustainable building issue interactions in case of natural buildings implementation.

Earth as the building material is widely available, natural, recyclable, has a low environmental impact and can be used to create healthy, beautiful building. Culture of earth building as a part of our common heritage exists in many European regions.

photo. 2,3, Traditional Building Culture examples as a pattern to develop a new approach to natural building materials implementation in every day, adaptive design.

Fourteen partners from six European countries are co-operating to develop a vocational training Unit **Clay Plaster and Design** as a common product of a European pilot project **Modern Earth Building for Promoting Regional Development.**
A common European vocational qualification is still only vision. Therefore, to begin with, each partner country should create its own national vocational training diploma **Clay Plaster and Design**. The three year project, which began on 01.11.2002, aims to promote regional development by improving the quality of the vocational qualification and sharing the experience throughout Europe.

Customer demand for Clay plasters and clay finishes in interior design is growing in the West European market. The construction industry is already offering numerous earth and clay products, but training courses in their application and use are not currently available. The three year project, aims to promote regional development by improving the quality of the vocational qualification to offer new job opportunities. Co-operating on a European level will require consideration of different vocational training systems, and will also be an opportunity to recognise regional specialisation and preferences in design with earth. A training unit on this new specialization aims to offer new job opportunities for craftsmen and women, be they bricklayers, plasterers, painters, or decorators.

The training will also provide recognition for self-taught specialists, who have gained experience in earth building, without having gained an officially recognized certificate. Co-operating on a European level will require consideration of different vocational training systems, and will also be an opportunity to recognize regional specialization and preferences in interior design using earth.

Fig. 2 Comparison of approaches presented by communities in context of natural building materials and implementation of new ideas.

Communities in developed countries WEST EUROPE	**Communities in developing countries EAST EUROPE**
More organized, more formal, more institutions	Informal, organized just for events
Team working	Individuals
Open (more progressive)	Closed (more conservative)
Depletion of natural resources	Exploration of natural resources
Relatively high environmental awareness	Relatively low environmental awareness
Looking for knowledge improvement, active	Passive, no tradition of knowledge improvement
Looking for new skills	Existing skills of craftsman's
Growing market niche	No market
Associated as a kind of fashion	Associated as a symbol of not modern, poverty
High price of craftsmen labor	Low price of craftsmen labor
Developing sector	Unknown, exotic sector
High level of building culture (quality standards, maintenance)	Low level of building culture (quality standards, maintenance)
Big ecological footprint	Small ecological footprint
They consume a lot, and they are talking about limits	They want to consume more
The consumption model of life is contested	Consumption pattern as a life style model
Common facilities	
Common future, one planet	
That type of buildings and natural materials existed in traditional architecture in history	
People feel better in buildings made from natural building materials	

The aim of offered courses is to develop basic knowledge for sustainable building, the environment friendly materials and their application with focus on ecological and indoor climate aspects. The main objective is to develop practical skills in applying clay plaster. It is specially important on the level of cultural heritage conservation and renovation plans. Understanding of the natural materials and their range of uses is crucial for sustainable building design. Comparison with existing, popular building materials will discover the ecological footprint of each participating countries. In Germany, France or United Kingdom many affordable products are prefabricated as a clay plaster mixture and can be processed by using modern silo-techniques. The real problem is a lost of traditional skills by building companies there. In Poland, Bulgaria or Greece traditional skills exist but customers` demand for clay finishes is rather low.

 

photo. 9,10, Sun Flower Farm in Strzeszów (near Kraków) is one of pioneers communities promoting earth building in Poland .

Awareness raising seems to be important part of Clay Plaster Project dissemination plan in Eastern Europe. Promoting the use of natural building materials and products could be a part of sustainable, regional development, based on locally existed resources. Involvement of local communities to that project will be a part of capacity building to empower a wisdom choices for our common future.

THE ECOLOGICAL SOLUTIONS OF THE COMPOSITE FLOOR STRUCTURES AND DENSE PERFORATED CONCRETE WALLS.

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1. Introduction

In the world solutions of environmentally friendly buildings, the walls and the floors have to be designed of ecological materials, as well as they should actively regulate the microclimate of the rooms (constant temperature and humidity). This is possible when the external layer of building elements has a sufficient mass and low vapour infiltration resistance. The vapour condensate is accumulated in porous material and after reaching the sorption equilibrium is given back to the interior's atmosphere. In contemporary design to achieve self regulation of humidity in the interior there should be used materials such as: ceramics, gypsum, gypsum polystyrene, keramsite aggregate concrete and wood –fibre cement. Disadvantage for microclimate of interior are such materials as: concrete, polystyrene and foil insulation under thin plates of gypsum plaster. In the paper there are presented the new Polish solutions of floor and walls' structures, which form full ecological interior.

2. The composite multirib JZP -45/28 floor system

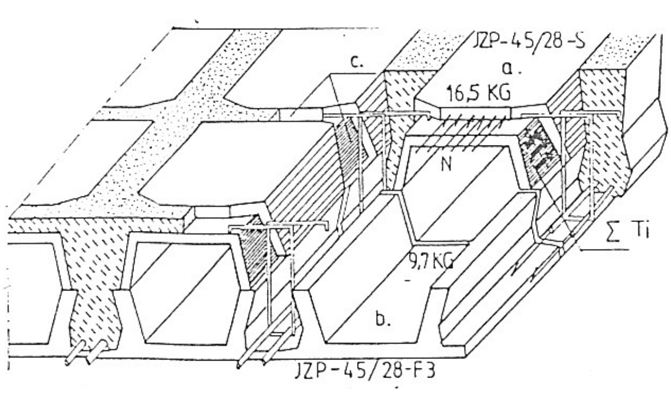
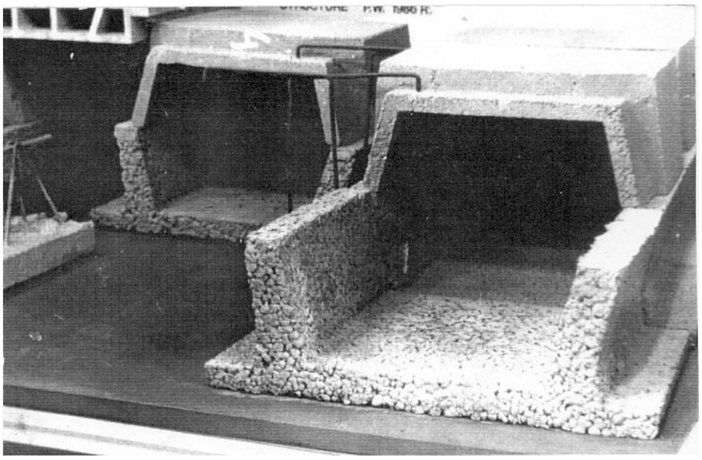


Fig.1. Composite multirib JZP-45/28 system

In the composite multirib JZP-45/28 system the precast units were divided on upper-structural and down -filled (*Fig.1*). The structural element has original key edges divergent shear joints and transfers shear forces in the compressive zone, what considerably reduces the negative influence of creep and concrete shrinkage on the beam deflection [1].



The laboratory tests of JZP -45/28 structure 7,20 m span have showed the increasing of loading capacity and system rigidity as well as very small deformability of the key edges divergent shear joints, what ensured the transfer of horizontal shear forces from the monolithic ribs to the precast concrete upper elements. In the JZP -45/28 structure there were used the down filling elements of keramsite aggregate concrete (*Fig.2*), gypsum (*Fig.3*), and gypsum – polystyrene (*Fig.4*).

Fig2. The down filling elements made from keramsite aggregate concrete

Fig3. The down filling elements made from gypsum

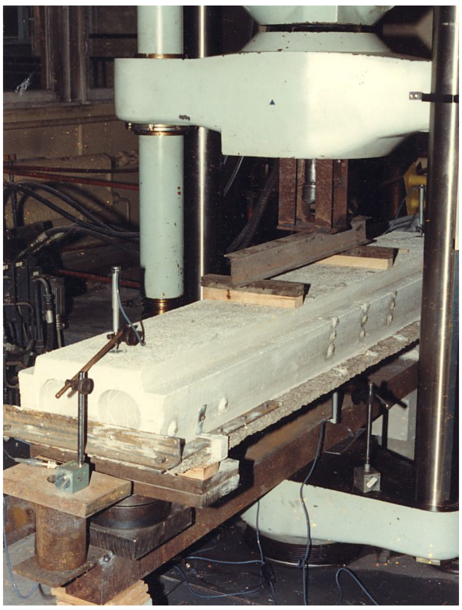


Fig.4. The down filling element made from gypsum – polystyrene

Fig.5. The Centre Kodak building in Konstancin near Warsaw

The ecological structure JZP -45/28 span 7,20m with keramsite aggregate filling units was applied in the Centre Kodak building in Konstancin near Warsaw (*Fig.5*).

