SUSTAINABLE REHABILITATION OF BUILDINGS

A STATE-OF-THE-ART

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CONTENTS

PREFACE

This is the first report produced in the SURE-BUILD project, a research co-operation between Norway and Poland for sustainable re-development of buildings in Poland. The project is one result of contact efforts between major technical universities in the two countries, Warsaw University of Technology (TUW) and Norwegian University of Science and Technology (NTNU) during the period 2000-2002.

The project work is shared among academic personnel from different units within the two universities. In Trondheim, NTNU is assisted by the research institution SINTEF.

The project is financed by a grant from an R&D programme established by the Norwegian Ministry of Foreign Affairs in order to further co-operation with the new EU candidate countries. Support has also been provided by the two universities. Project leadership rests with NTNU.

The major contributors to this State-of-Art report have been Alexander Panek and Jerzy Sowa, with assistance on Polish conditions by the other two Polish participants, Piotr Pracki and Dagny Rynska. Arne Nesje has contributed on international and Norwegian matters in chapters 3 and 5, Øyvind Aschehoug in chapter 2, while Inger Andresen has been responsible for chapter 6, with assistance from most of the participants. Inger Andresen, Barbara Matusiak, and Øyvind Aschehoug have been responsible for the final editing and proofreading.

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 fora 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.

SURE-BUILD – Sustainable Redevelopment of Buildings in Poland – is a multidisciplinary research project based on close co-operation between the Technological University of Warsaw (TUW), and the Norwegian University of Science and Technology (NTNU) in Trondheim. The Foundation for Industrial and Technical Research (SINTEF) participates as a subcontractor on the Norwegian side.

At TUW, the Faculties of Environmental Engineering, Architecture and Electrical Engineering participate in the project, at NTNU the Faculty of Architecture and Fine Art, which is also responsible for the overall project management. The SINTEF division Architecture and Building Technology in the Department for Construction and Environmental Engineering is also engaged in the project.

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.

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. This will be achieved through development of new solutions or "user packages" that will satisfy the whole range of end-user needs such as comfort, aesthetics, costs, operability, reliability, and functionality.
- Contribution to the EU goal of at least 18% energy savings and at least 10% reduction of CO_2-emissions by 2010. This will be achieved by the introduction of new, integrated energy saving strategies in Poland, including on-site production and use of renewable energy in buildings.
- 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.

This State-of-the-Art report summarizes the development for sustainability in the construction sector, internationally and in the two collaborating countries, Poland and Norway. An overview of the building stock in Poland is presented, together with a menu of potential redevelopment technologies. The choice of project case study building category is discussed, and the report concludes with the selection of school buildings as case study.

2. SUSTAINABLE DEVELOPMENT

2.1 Sustainability indicators

The natural tendency of human beings is to make assessments in relation to their own experience. The subject of assessment could be a performance of human development itself or the human product. For this sake the number of typologies of categories and methods of assessment have been developed which describe the features of interest.

Depending on the analyzed phenomena, the subject of assessment could be the quality of a mathematical model, the performance of specific product as e.g. the building, and finally the performance of the economy as it is done by different framework of statistics. The economics are usually following the declared paradigm among them sustainable development is recently the most important. Sustainability itself defines the long range of general principles. General principles are translated into indicators, and the indicators should address all the aspects of the principles. The assessment and evaluation of systems using indicators should choose the set of indicators which are most significant, and which are accompanied by the proven methods of determination its value.

Indicators are supposed to be simple figures or other signs, with help of which the information on a complicated phenomenon like environmental pressure is simplified in a more easily understandable format. This is how the information is easier to explain also for those who are not experts or who need the information quickly.

Indicator could be understood as a quantitative model and a form of information that makes a certain phenomenon perceptible that is not immediately detectable. Indicators therefore provide a simpler and more readily understood form of information than complex statistics or complex phenomena. The three main functions of indicators are:

1) Quantification
2) Simplification
3) Communication.

Indicators also help to follow the change of phenomena with time, and the development of phenomena in relation to the stated objects. One of the important functions of an indicator with reference to decision-making is its potential to show the trend, i.e. the course of development, in an early stage. In order to work with indicators one needs data, which comes from a monitoring process. Indicators should be objective and the results should be repeatable. In many cases indicators should also be internationally comparable, *although they are mainly used nationally* The main risk with regard to indicators concerns excessive simplifying and loosing importance.

According to OECD terminology an indicator is a parameter, or a value derived from parameters, which points to, provides information about, and describes the state of a phenomenon / environment / area, with a significance extending beyond that directly associated with a parameter value; a parameter being a property that is measured or observed. An index is defined as a set of aggregated or weighted parameters or indicators.

2.2 UNCSD list of indicators

The United Nation Commission of Sustainable Development (CSD) has established a a working list of general indicators of sustainable development. This should be seen as a flexible list from which countries can choose indicators according to national priorities, problems and targets. The indicators are presented in a Driving Force - State - Response framework. "Driving Force" indicators indicate human activities, processes and patterns that impact on sustainable development. "State" indicators indicate the "state" of sustainable development and "Response" indicators indicate policy options and other responses to changes in the "state" of sustainable development. The social, economic, environmental and institutional aspects of sustainable development are covered by this list of indicators following the chapters of Agenda 21 [Annex 1, UNCSD list of indicators of Sustainable Development, www.un.org/esa/sustdev/natlinfo/indicators/worklist.html]

2.3 OECD Indicators

The OECD in the publication Towards Sustainable Development provides a list of environmental criteria for selection of relevant indicators.

The criteria for selecting environmental indicators have been referred that the indicators should reflect policy relevance, among others:

- provide a representative picture of building's environmental conditions
- be simple, easy to use and interpret, and be able to show trends over time
- be responsive to changes in the environment and related human activities
- provide a basis for national and international comparisons
- have a threshold or reference value against which to compare it, so that users can assess the significance of the values associated with it (benchmarking)

Also, they should characterize the analytical soundness:

- be theoretically well founded in technical and scientific terms
- be based on international standards and international consensus about its validity and measurability:
- be readily available or made available at a reasonable cost/benefit ratio
- be adequately documented and of known quality
- be updated at regular intervals in accordance will reliable procedures

The OECD set of environmental indicators

1. Climate change	8. Cultural landscape
2. Ozone layer depletion	9. Waste
3. Eutrophication	10. Water resources
4. Acidification	11. Forest resources
5. Toxic contamination	12. Fish resources
6. Urban environmental quality	13. Soil degradation
7. Biodiversity	14. Socio-economic, sectors' and background indicators

The indicators listed above are supplemented by a set of socio-economic OECD indicators.

2.4 Sustainability Indicators at EEA

The European Environment Agency EEA uses the DPSIR framework (Driving forces, Pressure, State, Impact, and Response) in its reporting activities. The report 'Environmental indicators: Typology and overview' can be downloaded from the CRISP website and from the web-site http://themes.eea.eu.int/toc.php/improvement/reporting .

According to DPSIR framework social and economic Driving forces exert Pressure on the environment and, as a consequence, the State of the environment changes, such as the provision of adequate conditions for health, resources availability and bio-diversity. This leads to Impacts on human health, ecosystems and materials. On the other hand, this may elicit a societal Response that feeds back on the Driving forces or on the State or Impacts directly, through adaptation or curative action. In addition to elements, it is useful to look at the links between the elements. For example, the relationship between the Driving force and Pressure is the eco-efficiency of technology, with less pressure coming from driving force if eco-efficiency is improving. Similarly, the relationship between the Impacts on humans and eco-systems and the State depends on the carrying capacities and thresholds for these systems. Whether society responds to impacts depends on how these impacts are perceived and evaluated; and the results of response on the driving forces depend on the effectiveness of the response.

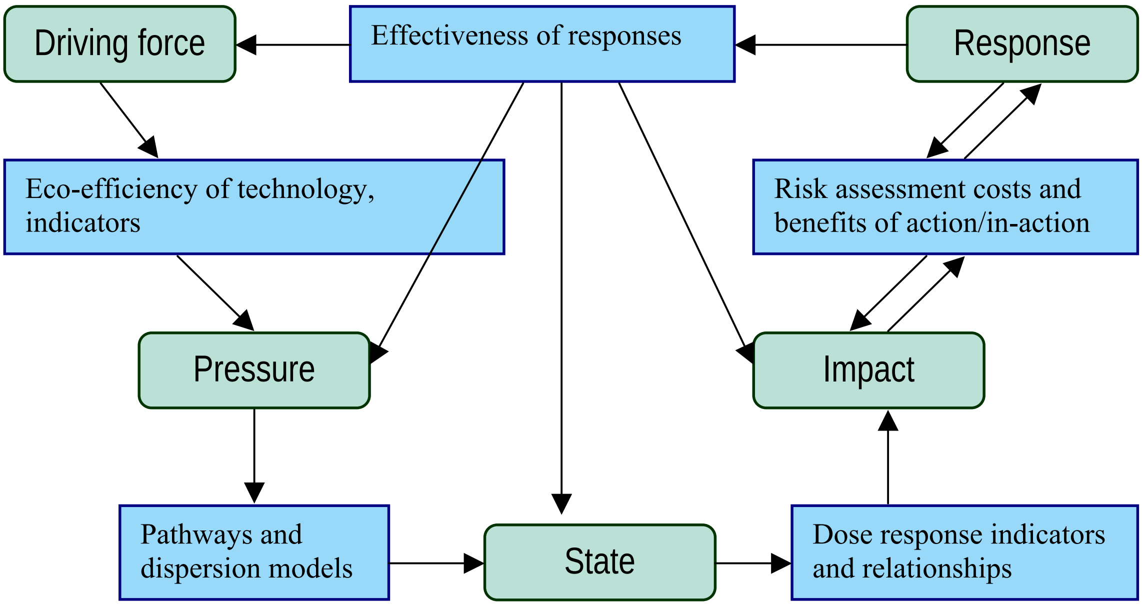
According to the EEA report indicators can be classified into four groups (*EEA Typology of indicators)*:

A. Descriptive indicators or Type A indicators (What is happening to the environment and to humans?)

B. Performance indicators or Type B indicators (Does it matter?)

C. Efficiency indicators or Type C indicators (Are we improving?)

D. Total welfare indicators or Type D indicators (Are we on the whole better?)



Indicators and information linking DPSIR elements CRISP State of the Art Report

Descriptive indicators (Type A)
Most sets of indicators presently used by nations and international bodies are based on the **DPSIR-framework** or a subset of it. **Driving force indicators** describe social, demographic and economic development in societies and the corresponding changes in life styles, levels of consumption and production patterns. Primary driving forces are population growth and changes in the needs and activities of individuals. These provoke changes in production and consumption levels, and this is how driving forces exert pressure on the environment. **Pressure indicators** describe developments in the release of emissions, use of resources and land. **State indicators** describe the quantitatively and qualitatively physical phenomena (like temperature or level of noise in certain area), biological phenomena (like wildlife resources present) and chemical phenomena (such as concentrations of harmful substances). **Impact indicators** describe impacts caused by the changed state of the environment, for example impacts with regard to bio-diversity, available resources and provision of adequate conditions for health. **Response indicators** describe responses by groups in society as well as governmental attempts to prevent, compensate or adapt to changes.
Performance indicators (Type B)
Performance indicators compare actual conditions with a specific set of reference conditions. They measure the distance between the current situation and the described situation (target).
Efficiency indicators (Type C)
Efficiency indicators relate pressures to human activities. These indicators provide insight in the efficiency of products and processes in terms of resources used, emissions released and waste generated per unit of product.
Total welfare indicators (Type D)
Total welfare indicators would aim at describing the total sustainability. Some measure of total sustainability like Index of Sustainable Economic Welfare would be needed.

2.5 UNDP - HDI Human Development Index

The United Nation Development Programme has published *Human Development Reports (http://hdr/undp.org/)*, since the first in 1990, estimating the human development index (HDI) as a composite measure of human development. Since then three supplementary indices have been developed: the human poverty index (HPI), gender-related development index (GDI) and gender empowerment measure (GEM). The concept of human development, however, is much broader than the HDI and these supplementary indices. It is impossible to come up with a comprehensive measure—or even a comprehensive set of indicators—because many vital dimensions of human development, such as participation in the life of the community, are not readily quantified. While simple composite measures can draw attention to the issues quite effectively, these indices are no substitute for full treatment of the rich concerns of the human development perspective.

The HDI measures the overall achievements in a country in three basic dimensions of human development —longevity, knowledge and a decent standard of living. It is measured by life expectancy, educational attainment (adult literacy and combined primary, secondary and tertiary enrolment) and adjusted income per capita in purchasing power parity (PPP) US dollars. The HDI is a summary, not a comprehensive measure of human development. As a result of refinements in the HDI methodology over time and changes in data series, the HDI should not be compared across editions of the Human Development Report. The search for further methodological and data refinements to the HDI continues.

The general formula for HDI is as follows:

$$HDI_j = \frac{1}{2}\sum_{i}^{3} Hij$$

$$H_{ij} = \frac{X_{ij} - \min_k\{X_{ik}\}}{\max_k\{X_{ik}\} - \min_k\{X_{ik}\}}$$

where:

j – denotes the specific country

i – denotes the parameter (longevity, knowledge or a decent standard of living),

k – denotes the boundary values of parameters.

The boundary values have been defined as:

longevity 25-85 years on average, but 22,5-82,5 for men, and 27,5 – 87,5 women;

knowledge regardless to gender 0-100%;

literacy 0-100%;

GDP gross (PPP) 100 – 40000 USD

The last methodological change introduced to HDI comprises a new formula of GDP standardization by using its logarithmic values. This amendment allows a wider dispersion among the high ranked countries. The values of HDI are from interval 0-1, where 0-0,5 underdeveloped country, 0,5 – 0,8 country mid developed, 0,8 – 1 developed country.

The UNDP provides an extensive data base beside the HDI of other indices and parameters which is available through the internet. One can find there different correlations with other indices and parameters. The figure below presents the plot of HDI values vs. consumption of tons of oil equivalent per capita for the developed countries.

Poland has been ranked 37th among 173 countries in 2002, Norway get the first rank with HDI = 0,942. The table 2.1 shows 35th rank for Poland, this is because the list of countries has been decreased by two because of the availability of oil consumption data.

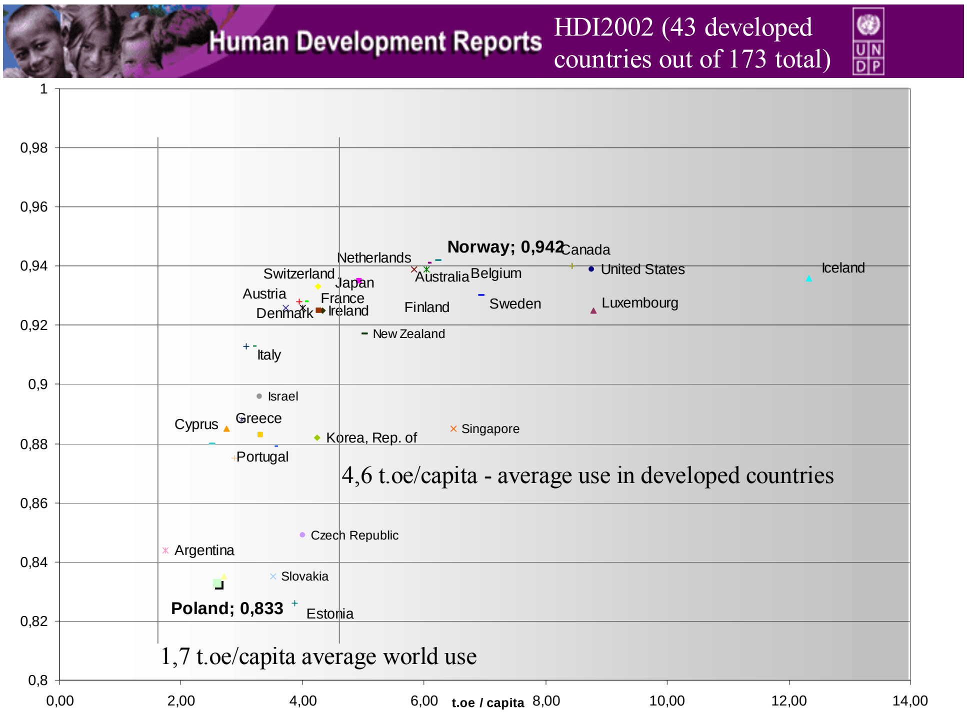


Figure.2.1 HDI for developed countries vs. t. oe. per capita

Table 2.1.HDI rank for developed countries in 2002

HDI-2002	**Country**	**HDI-2002**	**Country**	**HDI-2002**	**Country**
1	**Norway**	16	Germany	31	Czech Republic
2	Sweden	17	Ireland	32	Argentina
3	Canada	18	Luxembourg	33	Hungary
4	Australia	19	New Zealand	34	Slovakia
5	Belgium	20	Italy	**35**	**Poland**
6	United States	21	Spain	36	Bahrain
7	Iceland	22	Israel	37	Chile
8	Netherlands	23	Hong Kong, China (SAR)	38	Uruguay
9	Japan	24	Greece	39	Estonia
10	Finland	25	Singapore	40	Costa Rica
11	France	26	Cyprus	41	Kuwait
12	Switzerland	27	Korea, Rep. of	42	Croatia
13	United Kingdom	28	Portugal	43	Lithuania
14	Austria	29	Slovenia	44	Trinidad and Tobago
15	Denmark	30	Malta		

2.6 Environmental Sustainability Index

The Environmental Sustainability Index (ESI) is the result of collaboration among the World Economic Forum's Global Leaders for Tomorrow (GLT) Environment Task Force, the Yale Center for Environmental Law and Policy (YCELP), and the Columbia University Center for International Earth Science Information Network (CIESIN) www.ciesin.columbia.edu.

The Environmental Sustainability Index (ESI) measures overall progress toward environmental sustainability for 142 countries. Environmental sustainability is measured through 20 "indicators," each of which combines two to eight variables, for a total of 68 underlying data sets. The ESI tracks relative success for each country in five core components.

Table 2.2. Components of environmental sustainability Component

Environmental Systems	A country is environmentally sustainable to the extent that its vital environmental systems are maintained at healthy levels, and to the extent to which levels are improving rather than deteriorating.
Reducing Environmental Stresses	A country is environmentally sustainable if the levels of anthropogenic stress are low enough to engender no demonstrable harm to its environmental systems.
Reducing Human Vulnerability	A country is environmentally sustainable to the extent that people and social systems are not vulnerable (in the way of basic needs such as health and nutrition) to environmental disturbances; becoming less vulnerable is a sign that a society is on a track to greater sustainability.
Social and Institutional Capacity	A country is environmentally sustainable to the extent that it has in place institutions and underlying social patterns of skills, attitudes, and networks that foster effective responses to environmental challenges.
Global Stewardship	A country is environmentally sustainable if it cooperates with other countries to manage common environmental problems, and if it reduces negative transboundary environmental impacts on other countries to levels that cause no serious harm.