3. The composite JZP –LC floor plank system (P362237, 17.09.2003)

In the modern design with the application of large spans - the slab -column skeleton structure has became too weighty and not economical. At present on the precast floor planks there are placed the thinwalled infill cassette elements.

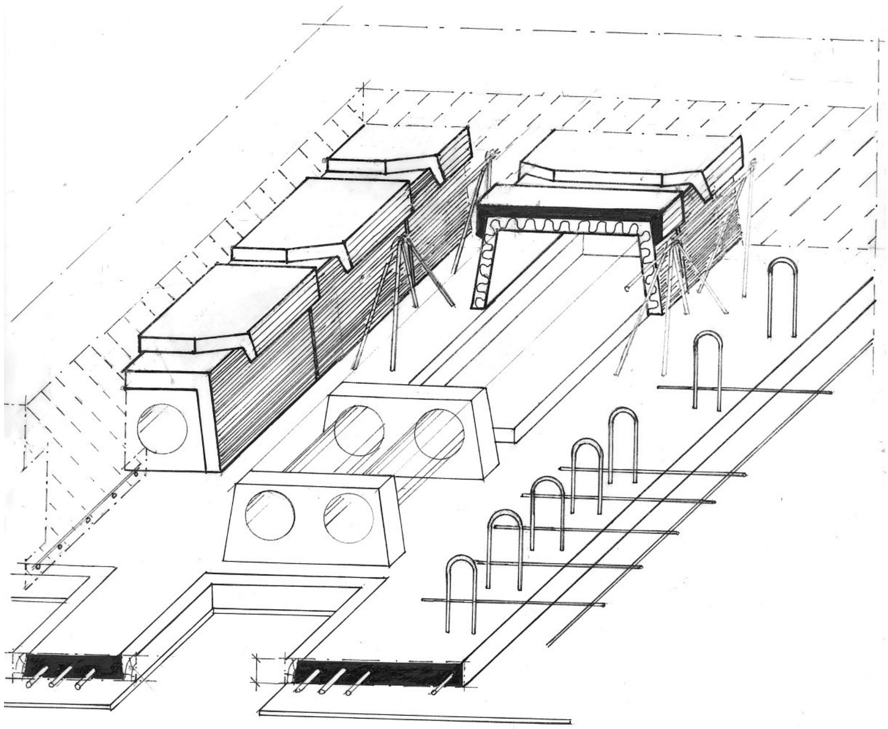


Fig.6. JZP-LC composite floor plank system

For the purpose of obtaining the inside space for installation system and the ecological ceiling, authors decided to open the floor and to introduce double material element: structural concrete combined with concrete in situ and porous material as an absorbent of humidity - JZP-LC composite floor plank system (*Fig.6*) (P.362237, 17.09.2003).

For the down layer of the element there are recommended: ceramics, poroceramics, light concrete and wood –fibre cement plates. Especially wood –fibre cement plates have a very low vapour diffusion resistance, and also are an excellent sound insulation. The structure may be applied in unidirectional system as well as in grid system. In the second case the stiffening ribs have to be more dense situated.

4. The dense perforate concrete walls with free vapour diffusion through the wall.

The polystyrene panels have very high infiltration resistance, what makes the vapour diffusion through walls impossible. Authors have introduced in wall's elements the gypsum - polystyrene' layer reaching to the mineral thinwalled plaster, what assures the constant vapour transmission (P.362238, 17.09.2003), *(Fig.7)* [2].

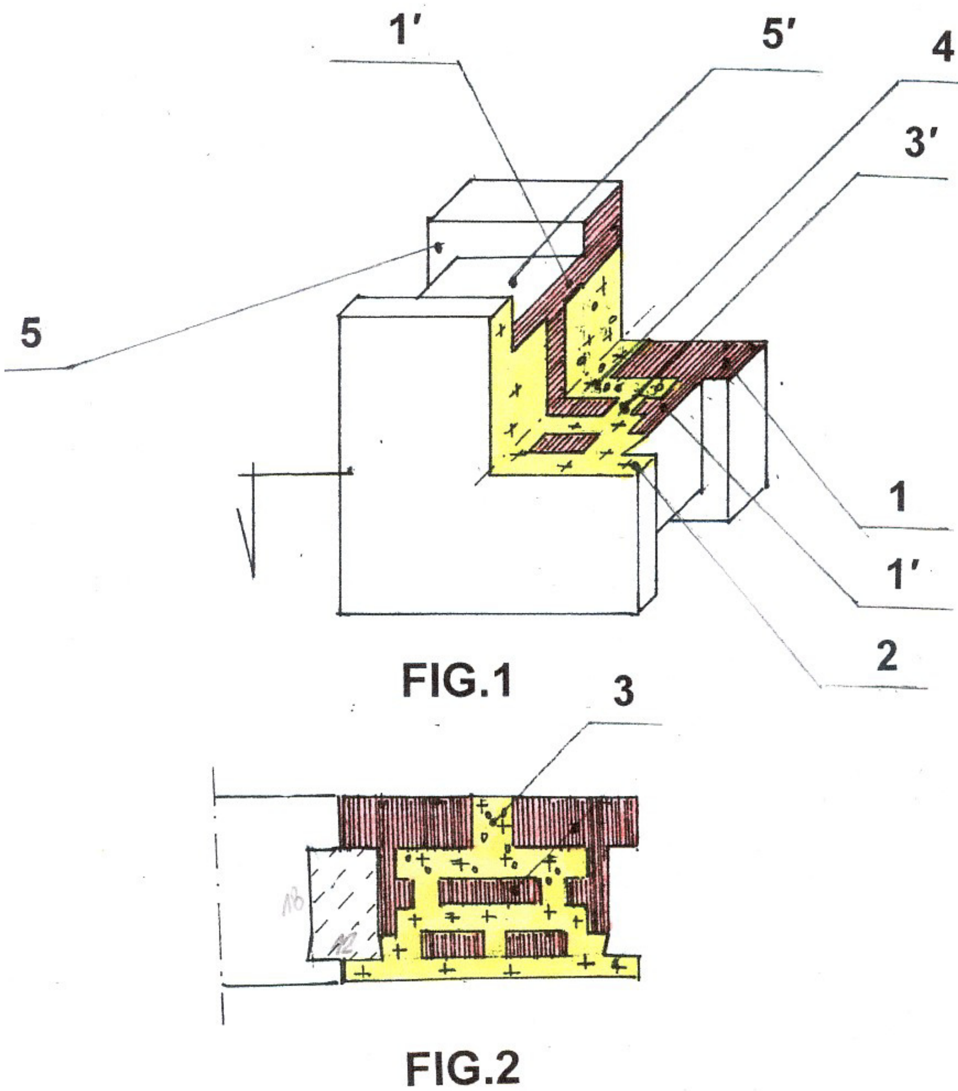


Fig.7. JZP –LC dense perforated concrete walls system

The basic wall element creates the vertical and horizontal concrete ribs as an open bear system. The continuous gypsum –polystyrene layers reaching the thinwalled mineral plaster let to achieve the constant vapour diffusion through the wall, what prevents the development of mould.

5. Conclusions

At present according to the idea of sustainable development of human settlements, including sustainable building and construction there should be used "materials conducive to health and production of a good indoor climate in buildings" ("The European Urban Charter", adopted by the Council of Europe's Standing Conference of Local and Regional Authorities of Europe in 1992, Strasbourg) [3].

The examples of such building materials for floors and walls and arrangement of layers are presented in the paper. They could be used by local construction industry. Presented system of multirib floor structure JZP -ECOL - a new element of polish building technology development has been applied in the practice and would be recommended to the modern construction, especially ecological (system has been tested in laboratory and certified by Building Research Institute). The laboratory research has showed very good collaboration of composite elements. The solutions have fulfilled the requirements for an ecological interior and at the same time have ensured high standard of interior's architecture. Presented solutions are profitable building' structures owing to reduced dead load, and create the possibilities of leading installation systems in the space inside floors.

The development of new environmentally friendly construction technologies is one of the main problems in achieving sustainable development of the region.

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Paper to be presented at
the Regional Central and Eastern European Conference on Sustainable Building, Warsaw, Poland, 27-29 October, 2004

STRATEGIES FOR THE SUSTAINABLE RENOVATION OF APARTMENT BUILDINGS

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Abstract
For the period 2000 to 2015 the Netherlands are confronted with an important building challenge. Because of the lag that has developed in the quality of facilities and housing stock, the redevelopment of inner city areas requires a large-scale integrally organised approach. This is specifically the case for the restructuring of post-war (1945-1965) residential districts. The owners of apartment blocks in these districts are faced with a very complex task. The most important question is how to renovate and improve the cramped and out-of-date housing stock, avoiding massive demolition. How can, by using IFD technology[1], the housing types be re-differentiated and the apartment blocks sustainable renovated in order to house the different target groups?
The most important strategies for the renovation of apartment blocks are given as used in the actual practice of the restructuring of housing districts that were built in the period 1945 to 1965. The strategies are divided into solutions for allocations with low-rise housing and for districts with apartment blocks, mostly four storeys high. Each strategy is clarified with an example of a recent practical experiment. In particular the paper shows the results of a case study, the concept 'Flexible Breakthrough'. The basic principle of the project is to completely remove (demolish) one of the four bearing walls in each apartment and replace this wall by a steel-supporting frame. The resulting much larger space is to be redesigned with IFD-technology.
The paper describes the systematic methodology to analyse the possible solutions and the design of the Flexible Breakthrough concept. This concept provides maximal industrialisation, flexibility and demountability within the given constraint of remaining the major part of the existing apartment building.

[1] IFD stands for: Industrial, Flexible and Demountable.

Keywords:
Sustainability, Renovation strategy, housing stock, re-differentiation, IFD-technology, apartments, existing buildings, partial demolition

INTRODUCTION

The Netherlands is faced with a major undertaking in the period from 2000 to about 2010, the redevelopment of city-centre areas. In addition to the redevelopment of industrial estates, a sizeable part of this undertaking consists of restructuring residential districts built in the period 1945 to 1960.
This latter part, the restructuring of post war residential districts is gone into in greater detail in this paper with respect to the problems, policy, solutions and strategies and experiences with practical experiments.
An overview will be given of the solutions and strategies developed in the Netherlands to upgrade the existing post war housing stock.

Information about the quality of the existing housing stock in the Netherlands and the government's policy with respect to housing, sustainable building, urban renewal and restructuring is published by a paper presented at the 9th International Conference on Durability of Building Materials and Components, Brisbane, Australia, 17-21 March 2002

Market situation

In general, housing consumers are demanding better quality and larger floor areas. In addition, there is a clear need for greater flexibility and adaptability. The Netherlands is on the eve of extensive measures being taken to the housing stock. This concerns the large-scale redevelopment and restructuring particularly of residential areas built after 1945. This means flats accessed from a common entrance hall, blocks of flats, single-family houses and high-rise flats. This is a substantial part of the housing stock.
The main problems these districts now face are:

- houses no longer meet current statutory, functional and technical requirements;
- amenities in the district and housing stock no longer meet the requirements of the residents;
- the composition of the residents has slipped down to the level of people with the lowest income. 80% to 90% of these houses are rented to ethnic groups.

The problems in these post war districts in relation to the aforementioned characteristics require a district-oriented integrated approach. Based on forecasts made by the Economic Institute for the Construction Industry, the following trends in housing market are expected until 2005: A slight fall (7%) in the building volume of new houses and a substantial growth (15%) in the refurbishment and renovation sector.
Quite a lot of information is available about the quality of the housing stock in the Netherlands. The main source of this is a national survey carried out by the government on the functional and technical quality of the whole housing stock. This is expressed in terms of the extent of the backlog in housing quality.

Tools required for restructuring

The traditional approach of managing the housing stock, especially by housing associations, has three forms:

- regular maintenance and replacement of building components aimed at maintaining the property;
- major repairs aimed at qualitative home improvements;
- replacement new building by carrying out massive demolition of houses.

This traditional approach has not proved to be adequate to keep the district as a whole up to a certain standard. Encouraged by government policy, progressive housing associations and residents' associations, a range of strategies and solutions has been added to the existing traditional approach over the last 5 years.

The strategy employed in addition to this has the following broad elements:

- using the abundant public space especially the green areas to create more private spaces, such as allotments, play areas and private gardens next to stacked housing;
- breaking through the separation of functions by combining residential and business areas and encouraging urban living in the district;
- restructuring the existing unbalanced housing supply into a differentiated supply for several target groups, also with combined home and office;
- applying high requirements with respect to urban planning and architecture.

The solutions developed by applying this strategy will now be dealt with briefly, divided into solutions for low-rise buildings and for stacked housing (blocks of flats). The various solutions are illustrated with practical examples.

Strategy for low-rise building

Residential districts built in the 1950's and 1960's are characterized by monotonous rows of the same type of house, only intended to provide housing for families with children. Here and there this is interspersed with terraced houses for elderly people.

The approach used for low-rise building focuses on:

- qualitative improvement of the possibilities for use, environmental and energy performance and the comfort of the house.
- extending the floor area by providing residents with a package of options;
- breaking through the architectural monotony by enlarging the house combined with a series of external wall variations.

Low-rise building pilot project (Hoogeveen, the Netherlands)

The Municipal Council of Hoogeveen wants to demolish the whole of the Wolfsbos district of Hoogeveen built in 1967 to 1969 because of the poor quality and the difficulty of letting the houses. The residents only want it to be renovated. The owner (housing association) of the houses has decided, based on an analysis, which included the urban planning quality of the district and differences in quality between the various types of houses, to take a combined approach of limited demolition (14%) and replacement new building with a differentiated renovation of 76% of the houses. The new houses are especially aimed at attracting new higher-income target groups to the district.

Extending the houses firstly carries out the requirements of the sitting tenants and secondly is used architecturally to reinforce the spatial picture of the district.

various ways of extending houses and types of architecture for the houses to be renovated

The main measures with respect to sustainability are:

- using durable materials;
- separate collection of rainwater for use in the district and direct infiltration into the soil;
- replacing collective district heating with individual heating systems making use of solar collectors.

An important strategy, which operated as a control mechanism for urban planning design, is that new owner-occupied houses faced onto an inner courtyard of the plan and not onto the green outer edges.
The argument here is that a good balance is created between the lettability of the houses to be renovated on the green periphery and the owner-occupied houses to be built.

Strategy for stacked building
Most of the flats dating from the period 1945 to 1960 were built in linear rows in an open parcelization. The housing complexes usually have 3 to 5 floors.
The ground floor is in direct contact with the public space (parking and green areas) and do not have hardly any living space but nearly always just storage space.
On average, the houses have three to four rooms with a floor area of 60 to 70 m².
This floor area can now only be let to one or two households with a low to average income.
In order to be able to retain these housing complexes, they must be made socially and economically attractive again. The main condition is that the unbalanced supply is widened into a differentiated supply aimed at three target groups:

- elderly people with low incomes;
- large households with low incomes (especially ethnic groups);
- households consisting of 1 or 2 people and families with high incomes.

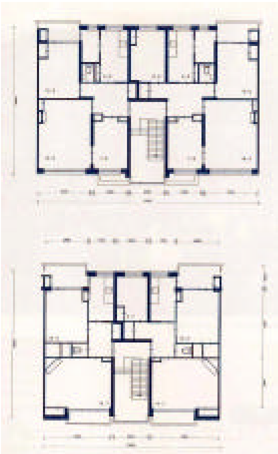
In order to be able to realize such a mix within an existing district without having to carry out large-scale demolition of houses, a range of solutions have been experimented with over the last few years.
All these solutions are based in one way or another on transforming the existing complex.
The various sorts of solutions applied in practice are:

1. vertically combining two houses one built above the other into one new house;
2. horizontally combining two adjacent houses into one new house;
3. adding an additional floor on the roof (termed ‘optoppen’, topping up);
4. replacing the storage spaces on the ground floor with large houses consisting of two floors. This means that the small house above the storage space no longer exists. These houses also have their own garden (termed ‘uitplinten’, changing the function of ground floor);
5. partial demolition of upper floors in such a way that spacious single-family houses can be created in the remaining lower space (termed ‘aftoppen’, topping);
6. A completely new form, which is still in the development stage, is based on a partial adaptation of the existing shell of a complex. The basic idea here is that for each house one solid load-bearing wall is replaced by an industrially manufactured portal frame with the result that a much more spacious and flexible layout is created for installing a differentiated fitting-out package into houses with a high degree of flexibility by using IFD-technology.

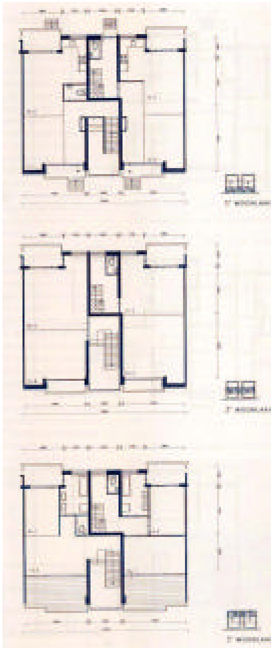
1. Vertical combination pilot project
The three-storey flats accessible from a common entrance hall (average of 44 m2) in this complex, which was built in 1953, have been converted into individual houses. The floor

plans show how both narrow and broad types of new houses have been designed. Part of the top floor has been demolished to create a roof garden.