The indicators and the variables on which they are constructed were chosen through an extensive review of the environmental literature, assessment of available data, and broad-based consultation and analysis. The five highest ranking countries are Finland, Norway, Sweden, Canada, and Switzerland. The five lowest countries are Haiti, Iraq, North Korea, Kuwait, and the United Arab Emirates. The higher a country's ESI score, the better positioned it is to maintain favourable environmental conditions into the future. No country is above average in each of the 20 indicators, nor is any country below average in all 20. Every country has room for improvement, and no country can be said to be on a sustainable environmental path. The ESI permits cross-national comparisons of environmental sustainability in a systematic and quantitative fashion. It assists the move toward a more analytically rigorous and data driven approach to environmental decision making. In particular, the ESI enables:

- identification of issues where national performance is above or below expectations
- priority-setting among policy areas within countries and regions
- tracking of environmental trends
- quantitative assessment of the success of policies and programs
- investigation into interactions between environmental and economic performance, and into the factors that influence environmental sustainability

Although the ESI is broadly correlated with per-capita income, the level of development does not alone determine environmental circumstances. For some indicators there is a strong negative relationship with per-capita income. Moreover, within income brackets, country results vary widely. Environmental sustainability is therefore not a phenomenon that will emerge on its own from the economic development process, but rather requires focused attention on the part of governments, the private sector, communities and individual citizens. The ESI combines measures of current conditions, pressures on those conditions, human impacts, and social responses because these factors collectively constitute the most effective metrics for gauging the prospects for long-term environmental sustainability, which is a function of underlying resource endowments, past practices, current environmental results, and capacity to cope with future challenges. Because the concept of sustainability is fundamentally centred on trends into the future, the ESI explicitly goes beyond simple measures of current performance. The ESI has been developed through an open and interactive process, drawing on statistical, environmental, and analytical expertise from around the world. The ESI has been subjected to extensive peer review and the methodology has been refined in response to a number of critiques. The ESI integrates a large amount of information on a number of different dimensions of sustainability. Because individuals may weigh these dimensions differently in judging overall performance, this report provides detailed information on the ESI's methodology and its data sources. This transparency is meant to facilitate understanding of the ESI and exploration of alternative analyses, and debate over how best to promote environmental sustainability. The ESI demonstrates that it is possible to derive quantitative measures of environmental sustainability that are comparable across a large number of countries. Comparative analysis supports efforts to identify critical environmental trends, track the success (or failure) of policy interventions, benchmark performance, and identify "best practices." The effort to construct a comprehensive index covering the full spectrum of pollution control and natural resource management issues spanning a large number of countries reveals the impoverished state of environmental metrics and data across much of the world. It also reinforces the conclusion that significant data gaps hamper good environmental analysis in every country.

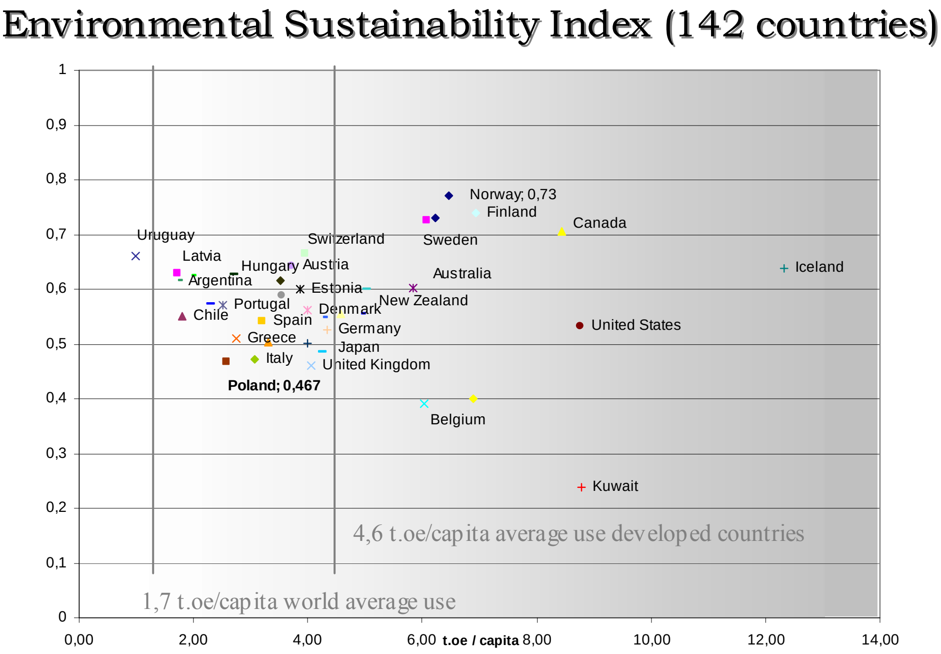


Figure 2.2 HDI for developed countries vs. t.oe. per capita

Table 2.2. Environmental Sustainability Index 2002 (ESI) for developed countries

ESI-2002	COUNTRY	ESI-2002	COUNTRY	ESI-2002	COUNTRY
1	Norway	16	Germany	31	Uruguay
2	Sweden	17	Ireland	32	Estonia
3	Canada	18	New Zealand	33	Costa Rica
4	Belgium	19	Italy	34	Kuwait
5	Australia	20	Spain	35	Croatia
6	United States	21	Israel	36	Lithuania
7	Iceland	22	Greece	37	Trinidad and Tobago
8	Netherlands	23	Portugal		
9	Japan	24	Slovenia		
10	Finland	25	Czech Republic		
11	Switzerland	26	Argentina		
12	France	27	Hungary		
13	United Kingdom	28	Slovakia		
14	Denmark	29	Poland		
15	Austria	30	Chile		

The detailed results of ESI components for Norway and Poland is presented in Appendix 2.

2.7 Sustainable Development in Norway

There is a general consensus among the common public and in the political systems that environmental problems have high priority, although on could often wonder if this is more a moral attitude than effective actions. This general attitude crosses party-lines, even though the actual political measures enforced, and their intensity, may differ by change of government. Public policy by the Norwegian governments are published as “Reports to the Storting (the Parliament)”, “Stortingsmeldinger”, also called “White papers”. The following is based on recent reports from the Ministry of the Environment and the Ministry of Petroleum and Energy.

2.7.1 Policy on sustainable development (Report No. 58)

Sustainable development is defined as development that meets the needs of today's generations without compromising the opportunities for future generations to meet their needs. Man's needs can broadly be split into basic needs, that must be satisfied to ensure survival at a certain minimum level, and socio-cultural (secondary) needs that can be developed in many directions.

Faced with the risk of serious and irreversible damage to the ecological resources, the Government will follow two key principles in establishing its environmental goals:

- We must not exceed the levels of critical loads on ecosystems (nature's carrying capacity). The goals thus must be set so that ecologically damaging discharges or impacts do not exceed the levels where strain on the environment means damage to sensitive parts of ecosystems.
- We have to act in a precautionary way. The interrelationships of the natural environment and the economy are so complex that in practice we cannot have full knowledge of all effects. For instance very extensive knowledge is needed to determine what levels represent a critical strain on an ecosystem. The precautionary principle means that if there is a risk of serious or irreversible damage then lack of full scientific evidence cannot be wielded as an argument to justify an encroachment on nature or defer an environmental policy measure. Potential harmful effects must be given due consideration when setting goals.

2.7.2 Policy on energy use (Report No. 29)

One important element of the energy framework is that Norway is above all an electricity producer and consumer. Energy use is closely related to economic growth. Norway has a large energy-intensive manufacturing sector. Electricity consumption has grown rapidly in recent years. The energy supply infrastructure consists almost entirely of the electricity transmission grid. Hydropower accounts for practically all electricity production, which means that Norwegian electricity production does not result in emissions to air. Hydropower is an important part of the national wealth. However, the strong emphasis on hydropower means that Norwegian energy production is vulnerable to variations in precipitation.

During the 1990s, there were a number of changes in the basic framework for Norway's energy policy. A headline for current energy policy is that environmental objectives will determine the limits of energy production, and that active steps must be taken to limit energy use. There are two main driving forces behind this development: The increased awareness on climate issues, made more specific by the Kyoto Protocol, and the political decision to stop further development of large-scale hydropower capacity. Energy policy, in the short and medium term, focus on new renewable energy sources such as wind and bio, reduced energy consumption, a more flexible energy system, distributed power production and gas-fired power plants with reduced or no emissions.

In the White Paper no. 15, 2001/02, the Government prescribes a more pro-active approach to the climate issue. It suggests that initiatives will be taken to make progress in the period up to 2005, and proposes a domestic emissions trading system to be established from 2005. Such a system will ensure real emission reductions, and will provide a more predictable framework. Further, early introduction will give valuable experience on emissions trading. The Government considers an emissions trading system to be a much more effective policy instrument than agreements with the industry.

One of the Government's targets is to reduce the use of mineral oils for heating by 25 per cent in the first commitment period under the Kyoto Protocol (2008-2012) compared with the average for the period 1996-2000. One step in this direction will be to draw up a strategy for conversion from oil-fired heating to new renewable energy sources. The Government will also strengthen research into the development of environmentally-friendly energy technologies. Another target is to establish a framework that will make it possible to establish gas-fired power plants with CO2 reduction technology.

In the White Paper no. 9, 2002-03, the Government presented a policy on increased domestic use of natural gas, increased efforts on hydrogen, provision of electricity from the mainland to installations on the Norwegian continental shelf and a policy on green certificates. It is proposed that Norway should contribute to an advanced development of an international certificate market. In doing so, consideration must be given to environmental concerns, security of supply and an acceptable management of natural resources in Norway.

2.7.3 Policy on international co-operation

Participation in international cooperation on renewable energy and energy efficiency is given high priority and is an important supplement to national research efforts. One of the reasons is the new challenges that have arisen in the energy and environmental fields. Norway is primarily involved in cooperation within the EU system an d the International Energy Agency (IEA) and at Nordic level.

The Baltic Sea Region Energy Co-operation (BASREC) is organised as part of the co-operation under the Council of the Baltic Sea States (CBSS). Eleven countries and the EU Commission are involved. BASREC has established ad hoc groups in the areas of climate change, energy efficiency, gas markets and electricity markets. In 2002, it was decided to make the region a testing ground for Joint Implementation projects for reducing greenhouse gas emissions in the energy sector.

2.7.4 Policy on renewable energy

New renewable energy sources are the energy sources of the future. The Government believes that technological advances will result in solutions that in the long term can make a substantial contribution to world energy supplies. Conditions in Norway are favourable for increased use of new, renewable energy sources such as wind power, bio-energy, heat pumps and solar energy.

According to the White Paper No. 29 (1998/99) which deals with Norway's energy policy, growth in production must to a greater extent be based on new, renewable energy sources. In the White Paper, the Government proposed quantified targets for energy production from renewable energy for the first time:

- An additional of 4 TWh/year of water-borne heat by 2010, which will reduce the dominance of electricity for household heating. The heat is to be produced from new renewable energy sources, heat pumps or waste heat.
- To construct wind farms that will produce at least 3 TWh/year of electricity by 2010.

2.7.5 Policy on end-use reduction of energy

From 1980 to 2001, net domestic energy use increased by an average of 1.4 per cent per year, despite a decrease in the energy intensity. Increased economic activity and a considerable increase in the number of households are important factors to explain the increase in energy use. The number of households has increased from approx. 1.5 million households in 1980 to close to 2 millions in 2001.

Net domestic energy use in Norway in 2001 was 225 TWh. Net energy use for stationary purposes was 150 TWh. Net electricity consumption in 2001 was 112.2 TWh, being 50 % of net domestic energy use. All electricity consumption was used for stationary purposes.

The main reasons for the high proportion of electricity use are the access to rich supplies of relatively cheap hydropower, and that government policy over several decades was focused on hydropower development. A large electricity-intensive industrial sector has developed as a result. Further, electricity is widely used to heat buildings and water.

Energy efficiency plays an important role both in achieving Norway's reduction target of greenhouse gas emissions and securing a more rational use of natural resources. National climate policy is based on a situation where the Kyoto Protocol enters into force.

The provisions of the Energy Act, the Planning and Building Act, labelling requirements, and standards for electrical equipment represent some of the legal framework having an influence on energy consumption, and on how energy is used. The National Office of Building Technology and Administration is responsible for administering the building regulations. The technical regulations pursuant to the Planning and Building Act contain rules governing energy use in buildings. New requirements relating to energy use and a new method of calculating energy use in new buildings are being reviewed.

2.8 Conclusions

The direction of desirable development would be a balance between well-being indicated by HDI and the tendency towards environmental sustainable development described by ESI. To illustrate this common feature we can use the product of the two indexes, as we are seeking for the efficiencies of the countries to find the balance. The product of the two mentioned indices gives some information about the way of evolution for the analyzed country. As for the developed countries, the average of fuel use is nearly three times higher than the world average. It is difficult to assume that the foreseen development of Poland will follow th average, however from a point of view of sustainability it would be desirable Norway got a highest rank in both inventories but nevertheless its use of fuel is far above the average for developed countries. This indicates that Norway as a country should limit, in the future the use of energy, while maintaining the same living condition for its citizens. This can be achieved by technological and social means, and among them is the promotion of sustainable construction in both countries.

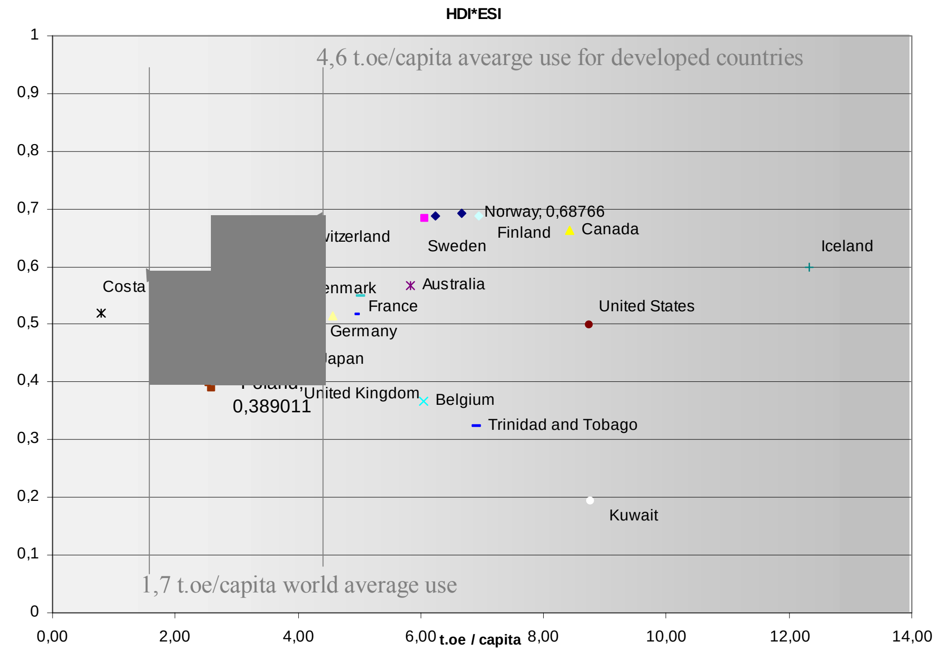


Figure 2.3 Product of HDI*ESI vs. toe/capita

The arrows on figure 2.3 illustrate potential developments of Poland. The left arrow indicates development with decrease of today's energy consumption to the world's average. The right one shows the achievement of the high development with increase of energy use up to the average of developed countries. As the energy consumption is dependent of climate conditions the figure gives boundaries for two possible scenarios of development.

The short overview of state of the art in sustainable development measures in respect to economies of the whole countries indicates the use of different typology of categorization and wide variety of parameters or basic statistics variables. The methodology of defining the indices is based on normalization and direct (HDI) or indirect weighting (ESI - by number of components). The number of different indexes confirms a need for their standardization, which can significantly improve communication. From another point of view, this problem provides information regarding to the possibility of implementation of the same methodology to assessment of other elements than economics. This guides to the concept of multi-criteria indices related to products and buildings. As will be presented in the next chapter this idea has been picked up by building and construction society by the last decade when a number of different typologies and indices have been proposed for the development of assessment frameworks of building products and buildings in many countries.

3. SUSTAINABLE DEVELOPMENT IN THE BUILDING SECTOR

3.1 Assessment of sustainability

The purpose of this chapter is to discuss the introduction of sustainable development rules in the building sector. The rationale of increasing world attention towards sustainable development has been given in Chapter 2 together with list of different indices describing the performance of economics in sustainable direction. The construction and building sector is one of the most important in this point of view, as it consumes approx. 50% of the energy and material flows (Europe average). There are many initiatives undertaken on different levels supporting the sustainability idea in the building sector. To obtain an overview of the state of the art of sustainability we will refer to the development of assessment systems of environmental performance of buildings, as they are defining the scale and references or benchmarks. Thus, they define the desired goals for all the stakeholders from occupants to scientists. Understanding the performance criteria helps to review the state of the art of the building sector in direction of the criteria fulfilment. Sometimes, it even indicates the demand for new research. The systems which gain official support in some countries will be our interest and will be discussed relatively in more detail, as we intend to end up with the commonly agreed framework of assessment to be used for the case study building. Therefore, below we will concentrate on the discussion of environmental assessment systems developing in many countries and on the support to sustainability of international organizations as CIB (International Council for Research and Innovation in Building and Construction), OECD and ISO.

During the last ten years considerable research has been focused on the development of systems to assess the environmental performance of buildings. Several of these systems have gone the next step, to result in a labelling system that indicates clearly the building's approximate performance to end users. It is best to say "approximate", since building performance includes many factors, only some of which are measurable in an exact sense. 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. Many spin-off 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 no countries in Europe which do not attempted to develop adaptation of existing or entirely new system. Several other systems (largely inspired by BREEAM and the Green Building Challenge initiative) are in various stages of development in Europe and the world. 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).

The number of different assessment systems developed independently in many countries, agencies and international organisations lead to the idea of standardization of assessment methods and to the re-establishment of Sub-Committee SC17 within ISO TC59 to work out an international proposal of assessment framework.

3.2 Green Building Challenge Initiative

The project Green Building Challenge has been initiated by National Research Council of Canada in 1996. Preliminary, the project aim was a creation of an assessment method to be used for the international architectural challenge exhibit at Vancouver Conference in 1998. For this purpose, an international co-operation process has been launched to develop a system that would be fully adjustable to regional differences, while sharing terminology and structure.

The process called Green Building Challenge (GBC) is a consortium of varying number of countries that are developing and testing environmental performance assessment system. The GBC project (ongoing since 7 years) is an attempt to develop an assessment system to reflect the very different priorities, technologies, building traditions and even cultural values that exist in various regions and countries. In order to use the system, national teams (taking part in the project) must first adjust the values and weightings embedded in the system, thereby assuring results that are relevant to local conditions. The direct output of this process is primarily at the level of R&D; specifically, a thorough understanding of issues involved in designing such a system, as well as a continuing exchange of ideas on the subject by the researchers interested in the field. However, public- and private-sector organizations are encouraged to use the results to develop a new generation of commercial labelling systems, and this is expected to have positive practical results in the near term for industry applications. Those European countries that are already developing their own systems (E-audit in case of Poland) are using the GBC process to exchange ideas and to improve their own systems, and GBC has already influenced the recent version of BREEAM. The project has consisted of two stages: the framework of assessment consensus process and case studies presentation, which culminated in the Sustainable Building Conferences held in Vancouver 98, Maastricht 2000, Oslo 2002 and the future one planned in Tokyo 2005. Today the GBC process is managed by non-governmental international initiatives for Sustainable Built Environment iiSBE. Among the other work, iiSBE manages the Sustainable Building Information System available trough the Internet http://www.sbis.info/index.html which is a database for R&D-projects going on in different countries. The system provides information on series of Sustainable Buildings Conferences, works of IEA, results of Green Building Policies Network project managed by IHS, work of CIB as e.g. Sustainable Construction-- TG48 - Social and Economic Aspects of Sustainable Construction. Nowadays over 10 000 documents related to sustainability in building and construction are available trough SISB.

The scope of the GBC assessment encompasses new and retrofit buildings with up to four occupancies in a building; multi-unit residential plus three other user-defined uses. The building types of interest, beside multi-residential, are school buildings and offices. The system measures potential performance before occupancy, not actual performance. The following environmental issues are covered by the system:

Resource Consumption

- Environmental Loadings
- Indoor Environmental Quality
- Quality of Service
- Economics
- Pre-Operations Management

The system structure is modular, and with some exceptions, calculations are done outside the system. Building parameters are nested in four levels, the are comprehensive and mutually exclusive to the extent possible.

Weights are established by national teams and assigned to all levels of assessment, the benchmark performance values are established for all parameters, using either regulations or industry norms to set minimum values; although defaults are provided, it is important to question and adjust them

The system handles both hard data from external calculation programs, and soft assessments made by expert panels. It uses a series of text statements to guide in scoring from-2 to +5. Hard data (e.g. kWh/m2) are easily inserted, while text statements can guide scoring for “softer” variables (e.g. flexibility of lighting system).

Many performance measures are normalized against occupant density and schedules - kWh/m2 * maph – million annual person hours. The current version also includes a small number of Environmental Performance Indicators (absolute numbers).

3.3 Some chosen national assessment systems

3.3.1 Austria Total Quality TQ system

In Austria, the TQ Information Package has been developed since 1998 in order to stimulate the construction of user friendly, environmentally friendly, and cost efficient buildings.

The main parts of the TQ Information Package are:

- a computer based assessment framework with an automatic assessment procedure done by the programme, delivering the assessment result after all required data have been entered;
- a guideline how to achieve the best score.

It is the aim of TQ to provide the information necessary for designing a high performance building and to confirm the result by assessing the building in two steps:

- prior to construction and
- prior to handing over.

The TQ system does not assess architectural quality, but technical parameters that have to be taken into account during the process of designing the building. At the beginning of the design process, the design team and the client define the design targets for the building by means of criteria for the assessment framework and the scores they want to achieve; after assessment, a group of independent experts certifies that all the information used for assessment is correct. Result of the TQ assessment is confirmed information about the building, the assessment result and the certificate.

The examined assessment file is the basis for issuing the building certificate. The certificate consists of brief summary of all relevant information in short form with approximately 30 page computer printout attached containing detailed information.

The briefcase consists of the following pages:

1st page: Photo of the project and certification acknowledgement

2nd page: Objectives of the evaluation program and presentation of the TQ working group

3rd page: Summary project description and issue level results of the evaluation:

- Resource Consumption
- Environmental Loadings
- Indoor Environmental Quality
- Durability
- Safety and Security
- Quality of the design process
- Quality of the construction process
- Quality of amenities and site
- Total average gained

4th page: Selected results with special meaning for the inhabitants (According to the results of an tenant inquiry carried out as part of the TQ project).

3.3.2. Environmental declaration and classification, Danish BEAT system

Environmental classification means categorizing the actual building in one of three environmental classes defined by a classification of each indicator. Some of the indicators are weighted and added to a final result with seven indicators.

A number of environmental indicators selected are obviously essential and can be evaluated quantitatively by using the computer programme BEAT 2001. These are:

- Energy consumption
- Material consumption

- Waste (volume waste, slag and ashes and hazardous waste)
- Climate impact (global warming potential and stratospheric ozone depletion potential)
- Air pollution (acidification and photochemical ozone formation).
- Environmental indicators concerning indoor climate are essential but difficult to handle in a declaration process because they cannot be quantified and added. They are divided into four groups each of which includes 4 or 5 indicators. Through a point system they are added to one overall Indoor Climate indicator The four groups are:
    - Air quality
    - Thermal climate
    - Daylight, view out, artificial lightning
    - Noise and acoustics.

Furthermore, a number of "Other Indicators" are included. Other indicators are added to one indicator by a point system. Other indicators are:

- Undesired chemicals
- Water consumption
- Building operation
- Location of the building
- Personal choice (open for new indicators found essential).

Indicators of the working environment, land use, architecture and flexibility of the building have been discussed but are not included, primarily because useable evaluation methods are not available at present.

3.3.3 PromisE the Finnish system

The Finnish Environmental Assessment and Classification System of Buildings (PromisE) is a tool for actors in the property, construction and building services industry The PromisE system is developed as a result of the Finnish Government decision (in December 1998) concerning the promotion of sustainable construction in Finland. It is still under a development and testing phase. Its contents (data gathering, indicators and assessment) have been tested in six buildings. The PromisE tool is available trough the Internet.

The PromisE system consists of four main categories: Human health, Natural resources, Emissions and Environmental risks. Those main categories are divided into sub categories with a defined content, input data and assessment methods. The management group of the development project had defined preliminary weights for different categories of the system before the weighting system was revised with a group of other stakeholders.

Human health is part of the PromisE system addressing to the health issues of people staying indoor. Emissions, moisture risks and infiltrated outdoor air pollution are given measurable indicators that can be used when assessing human health in buildings. Human health is weighed as 25 % of the PromisE system.

Use of natural resources emphasises energy, water and service life. Since there aren’t yet simple methods for considering the land use and materials issues they are, for the time being, left out from the system. The service life part includes service life design, flexibility and adaptability, and procedures for systematic maintenance planning. Thus, the materials omission is partly compensated by the service life items. The weight factor for natural resources is 15 % of the total system.

Ecological consequences are counted from emissions to air, solid waste and sewage, local biodiversity and emissions from transports. Emissions to air (greenhouse gases, acidifying emissions and volatile organic compounds) are the most important group of parameters under ecological consequences. The structure of waste and transports categories differs depending on the building type in question. Ecological consequences are weighted to represent 40 % of the PromisE score.

Environmental risk management is defined as measures taken in order to identify and eliminate potential environmental risks on site and built into the building itself. These include measures related to contaminated land and harmful substances. Environmental risks may lead to operations with major environmental impacts if they are not identified and dealt with in time and systematically. In an existing property these may remain harmless until refurbishment takes place or something unexpected occurs. The share of environmental risk management in the overall score is 20 %.

3.3.4 EcoEffect – tool to measure environmental impact of buildings properties, Sweden

EcoEffect is a method to calculate and assess the long-term environmental effects caused by the use of a real estate. It is developed for managers, consultants and contractors who need information about the environmental impacts associated with the built environment. Energy use, Materials use, Indoor environment, Outdoor environment and Life cycle costs are treated individually in the analysis. The assessment is based on life cycle analysis (LCA) for use of energy and materials and on criteria for indoor and outdoor environment. The result is presented as an environmental profile for each area with bars showing potential environmental effects for different impact categories. A possibility to aggregate this information into a few environmental load numbers for each area is offered to simplify a comparison between elements, buildings or estates. For use of energy and materials load numbers for emissions, waste and natural resource depletion can be calculated, and for indoor and outdoor environment the load numbers that may be calculated represent ill health, discomfort, biodiversity and biological productivity. The features of EcoEffect described below are related to real estate, the tool is still developed to encompass offices and existing buildings.

In EcoEffect the environmental impacts outside a real estate caused by erecting, use and demolishing constructions on the property have been called impacts on the “exterior environment”. The methodology and effect categories are to a considerable extent taken from the Danish LCA methodology. The impact scale expresses the relative impact of an average user of the real estate in relation to the average impact per capita in the country. Since this normalisation brings all the effects into the same unit, if weighted with respect to their relative importance, they can be added. The weighting process used is inspired by the Analytic Hierarchy Process, AHP and Green Building Challenge. The impact categories are compared pairwise with respect to one weighting aspect at the time. Extent, Intensity and Reversibility have been chosen as weighting aspects.

The environmental state and the potential impacts occurring within the real estate have been called impacts on the “interior environment”. It covers comfort and health for people staying indoors and out of doors at the estate and the actual and potential state of biological life at the property. The assessment is based on criteria giving scores between 0 and 3, where 0 means good conditions or low risk for impact and 3 means poor conditions or high risk for potential impact. The assessment of indoor conditions in existing buildings is mainly based on a questionnaire to the users that has been applied to more than 10.000 dwellings in Stockholm Results from a building compared with the expected ones based on statistics give the scores of the indoor profile. Assessment of future indoor conditions, i.e. an assessment made at the planning stage, is based on the target level chosen by the client and an evaluation of performance made from drawings and documents. This part of the method is still under development.

The impact on health and comfort for people staying out of doors is assessed from the physical conditions of the surroundings, like distance to noise and pollution sources, exposure for high winds speeds. The second impact group, biodiversity, is assessed from factors like access to free water surfaces, large trees, and soil conditions.

The last impact group, eco-cycling, gives credit to waste separation, composting and storm water infiltration at the site. This group represents actually a part of the mass flows across the real estate and will be judged by its effects on the exterior environment. The question of extra costs related to environmental improvements is always brought up. EcoEffect calculates the life cycle costs for issues which give impacts on the exterior environment, like energy, water and waste costs, materials costs, etc. The aggregated life cycle cost is shown for two standard scenarios. The first scenario is a steady state development, i.e. the cost relations in the society are constant. The second scenario shows an increased cost for energy, waste etc by 3% per year compared to other costs. A probable future is believed to lie in between these two examples.

3.3.5 Ecoprofile for Commercial Buildings-Simplistic Environmental Assessment Method, Norway

Ecoprofile is a method for simplistic environmental assessment of buildings and gives a good picture of the building's resource and environmental profile. A good environmental classification can lead to a market advantage in the sale and rental of commercial buildings. Ecoprofile can also be used as an internal management and steering tool for the building owner.

The Ecoprofile of a building is divided into three principal components. These components consist of ”External environment”, ”Resources” and” Indoor climate”. The principal components are divided into sub-areas that have different consequences for the principal components and are therefore weighted. Several of the sub-areas also have underlying sub-areas. Each sub-area and underlying sub-area contains a number of parameters. There are currently 82 parameters included in the method. Each of the parameters is individually evaluated and given a grade. A description of the classes is similar to that found in NS 3424 Condition Evaluation of Structures. The grading scale is 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. Ecoprfile deals with office and residential buildings.

For most of the sub-areas, the classification is just the average of the classifications of the parameters that make up the sub-area. This type of averaging implies similar weighting for all of the parameters within a sub-area. In some cases, however, matrix tables are used to define the classification of a sub-area.

The sub-areas are thereafter weighted such that each principal component can be given a classification. The three principal components are not weighted.

An Ecoprofile classification does not require use of measuring instruments during the on-site inspection. Interpretation of the results is best accomplished using the computer programs ”Enøk Normtall” and ”Indoor climate in office buildings (IMK)”. Enøk Normtall is used to calculate recommended values for energy use in a building. Actual energy use in the building is compared with the recommended value. The IMK program is used to calculate the thermal and atmospheric climate in the building.

An environmental evaluation method such as Ecoprofile can in principal be used for three different applications:

1. To *environmentally classify buildings*. A good environmental classification can lead to a market advantage in connection with the sale or rental of a commercial building.
2. As an *internal management and steering tool*, where the building owner, through environmental classification, gets a good overview of the building's environmental condition and what needs to be done to improve that condition.
3. As an *aid in project engineering*, where the goal is to create a building in a way that the requirements for best classification are achieved for each and every parameter.

It is important to keep separate these three use areas in the development of Ecoprofile, as choice of use area can influence both the content and use of the method.

Ecoprofile is well suited as a tool for environmental classification of buildings and has an official status because the method is tied to the GRIP Centre, which is an organisation under the Environmental

Protection Dept. There is therefore good reason to believe that the method will be of considerable importance in the area of environmental classification of buildings.

To achieve credibility for the Ecoprofile classification system, the inspectors responsible for carrying out the classification must uphold rigorous standards of competence and neutrality.

An Ecoprofile classification gives an easy-to-understand overview of a building's environmental characteristics. By improving the environmental characteristics that receive the worst scores in the classification, the building owner and user have the possibility to improve the building's environmental standard.

The obtained environmental information must be interpreted if Ecoprofile is to be used as an internal management tool. By improving the environmental characteristics that receive the worst scores in the classification, the building owner and user have the possibility to improve the building's environmental standard.

The methodology that includes listing of prioritised measures for improving the standard in each sub-area is retained in the new Ecoprofile. The new Ecoprofile therefore can also be used as an internal management and steering tool. If the new Ecoprofile is to be a unique tool for internal management and steering, the method should probably be further developed specially for that application.

The Ecoprofile used as an internal management and steering tool does not require formal adherence to standards of competence and neutrality for persons who use the tool.

It must be mentioned that it became evident in connection with an interview round concerning Ecoprofile in the fall of 1997 that many building owners lacked a tool for internal management and steering. A willingness to pay for the Ecoprofile method as an internal management and steering tool was recognised to be greater than for Ecoprofile as a tool for environmental classification.

Ecoprofile can, with some adjustments, also be used in the project design phase of a building as a useful aid in making environmentally friendly choices. A building with good environmental qualities can in principle be achieved by designing a building such that the best classification is achieved for the different parameters in Ecoprofile. However, the method does not at present give an incentive to go past the best class. For new buildings it will often be desirable to impose stricter standards than the Ecoprofile requirements for the best classification. An example is the insulation grade (U-value) for outer facades, where the criterion for best class is given as better than the requirements in the Norwegian Building Code from 1987. A new Building Code with stricter standards came into effect in 1997. Therefore all new buildings will automatically end up in the best class.

Life-cycle perspective should receive more emphasis if Ecoprofile is to be used as a project design tool. The choices in the project engineering phase should be made from a total life-cycle analysis where production, operation, demolition and removal of materials are taken into consideration. This type of life-cycle perspective is not as relevant in connection with classification of a building that is already built. A life-cycle analysis implies other problems and to some extent other parameters than those that are included in today's method. The best course will therefore be to develop a specific version of Ecoprofile as a project design tool.

The formal requirements of competence and neutrality are not as important for persons using Ecoprofile as a project design tool.

The detailed description of the method itself can be found in the Reference Document, where detailed description of parameters is provided.

3.3.6 E-Audit Polish method

The E-Audit method of environmental performance assessment of buildings (new and existing) has been created as a result of analysis of existing methods, work of GBC and ISO, as the experts' proposal, which could be a prototype of an official method for assessing the environmental impact of buildings on 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, 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 one level are the input to the higher level. Detailed description of issues, categories and their components criteria and sub-criteria are provided in [5]. 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 unit (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 an air conditioning system, the criteria is not considered and marked as non applicable - N/A

Every component of 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 regulations for buildings and the code requirements beyond the existing norms and commonly used technologies. The range of the relative scale is from -2 to 5, where -2 represents buildings below the existing regulations, and 5 reflects the best available solution.

All buildings are assessed in 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 (such items are called direct}. These direct elements are, as for example the composting organic wastes feature, assessed based on their existence, for these 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 the E-Audit system is the same as the framework of a recent system being under the development by ISO TC59 SC17 WG3, 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. The main and obligatory issues of the framework are: Resources use, Environmental Loadings, Health and Indoor Environment.

3.4 CIB focus on sustainable construction

CIB is the acronym of the abbreviated French (former) name: "Conseil International du Bâtiment". The abbreviation has been kept but the full name changed into: International Council for Research and Innovation in Building and Construction

CIB has developed into a world wide network of over 5000 experts from about 500 member organisations active in the research community, in industry or in education, who co-operate and exchange information in over 50 CIB Commissions covering all fields in building and construction related research and innovation.

CIB Members are institutes, companies and other types of organisations involved in research or in the transfer or application of research results. Member organisations appoint experts to participate in CIB Commissions. An individual also can be a member and participate in a Commission.

CIB Commissions initiate projects for R&D and information exchange, organise meetings and produce publications. The following three themes are for the time being high priority issues:

1. *Priority Theme 1* Sustainable Construction was implemented as such - in a somewhat less formal way - already in 1995-1998, culminating in the CIB Triennial World Building Congress in 1998 in Sweden. For the Triennium 1998-2001 it has been given this status in a more formal way, with the production of "Agenda 21 on Sustainable Construction" in 1999 as a first highlight.
2. *Priority Theme 2* Performance Based Building Codes and Standards has been given this status as the second CIB Priority Theme so far is the establishment of the EU funded Thematic Network PeBBu - Performance Based Building
3. *Priority Theme 3* Business and Process Re-Engineering is still in an early stage.

An inventory of projects initiated by CIB Task Groups and Working Commissions which are expected to contribute to the programme Sustainable Construction is as follows:

Task Group TG34 - Regeneration of the Built Environment

Task Group TG39 - Deconstruction

Task Group TG48 - Social and Economic Aspects of Sustainable Construction

Task Group TG51- Usability of workplaces

Working Commission W067 - Energy Conservation in the Built Environment

Working Commission W092 - Procurement Systems - Project: Sustainability and Procurement

Working Commission W100 - Environmental Assessment of Buildings

Working Commission W105 - Life Time Engineering in Construction

DisCo - Dissemination of Sustainable Construction

In June 2002 CIB submitted a so-called EoI - Expression of Interest (indication of the intention to submit a proposal for funding in the context of the EU Sixth Framework Programme) for the Network of Excellence DisCo - Dissemination of Sustainable Construction. The following related document can be downloaded: EoI - DisCo - draft from the Cordis database.

3.5 ISO work on sustainable building

ISO (the International Organisation for Standardisation) is a world-wide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO Technical Committees TC, composed on Sub-Committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee.

International organisations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO is performing works related to Environmental Management of production process. The ISO standard 14031 (Environmental performance evaluation) gives guidance on the design and use of environmental performance evaluation within an organisation. ISO 14031 defines environmental condition and performance. According to ISO 14031, an environmental indicator is defined as a special expression that provides information about environmental condition or performance. The definition does not put any other requirements on the type of "specific expressions", but providing information on environmental issues.

The separate stream of interest born as an outcome of ISO 1400 series among them the following Subcommittee's within TC59 are dealing with environmental performance of products (not necessary building products):

SC 3 Environmental labelling

SC 5 Environmental management

SC 14 Design life

SC 16 Accessibility and usability of the built environment

The SC 3 had a WG12 which was dealing with sustainability in building construction. The SC 3 having 11 other working groups expressed an idea to elevate the WG12 to the statue of SC, and their working items into working groups. This was a basis to establish SC17 Sustainability in Building Construction with four working groups:

1. Environmental declarations of building products
2. Framework for assessment of environmental performance of buildings and their assets
3. Sustainability Indicators
4. General principles and terminology

Norway is leading works of the first group; Poland joined (October 2003) the SC 17 as an observer with a will to become a participant.