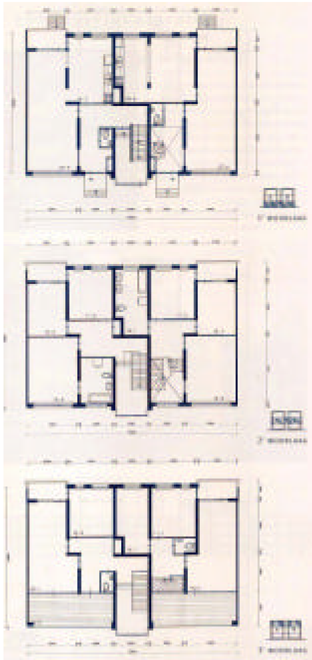
Old flat: narrow and broad type



New house: narrow type



New house: broad type



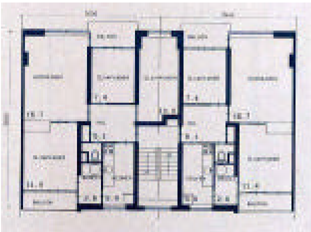
2. Horizontal and vertical combination pilot project

This example concerns an extensive urban renewal project in one of the large southern garden cities of Rotterdam, the Pendrecht district. Ninety per cent of the district consists of subsidized rented housing in stacked complexes.

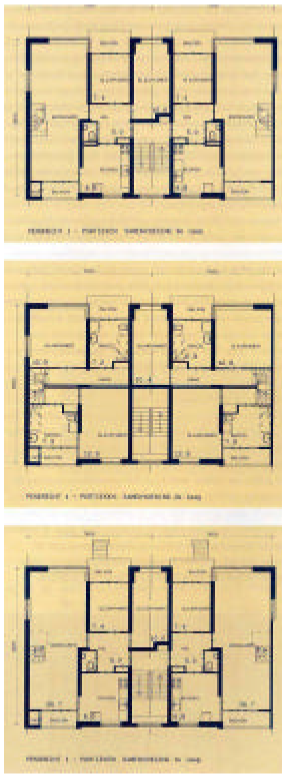
In order to prevent the district from deteriorating even further and vacancy from arising there due to the poor quality of the houses and the unbalanced supply, the Rotterdam housing association has taken the initiative for a well-thought out combination of maintenance, restructuring and new development.

The restructuring consists of the horizontal and vertical combination of small flats into large houses for families. The process is controlled by the participation and requirements of the residents.

From three to two
The strategy with respect to the blocks of flats accessed from a common entrance hall includes vertical combination, major repairs and home improvements. Two out of each block of five flats are reserved for combination. Part of the housing units on the second floor is added to those on the first floor and part to those on the third floor. Major repairs consist of a uniform approach with respect to external walls and pipe work, and an approach with respect



Existing floor plan of flats accessed from a common entrance hall



Vertical combinations on the 1st, 2nd and 3rd floors

to the fitting-out work, which is at the resident's choice. The options available to the residents range from a modest upgrading to a completely new house.
The composition of each fitting-out package is arrived at in close cooperation with the residents.

3. Topping up pilot project
The Municipality of Schiedam has drawn up an integrated plan for urban renewal for the Nieuwland district (6,700 houses) built between 1950 and 1960. The approach, besides traditional solutions such as major repairs and home improvements also consists of a series of innovative restructuring proposals such as:

- in the case of blocks of flats, combining the built-in lock-up garages and the flats above into spacious family houses with access on the ground floor;
- extending houses by building conservatories and roof gardens;
- making houses suitable for elderly people;
- adding housing for the elderly on the roof of blocks of flats accessed from a common entrance hall (topping up).

As part of the plan, the municipality has applied the so-called topping up in order to meet the need for affordable housing for the elderly.
Topping up is realized by means of a timber-frame construction to enable the building work to be carried out quickly (completion after 16 weeks) and so the maximum possible increase in weight of 10% is not exceeded.

This technique of topping up has also been used in other cities over the last few years. The Foundation for Building Research, together with the Steering Group on Experiments in Public Housing, has evaluated the various projects.
The following lessons have been learned from this evaluation.

Topping up makes it possible to redifferentiate two target groups:

- *elderly people with low incomes*. A condition here is fitting an additional lift. This is easily feasible economically in gallery flats. But is much less so in flats accessed from a common entrance hall. In the latter case, various solutions are possible such as converting flats accessed from a common entrance hall into gallery flats or adding a lift to the flat accessed from a common entrance hall, which then serves a gallery with the roof top housing units.
- *households with higher incomes.* Topping up is used here to add luxury housing such as penthouses. This solution often makes use of light prefabricated steel structures.

4. Ground floor pilot project

So-called 'uitplinten', changing the function of the ground floor is another example of a type of innovative restructuring with the aim of redifferentiating the existing housing stock in the post war districts.
The definition of 'uitplinten' is: the realization of space for housing, working and facilities on the bottom floor or floors of a block of flats. The existing storage space and lock-up garages are partially removed.
The aim of this type of redifferentiation is principally to increase the urban quality of the ground floor, in addition to being designated for larger houses (by combining with the flat above). As a result, the cohesion and quality of life in the district are strengthened. In addition, by converting public green areas into private gardens and creating individual entrances (houses and workspaces), social control and the sense of space are very much improved.

5. Partial demolition (termed 'aftoppen', topping)

The principle of this strategy is to use the existing bearing construction of the apartments to build single-family houses. This can be achieved by partial demolition of the upper layers. The example shows how this is applied to apartments by means of prefabricated structures. The demolished supporting walls will be re-used.

Existing flats

After topping

6. The Flexible Breakthrough concept

This project was started for a research to find a solution for reconstruct apartment buildings, at the same time using, as much as possible, IFD-technology**.** IFD stands for: Industrial, Flexible and Demountable. This resulted in the concept 'Flexible Breakthrough'
This concept provides maximal industrialisation, flexibility and demountability within the given constraint of remaining the major part of the existing apartment building.

The major aspects of IFD Technology are:
Industrial construction: prefabrication, which means also less waste with the actual production, often production recycling is feasible;

- No waste on the building site, which is a boundary condition;
- Construction becomes assembling: completely dry building method, which is also a boundary condition;
- Flexible also means "changeable" during the course of life of the building, so there is also less waste;
- Flexible in the design phase means for example that the developer of the building can wait until the last moment with final decisions about the lay-out of floors;
- Demountable also means that reuse or at least recycling is possible;
  perhaps IFD technology can mean: less construction (in general).

The desk study on the project Flexible Breakthrough showed that the specific advantages of the (partial demolition) approach are:

- Substantial reduction of waste, due to less demolition and application of IFD-technology.
- Better possibilities for the improvement of the houses with respect to acoustical properties and quality and flexibility of building services.
- Complete demolition and new construction would cost about € 27.000, - more per house.
- Faster availability of apartments for rent.

Because one of the four bearing walls has to be demolished it was not possible to apply all the principles of IFD-technology in every detail. The consequence of the removal of such a wall is that the floor slabs also partly must be demolished. After the installation of the new steel-supporting frame the floor slabs have to be reconnected, which must be done with in situ concrete. But for the remaining part IFD-technology can be applied.

Methodology
The methodology that has been used by the design team is based on the approach that has been introduced by Rutten. The members of the design team represent the following disciplines: IFD building technology, structural design, building services and architecture. The results of the design teamwork were presented at every relevant stage to a steering committee with representatives of the housing corporations and Stichting Bouwresearch. First so-called system development areas have been selected. Evaluation points relate to critical details and other aspects of the design that need to be analysed. For every evaluation point a maximum of three alternatives has been determined. The balanced multi-criteria selection process not only showed a high degree of industrialisation during construction, extreme flexibility during use of the building and demountability at the demolishing stage, but also a high degree of sustainability and personal comfort.
The following system development areas have been selected:

1. Foundation
2. Position of supporting beam
3. Sound proofing
4. Demolition
5. Construction and stability
6. Façade
7. Building services

8. Execution

Figures 1 through 3 give an impression of the demolition and rebuilding process.

Figure 1. Removal of the bearing walls.

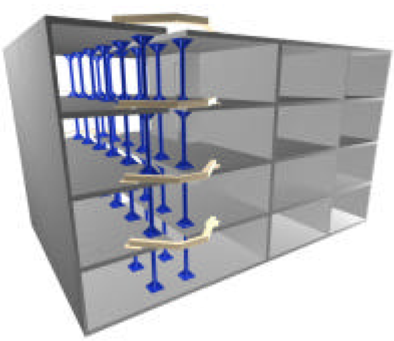


Figure 2. Installation of the integrated supporting frames.

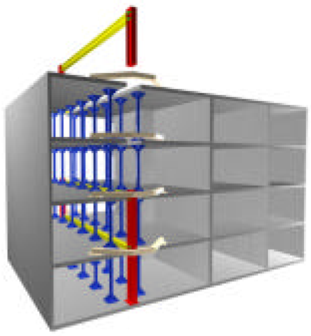
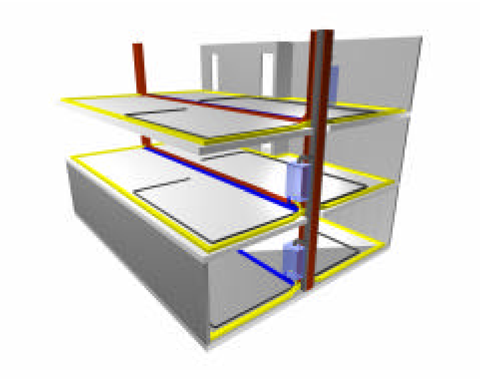


Figure 3. End result with possible building services concept.



Demolition test project

The next phase of the project was prototype testing of the demolition phase in combination with the installation of the steel supporting frame. This testing was done on an apartment building of housing corporation Het Oosten that had to be demolished anyway. Figures 4 and 5 give two stages of the test project: the removal of the bearing wall elements and the situation after the installation of the steel frame.

Figure 4. Removal of the bearing wall elements

Figure 5. Situation after installation of the steel frame

The most interesting results of the demolition test were:

- The removal of the bearing wall elements through the opening in the roof required four times less labor than conventional demolishing.
- The installation of the four floor steel frame only took half a day.
- The connection of the concrete floor to the steel beam proved to be very simple and cost effective. A loading test showed a good structural integrity.
- The complete costs of reconstruction with this concept will be at least 15% less expensive than complete demolition and new construction on the basis of equal building physical quality.

On the basis of the desk study and the demolition test project the program was awarded with a governmental subsidy for the application of IFD technology to the existing housing stock. This will be used for a demonstration project, in which eight apartments will be renovated according the Flexible Breakthrough principles. At the time of the presentation of this paper the design of the demonstration project will be under construction.

Final conclusion

A strategy for the redevelopment of residential districts built in the period between 1950 and 1965 requires solutions which are based on:

- keeping the existing spatial structure, especially the green areas and buildings;
- redifferentiating the housing stock by using a range of architectural and innovative restructuring concepts such as vertical and horizontal combination, 'optoppen'(topping up, building roof-top housing units, 'uitplinten'(changing the function of the ground floor), 'aftoppen' (topping, removing one of more top floors) and flexible breakthrough concept (Hendriks, Van Nunen and Rutten);
- applying sustainable improvement and fitting-out techniques which are aimed at realizing savings in energy and water, flexibility and the use of environmental friendly materials.

Evaluation of the economic impact of these strategies has shown that differentiation of housing is on average 15% higher in cost than the combination demolition – new building. The new strategy "flexible breakthrough" has the potential of being 15% lower in price than the strategy demoliton – new building.

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An outline of a program for sustainable development of construction in Poland

Jerzy Pogorzelski[1] (BRI Warsaw)

1. Introduction

The idea of sustainable development [1] is beautiful, rich in substance and noble. Full depiction of sustainable development encompasses the shake-up of human psyche with making people aware of environmental protection and needs of other people, revamping of society's outlook on life towards greater activity, increase of national gross product and general „leveling up" with elimination of poverty and social marginalization of whole groups and regions, development of transportation infrastructure, protection of natural environment and landscape, providing of affordable housing of good quality, improvement of technical condition of existing building stock, especially of housing sector, combined with reduction of energy use and emission of green house gases, revitalization of old valuable houses and town quarters, improvement of spatial order in existing and new housing taking into consideration needs of land saving, erection of new houses meeting the criteria of sustainable development and consistent with existing architecture.

So broad approach to sustainable development is accepted in intentions of UK according to the program announced in 2000 [2]. For Poland such a program would be certainly too ambitious of economic reasons and too difficult for coordination. Even during The Third Conference of UE Housing Ministers [3] not all mentioned problems were accepted for realization in all countries. On the other hand Polish intentions formulated by Ministry of Environment in „Action Plan" after Johannesburgh Summit [4] are certainly too limited and do not take into consideration the whole of problems connected with the technical infrastructure of the population, transportation, spatial order, erection of new buildings, exploitation and modernization of existing building stock.

To the Polish „Action Plan" resulting from Johannesburgh Summit should be added the Action Plan on sustainable development in the field of construction and existing building stock, parallel to already existing programs.

The outline of such program has been prepared by Ministry of Infrastructure in a paper of Minister Bryx [5] but it needs providing with some details.

[1] With participation of Marian Kawulok, Marek Niemas, Halina Prejzner and Lech Wysokinski.

As the crucial the following problems should be accepted, with the order of mentioned items not so much important:

- serious increase of affordable housing,
- prevention of decapitalization of existing building stock by refurbishment,
- wide revitalization of valuable town quarters,
- development of transportation infrastructure,
- landscape protection,
- improvement of architecture and spatial order connected with land economy,
- erection of new buildings in accordance with sustainable development rules put down into Building Regulations,
- adjustment of existing buildings, whenever possible, to the accordance with sustainable development rules.

Some of the problems mentioned above are already formulated in different action programs with different level of preparation, as for instance the drafts of Parliament Acts on refurbishment of existing building stock, revitalization of valuable town quarters and spatial order. The idea of affordable housing is already realized by Companies of Social Housing. The thermomodernization of buildings with the state support in form of state supported credits is realized within the frames of Thermomodernization Act of 1998, the scale of thermomodernization still too small.

The existing programs and the new one can run simultaneously, not disturbing each other. The problem of meeting the requirements of sustainable development by individual buildings can be separated from quantitative changes concerning the volume of erected new housing and qualitative changes concerning the architecture and order in physical planning.

In aspect of sustainable development we must accept the philosophy of consideration of buildings in their Life Cycle, depicting the erection, exploitation, deconstruction and disposal or recycling of waste material.

The biggest flows of mass, energy and costs in buildings Life Cycle are connected with energy management, covering both expenditure and gains due to decreased costs of exploitation. In new buildings expenditures for major decrease of energy use in comparison to old houses (about 50%) have SPBT up to 5 years. In existing buildings the SPBT of expenditures is a bit higher (usually up to 8 years). Decreasing of exploitation costs due to thermomodernization allows the saving up the means for refurbishment and modernization of buildings with respect to other Essential Requirements.

2. Program goals

The following goals should be foreseen in the program of sustainable construction:

- improvement of quality of buildings (especially dwelling and public utility houses) with respect to meeting the Essentials Requirements,
- implementation of methods of assessment of buildings for environmental performance according to ISO International Standard under preparation,
- support to thermomodernization of buildings and revitalization of town quarters,
- implementation of Energy Performance Directive,
- improvement of use the waste materials and recycling in construction.

It seems necessary to concentrate the activity on the problems connected with:

- preparation of legislation,
- research background,
- public education and preparation the professional specialists,
- pilot programs (e.g. low energy houses), first of all using the private funds.

The special attention should be given to:

- public education and waking the peoples awareness in the field of sustainable development,
- proper preparation of professional specialists by training and equipment with design tools.

The role of public education in the field of sustainable development is above all waking the peoples awareness to the topic of ecology, reducing the environmental loads, conservation of non-renewable energy resources. Such education is necessary also for specialists of different branches in order to counteract the retirement in the shell of the former specialty. Very good examples of good education models are already developed in UK.

Whereas with respect to sustainability we want consider the buildings in the whole Life Cycle (erection, exploitation, deconstruction and disposal or recycling of waste material), at the moment the training of civil engineers prepares them only too erection of buildings. Of the Essential Requirements they learn the requirement of Stablility.

It seems necessary:

- introduction to the syllabus of Faculties of Architecture and Construction the topics of Building Physics and Sustainable Development in such dimension as in German TU's,

- in future remodeling the syllabus to take into consideration the topics of Life Cycle and all Essential Requirements.

The detailed proposals of legal and education measures are presented in the table below.

Action plan of sustainable development of construction in Poland

The target and substancje of action	Means of realization				
	Legal means	Analytical and Research tasks	Education of specialists	Education of public	Pilot programs
Improvement of quality of buildings with respect to meeting the Essentials Requirements	Novelization of the Act on Building Law and Ordnances on: - Building Regulations, - Technical Requirements of Use, - form and scope of technical documentation, - scope and methods of obligatory control by technical acceptance.	Preparation of catalogues of robust building elements and details. Preparation of packets of PC programs for CAD of sustainable building. Preparation of requirements for ventilation of energy efficient buildings and methods of meeting them.	Preparation and application by TUs the program minima concerning Building Physics and Sustainable Construction Proper programs of teaching in technical colleges and professsional schools Handbooks, commentars to standards with examples of design and calculations Modification of teaching programs for faculties of Architecture and Construction with respect to Life Cycle.	Popularization brochures for investors, especially the indyvidual ones.	Competitions for designs and erection of buildings with respect to sustainability.