3.6 OECD support to sustainable building

The Organisation for Economic Co-operation and Development OECD initiated in May 1998 Sustainable Building Project as a four-year project with the objective of providing guidance for the design of government policies to address the environmental impacts of the building sector. Among the various environmental issues related to this sector, the reduction of CO_2 emissions, minimisation of construction and demolition waste (C&DW), and prevention of indoor air pollution were selected as priorities for the project.

As the final output of the four-year project, the Synthesis Report presents the results of four years of work done in the OECD Environment Directorate for this project. The report is intended to help policy makers in OECD countries to improve environmental policies for the building sector and stimulate further discussion on this issue in the future. The report could also be of interest to other international organisations, researchers, industry, and NGOs. The report is divided into seven chapters.

Chapter 1: Introduction

Chapter 2: Environmental and economic impacts of the building sector

Chapter 3: Current environmental policies for the building sector

Chapter 4: Unique characteristics of the building sector and barriers to improvement

Chapter 6: Designing and implementing policies for environmentally sustainable buildings

Chapter 7: Conclusions: policy recommendations

Below the list of policy recommendations in means of potential instruments for the countries to follow in order to support sustainability in buildings and construction are listed:

General policy framework

- Establish a national strategy for improving the environmental performance of the building sector.
- Establish a framework to regularly monitor the environmental performance of the building sector.
- Develop a close partnership between government and industry for the support of R&D and technology diffusion.
- Introduce a greener public purchasing strategy for construction procurement. ENV/EPOC/WPNEP(2002)5/REV1
- Minimise administrative cost by eliminating the duplication of administrative processes.
- Undertake more *ex-post* evaluation of policy instruments by means of a close international co-operation.

Policy instruments for reducing CO2 emissions from buildings

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

Policy instruments for minimising C&DW

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

Policy instruments for preventing indoor air pollution

- Improve the quality of building materials by implementing instruments that target building materials manufacturers.
- Avoid providing misleading information to consumers.
- Undertake more studies on the causal mechanisms of indoor air pollution.
- Establish a framework to identify newly emerging indoor health problems.

3.7 Conclusions

This chapter provides very brief and incomplete information about sustainability in the building sector. The basic elements which are important for the SUREBUILD project has been picked up and referenced. For more detailed information we recommend to visit the websites of the presented organisations, and undoubtedly to take an opportunity and browse the Sustainable Building Information System as a comprehensive data base covering most of the activities in this field undertaken world-wide.

4. THE BUILDING STOCK IN POLAND. ENERGY, INDOOR ENVIRONMENT AND OTHER IMPORTANT SUSTAINABILITY ISSUES.

4.1 Basic statistics related to the building stock in Poland

According to 2001 data Poland has approx. 12 million housing units with a total usable space of approx. 710 million m^2. The scale of recent construction in Poland is far below the needs and reaches approx. 80 thousand units per year. In order to achieve by the year 2020 average European 400 units per 1000 inhabitants, 200 000 apartments should be constructed per year. There is a strong need for new housing in Poland (there are approx. 300 dwelling units per 1000 people), so it should be expected that sooner or later it will result in intense construction activity.

In this context it is worth to know that 1.44 million of housing units were constructed before 1918. 2.28 million of them were erected between I World War and end of II World War. The majority of housing units was constructed after 1945 but the production of Polish construction industry changed very much over years: 1.50 million in years 1945 -1960, 1.91 million in years 1961 - 1970 and 4.40 million in years 1971 – 1996. The highest number of dwellings was built in 1978 (286 thousand) after this year the decline was observed. While the depression in the number of dwellings constructed per year continues, the standard of new dwellings measured as an average usable floor space follows a quite different pattern. Rising in the 1960's, it experiences a downturn in the late sixties, which is followed by a steady increase.

Table 4.1. The basic statistics of the construction industry

Year	Number of completed dwellings in thousands in a given year	Average usable floor space m^2/dwelling
1950	59.5	50
1960	142.1	57
1970	194.2	55
1980	217.1	64
1990	134.2	77
1995	67.1	89
1996	77.3	91
2000	87.8	90
2001	106.9	86

Source: Own calculations based on Central Statistical Office and CSO (1998b) and CSO (2002)

There are some differences between urban areas and rural areas in shares of buildings from different periods in the housing stock. The higher share of buildings constructed before 1945 in rural areas in comparison to urban areas can be explained by the larger destruction of cities during the Second World War. The table reflects to some extend the migration from rural to urban areas. Therefore, in the seventies and the eighties the demand for new houses in rural areas was relatively smaller. This phenomenon may be explained also by the explosion of supply of apartments in the cities. This was due to proliferation of the large-panel technology.

Table 4.2. The structure of buildings in 1993 according to the year of construction (%)

Year of construction	Rural	Urban
before 1945	29	22
1945-70	31	30
1971-78	19	24
1979-88	16	20
after 1989	5	4

Source: CSO (1998b)

Changes after 1989 forced also changes in the ownership of dwellings (table 4.3). The percentage of private dwelling is constantly increasing and exceeds 50% while the percentage owned by local-governments and by companies (popular form in previous time) is decreasing. In buildings with part of dwellings owned by natural person and part in municipal ownership or company ownership new form of appeared, the condominium.

Table 4.3. Inhabited dwellings by type of ownership

Specification	1996	2000	2001
Dwellings in thousands	11547	11845	11946
Private	45.7 %	49.4 %	50.9 %
Housing co-operatives	27.8 %	28.6 %	28.5 %
(of which member owned)	(15.5 %)	(18.8 %)	(19.7 %)
Municipal (gmina)	14.7 %	11.6 %	10.7 %
Company	7.9 %	4.6 %	4.0 %
Condominiums - dwelling of natural persons	4.0 %	5.8 %	5.8 %

Structure of buildings completed in last years is presented in table 4.4. Low activity of local communities at housing construction market can be observed.

Table 4.4. Buildings completed by type of building

Specification	1995	2000	2001
Residential buildings	33 998	32 151	36 996
One-dwelling buildings as well as two- and more dwelling buildings	33 965	32 114	36 098
Residence for communities	33	37	29
Non residential buildings	27 235	18 054	17 223
Office buildings	376	444	514
Hotels buildings	1905	1419	647
School, University and Research buildings	467	155	203
Hospital or institutional care buildings	111	108	182

According to the opinion expressed by the State Office for Housing and Urban Development, presented at the meeting of Ministers responsible for human settlements in European transition countries, "Modernisation of urban areas barriers , experience and tasks" the biggest problems in redevelopment of Polish building stock are related to the great housing tenements' complexes, erected by means of industrialised methods throughout the years 1960 to 1990. Their major problem source is comprised by:

- the erection system prevailing throughout the period of centrally steered economy, which put preference on the number of erected housing units and not on the standards of living, which founded an excuse for limiting and delaying works associated with the realisation of the social infrastructure,
- shoddiness of execution and poor quality of applied materials occasioning rapid technical degrading of buildings,
- antiquated technological solutions and technological standards giving rise to high exploitation costs on buildings.
- low dwelling usable floor area standards (especially those dating back to the '60s) and poor standards of finishing causing the functional degradation of these assets, '
- failure, at the time of erecting, to recognise ecological requirements, the needs of disabled people. etc., the monotony of building developments,
- uneconomical rents and resulting faulty exploitation failing to secure successive execution of all necessary repairs and modernisation,
- the feeling of "anonymity in the crowd" amongst the dwellers emanating from aggrandisement of the scale of projects and complexes and favouring the processes of devastation of settlement buildings and utilities.

4.2 Energy efficiency of buildings in Poland

Poland is located in Central Europe on the border of mild and continental climate zones. With respect to designing of heating systems, Polish Standard PN-82/B-02403 divides Poland into five climatic zones. External temperatures decrease with the number of the zone starting from -16 ^{o}C for zone number I, to -24 ^{o}C for zone V (-2 ^{o}C step). Assuming indoor temperature +20 ^{o}C, the number of „degree-days" for different building locations equals 3700 ÷ 4400 ^{o}C.

Traditionally the requirements for thermal performance of the building envelope have addressed values of heat transfer coefficient U. Table 4.6 presents changes of permissible values of heat transfer coefficient U over last 45 years. Current requirements are presented in later sections of the chapter in Appendix #.

Table 4.5. Computed temperatures of ambient air, according to PN-82/B-02403 (PN, 1982)

Climatic zone	I	II	III	IV	V
Computed temperatures of ambient air, °C	-16	-18	-20	-22	-24

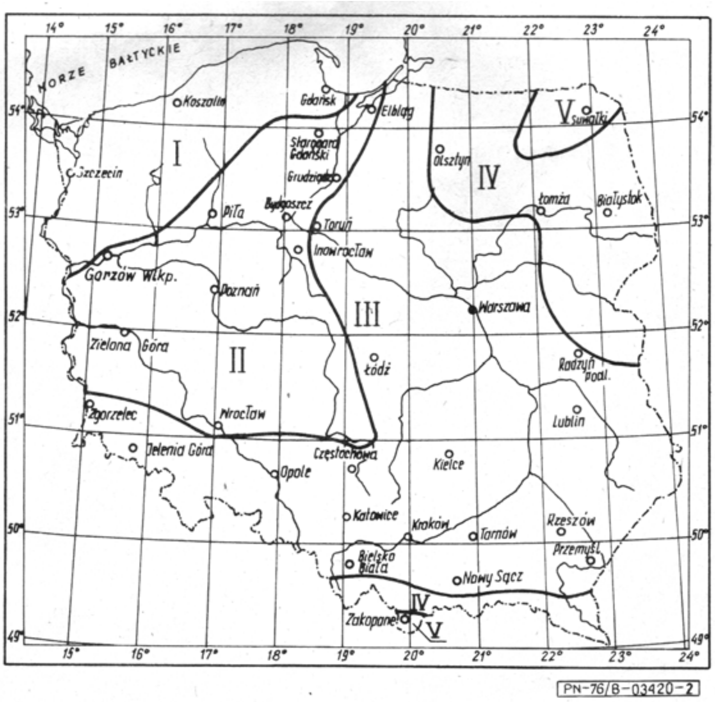


Figure 4.1. Climatic zones in Poland according to PN-82/B-02403 (PN, 1982)

Table 4.6. Permissible values of heat transfer coefficient U, W/(m^2·K) over last 45 years.

Type of envelope component	Year of publishing the standard				
	1957	1964	1974	1982	1991
external wall	1.16	1.16	1.16	0.75	0.55-0.7
roof	0.87	0.87	0.7	0.45	0.3
garret	1.05	1.16	0.93	0.4	0.3
windows	-	-	-	2.6 zones I ÷ III 2.0 zones IV, V	2.6 zones I ÷ III 2.0 zones IV, V

In the 1990's new indicators of building performance - the energy standards, have been introduced to energy assessments:

E_0 – seasonal heat demand for space heating during a standard heating season related to usable space of heated parts of the building (the value of the indicator depends on: location and technical characteristics of the of the building envelope and may be useful during energetic assessment of building technology);

E_s – seasonal heat demand for space heating during a standard heating season (including efficiency of heating system) related to usable space of heated parts of the building (this indicator taking into account the efficiency of the heating system and heat source is of key importance for assessing project viability).

The methodology for calculations of indicator E_0 has been standardised. Polish Standard PN-99/B-02025, developed on the base of the European prestandard prEN 832, describes the methodology of relevant calculations for residential and public buildings. Of course a universal method developed for standardisation purposes includes a lot of simplifications. The most important one, regarding by some specialists as unacceptable, is the ventilation module. For all types of ventilation the methodology assumes constant flow, equal to the required by Polish Standard minimal values. Also, the methodology assumes that there is no difference between supply air temperature and outdoor air temperature. These simplifications cause that all calculations for natural ventilation (the most popular way of residential building ventilation in Poland) and mechanical systems with heat recovery (the very interesting alternative for energy efficient designing) have a great error. Moreover, the methodology presented above does not allow energy auditors to justify the investment in heat recovery from the exhausted air.

One should remember that the results of energy standard estimations based on presented methodology should be read with a huge margin of confidence. Seasonal heat demand indicators E_0, kWh/(m^3·year), relative to periods of different thermal standards, are presented in the table 4.7.

Table 4.7. Estimated seasonal heat demand indicators E_0, kWh/(m^3·year) related to periods of different versions of insulation standards.

Year of construction	Heat demand indicator E_0, kWh/(m^3·year)
before 1966	80 - 120
1967 - 1985	80 - 95
1985 - 1992	55 - 65
1993 - 1997	40 - 55
after 1998	30 - 40

Table 4.8 presents the breakdown of energy standard for residential buildings in Poland, expressed as E_s coefficient. Typical efficiency of the heating system equals 65%. The table has been prepared on the base of energy audits completed by National Energy Conservation Agency.

Detailed analysis of these audits leads to the conclusion that the most common technical reasons of this excessive energy consumption were:

- insufficient insulation of external walls, roofs, windows and doors,
- shapes and locations of buildings not taking into account energy losses and potential energy gains,
- low efficiency of heat sources,
- significant heat losses between heat sources and heaters,
- lack or low level of control systems in heating installations,
- lack of individual heat meters.

Table 4.8. The breakdown of energy standard for residential buildings in Poland expressed as E_s energy indicator.

Energy standard E_s, kWh/(m^3·year)	Part in %
50 - 65	4
65 - 85	20
85 - 100	24
100 - 115*	24
115 - 135*	20
> 135 *	8

NOTE: *- for single family buildings with energy standard E_s of above 100 kWh/(m^3·year), usually the heat comfort is not maintained.

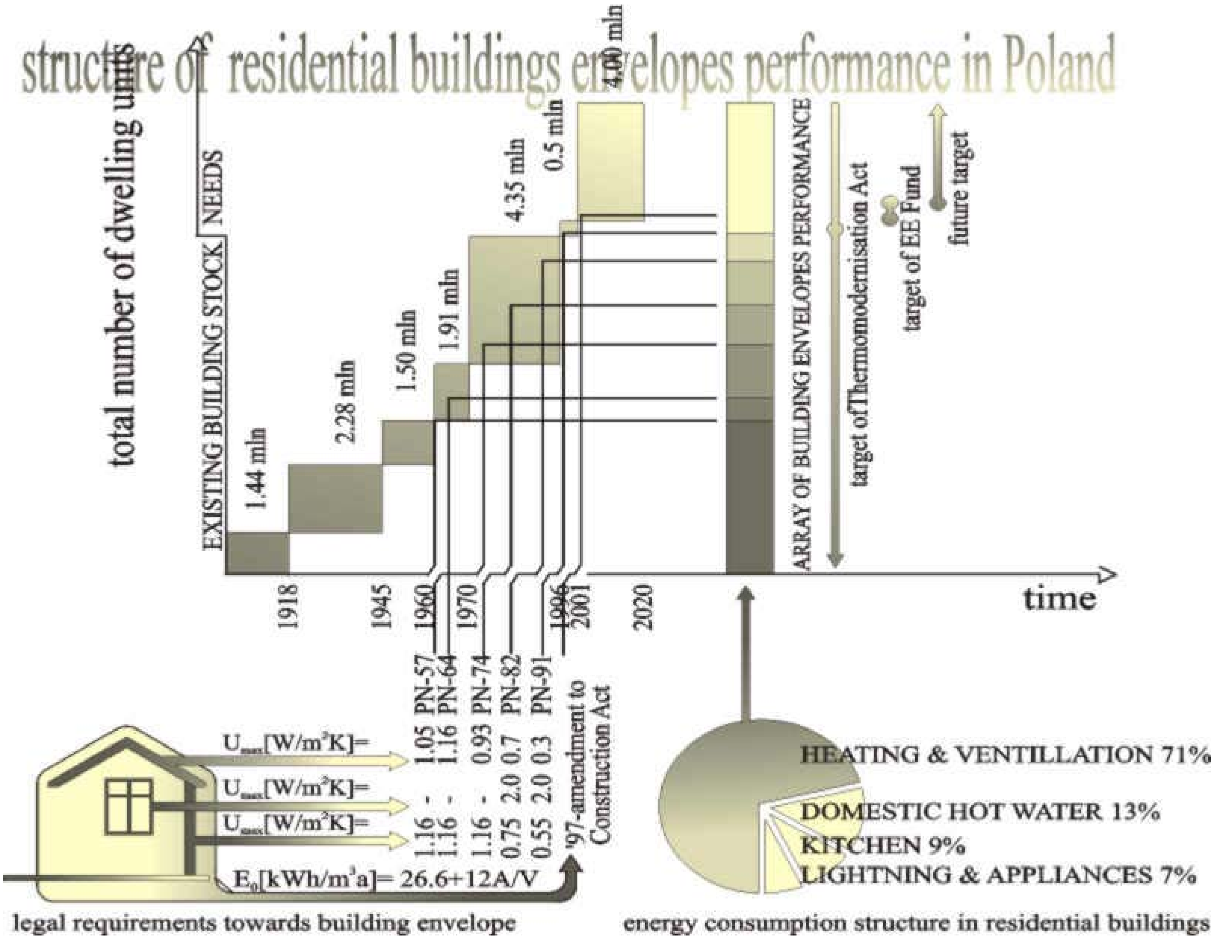


Figure 4.2. Importance of energy saving measures on the background of existing and predicted numbers of dwelling units in Poland.

Considering the data shown in Figure 4.2 it is obvious that thermal modernisation of existing buildings and modernisation of their systems to reduce energy and water consumption is most urgent. On the other hand, there is a chance to balance housing deficiency with new, sustainable buildings.

4.3 Indoor environment and other important sustainability issues

A vast majority of Polish residential buildings is equipped with stack ventilation. Unfortunately, this type of ventilation is not a subject of any calculations during the design process. Cross sections of stacks, the type of ventilation grilles, air tightness of envelope components are selected by a rule of thumb or are no taken into consideration at all.

Great action of energy conservation, supported by the Government, advised for air sealing of the building envelopes by installing air tight windows or by adding additional gasket in the windows cracks. Introduction of systems for heating cost allocation increased the users interest in energy conservation. Intentional or unintentional reduction of ventilation rates became the routine. However, very often it resulted in very negative consequences.

As gas appliances with open flame are still used in number of Polish apartments for preparing hot water or cooking, an inadequate ventilation is not only a problem of comfort or long term illnesses. Additionally, gas appliances are usually in very bad state. A study carried out in the Silesia region showed that small hot water boilers installed in bathrooms and kitchens are very often in really bad condition. Among 10 000 checked devices 2000 had a CO content in flue gases in the range 0 – 0,002 %, 3000 in the range 0,002 – 0,05 % and 5000 appliances had a CO content above > 0,05 % level allowed by Polish Standard PN-87/M-40301. Extreme values of CO content in flue gases reached 3%.

This situation creates direct risk for occupants' health or even life. One may expect (unluckily there are no official statistics) that each year there are 600-800 cases of carbon monoxide poisoning, many of them with mortal end.

Reduced level of ventilation intensity in retrofitted buildings with airtight windows resulted also in the number of buildings with moisture problems. Moulds that previously were met in poor insulated buildings or in buildings with damaged roofs are currently met in well insulated buildings but without necessary ventilation.