Improvement of use and economy of grounds for construction and settlements	Formulation in Acts and Ordnances concerning the Physical Planning the rules of geotechnics (evaluation of ground with respect to floods, landslides etc.).	Elaboration of rules of protection of ground surface (e.g. landfill sites). Elaboration of rules of land reclamation, design of insulation diaphragms, testing and control of soils planned for reclamation, system of excavated soil management for administration units (e.g. comunes).			
	Novelization of the Act on Geological and Mining Law with respect to responsability for buildings damages on mining areas.	Elaboration of rules of compensation the building damages and inconveniences depending upon their scope and extent.		Popularization brochures for occupants of buildings situated on mining areas.	

Implementation of rules of sustainable development to the construction		Implementation of standard "Sustain-ability in building constructions – Framework for methods of assess-ment for environ-menttal perform-ance of construction work: Part 1 buildings" by elaboration a Polish tekst with commentary Elaboration of criteria for contaminations emissions for building products (classes M1, M2, M3).			
Support to the refurbishment of old buildings and revitalization of towns quarters using the exploitation savings due to thermomodernization	Novelization of the Thermomodernization Act to include the re-furbishment and the re-vitalization.				

Implementation of Energy Performqnce Directive	Preparation of Ordnances on: - energy performance of buildings (implementation of EP Directive), - energy labeling of small AC devices (AC Directive), - thermal insulation products (IPPC Directive).	Elaboration of methods for calculation and tests of energy performance of new and existing buildings with necessary PC programs.	Training of the Corps of Experts. Post-graduated courses for designers.	Preparation of public oriented information and publicity.	Pilot programs for exemplary energy efficient houses.
Improvement of use of waste materials in construction and recycling	Preparation of proper statements in the Act Building Law and Ordnances	Preparation of appropriate instructions and guides.			

3. Financing of the program

Realization of every large scale (national) program requires the financial means and in the present situation of public finance it is hard to imagine it's major engagement in sustainability. As however even in critical situation of public finance the investments and refurbishments of private persons, companies and local and municipal governments must go on, there is only the need of proper orientation – through legal and education means – to consider the problems of sustainable development in construction and sustainable buildings.

Therefore, despite the present troubles with public finance it is necessary to prepare the legislation, public education and the corps of professionals for the nearest future that can bring change for the better.

Quite a lot of money can be extracted from the ECOFUND and Funds of Environment Protection after the change of approach.

At present the energy statistics of GUS and URE deals only with supply side of energy carriers, and on the demand side mentions only power plants and heat-generating, not taking into consideration the households and building heating.

From the point of view of sustainable development and considering buildings in life cycle, the "Construction" as a branch of national economy should depict not only the erection of buildings, buy also other phases of Life Cycle, especially the exploitation. The house owners should benefit from the reduction of the greenhouse gases due to thermomodernization and meeting the energy requirements.

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LECH WYSOKINSKI
MAREK SWIECA

THE ROLE OF GEOTECHNICS IN "SUSTAINED DEVELOPMENT" OF BUILDING INDUSTRY IN POLAND.

1. Introduction

Geotechnics is an interdisciplinary field of science and technique dealing with soil investigations and its behaviour as a consequence of construction action and is closely related with land, geological environmental and climate conditions. Geotechnics is concerned with soil and rocks investigation for designing, constructing and exploitation of objects, especially building: foundations design, construction of roads, airports, railway lines, dams, flood embankments, dumping sites and other facilities necessary for human existence.

From the point of construction engineering, geotechnics dealing so far with interactions between building and ground and physical and mechanical properties of soil, is now forced to deal with chemical contaminations which are usually cause the biggest problem. There are usually no signs that the ground is contaminated and it's very difficult to assess its impact on a man. Chemical contamination appeared in the twentieth century due to the industrial development.

The main commandment of any activity, either practical, technical or professional is "Think globally, act locally". This slogan and ecological education of society are the only chance for saving our future. New inventions will be approved only when they will solve problems without any negative results in the future. Now, the environment is included in evaluation of new technologies. Hence, there are strict restrictions for constructions designing with no possibility of transmition of any contamination beyond its own "niche"; - our house, site or object. Correct ecological thinking will lead to restrained size of "ecological niches". They will be restricted first to the city area, then to districts and finally to particular houses. It will probably cause coming back to natural materials and old, "primitive" methods of construction. The management will become more economic. Water and wastes separation as well as restrictive energy management and fresh air control will be common.

Poles live in a particular place on the Earth, determined by landscape, geological structure, soils fertility and climate. The heating period in Poland lasts 7 months while not far away to the south of Europe nobody even thinks about designing heating installations in buildings. Our place in the world is described by numerous physical parameters, such as precipitation per one square metre, snow depth cover, wind strength, freezing depth, average temperature fluctuations, seismic activity and types of soils and rocks. All these parameters determine some peculiar requirements of a place (a home) where we spend the most of our time and which is our environment.

Various conditions are required to locate a building. Some of them are connected with geotechnics. Currently the geotechnical information comprises a large package of data on the area surrounding the object, groundwater level, type of soil and its chemical contamination.

2. The scale of degradation in Poland – degraded areas.

In Poland there are 120 people per 1 square kilometre (In Silesia – over 300 people). In the world scale Poland is a relatively developed country but backward in comparison to developed European countries. Poland (territory 1/500 of Earth's continents) has got its own specific problems connected with agriculture and the level of industrialisation left after long period of communism. It seems that the main threat to Poland is not connected with our environmental problems, which we can easily handle with, but with global threats and the possibility of global catastrophe.

After 1989, social and economical transformations in Poland have caused changes and limitation of industrial production. Plants, which couldn't meet the requirements of environmental protection, were closed. For 15 years we have been observing some distinct trends: changes of environment, e.g. reduction of acid rains and reduction industrial wastes, but more municipal ones. Polish rivers and surface waters are much cleaner than before. But these social and political changes caused high level of unemployment (about 3 million people, what is about 18%). It is our social disaster, however with proper politics, it may mobilise people to get higher qualifications and will bring large number of well-educated workers in the nearest future.

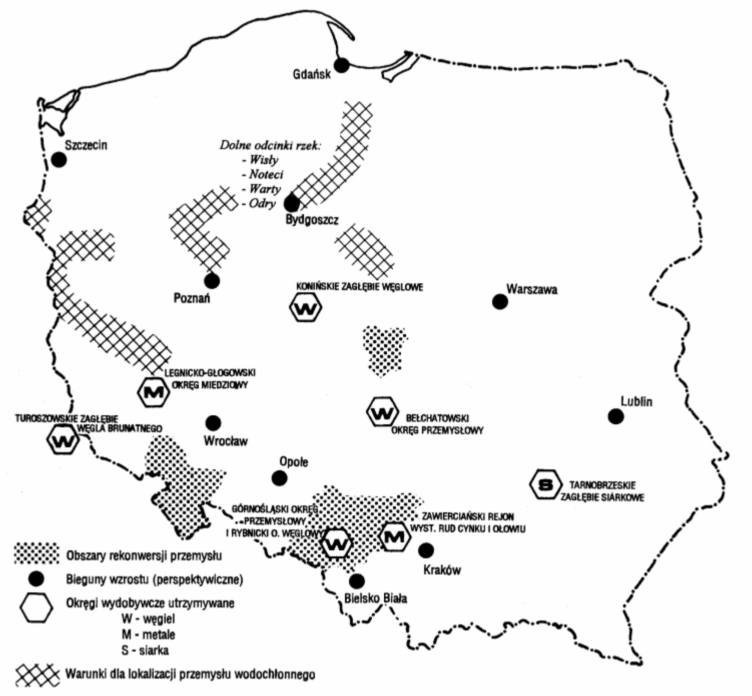

Fig. 1

Areas of industry reconversion

Pole of growth (long-term)

Maintained mining districts

W – carbon

M – Metals

S – Sulphur

Figure 1 Industrial problem areas [2]

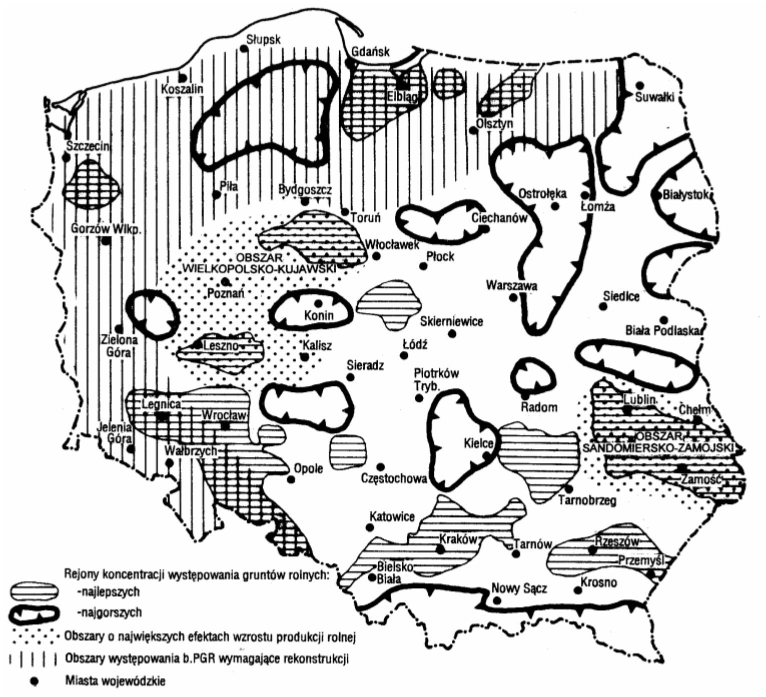

Fig. 2
Concentration regions of farmlands' occurrence:
- the best lands
- the worst lands

Lands with the highest increase in farm output .
Land occurrence of Former State Farms' (*PGRs'*) requiring reconstruction.

Figure 2 Agriculture problem areas [2]

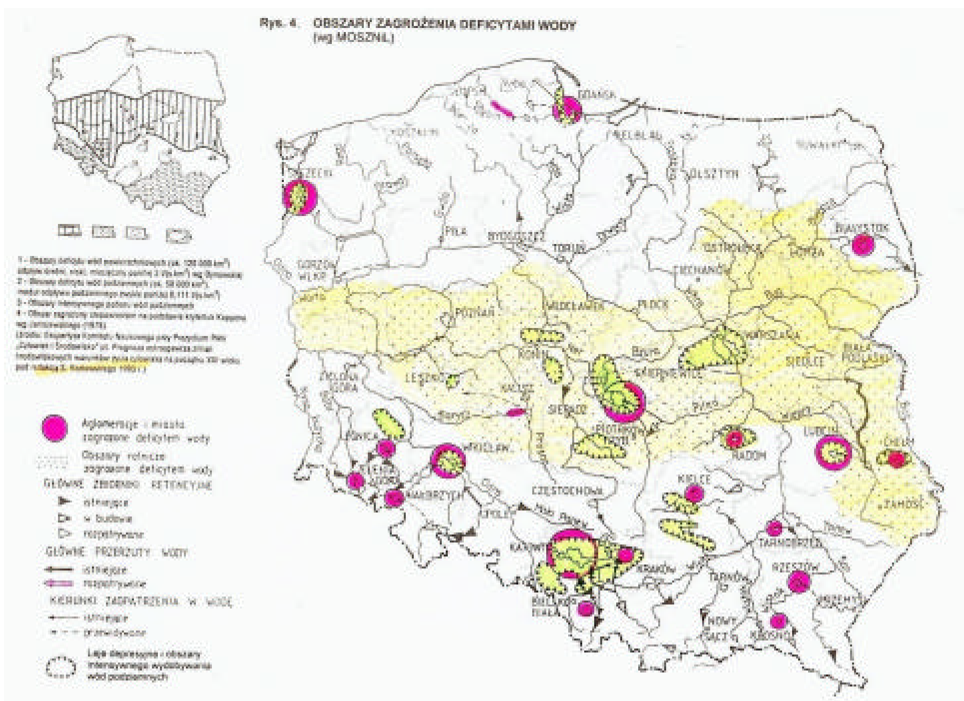

Fig. 3

- Agglomerations and towns with water shortage menace

Farmland regions with water shortage menace

MAIN STORAGE RESERVOIRS
> Existing
> Under construction
> Under consideration

MAIN TRANSFER OF WATER
Existing
Under consideration

DIRECTIONS OF WATER SUPPLY
Existing
Under consideration

Cones of depression and areas of intensive withdrawal of water

Maps (Fig. 1, 2 and 3) show some main problems of Poland that appeared after two World Wars and after 60 years of soviet domination. The major ecologic problem is the menace of water shortage presented in Figure 3. It includes both ground and surface water. The retention and purification of waters is a great challenge for Poland.

In the coming 20-30 years reclamation of the areas degraded by mining industry and other industrial activities will probably be managed. We'll also be able to return to the state before 200 years, when Silesia region was green. However degradation process in World-scale should be seen in a different way.

The difficulties in improvement of the state of environment should be foreseen in the forthcoming years. In China, Japan or Korea the need of development at any prise and the whole effort of the poor countries to meet basic social needs is so strong that the problems of environmental quality are still a background.

Colossal costs entail long-term projects aimed to pollution emissions reduction. Nowadays about 30% of outlays for pollution-control equipment of a new industrial object have to be foreseen. It takes sometimes a few years to remove a small-scale contamination, for example after the breakdown of a fuel tank truck. However, Polish problems despite their large scale (Silesia) are incomparably smaller than Czarnobyl or a chemical contamination of soils in Western Europe.

In Poland, farmlands occupy the area of ca. 18 million hectares and this number is systematically getting smaller (by about 2 million hectares during 40 years). Arable lands occupy 45%, orchards – 1%, meadows and grass lands – 13%, forests – 29% and others, including urban areas – 12%.

In 1990 the degraded and devastated lands were estimated on 93 thousand hectares. Now, as the annual rate of reclamation is about 2,5 thousand hectares, the area of degradation is smaller of about 70 thousands hectares, hence scarcely ca. $^{70}/_{18\,000,}$ so it is less than 0,5% of total Polish croplands area. Similar value is presented by the Building Research Institute in 1990 in his balance of weak and degraded areas. According to these results, only 3-3,5% of urban areas in Poland are polluted, but in a small level. The serious threat for Polish agriculture is high acidity of soils. Over 25% of soils is determined as very acidic and 40% as acidic. Investigations show that ca. 97% of croplands are free from increased values of heavy metals, what makes high quality crop production possible.

Ecological food is now getting more and more popular in the world, especially when grown on small farms, where only natural methods of cultivation are used. Poland has really good conditions for such cultivation. It is because of low degree of urbanization and clean soils. Such clean places as *Mazury*, *Bieszczady* Mountains, *Bialowieza* or *Biebrza* swamps are really unique in Europe. The Vistula River is the last non regulated big river in Europe.

Geotechnics changes indirectly the properties of the subsoil and leads to formation of new soils (e.g. mixing with cement or loam grouts), but some issues related to earth bodies lie beyond direct geotechnical action (possibility of control), for example: exploitation of geological resources, agriculture, natural geological processes such as erosion, mass-movements, earthquakes, etc., which can be eliminated, although we have no influence on their occurence.

Principal factors that cause surface transformations of geological formations and relief are:

- exploitation of mineral resources
- waste disposal
- industrial, housing and road construction
- hydro-engineering, river regulation and land improvement
- surface water erosion, gully erosion, river erosion, abrasion and wind erosion
- mass-movements, landslides, flows, avalanches and screes
- floods.

Deep and opencast mining has strongly deformed land surface and has devastated soils and plant cover of the exploitation area.

Fig. 4 Open pit of lignite mine Belchatów. Length of lignite deposit-30 km, width 1,6 km. Depth of the pit 300 m. Power plant gives 25 % of polish requirements for electrical energy.

Waste disposal does not deform geological structure as much as mining, but it covers large areas with ground masses mostly with physical properties different than oryginal grounds. Thereby it changes strongly the geological structure, physical, chemical and biological properties of ground's surface. Waste dumps have negative impact on adjacent soils and ground waters.

In urban areas and industrial regions mechanical and chemical deformation of geological formation are tremendous. Housing, industrial, road and hydro-engineering as well as underground installations substantially change the properties of surface soil layers. The most transformed areas are built-up ones, permanently devoided of any biological activity. Some areas, covered with embankments and waste dumps are not able to recover their environmental values spontaneously so land reclamation is required.

3. Activity of the Building Research Institute

In the early 90's the Building Research Institute elaborated a balance of weak and degraded areas for 300 of chosen towns in Poland. It demonstrates large regional differences between specific towns. Urban degraded areas occupy only ca. 2-4% of Polish towns. The higher values are only for some regions of Silesia (Table 1). Heavy degraded areas make up only a fraction of percent of towns territory.