As the quality of building materials available on the Polish market has seriously improved (Polish producers usually fulfil the EU requirements) the problem of indoor air pollution due to this source of emission does not seem to be key issue at the moment. Often increasing ventilation rate to the required level solves the problem.

A study on radon exposure in Poland indicates that mean concentration of radon in residential buildings is below 50 Bq/m^3. There are two regions with higher radon concentration: the southern part of Poland, close to the Carpathian mountains 75 Bq/m^3 and upper Silesia (hard coal mining area) 65 Bq/m^3. However there are some areas where the probability of finding dwellings with radon levels above 200 Bq/m^3 reaches a few percent. Presence of buildings with radon concentration level above 800 Bq/m^3 is very unlikely.

The majority of buildings erected by means of industrialised methods throughout the years 1960 to 1990 has also poor acoustic environment. As concrete prefabricated elements used in that period had rather poor acoustic isolation, and disturbing noise from neighbourhood as well as lack of privacy was identified in many studies. The acoustic insulation should be improved especially between spaces located in one vertical line:

5 -10dB kitchens and bathrooms,

3 - 7 dB rooms with adjacent shafts for water installation

8 - 13 dB halls with prefabricated electrical shafts

Acoustic problems are also identified in high rise residential buildings (above 11 storeys) where mechanical extract ventilation systems were applied by law. Noisy fans and lack of sound attenuators caused a lot of problems at higher levels of this type of buildings.

4.4 System of Polish regulation related to buildings

4.4.1 Introduction

The constitutional responsibility of the state for the living conditions of its citizens and its obligations stemming from international conventions, EU directives, and other binding decisions of international organisations, are reflected (sometimes very partially, alas) in the hierarchically ranked Polish legal acts, such as:

- the Constitution (health protection, civil rights, sustainable development) which is the grounds for drafting Government bills,
- Government bills, defining the rights (the environmental protection law, the construction law, the energy law, the health protection law, the compliance evaluation system, the inspection services' obligations and scope of competence) etc.
- Government and ministerial ordinances, supporting the implementation of legal acts (technical conditions to be met by buildings and their localisation, the technical conditions of the use of dwelling buildings, safety certification and safety mark, conditions of connecting the users to the heating network, energy efficiency requirements for heating systems, power labels and profiles, scope and form of the construction design),
- ministerial instructions, setting forth detailed requirements.

The structure of legal acts and ministerial ordinances envisages the formulation of requirements and it defines the formal grounds for the functioning of control institutions (e.g., construction inspection, sanitary inspection, labour safety inspection). The ministerial ordinances precisely define the scopes of responsibility by allocating specific tasks to the individual levels of power, institutions or positions (local government structures, designers, construction managers, school head masters, the Sanitary and Epidemiology Stations). Despite the fact that the controls bodies are in place, the state's responsibility ceded onto the government agencies is not sufficiently implemented.

4.4.2 Construction law

The construction process in Poland is based on the Building Code, which is the major legal act regulating all basic aspects of the construction. The Act's complete text is divided into Chapters:

Chapter 1. General provisions

Chapter 2. Independent technical functions in the building industry

Chapter 3. Rights and obligations of participants in the construction process

Chapter 4. Proceedings preceding commencement of construction work

Chapter 5. Construction of building and their release for use

Chapter 6. Maintenance of buildings

Chapter 7. Construction accidents

Chapter 8. Architectural and construction administration and construction supervisory authorities

Chapter 9. Penalties' provisions

Chapter 10. Vocational liability in construction process

Chapter 11. Temporary and final provisions.

The vast majority of requirements have prescriptive form but some of them (especially those very general requirements) look like this performance based example art 5.1 from the Building Code:

Art. 5.1. Taking into consideration expected period of exploitation, a built structure as well as connected built devices should be designed and constructed, in accordance to the regulations, including the technical and construction regulations, the binding Polish Standards, and the principles of technological knowledge, in a way ensuring:

1) meeting the essential requirements on:

- *a) structure safety*
- *b) fire safety*
- *c) safety of use*
- *d) appropriate hygiene, health, and environmental protection conditions*
- *e) protection against noise and vibration*
- *f) energy conservation and good thermal insulation of the partitions.*

2) the usage conditions concurrent with the building's destination, particularly:

- *a) water supply, power supply and respectively to demands heat supply and fuel supply assuming effective utilisation of these factors*
- *b) removal of sewage rain water and garbage;*
- *c)*

3) possibility of keeping proper technical conditions

4) necessary conditions for using public facilities and multi-family houses by disabled persons, especially those on wheel chairs.

4.4.3 Technical criteria to be met by built structures and their localisation

Efforts were made twice in the recent decade to adjust the legal regulations to the new requirements supplement and enrich the contents of the ordinance without changing its structure, traditionally accepted by the technical world. After implementing the CPD Directive, despite the fact that this ordinance mainly describes the detailed technical solutions, there were also provisions of a performance character.

Ordinance on the technical criteria to be met by built structures and their localisation - contents:

Chapter I.	General provisions
Chapter II.	Building plot’s development and management
Chapter III.	Buildings and rooms
Chapter IV.	Technical outfit of buildings
Chapter V.	Structure safety
Chapter VI.	Fire safety
Chapter VII.	Safety of use
Chapter VIII.	Hygiene, health, and environmental protection
Chapter IX.	Noise and vibration protection
Chapter X.	Energy saving and thermal insulation
Chapter XI.	Transition and final provisions

The above list of contents, in which the technical solutions are determined first and then recommendations on meeting the basic requirements are defined, does not help to successfully fulfil the user’s needs. However, the proposal (made in the process of amendment) to change the structure and subordinate the technical requirements to the implementation of fundamental safety principles was not appreciated and the editorial team decided to keep the existing structure unchanged. The fact confirms a strong traditionalism of the construction milieu and its clear reluctance to see “non-technological” innovations.

4.4.4 Control activities

The execution of the implementation of statutory tasks was delegated in Polish legislation to respective inspection services: *the State Sanitary Inspection, the State Environmental Protection Inspection, and the Main Construction Supervision Office*. However, poor consistency of the provisions leads to a poor enforcement of these regulations and is a reason why “the protection of the natural environment and the building” in practical life remains beyond the reach of all these inspections.

We must note that the legal regulations now existing in Poland, despite their great number, do not ensure an appropriate level of satisfying the basic safety requirements and the expected conditions of use as expected of the built structures. They are too partial, inconsistent, and based on statements and instructions, which are not followed up by appropriate controls. This is a difficult area to implement a new policy and far-going changes in the building construction sector. This applies to PeBBu and to the implementation of the *sustainable development* strategy.

4.4.5 Standards

Standards should be an inseparable supplement for legal documents to define the methods for requirement definition, performance criteria, calculation methods, measurements strategy and methodology, research procedures, etc. With the relatively small set of national standards in Poland, the ISO and CEN standards are being discretionary adopted. In the area of performance concept (expressing the user’s requirements, environmental management LCA, environmental labelling, building environment design, etc.) we should recognise the normative efforts done by ISO (TC 59, TC 207, TC 205) as the most advanced work. Although it is accepted that some normative documents are not binding, they are occasionally mentioned in ministerial ordinances as legal grounds for formulating requirements.

4.5 Requirements for new buildings and retrofitted buildings

Basic Polish requirements for new buildings and retrofitted buildings are presented in the Appendix to chapter 4.

5. EXISTING RESEARCH AND DEVELOPMENT PROGRAMS IN POLAND AND NORWAY

This chapter gives a state of the art of ongoing research within sustainable development in the building sector both in Poland and Norway. It is difficult to make a complete list of existing research- and development programs. We have collected some main topics that we believe are useful to know about. Instead of providing all available information related to building and construction R&D activities in both countries we have made an extract. It contains ongoing work or newly finished work. Most of the activities, programs, networks, organisations or projects mentioned are included because the Polish or Norwegian research group have been involved or know them well. Since the list is not complete, there are probably activities that should be included. Even with these limitations it gives an overview to projects that deal with issues interesting for further work in the SureBuild-project.

5.1 Projects and activities in Poland

All government support for separately budgeted research is channelled entirely through the Polish Ministry of Scientific Research and Information Technology (former State Committee for Scientific Research)

There are six ways of financing:

- Core funding for statutory R & D activities, i.e. institutional finance provided selectively to designated research establishments, units and university departments for covering the costs of their own research activities. Schools at the university level cannot use those funds to finance their educational or training activities. Polish Building Research Institute gets some funding from this source.
- Investments in R & D infrastructure, such as buildings and equipment.
- Peer-reviewed research grants based on research proposals, presented by small research teams or individual researchers, no matter where they are employed or what scientific degrees they hold. Applications are evaluated by an appropriate group of the Committee twice a year. Research projects should deal with new scientific problems and must not be financed from the state budget in any other form.
- Subsidies for R & D programmes of national importance commissioned by enterprises, state administrative bodies or local authorities. The financial means are allocated for the implementation of projects and the utilisation of research findings.
- Subsidies for international scientific and technological co-operation resulting from intergovernmental agreements.
- Subsidies for selected R & D support activities (e.g. information services).

The outlays for R&D reached approx. 0.5% of Polish GNP (with approx. 3% of European average); moreover building and construction industry did not get priority among the political goals. All of this caused that there is not any country wide programme answering in a complex way all needs for research in the building sector. However, there are some projects financed under instruments mentioned in point 3 above. The list of accepted project is available (in Polish at http://nauka-polska.pl), in spite of many small projects on the list there is one related to school buildings. Therefore, all the references provided below are the international projects financed externally with the participation of Polish entities. The list of projects is of course not complete and it is subjective. It reflects the authors' knowledge up to the date.

5.1.1 Thermomodernisation Act

Goal: Decrease of energy use for heating and hot water preparation in housing and public buildings sector. The Thermomodernisation Act is a unique example of a country wide development programme offered for the owners (private people, local government assets with school among them) of buildings willing to improve their energy standards.

Financing: The act has been established by Parliament on December 1998, with latter amendments in July 2001, called into being the Thermomodernisation Fund.

Project organisation: The Bank of National Economy manages the Thermomodernisation Fund which is the main mean of financing in form of thermal modernisation bonus assigned to projects aimed at the improvement of buildings' envelope, internal technical systems, local energy sources and distribution networks. After providing an energy audit (elaborated by an independent energy auditor under very strict form and method) proving that the investment fulfils the terms of the Act, the investor using bank credit for thermomodernisation is granted a bonus. The bonus may reach up to 25% of the credit raised for the investment, and is paid by the Fund to the bank servicing the credit after completion of construction. It is a significant decrease of the cost of investment. The premium is paid only for measures which fulfil conditions concerning level of profits, the type of modernisation activities and its economic result. The bonus may be granted both to the owners or administrators of buildings, and operators of local heating networks and central (town) heating plants.

Duration: Thermomodernisation support is offered from 1998 and during this time has undergone several amendments in order to make it more attractive for investors.

Results: Total investment in thermomodernisation till now (2004, January) is 192 million PLN (4,5 PLN= 1 euro), credits 119,8 million PLN, bonus 29,9 million PLN. The result till now is thermomodernization of:

362 single-family buildings, 699 multi-family buildings, 102 public utility buildings, 55 local heat sources, 14 local heat networks and 8 others.

The programme to support thermomodernisation showed differentiated interest of different investor's and its development has been criticised by different groups, especially by management of co-operatives. Financial resources dedicated every year for the Fund remained till 2002 not spent. It seems, however, that situation is slowly improving. Generally, the system of thermomodernisation based on credits and energy audits gives profits in terms of energy conservation and it is still available for a wide group of owners. The system has operated for 5 years and has very positive influence on the market. Now, most of the financing institutions are asking for energy audits prior to the decision of financing, also there is a feedback on investors in a sense of creation of need for modern technologies and application of renewable energy, as the Act provides favouring terms for their implementation. Within the 2003 the acceleration of thermomodernisation investment is significant out of 1600 total number of investment 600 have been prepared in this year.

Publications/ references: Herbst, The role of the National Economy Bank (BGK) in Financing of Social Rental Housing Construction and Thermal Modernisation in Poland, IEA Energy Conservation in Buildings and Community Systems, 50th Executive Committee Meeting, Technical presentations, Kraków, November 7, 2001 (in English).

Web site of Bank of National Economy www.bgk.com.pl,

Website zae.org.pl of the Polish Association of Energy Auditors, and proceedings of Yearly Auditors' Forum since 1999 (in Polish).

5.1.2 Global Environmental Facility Project

Goal: The GEF project, managed by the World Bank, was dedicated for new housing construction and for demonstration of non-market new technology solutions leading to significant improvement of energy standard comparing with houses built nowadays in Poland.

Project organisation: The World Bank, the project manager, signed an agreement with Polish Bank of Environmental Protection in order to organise Project Management Unit PMU, to supervise investment and providing financing. PMU contracted the project energy consultant in order to assess financial outlays and potential improvements of energy standards.

Duration: The project started in 1997 and the investment phase of the project is now completed. The monitoring process of investments results is now under execution. It is foreseen that in the 2004 it will be concluded.

Financing: In the five-year period (1997-2002) over 10 new-built housing projects in Poland underwent the process arranged by Global Environmental Facility (GEF) demonstration project - the

Energy Efficiency in Buildings component GEF project was tailored to specific needs of Polish housing construction given the name of Energy Efficiency Fund for New Residential Buildings. The main resulting arrangements were as follows:

- EE Fund would grant-finance 100% of incremental energy efficiency and conservation measures, i.e.: extra improvement above the current Polish building code.
- EE Fund would be provided to applicants who have secured construction financing
- one of the strict requirements to be met by granted projects was cost-effectiveness of extra features. That means, the cost per unit of conserved energy had to be lower than cost per unit of electric energy on the market. Given that, several extra features were successfully applied in new designs. The most efficient of them are:
- an additional insulation of walls, roof and basement floor, above that required by Polish regulations combined with high thermal efficient windows and doors
- mechanical ventilation system with waste heat recovery
- passive energy collecting features incl. solar energy and recovery of waste heat from technical systems
- detailed energy audits revealed very promising energy savings (up to 90%+ for the combined systems) and reasonable incremental cost efficiency.

Results: Investors applying for the EE grant were to undergo complicated and time-consuming process of auditing construction projects, accepting applications by GEF Project office, co-operating with auditors and supervisors. What's more, it was the investor's financial risk, since it was the investor who was to secure all the construction costs including incremental cost of energy-conserving extra features before grant was paid after successful completion of recommended measures.

Table 5.1. Costs and Benefits of the 2 Groups of Energy efficiency Strategies

Unit type	Energy savings	Incremental construction cost	Cost of Conserved Energy	Simple Payback **(1)**	GEF Cost - effectiveness
	%	zł/m^2	CCE **(2)**	Years	USD/tonCO_2
Group 1: Improved insulation and windows:					
Townhouse	27-34	14-31	0.054-0.083	2.2-3.3	19-26
Multi-unit	21-32	17.1-23.1	0.136	1.6-5.4	15-81
Group2: Mechanical ventilation, waste heat recovery and control, plus improved insulation and windows:					
Townhouse	68-75	148	0.158	6.3-7.7	42-45
Multi-unit	63-77	75.9-98	0.1-0.144	4.6-6.7	76-130

Simple Payback = (Average Cost of Energy Consumption – Given Cost of Energy consumption) / Incremental Construction Cost **(1)**

- using the national cost of electricity as the base (0.18 – 0.2088 zł/kWh – depending on year of analysis).

$$CCE = (\Delta \text{ Cost} / \Delta \text{ Energy}) * (\text{discount rate} / (1- (1+ \text{discount rate})^{-n})) \quad \textbf{(2)}$$

- discount rate = 0.12, and n = 50 years.

We can measure success of main goals of the project by two indicators of achievement: the quality of experience and the scale of it. The quality of experience means effectiveness of dissemination of technical and organisational solutions, while the scale of the programme means recorded repeatability of implemented ways of development countrywide. Taking this definition as a basis we can conclude that the EE project did not perform in a predicted way. The programme did not attempt directly to help investors to overcome the barrier of higher initial cost, but their willingness to pay (WTP) was enforced by expected refunding despite the risk that they would not comply with the final requirements of the detailed procedure due in time and not known technology. GEF building component project is over, and the monitoring process of real effects is now conducted.

Publications/ references: R. Benssamoud, J. Deringer, G. Dyduch, A. Panek, Sustainable Housing in Poland, World Bank Seminar of Polish GEF project, Washington 2000.

5.1.3 European Green Cities Network

Goal: The EGCN goal is accelerating the development towards sustainable urban housing by achieving two main objectives

- to speed up innovation and
- to stimulate market development.

Project organisation: The EGCN is a Fifth Framework project managed by Green Cities Network located in Denmark, with participants from Denmark, Belgium, France, Italy, Greece Austria and Germany which has been extended by three NAS countries: Poland, Hungary and Czech, based on the Accompanying Measures on a professional campaign for Green Cities minimum energy and environmental standards concerning performance and quality requirements for best available technologies. Goal: In the existing EGCN, these objectives are achieved through the following four mutual supporting project parts:

- Network secretariat to optimise a continuous dissemination of new developed technologies and experiences within European sustainable housing projects.
- Sustainable urban housing conferences, focusing on new technologies and latest best technologies within the EU target actions
- Green Financing to increase activities and market opportunities in sustainable urban housing
- Training courses for key actors in the housing sector, to achieve better understanding and communication of the principles of sustainable urban housing.

NAS partners are involved in all four project areas in order to exchange experiences and methodology for a new, enlarged EU with high technological standards and common standards.

The solutions provided for efficient space heating, cooling, ventilation, lighting systems, domestic appliances, and integration of renewable into buildings, etc. are continuously being improved, however the improvements do not always reach full market effect why there is an urgent need to emphasise demonstration, dissemination and development of the latest technologies to both the supply and demand side of the market for sustainable urban housing. If the current level of information could be lifted into the mass market, obvious socio-economic gains are awaiting and a substantial amount of energy can be saved. Especially in NAS partner countries there is a great potential for technology transfer and substantial awareness lift as well as social and community gains for a new enlarged EU.

Project duration: 2002-2004

Financing: Funds for project execution are provided from the 5th Framework Programme which covers 90% of the project costs.

Results: The project aims to create a common network for EU and associated countries that will contribute to an accelerated development towards sustainable urban housing. The project work falls into three mutual supporting work groups:

1. European Best Practice – Dissemination for giving inspiration and continuously dissemination of new developed technologies and experiences within European sustainable housing projects. It will be a platform for transfer of technology from EU to NAS partner countries and a unique opportunity for both to develop and adapt social and technological solutions for a new enlarged Europe.
2. Sustainable Urban Housing Conferences. The NAS partners will arrange two conferences related to the existing EGCN RTD groups on:

a) Building integrated solar energy technologies and advanced energy efficient glazing

b) Healthy/emission free building materials and energy efficient ventilation systems

c) Renewable energy integrated energy supply for heating /cooling at building /district level

The NAS conferences will be adapted to the specific market/country conditions.

3. Training Course on Sustainable Energy Management. Based on initial study tour to selected EGCN demonstration projects and partners and the evaluation of existing EGCN training modules, the NAS partners will design own training for key persons from city authorities, utilities, builders, contractors, consultants, manufactures, service partners, etc. in order to ensure good management and comprehension of various technological alternatives and their consequences.

Publications/ references: Web site of EGCN www.greencity.dk provides updated information on project development

5.1.4 Demohouse STREP

Goal: The aim of the project is to develop minimum standards and recommendations in connection to healthy, cost effective, energy efficient and sustainable rehabilitation and to agree on actual quality agreements in this field. It is here the intention to realise a common action that can make a real difference in Europe. It is aimed in the project to initiate important quality oriented R&D and demonstration activities concerning eco-rehabilitation and best available retrofitting techniques on a European scale by initiating R&D activities, which will later be tested in connection to real renovation projects. In fact, these are "full size prototype" tests, which can be monitored in a realistic environment and improved before the developed technologies are implemented on a larger scale.

Project organisation: It is a Sixth Framework project (accepted in October 2003) which uses the STREP mechanism with 19 participants from 9 countries, among them are two Polish entities. Polish project is focused on model rehabilitation of multi-residential building. The project leader is Dutch Energy Research Centre of the Netherlands ECN. Per participating country a Pilot project and a Reference project will be defined. The Pilot project will be the actual demonstration project, where the recommendations of the investigations and research will be implemented. The Reference project is a housing complex that has recently been renovated (or which is in the process of renovation) according to the usual local standards.

Duration: The project starts in the mid of 2004 and lasts for 3 years

Financing: 6th Framework Programme finances up to 35% of extra measures costs, remaining funds will be provided by investors/participants in the project.

Results: The selected complexes will be analysed on possibilities for improving the performance. Based on the state of the art within and outside the country concerned, solutions will be proposed. New solutions will be developed for the Pilot projects if existing solutions are not applicable. The selected solutions will be implemented in the Pilot projects. Also new management approaches and new financing models will be developed and demonstrated. These management approaches should assess the sustainability aspect of future maintenance measures, whilst new financing models will help to ease implementation of energy efficiency measures in renovation processes.

Publications/ references: As the project is in early stage of development the only references available are unpublished documents distributed by the leader of the project (www.ecn.nl) searching for partners Europe wide.

5.1.5 SARA Integrated Project

Goal: SARA Sustainable Architecture Applied to Replicable Public-Access Buildings project aims to construct sustainable, cost effective, high energy performance, public-access eco-buildings that are immediately replicable at a large scale in many locations. The eco-buildings will be equipped with advanced sustainable energy technologies integrated by an innovative architectural approach and combined monitoring and building management systems, BMS. Given that public-access buildings tend to have relatively intense energy consumption the overall impact in terms of absolute energy savings and pollution reduction will be particularly significant.

Project organisation: SARA is a 6th Framework integrated project (accepted in October 2003) it involves the demonstration of 8 highly sustainable and replicable Public-access buildings in 5 EC Member States (A, E, F, I, UK), 2 EC Candidate countries (PL, Sl) and 1 New Independent State (UZ). There are 16 participants in the project: the promoters and research organisations of the countries involved in the 8 countries of demonstration plus research and technical development (RTD) from Germany. The project leader is Spanish University of Barcelona. In order to obtain efficient integration, demonstration is focussed locally with horizontal transfer of knowledge between eco-buildings provided by a expert advice team. Other concentrated teams of participants will work in parallel on specific RTD issues related to integration of BMS, remote monitoring, internet based dissemination, socio-economics studies and training so as to exploit synergies of all aspects of the project.

Duration: The project starts in the mid of 2004 and lasts for 4 years

Financing: 6th Framework Programme finances up to 35% of extra measures costs, remaining funds will be provided by investors/participants in the project. The R&D part is financed by the Commission in different levels.

Results: The key aspects of the project are public-access, innovative yet cost effective and replicable results, consideration of end users and an interdisciplinary team working on various RTD activities. These aspects, applied across various climatic regions will produce large scale social, urban and environmental benefits. The project will therefore contribute to future development of European energy policy and legislation that will accelerate market penetration of innovative sustainable technologies.

Publications/ references: As the project is on early stage of development the only references available are unpublished documents distributed by the leader of the project (www.pcb.ub.es) searching for partners Europe wide.

5.1.6 SUBURET Integrated Project

Goal: SUBURET Advanced Concepts for Sustainable Building Retrofit project aims are:

adaptation of.

- Goals: a set of advanced technologies available for new buildings (e.g. such as for Passive Houses) for the needs of building retrofit.
- availability of advanced technologies in all participating countries.
- proof that the energy efficiency of existing buildings can come close to that of new energy efficient buildings.

The background of this concept is that:

- Sustainable development can only be achieved if the energy demand and environmental impact of the existing building stock is reduced by a factor 5 to 10.
- Every building renovation without adequate energy saving retrofit measures is a waste of money and a lost opportunity for many years.
- First demonstration project have proven that such an ambitious goal can be achieved.

Project organisation: SUBURET (under the negotiation with EC, October 2003) is a Sixth Framework Integrated Project with Polish participation among 8 European countries. Project leader is EMPA (Swiss Federal Laboratories for Material Testing and Research).

Duration: Project starts in the mid of 2004 and lasts for 3 years

Financing: The 6th Framework Programme finances up to 35% of extra measures costs, remaining funds will be provided by investors/participants in the project. The R&D part is financed by the Commission in different levels.

Results: Promotion of advanced retrofit technologies especially focussed on housing and office buildings SUBURET will offer a set of advanced retrofit measures, which allow future oriented building retrofit step by step or as a full package. It will focus on a set of well evaluated and internationally available advanced retrofit technologies. It is based on the extensive European experience with Passive Houses and aims to provide this technology also for building renovation.

Publications/ references:

As the project is on early stage of development the only references available are unpublished documents distributed by the leader of the project (www.empa.ch) searching for partners Europe wide.

5.1.7 GREEN Catalogue (Global Renewable Energy Efficient Neighbourhoods)

Goal: The idea of the project is to define a status for approximately best practice technologies and then to agree on which indicators are important to be able to check the quality of the technologies. Among the technologies considered in the project there are: insulation, energy efficient windows, heat recovery ventilation,, solar DHW construction, PV-installations, biomass heating system , heat pumps, CHP, water savings, and others. All together there are 25 different technologies. It is intended to let a working group of experienced partners concerning practical use of RUE and RES in buildings receive a feedback concerning this from 180-200 producers, builders, cities, offices, and energy companies. It is aimed that at least two producers of each of the best practice technologies will give an input to the project. As a whole it is aimed that at least 20 organisations from each country will give an input to the project, an input that at the same time will ensure that they will have influence in the results. The proposed work will be very relevant in connection to the common EU building directive where a common methodology will be introduced, e.g. for buildings regulations in the EU countries. In the "Green Catalogue" differently quality levels are introduced for a large number of best practice technologies and these can that in connection to the new building regulation be used as input for implementation and creation of a market for energy efficient buildings.

Duration: Project started in the mid of November 2002 and will be executed up to 2004

Financing: SAVE programme finances up to 50% of project costs, remaining part have to be provided by participants.

Project organisation: Green Catalogue is the SAVE project accepted in November 2002 with 10 participants from 9 countries working on the catalogue/manual with a definition of performance indicators and performance requirements/recommendations for best practice technologies in the area of Rational Use of Energy (RUE) and renewable Energy Systems (RES) in buildings.

Results: The Green Catalogue approach will make possible to ensure a quality-oriented implementation of building projects with best practice technologies, and it is the idea that it will be a useful supplement to already development tolls. The work on the Green Catalogue project can be also seen as an effort that builds on the result The target groups of the Green Catalogue projects are: decision makers in the building industry producers of RUE and RES best practice technologies, builders like housing associations, developers, contractors, utilities and energy auditors, architects and engineers.

Publications/ references: Information about project development is available on a site www.nape.pl/gc/ (in Polish) or www.salzburg.gv.at/prn/themen/bw/sir_haupt/sir_whonen.

5.1.8 Solar Regions

Goal: The main idea is to present a project where authorities, builders and energy specialists from the Copenhagen regions are working with the similar professionals from Piemonte and Poland to obtain an opportunity of having optimised solar designs and new developed low electricity ventilation technologies, with a very low electricity consumption, and introduced it into practice.

Project organisation: It is 5th Framework Programme, referring to the "Energy, Environment and Sustainable development" theme. The full name of the project is "Optimised Solar heating and Ventilation Design in Copenhagen, Piemonte and Poland". The aim of the project is demonstration, how to optimise use of innovative solar energy technologies together with energy savings and optimised energy supply for different types of buildings.

Duration: Project started in 1999 and ended in 2003

Financing: V th Framework Programme finances up Goal: to 35% of extra measures costs, remaining funds are provided by investors/participants in the project. The R&D part was financed by the Commission on different levels.

Results: In the Green Solar Regions project the guidelines presenting best available European practises for new-build areas concerning energy efficient, sustainable building with integration of solar energy design have been developed. The project encompassed local demonstration of best available solar low-energy technologies in the Copenhagen region in Denmark, the Piemonte in Italy and Rawicz and Piaseczno in Poland. Polish project consist of the two installations:

- solar collectors for hot water preparation in Hospital in Rawicz (204 m2 of collectors)
- heat recovery ventilation system supplied from PVP in a new building of Secondary School in Piaseczno the suburbs of Warsaw.

Publications/ references: Information about project development is available on a site www.greencity.dk.

5.2 Projects and activities in Norway

The outlays for R&D reach approx. 1.67 % of GNP. The building and construction sector are assumed to have a lower outlay.

The Norwegian Research Council have for the last five years reduced the budgets for research within this sector. Today (2003) very small funding goes to building research from the government. Moore governmental grants are canalized through the EU- commission. The industry does some research for their own interest; but sustainable- and environmental issues are difficult to get financed through the industry alone. First we describe research organisations and foundations, programmes and projects. .

5.2.1 The Grip- centre (Grip- senter) and EcoBuild Programme (Økobygg)

GRIP - the foundation for sustainable production and consumption - was founded by the Norwegian Ministry of the Environment. The foundation is an agent for promoting an environmental policy dedicated to the furtherance of sustainable production and consumption. GRIP takes its basis in the realities of the industries and cooperates with these.

Financing: The basic financing of GRIP is provided by the Ministry of the Environment. A large part of the project financing is contributed by the companies participating in projects.

GRIP works primarily with industries that are not traditionally considered to be polluting in a legal sense, but that do have an impact on the environment through the consumption of goods, chemicals and energy, transport and refuse.

WWW: GRIP centre

GRIP has two programmes with focus on the building sector: Eco-Build and Ecodesign.

The Grip-center runs the secretariat of Økobygg. See also chapter 2, state of the art for school-buildings.

Økobygg puts focus on schools with the goal to reduce energy use and improve indoor air quality.

In the period 1998 – 2002 the construction industry and the government founded the research programme Økobygg (ECOBuild), The programme intended to increase eco-efficiency in the Norwegian building- and real estate sector. The industry itself took in 1997 the initiative to establish the programme in order to co-ordinate increasing environmental activities.

Funding has been split evenly between the industry and government (four different ministries). The total budget was 20 million Euro. The programme has focused on solutions for:

- energy efficiency
- material efficiency
- waste
- hazardous chemicals
- indoor air quality

Reports/ references:

Some reports and newsletters are produced and distributed and are available at http:/www.okbygg.no.

5.2.2 Research Project "Smart Energy Efficient Buildings"

Goal and description: Multi-disciplinary project that focuses on the integration of building energy systems, the building itself, and it's users. It combines the knowledge of architects, engineers and social science researchers. 12 state-of-the-art reports within each the project sub-tasks have been completed ("The users and the Environment", "Environmental Criteria", "Indoor Environment", "Implementation Strategies", "Integrated Design", "Building Integrated Energy Systems", "Lighting Systems", "Photovoltaic Systems", "Heating, Cooling and Ventilation Systems", "Heat Pumps", "Operation and Automation", and "Storage").

Duration: 2003-2006

Financing: The project is financed by the Norwegian Research Council, NTNU and Norwegian industry. Budget: 25 mill NOK

5.2.3 Research Project: "Optimization of solar energy use in large buildings"

Goal and description: A research project within the Solar Heating and Cooling (SHC) programme of the International Energy Agency. The project focused its work on exploring the nature of the Integrated Design Process (IDP), an approach and design procedure that has proven to be highly effective in producing high-performance and environmentally-friendly buildings. The work in the Task focuses primarily on commercial and institutional buildings. In particular, office buildings and educational buildings are addressed. The primary results of the work are guidelines, methods, and tools for use by building designers in the early stages of design. The Task also includes demonstration buildings, as such buildings both provide an opportunity to test the design tools developed, and as they provide an effective way of demonstrating the integration of solar technologies in real buildings

Duration: 1996-2002

Financing: 2.5 mill NOK

Reference: http://www.iea-shc.org/task23/index.html

6. REDEVELOPMENT TECHNOLOGIES AND PROCESSES

The purpose of this chapter is to provide an overview of design strategies and technologies from which some may be selected for use in the redevelopment of buildings in Poland.

Chapter 6.1 gives a description of the recommended general design approach to be used for sustainable redevelopment of buildings.

Chapter 6.2 provides a list of possible technologies and strategies for sustainable redevelopment of buildings. This is meant as a menu to choose from when working on the design of a particular building project.

Chapter 6.3 gives a description of a general design process strategy for sustainable re-developments of buildings.

6.1 General Design Approach for Sustainable Redevelopment of Buildings

To really take on the challenge of moving towards sustainable development, building developers and designers need to produce buildings with a markedly higher level of environmental performance. Although various experts have somewhat different interpretations, a consensus view is that such buildings must achieve measurably high performance, over the full life-cycle, in the following areas:

- Minimal use of non-renewable resources, including land, water, materials and fossil fuels;
- Minimal atmospheric emissions related to global warming and acidification;
- Minimal liquid effluents and solid wastes;
- Minimal negative impacts on site ecosystems;
- Maximum quality of indoor environment, in the areas of air quality, thermal regime, illumination, and acoustics/noise.

Some authorities in this rapidly developing field would add related issues such as adaptability, flexibility, and operating cost as well as life-cycle cost. In addition to a new breadth of performance issues to be addressed, contemporary developers and designers are faced with more stringent performance requirements being imposed by markets or regulation, or both. Chief amongst these, however, is energy performance. This poses a definite challenge to designers, in terms of reducing purchased energy use and in the application of renewable technologies, all within the constraints of minimal fees and the time pressure of the modern development process.

Any design strategy that aim to include issues of sustainable development should therefore focus on minimizing the energy use through the life cycle of the building. For existing buildings, the energy use for operation is by far the largest. In aiming to reduce the consumption we recommend to use the “trias energetica” strategy for design. This strategy emphasizes the need to first reduce the energy needs through the use passive energy efficiency strategies, then utilize renewable energy resources, and lastly supply remaining demand with clean fossil fuels, e.g. bio and gas without CO_2.

The “trias energetica” methodology includes the following stepwise energy strategy for design:

1) Energy conservation and efficiency i.e. use of space and materials, envelope insulation and better glazing.

2a) Building integrated renewable energy strategies, i.e. passive solar systems

2b) Active renewable energy technologies, i.e. solar thermal systems, heat pumps and photovoltaics

3) Auxiliary energy systems based on clean use of fossil fuels

Such a strategy may also be used for environmental design in general. Based on the principle of first reducing, then reusing, and at last recycling, this strategy ensures that the most robust and environmentally sound solutions are prioritized.

6.2 Technologies and Strategies for Sustainable Redevelopment of Buildings

6.2.1 Technologies and strategies for effective space and water heating

- Energy saving technologies at envelope:
    - Air-tightness (low infiltration)
    - Effective insulation avoiding thermal bridges
    - Transparent insulation materials
    - Insulating glazing
    - Solar walls
    - Double facades
- Heat production technologies:
    - Point heaters (e.g. stoves) based on renewable energy sources (biomass)
    - Central heating systems based on renewable energy sources (solar, biomass, waste, heat pumps[1], geothermal)
    - District heating systems based on renewable energy sources (solar, biomass, waste, heat pumps[1], geothermal)
- Heat distribution strategies:
    - Demand control systems (based on occupancy, temperatures, weather forecasts, etc.)
    - Well insulated distribution system (i.e. pipes) with low pressure drops and efficient heat dissipation.

6.2.2 Technologies and strategies for effective heat storage

- Short term storage:
    - Water tanks
    - Rock filled storages with air circulation
    - Phase change materials
    - Thermochemical storage
- Seasonal storage:
    - Aquifer
    - Boreholes
    - Cavern
    - Ducts
    - Pit

6.2.3 Technologies and strategies for effective space cooling

- Passive strategies:
    - Reduction of internal heat loads, i.e. efficient lights and equipment, lighting control
    - Shading systems

[1] Heat pumps should use refrigerants with low ozone depletion potential (ODP) and low Global Warming Potential (GWP)

- Switchable glazing
- Hybrid technologies:
    - Cooling by ventilation using thermal mass
    - Ground-air heat exchangers
- Active technologies:
    - Heat pumps[1]
- Distribution strategies:
    - Demand control systems (based on occupancy, temperatures, weather forecasts, etc.)
    - Efficient distribution system (i.e. pipes) with low pressure drops and efficient dissipation.

6.2.4 Technologies and strategies for effective ventilation

- Passive strategies:
    - Building materials with low emission of VOC and particles
    - Solutions that are easy to keep clean
- Hybrid strategies:
    - Natural/hybrid ventilation systems
- Heat recuperation technologies:
    - Systems with heat recovery from exhaust air
    - Ground-air heat exchangers
    - Preheating of outside in cold periods using waste heat
- Distribution strategies:
    - Demand-controlled ventilation systems (based on occupancy, CO2, temperature, relative humidity)
    - Efficient air distribution in room (e.g. displacement ventilation)
    - Fans with low SFP (specific fan power)
    - Air ducts with low pressure drops

6.2.5 Technologies and strategies for effective artificial lighting

- Light sources:
    - Fluorescent linear lamps
    - Compact fluorescent lamps
    - Metal halide lamps
- Ballasts:
    - Energy-saving ballasts
    - Electronic ballasts
- Luminaires:
    - Luminaire for linear lamps
    - Downlights for compact lamps
    - Wall mounted and free – standing luminaires

- Lighting control:
  - Switching control
  - Dimming control
  - Local control
  - Central control

6.2.6 Technologies and strategies for effective daylighting

- Systems with shading
  - Systems that rely primarily on diffuse skylight and reject sunlight
  - Systems that primarily use direct sunlight, sending in onto the ceiling or to locations above eye height
- Systems without shading
  - Diffuse light-guiding systems
  - Direct light-guiding systems
  - Light-scattering or diffusing systems
  - Light transport systems

6.2.7 Other technologies and strategies for sustainable re-development of buildings

- Energy-efficient appliances
- Water saving devices
- High efficiency lifts
- Combined heat and power systems
- Photovoltaics
- Wind mills
- Building materials with low environmental impact during life cycle (low-emissions, re-cycling, re-use, etc.)
- Solid waste recycling systems
- Waste water treatment systems
- Devices that display the environmental status of the building to its users
- Green outdoor spaces

6.3 Effective Design Process

Within the project "IEA Task 23: Optimization of solar energy use in large buildings" (http://www.iea-shc.org/task23/index.html), a description of an effective process for achieving low energy and environmentally sound buildings has been produced. This process is called the Integrated Design Process (IDP). The Integrated Design Process is based on the well-proven observation that changes and improvements in the design process are relatively easy to make at the beginning of the process, but become increasingly difficult and disruptive as the process unfolds. Changes or improvements to a building design when the construction work is being carried out, or even contract documents are in the process of being prepared, are likely to be very costly, extremely disruptive to the process, and are also likely to results in only modest gains in performance. In fact, this observation is applicable to a large number of processes beyond the building sector.