Table 1 Balance of week and degraded terrains for selected towns - exemplary list from the Atlas of 300 Polish towns [10]

Town	Area km^2	Areas of adverse geotechnical conditions		Degraded terrains	Waterlogged areas	Groundwaters	Gradients	Borrow pits, waste disposals
		Peat, water, other	Made-grounds	Industrial grounds Polish State Railways	ground-water table < 1 m		> 15%	
Mragowo	12.250	11,14*	1,13*	1,67*	6,92*	22,07*	5,73*	0,51*
Białystok		8.22	0.41	9,41	7,5	-	0,63	
Bydgoszcz	174.00	7.50	3.58	8.34	11.3	3.53	1.24	7,4
Gdańsk	241.63	27.61	3.15	0,45	24,3	3.38	11,18	2,1
Gdynia	125.79	7.69	4.53	2,07	2,94	0,04	28,12	1,7
Kielce	109.72	8.02	5.87	0,73	6.41	0,34	16,3	
Wieliczka	13.37	17.50	4.82	46,9+0,34	0.97	0,52	1,68	0,24
Lublin	119.69	13.85	0.85	2.2	0.51	2,62	1,7	
Łódź	219.85	5.88	5.01	7.24	5,17	0.23	0,12	0.2
Olsztyn	72.69	15.96	1.92	2,04	0,97	10,10	6.20	0.25
Opole	101.04	33.27	2.97	11.86+1,2	13.9	3.23		0,94
Poznań	219.60	15.79	9.87	4,42	3,97	2,07	-	-
Rzeszów	53.06	5.41	4.01	1,42	3,11	2,97	0,97	
Szczecin	286.77	25.20	2.26	1,33	20.69	23,50	2.31	0,04
Warszawa	485,25	11.72	6.63	5,26	4.96	2.89	0,03	0,21
Wrocław	288.35	19.56	2.07	2.13	16,7	2.50		
Zielona Góra	55.89	6.94	4.38	0,45÷3,76	4,42	0.19	5,75	
Elblag	31.98	39.87	10.18	5.27	24,19	0.07	8.86	

* Values given in table in percent of town area.

According to the balance degradation of environment occurs mainly in regions with many troublesome industrial plants localized. The areas of very high and high-degradation degree covers ca. 0,5% of urban areas, while 2,2% for medium- and small. Similar values were estimated in independent research for woodlands. Regions with high degree of destruction cover 3,4 % of forest areas. According to these results it can be estimated that degradation of the natural environment in Poland makes-up only 3 % of Polish territory.

Around already degraded terrains, exist many areas threatened by degradation. These are larger than degraded areas and cover ca. 12,7% of Poland's territory. The highest percentage of degraded areas exist in the provinces: *Górny Slask*, *Dolny Slask* and *Malopolska*.

Projects on environmental protection and reclamation of post-mining and post-industrial areas have been made in the last few years.

Only 50% of degraded lands have been included in recultivation works so far, what indicates major needs in this scope. This estimation does not include the necessity of reclamation of post-mining areas and liquidated factories.

Every case of land recultivation must be considered individually and requires its own project. The managing system taken over from the European Union is sufficient for medium conditions and objects but does not provide a good solution to every, especially major, regional problem.

Such a project should be always preceded by long lasting and expensive investigations and requires cooperation of many specialists in various disciplines of science. Liquidation of the threat by heavy metals in the Upper Silesia (*Górny Slask*) may be a good example.

With the participation of Building Research Institute the problem of liquidation of chemical plant *"Tarnowskie Góry"* has been elaborating (Fig. 5). It is one of the most difficult problems in Poland or even in Europe. As this area had been used as a waste site for 100 years, the chemical degradation is very high. The area of 68 ha is to be recultivated at the cost of 2-3 mln $/ha.

Phosphor-gypsum chemical plant in *Police* near *Szczecin* (Fig. 6) may be another example of degradation. This figure depicts a 40 m high dumping site of phosphor-gypsum.

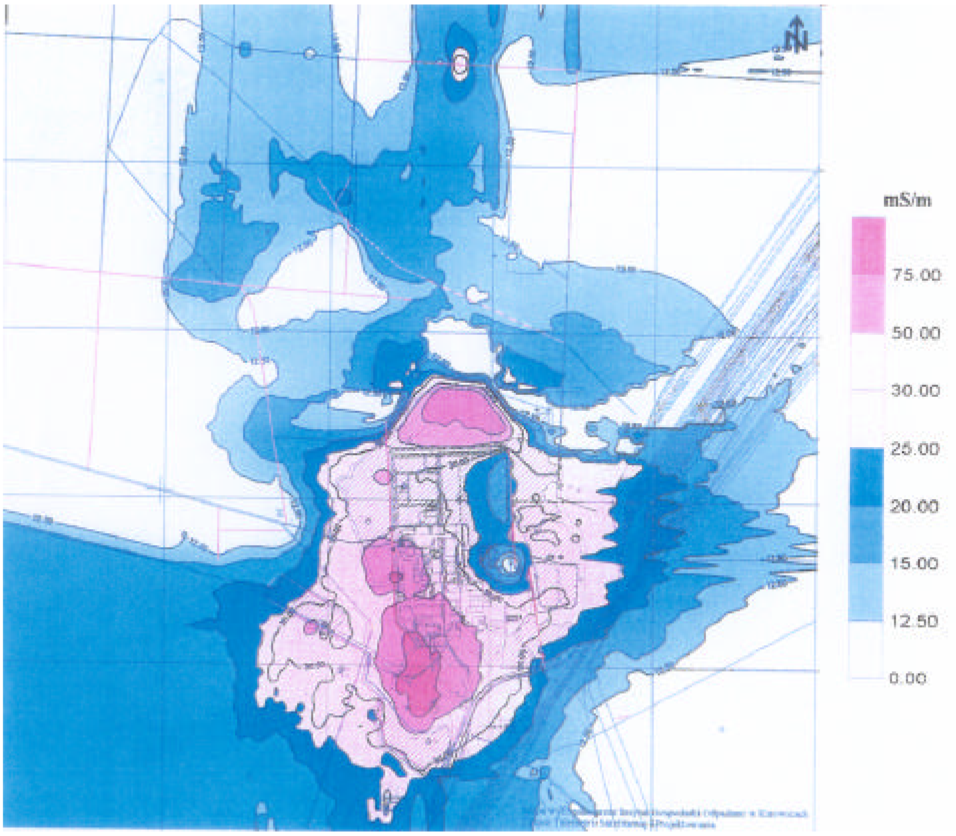

Fig 5 Spreading out of the water pollutions from chemical plant "Tarnowskie Góry.

According to electromagnet measurements (20HD) from 1998 year."

Fig. 6. Damping site of phosphor-gypsum Police near Szczecin 40 m high. Deposit ed -3 mln cubic meters of chemicals.

One of the main methods of geotechnical reclamation is sealing of ground. surface. This is to:

- stop infiltration of precipitation waters into subsurface
- maximize the transfer of clean precipitation waters beyond the devastated area.

Sealing the surface during the reclamation may be multilayer, made of natural or synthetic materials. The thickness of a such sealing (including reclamation and drainage layer) ranges between 2-2,5 m and requires accurate application of work procedures.

Ecological catastrophes are often connected with events such as typhoons, floods, etc. The flood of Odra river basin in 1997, which had also an impact on German lands, is a good example of ecological threats (Fig. 7) [4].

Fig.7 Waste fills near Wroclaw during the flood in 1997

Fig. 8 Post-operational land reclamation of chemical plant in *Tarnowskie Góry*. (recultivated ground surface ca. 70 ha, 4 landfills ca. 2 millions m^3 of waste).

Summing up all given examples it needs to take into account the scale of degradation which can be described as:

- point (object) degradation
- area degradation
- regional degradation
- global degradation.

The point (object) area of degradation is caused by one or a few industrial plants being a concentrated source of environmental pollution, for instance: chemical plants, metallurgical industry works and power engineering plant, as well as large industrial, chemical, power, metallurgical and mining waste deposits and dumping sites of municipal wastes.

The area of degradation is formed by more than one source of pollutants, for example: large industrial objects, urban structures and communication junctions. In the spatial structure of such areas, objects and zones of specific contamination or deformation of groundwater conditions may be distinctly evident. Multi-factoral degradation forms an area which requires an integrated system of damage estimation, ecological preventive treatment and reclamation.

***Regiona*l** degradation produces towns with environmentally hazardous industry. Coexistence of various degradation factors impedes, or even make impossible determining object areas of degradation. It is much easier to distinguish overall degraded areas, especially if main onerous objects are the industrial complexes or industrial-storage districts.

Global degradation refers to the degradation of the overall area of our globe.

4. Summary

Introduction of sustainable development criteria requires proper recognition of environmental threats, valorisation of the environmental (natural, cultural, economic and social) and creating an appropriate model of country and region development. National strategies for Poland and its regions, compiled up to now, should be criticised for its vague character – they hardly ever include building industry.

Criteria of ecological estimation for materials and construction technologies shall be worked out. BAT techniques are to be introduced as well as a system of ecological estimation implemented. Not only estimations by appointed experts but also results of regional research should be considered. Evaluations should be ordered from Universities and Institutes and not only from recognized individuals within tendering frames, where the price rules. A proper diagnosis pays a key role in finding solution in hazardous circumstances. The tendering system, where no experience and authority of contractors is taken into account, brings about wrong designing decisions and enables dishonest dealings of investors.

Pro-ecological activities, continued since the beginning of 90's, have already improved the natural environment condition. A significant restriction of industrial production, waste-free production, modern "clean" technologies, which had come to Poland after 1990, are the real progress in environment protection.

Rebuilding of urban and rural areas will undoubtedly improve the condition of our environment as well as building of transportation systems and water treatment plants. This confirms that geotechnics plays a significant role in eliminating threats to the environment.

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