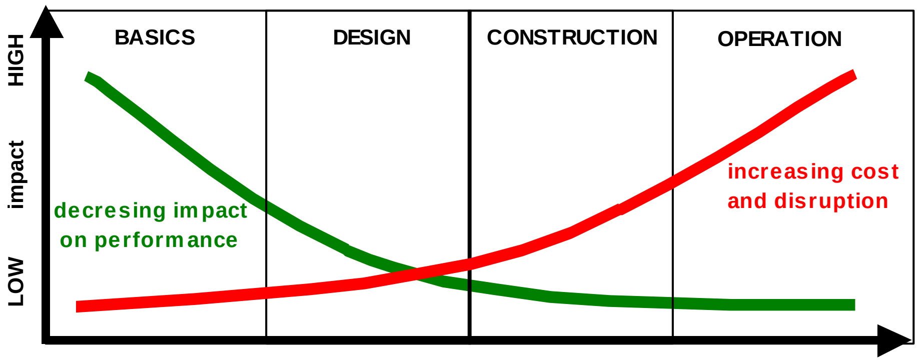


Figure 6.1 Diagram by Solidar, Berlin, Germany.

Although these observations are hardly novel, it is a fact that most clients and designers have not followed up on their implications. The Integrated Design Process includes some typical elements that are related to integration:

- Inter-disciplinary work between architects, engineers, costing specialists, operations people, and other relevant actors right from the beginning of the design process;
  - Discussion of the relative importance of various performance issues and the establishment of a consensus on this matter between client and designers;
  - Budget restrictions applied at the whole-building level, with no strict separation of budgets for individual building systems, such as HVAC or the building structure. (This reflects the experience that extra expenditures for one system, e.g. for solar shading devices, may reduce costs in other systems, e.g. capital and operating costs for a cooling system.)
  - The addition of a specialist in the field of energy, comfort, or sustainability;
  - The testing of various design assumptions through the use of energy simulations throughout the process, to provide relatively objective information on this key aspect of performance;
  - The addition of subject specialists (e.g. for daylighting, thermal storage etc.) for short consultations with the design team;
  - A clear articulation of performance targets and strategies, to be updated throughout the process by the design team;
  - In some cases, a Design Facilitator may be added to the team, to raise performance issues throughout the process and to bring specialized knowledge to the table.

Based on experience in Europe and North America, the overall characteristic of an Integrated Design Process is the fact that it consists of a series of design loops per stage of the design process, separated by transitions with decisions about milestones. In each of the design loops the design team members relevant for that stage participate in the process.

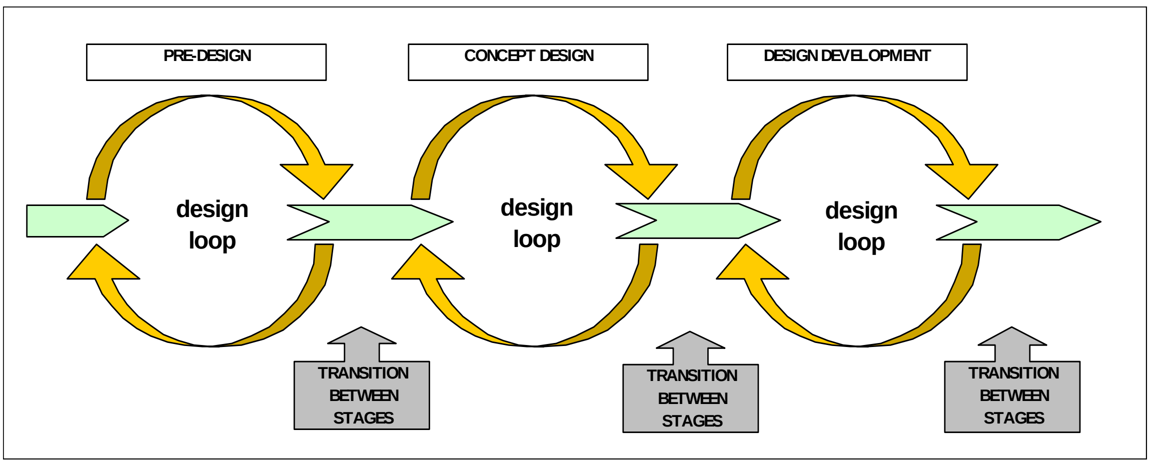


Figure 6.2 Diagram by Solidar, Berlin, Germany

The design process itself emphasizes the following sequence:

- First establish performance targets for a broad range of parameters, and develop preliminary strategies to achieve these targets. This sounds obvious, but in the context of an integrated design team approach it can bring engineering skills and perspectives to bear at the concept design stage, thereby helping the owner and architect to avoid becoming committed to a sub-optimal design solution;
- Then minimize heating and cooling loads and maximize daylighting potential through orientation, building configuration, an efficient building envelope, and careful consideration of amount, type, and location of fenestration;
- Meet these loads through the maximum use of solar and other renewable technologies and the use of efficient HVAC systems, while maintaining performance targets for indoor air quality, thermal comfort, illumination levels and quality, and noise control;
- Iterate the process to produce at least two, and preferably three, concept design alternatives, using energy simulations as a test of progress, and then select the most promising of these for further development.

As an example a more detailed description of the design loop during the concept design phase is pictured below. The central issue in this phase is to define systems in a conceptual way, based on the structure/scheme of the building. In a loop several options are considered, paying attention to the integration in the building as a whole, not just restricted to the technical aspects.

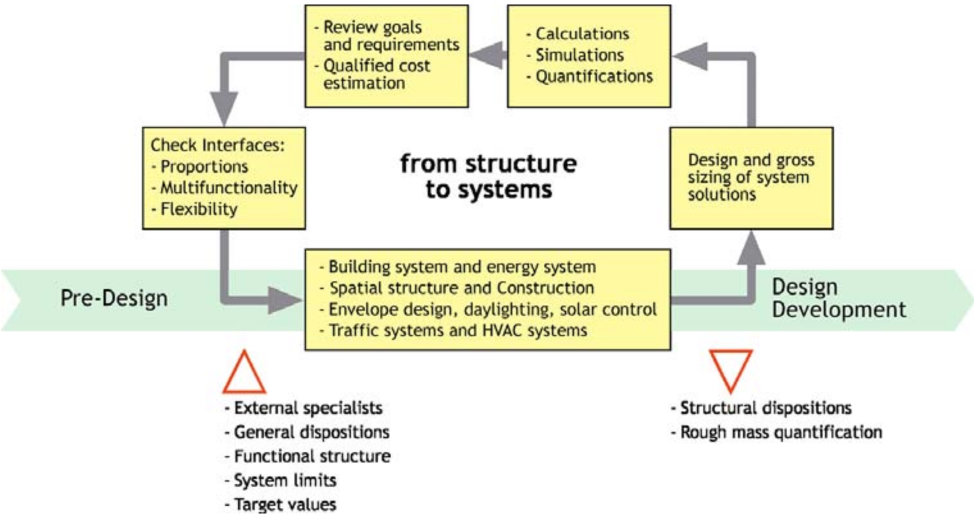


Figure 6.3 The Integrated Design Process in the Concept Design Phase. Diagram by Solidar, Berlin, Germany.

The Integrated Design Process contains no elements that are radically new, but integrates well-proven approaches into a systematic total process. The skills and experience of mechanical and electrical engineers, and those of more specialized consultants, can be integrated at the concept design level from the very beginning of the design process. When carried out in a spirit of co-operation amongst key actors, this results in a design that is highly efficient with minimal, and sometimes zero, incremental capital costs, along with reduced long-term operating and maintenance costs. The benefits of the Integrated Design Process are not limited to the improvement of environmental performance. The experience of Task 23 participants is that the open inter-disciplinary discussion and synergistic approach will often lead to improvements in the functional program, in the selection of structural systems, and in architectural expression.

The Integrated Design Process has impacts on the design team that differentiates it from a conventional design process in several respects. The client takes a more active role than usual, the architect becomes a team leader rather than the sole form-giver, and the mechanical and electrical engineers take on active roles at early design stages. The team should always include an energy specialist, and in some cases, an independent Design Facilitator.

7. CRITERIA FOR CHOICE OF PROJECT CASE STUDY

The technologies and processes to be developed within the framework of the SURE-BUILD project will be tested and demonstrated in case study buildings. Full-scale experiments in real buildings are themselves very time consuming, as planning, construction, and monitoring normally require more time than a regular construction project. It is therefore important to prepare this part of the project work in parallel with the theoretical R&D work right from the start.

The category of buildings used for project case study should meet a long range of requirements, discussed in detail below, the main criteria of course being that case studies should be instrumental in furthering the main objectives of the project.

7.1 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 places important restrictions on the choice of case buildings, as they should in principle be adaptable to test all types of technologies to be developed. This again implies that the case buildings should encompass all types of energy using equipment and energy systems normally found in buildings. Since the project is also focusing on integrated systems, this is also an argument for case buildings with comprehensive technical facilities. Therefore, dwellings are not an obvious case, but rather buildings with work spaces requiring optimal conditions for productivity. Because of the bilateral nature of the project, the case buildings should also encompass the same menu of technological solutions, both in Norway and Poland.

7.2 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. The type of building chosen should, for the same reason, also be typical for other categories of buildings.

7.3 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. The major policy item here would be to further sustainability, as this is currently very high on the political agenda all over Europe.

7.4 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. Since the project is publicly financed, this would be an argument for choosing case study buildings in public ownership. Public buildings are also as a rule more accessible to the general public, giving the project more visibility and our ideas a wider audience. In any case, the owners should be very motivated for improving their facilities in a sustainable manner.

7.5 Existing R&D work and development programs

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. This must of course be balanced against the remaining need for work – if most opportunities have already been exhausted, the potential for improvements are small. The best situation would be if there is available a large amount of relevant R&D results which we can exploit, but these results have not to any wider degree been implemented in the class of case buildings chosen. However, from our inventory listed in chapter 3, there seem to be

7.5 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. This could include designing for new activities, better adaptation to different user-requirements, more pleasing aesthetics and better architectural quality, and better functional flexibility.

7.5 Costs

It is important to find a class of buildings were major improvements can be introduced in a cost-effective manner. Since the relationship between energy costs, materials and components, and labour costs may be different in the two countries, it is important to analyse cost-effectiveness with Polish conditions in mind. Both private and public owners are in general looking for the solutions with the best cost-benefit ratio, but the willingness to pay for more marginal improvements may be higher in the private sector, given that these measures have the potential to give better visibility for the project.

7.6 Conclusion

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. Our arguments for this choice are as follows:

Technological opportunities

School buildings have in general a large person-load per m2, implying a large ventilation requirement. They are mainly used during daylight hours, making scheduling of energy systems, including lighting, an obvious opportunity. Some schools also have a substantial water heating demand through gymnasium and swimming pool. Therefore, it seems that schools do offer many opportunities for implementation of new energy technologies.

Energy saving potential

A special opportunity for using school buildings as a case study category is available in Poland: 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 with 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 lessons learned in school buildings should also be transferable to other types of buildings.

National and local policy

In Norway, the upgrading needs of the public schools has for some time been on the political agenda. A scheme for financing will most likely be available to the local communities soon. Sustainable redevelopment is very much within the public focus. Also in Poland, the need for redevelopment of the schools has been recognized.

Ownership and public impact

The users of our school buildings are the future consumers of energy and other resources. By designing the redevelopment measures in a manner that make them accessible as a teaching tool, the project will have an impact far into the future. The implication is of course that young people may accept new ideas more readily than the older folks, and bring the project ideas into their future lives. The energy systems implemented could be monitored as part of the school curriculum in relevant subjects, such as physics, natural sciences, and environmental challenges.

The school building is also something that most people remember through their life as an important reference. In many local communities, the school building has many other important public and social functions than education. With sustainability demonstrations available in the school building, it will be easier to make an impact on the general public through parents.

Existing R&D work and development programs

Some R&D projects for existing school buildings have already been carried out within the European framework, Norway has participated in some of these.

Architectural and functional considerations

In both countries, the school buildings have become more and more an arena for many other functions besides education: lectures, community meetings, elections, exhibitions, extension courses etc. Therefore, existing school buildings of some age will need much adoption to be able to cope with the new demands, clearly an architectural challenge.

Costs

Since school buildings are constructed and operated on local community budgets, only low cost redevelopment efforts with a high degree of cost-effectiveness can be expected to be implemented. The hope is that the central governments in both countries will be willing finance such measures through national programmes

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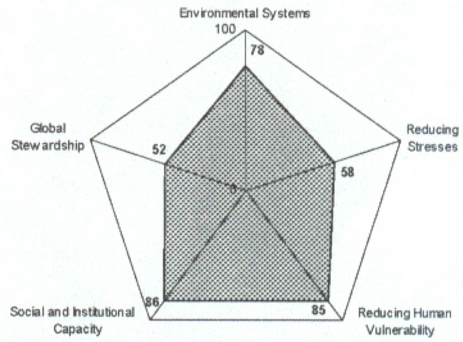
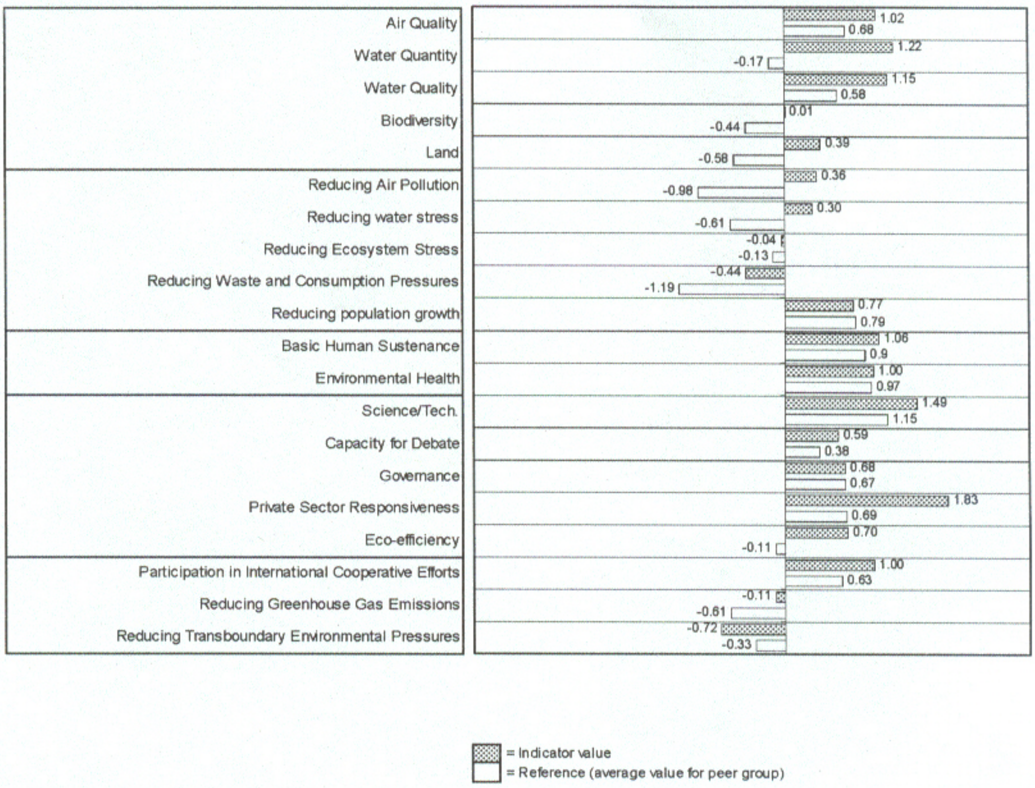
APPENDIX TO CHAPTER 2

Norway

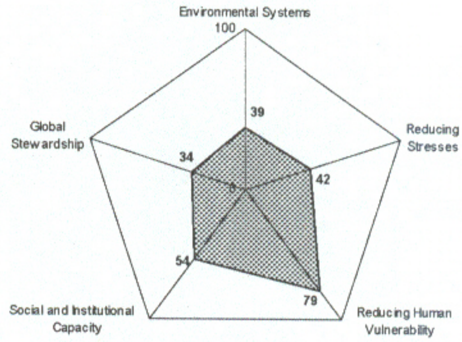
ESI:	73.0
Ranking:	2
GDP/Capita:	$27,864
Peer group ESI:	54.5
Variable coverage (out of 68):	64
Missing variables imputed:	3

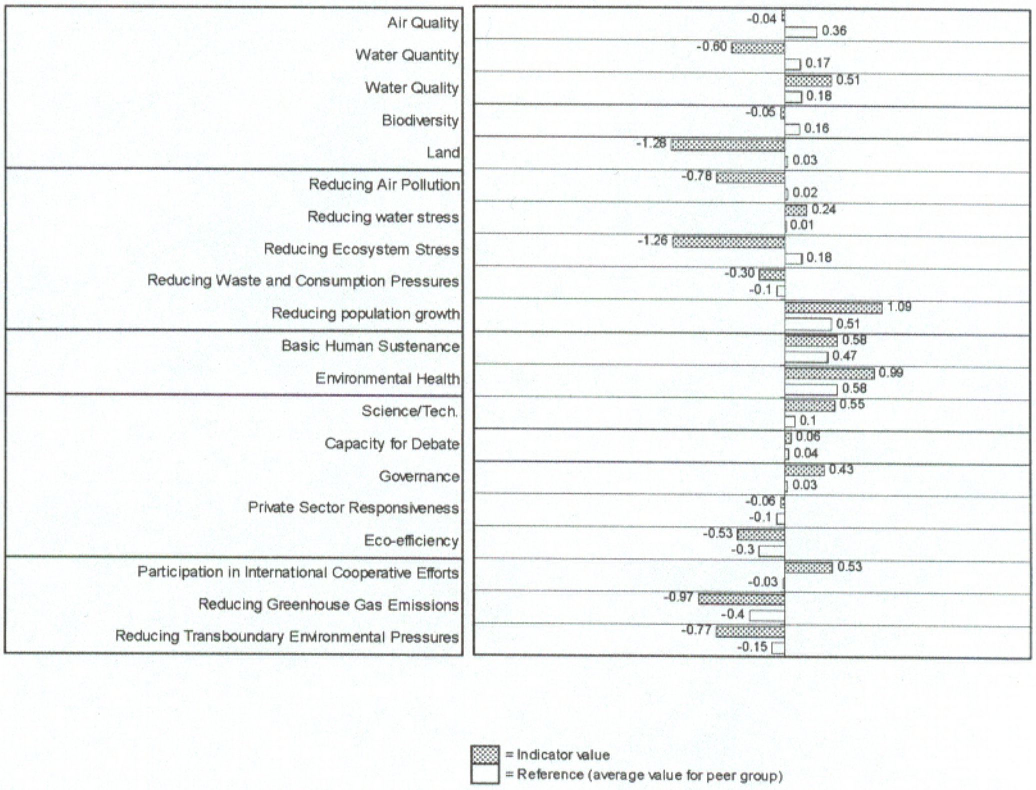




Poland

ESI:	46.7
Ranking:	87
GDP/Capita:	$8,006
Peer group ESI:	53.5
Variable coverage (out of 68):	63
Missing variables imputed:	2





APPENDIX TO CHAPTER 4. REQUIREMENTS FOR NEW BUILDINGS AND RETROFITTED BUILDINGS

A4.1. Polish requirements for energy efficiency

A4.1.1. Energy standards

Currently the thermal insulation requirements for buildings are regulated by the ordinance of the Minister of Infrastructure on technical criteria to be met by built structures and their localisation (2002).

In case of a multi-family building or a collective residential building, the energy conservation requirements are fulfilled, if the value of the *E* factor, representing the computational demand for heat consumed by the building during the heating season is smaller than the upper limit value E_0.

For a residential single-family house the energy conservation requirements are fulfilled, if:

- the *E* factor value is smaller than the upper limit value E_0, or
- the external walls meet the requirements of thermal insulation and other energy-saving requirements, specified in the annex to the resolution

For a public utility building the energy conservation requirements are fulfilled, if the external walls meet the requirements of thermal insulation and other energy-saving requirements, specified in the annex to the resolution

The required values E_0 of the building seasonal heat demand factor depend on the building shape ratio *A/V*, and for residential and collective residence buildings amount to:

- E_0 = 29 kW·h/(m^3·a) for $A/V \leq 0.20$,

- E_0 = 26.6 + 12 *A/V* kW·h/(m^3·a), for $0.20 < A/V < 0.90$,

- E_0 = 37.4 kW·h/(m^3·a), for $A/V \geq 0.90$,

where:

A – is the total surface area of all outer walls (including windows and balcony doors), roofs and floor-roofs, floors on ground, floors above unheated basements, floors above passages, which separate the building's heated section from ambient air, as measured along outer boundaries;

V – is the cubic capacity of the building's heated section, computed according to the relevant Polish Standard, which sets out the procedures to compute the building's cubic capacity.

A4.1.2 Requirements for heat insulation of walls and floors on the ground

The heat transmission factor *U* for walls, floors and floor-roofs, computed in accordance with the Polish Norm, must not be greater than U_{max} values, specified in table A4.1 for single family residential buildings, in table A4.2 for multi-family building and in table A4.3 for public utility buildings.

The heat transmission coefficient values (*U*) for windows, balcony doors and exterior doors must not be greater than U_{max} values specified in table A4.4 (residential buildings) and table A4.5 (public utility buildings). The minimum heat resistance values for floors laid on ground are presented in table A4.6.

Table A4.1. Maximum heat transmission factor values for external walls, walls of unheated basements, floors and floor-roofs, for single family residential buildings

	Type of walls and internal temperature of rooms	U_{max} W/(m^2·K)
1	2	3
1	External walls: a) at $t_i > 16^oC$: - multilayer* with insulation material (heat conduction coefficient) $\lambda \leq 0.05$ W/(m. K) - other b) at $t_i \leq 16^oC$ (for each type of wall)	 0.30 0.50 0.80
2	Walls of unheated basements	without requirements
3	Floor and floor-roofs under unheated attics or over passages: a) at $t_i > 16^oC$ b) at $8^oC < t_i \leq 16^oC$	 0.30 0.50
4	Floors over unheated and closed under-floor spaces	0.60
5	Floors over heated basements	without requirements
6	Internal walls between heated and unheated rooms	1.00

t_i – computed temperature in rooms according to PN

* - internal and external plaster non considered as a layer

Table A4.2. Maximum heat transfer coefficient for walls for multi family houses

No	Type of walls	U_{max}, W/(m^2·K)
1	2	3
1	Interior walls between heat spaces and staircases or corridors	3.00*)
2	Walls adjacent to expansion gap of width : a) up to 5 cm, permanently closed and filled with thermal insulation for a depth at least 20 cm b) above 5 cm, irrespectively from the way of closing and insulation of the gas	 3.00 0.70

Table A4.3. Maximum heat transfer coefficient for walls for in public utility buildings

No	Type of walls and internal temperature of rooms	$U_{max,}$ W/(m^2·K)
1	2	3
1	External walls: at $t_i > 16^oC$: - full (without interruptions) - with openings for windows and doors - with balcony cantilever passing through the wall b) at $t_i \leq 16^oC$ (for each type of wall)	 0.45 0.55 0.65 0.70
2	Interior walls between heat spaces and staircases or corridors	3.00$^{*)}$
3	Walls adjacent to expansion gap of width : a) up to 5 cm, permanently closed and filled with thermal insulation for a depth at least 20 cm b) above 5 cm, irrespectively from the way of closing and insulation of the gas	 3.00 0.70
4	Walls of unheated basements	without requirements
5	Floor and floor-roofs under unheated attics or over passages: a) at $t_i > 16^oC$ b) at $8^oC < t_i \leq 16^oC$	 0.30 0.50
6	Floors over unheated and closed under-floor spaces	0.60
7	Floors over heated basements	wihout requirements

Table A4.4. Maximum heat transmission factor for windows, balcony doors, and access door in residential buildings.

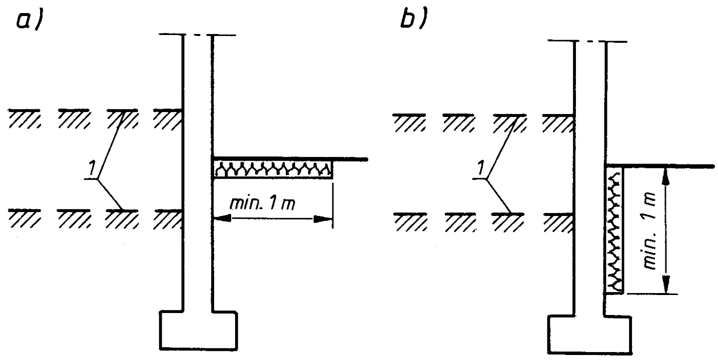
	Windows, balcony doors and access doors	$U_{max,}$ W/(m^2·K)
1	2	3
1	Windows (also roof window), balcony doors and non-opening transparent surfaces in rooms at $t_i \geq 20$ ^oC: - in climatic zones I,II i III - in climatic zones IV i V	 2.6 2.0
2	Windows in walls between heated and unheated rooms	4.0
3	Windows in basements and unheated attics and rooms over unheated staircases	without requirements
4	External access doors	2.6

Table A4.5. Maximum heat transfer coefficient for windows, balcony doors, and access door in public utility buildings.

Lp.	Windows, balcony doors and access doors	U_{max} .W/(m^2·K)
1	2	3
1	Windows(excluding roof windows) balcony doors and non-opening transparent surfaces: a) when $t_i > 16°C$ b) when $8°C < t_i =< 16°C$ c) wnen $t_i =< 8°C$	 2.3 2.6 without requirements
2	Roof windows and skylights	2.0
3	Windows and balcony doors in rooms with specific hygeic requirements (rooms intended for permanent ocupation in hospitals, nurseries and kindergartens)	2.3
4	Windows in basements and unheated attics and rooms over unheated staircases	Without requirements
5	External access doors	2.6

Table A4.6. Minimum total heat resistance values for floors laid on ground

	Components of heat resistance	R_{min} m^2 K/W	
		at $8^oC<t_i\leq 16^o C$	$t_i > 16^oC$
1	2	3	4
1	Floors, thermal insulation (horizontal and vertical) and external walls or foundation walls (fig.1)	1.0	1.5
2	Floors and ground layer under floor (in the middle zone)	without requirements	1.5



a) horizontal heat insulation, b) vertical heat insulation; 1 – ground level

Figure A4.1. Scheme of required heat protection of the floor on ground, in the zone adjoining the wall:

No heat insulation requirements are applicable to floors in contact with the ground, in rooms with computed temperature $t_i \leq 8^oC$, and floors located lower than 0,6 m above the ground level.

In case of residential houses in one-family building development, public utility buildings, as well as industrial buildings, the heat resistance values of walls adjoining the ground, along the sections of walls down to 1.0 m from the ground level,:

at $t_i > 16^oC$ must not be lower than 1.0 $m^2 \cdot K/W$,

at $4^oC < t_i \leq 16^oC$ must not be lower than 0.8 $m^2 \cdot K/W$,

however, no limitations apply to the heat resistance values on the wall sections below 1.0 m from the ground.

A4.1.3 Computation of the heat transmission factor

The European Standard EN ISO 6946 formed the basis for establishment of PN-EN ISO 6946 "Building components and building structure sections. Heat resistance and heat transmission factor – Computation method" (PN, 1998). As far as computation of heat transmission factor is concerned, this standard replaces the former PN-91/B-02020 (PN, 1991). There are no substantial differences between the new and old standards.

A4.1.4 Calculation of energy requirement for heating

The method of calculation of heat requirements for heating is given in the standard PN-B-02025: 1999 „Calculation of heat requirements for heating residential and public utility buildings" (PN, 1999).

Calculation of heat requirements for heating is performed for the standard temperature of heating season stated for the given area of the country (zone). 5 different zones are distinguished in Poland, and for each of them a computed standard temperature is determined in PN-B/02403 (PN, 1982). The temperature for each zone is given in table 4.5 The t.emperatures inside buildings are also standardised, according to PN-82/B-02402 (PN, 1982a) we have:

- rooms for non-continuous occupation by people - +5°C,
- rooms for continuous occupation by people in cloths - +12°C,
- habitable rooms - +20°C.

A4.1.5 Energy efficiency requirements regarding boilers

The energy efficiency requirements of heating equipment is formulated in the Ordinance of the Minister of Economy (1999). This Ordinance also states the necessity of labelling of equipment produced in the country and imported. Technical characteristics of heating equipment should give the basic information on the particular pieces of equipment.

Requirements concerning the energy efficiency are enumerated below.

Central heating boilers fired with coke, coal, lignite and wood:

-	fired with coke or coal	$\eta \geq 68.65 + 4.35 \log P_n$,
-	fired with lignite	$\eta \geq 65.65 + 4.35 \log P_n$,
-	fired with wood (P_n < 350 kW)	$\eta \geq 58.523 + 6.477 \log P_n$

Central heating boilers fired with fuel oil or natural gas:

		load 100%	load 30%
-	standard	$\eta \geq 84 + 2 \log P_n$,	$\eta \geq 80 + 3 \log P_n$,
-	low temperature	$\eta \geq 87.5 + 1.5 \log P_n$,	$\eta \geq 87.5 + 1.5 \log P_n$,
-	condensed.	$\eta \geq 91 + \log P_n$,	$\eta \geq 91 + 4.35 \log P_n$

Central heating boilers fired with coal at cyclic supply with fuel $\eta \geq 70 + 4 \log P_n$.

Heaters for heating tap water

continuous – specific use of electrical energy $E \leq 0.125$ kWh/kg, storage

for $V_{nom} \leq 30$ dm^3 – energy efficiency $\eta \geq 82\%$, losses of energy 0.90 kWh/24 h

for $V_{nom} > 30$ dm^3 – energy efficiency $\eta \geq 85\%$ losses of energy 0.85 kWh/24 h.

The Ordinance also formulates the requirements for the majority of household equipment.

Steam boilers are regulated by the standard PN-72/M-34128 „Steam boilers – requirements and tests" (PN, 1972). The standard formulates the requirements for commissioning tests of steam heat boilers. In practice, this standard is used also for water boilers, both those applied as heat sources, as well as those for industrial use.

The standard does not specify the numerical values of the tested boilers efficiency, providing only the procedure to be used to determine that efficiency in an experiment, nevertheless, it is applied in all operation and guarantee-related boiler tests.

A4.1.6 Heat networks

Requirements for heating networks are formulated in the polish standard PN-91/B-10405 „District heating. District heating networks – specifications and tests" (PN, 1991). The standard concerns heating networks for hot water up to a temperature of 300°C and steam up to a pressure of 2.5 MPa and formulates technical requirements and a scope of tests for commissioning. On the other hand, the selection and computations of heat insulation, which has impacts on heat losses in the network, should be based on PN-85/B-02421 „Heating and district heating. Thermal insulation of pipelines, valves and equipment – Specifications and tests" (PN, 1985).

In average, a typical Polish building uses energy for: heating and ventilation 71 %, hot water preparation 13 %, cooking 9 % and lighting and electrical appliances 7 %. The most important sources of heat are combined heat and power plants (36 %) and municipal heat sources (28 %). Individual ovens supply heat to 18 % of the housing units while local heat sources to 11 % of them. The rest is the housing sector is covered by the industrial heat sources.

A4.2 Polish requirements for indoor environment

A4.2.1 Indoor air quality

Permissible values of concentration and intensity of factors hazardous to health, emitted in all living areas by building materials, equipment and furnishing, are set out in a Regulation of the Minister of Health and Social Care of 12 March 1996. This regulation, rather unique in Europe and in the World, sets two categories of rooms, i.e. A and B. Category A covers rooms designated for living, rooms designated for permanent occupation by patients in health care buildings, rooms designated for permanent occupation of children in educational buildings and rooms designated for food products storage. Rooms designated for occupation in public utility buildings, other than included to category A, as well as auxiliary spaces in dwellings should meet criteria for category B spaces.

The Regulation specifies permissible concentration values (average 24 hrs) for 35 chemicals (table A4.7). Unfortunately Polish Standards do not determine measurement methods for 11 of these substances. In result, such methods must be agreed with the State Institute of Hygiene individually. Moreover, in the case of 17 substances and their mixtures this Regulation sets restrictions (in many cases their application is generally forbidden) as for their content in building materials (table A4.8).

These values are used for both checking indoor air quality in rooms and for obligatory checking building materials for hygienic approval. This second test is performed in small testing chambers according to Polish Standard PN-89/Z-04021/02. Testing conditions are:

- Volume of the test chamber 0.2 - 1.0 m^3,
- Air temperature 23 ± 2 °C,
- Relative air humidity 45 ± 5 %,
- Air change rate 1 h^{-1} ± 5 %,
- Air velocity in the central part of the chamber 0.2-0.5 m/s,
- Load ratio 1 m^2/m^3.

Table A4.7. Permissible values of concentration and intensity of factors hazardous to health, emitted by building materials, equipment and furnishing

No	Substance	Maximum permissible concentration $\mu g/m^3$ (24 hour average)	
		room category A	room category B
1	Acryloamide	1	3
	Acrylonitrile	2	3
	Ammonia	300	300
	Benzene	10	20
	Butadiene	100	300
	Butyl alcohol	300	300
	Chlorobenzene	15	40
	Chlorophenoles (excl pentachlorophenol)	15	20
	Chlorophtalenes	15	30
	Cyclohexane	250	250
	Cyklohexanone	40	100

	Dichlorobenzene	30	50
	Ehtylbenzene	100	150
	Phenol	20	50
	Formaldehyde	50	100
	Dibutyl phthalate	100	150
	Phthalic anhydride	40	80
	Ethylene glycol	15	50
	Cresoles	25	50
	Xylene	100	150
	p.-Kumylophenol	40	80
	Maleic anhydride	50	100
	Naphtalene	100	150
	Butyl acetate	100	150
	Ethyl acetate	100	150
	Vinyl acetate	50	100
	Ozone	100	150
	Pentachlorophenol	5	10
	Mercury	1	3
	Styrene	20	30
	Carbon monoxide (30 min)	3000 (10000)	6000 (10000)
	Toluene	200	250
	Trichloroetane	75	150
	Trichloroetylene	150	200
	Vinyl chloride	5	10

Table A4.8. Substances and their mixtures which contents in building materials undergo specific restrictions

No	Name of the substance or their mixtures	Restrictions
1.	Acryloamide and acrylonitrile (in not chemically bounded form)	Not allowed in building materials
2.	Asbestos	Asbestos addition not allowed in building materials
3.	Benzene (in not chemically bounded form)	Allowed content in building material up to 0.1 % of their mass.
4.	Varnish benzine or other mixture of volatile aliphatic and aromatic hydrocarbons or their chloral derivative	Not allowed in injection fluids for moisture removal from building walls

5.	Chlorophenoles including pentachlorophenol	Not allowed in building materials for indoor use
6.	Chromates (Cr^{+6})	Not allowed in building materials
7.	Carbon tetrachloride	Not allowed in building materials
8.	Farbasol (mixture of volatile aromatic hydrocarbons with addition of aliphatic ones)	Not allowed in building materials for indoor use
9.	Ethylene glycol	Not allowed in building materials for indoor use
10.	Cadmium as a pigment	Not allowed as addition to building materials
11.	Lindane as a component of impregnating and varnishing products	Not allowed in building materials for indoor use
12.	Methyl alcohol	Allowed content in building material up to 2 % of their mass.
13.	Lead as a pigment	Not allowed in building materials
14.	Lead as a corrosion protecting component	Use in buildings allowed, excluding agriculture and food industry.
15.	Carbon processing products (pitch, tar)	Not allowed for indoor use
16.	Aromatic hydrocarbons (single and multi cyclic like xylene, toluene, ehtylbenzene) excluding benzene	Allowed content in building materials for indoor use up to 20 % of their mass.
17.	Chloride derivative hydrocarbons as solvents excluding carbon tetrachloride	Not allowed content in building material above 5 % of their mass.

A4.2.2 Ionisation radiation

The Regulation of the Minister of Health and Social Care of 12 March 1996 describes also requirements for permissible values of concentration of natural radioactive isotopes in building materials. Tested materials should meet two criteria f_1 and f_2.

$$f_1 = 0.00027 \cdot S_K + 0.0027 \cdot S_{Ra} + 0.0043 \cdot S_{Th} \leq 1$$

$$f_2 = S_{Ra} \leq 185 \ \ Bq/kg$$

where:

S_K - concentration of the potassium - 40 isotope in building material, Bq/kg

S_{Ra} - concentration of the radium - 226 isotope in building material, Bq/kg

S_{Th} - concentration of the thorium - 228 isotope in building material, Bq/kg

A4.2.3 Ventilation

Standards of air quality may also be indirectly established, for instance, by defining required ventilation rate. In Poland the minimum flow of outdoor air in apartment houses, residential buildings and public buildings, which include schools, is specified in the Polish Standard PN-83 B-03430 (PKN, 2000).

Ventilation system in residential buildings should at least ensure:

- outdoor air supply to rooms and kitchen with external window,

- exhaust of used air from kitchen, bathrooms, separate toilets, auxiliary rooms without windows (cloak room, storeroom), rooms divided from any of these places by more than 2 doors or for rooms located on upper level in multi-storey single family house or multi-storey apartment in multifamily house.

Air volume for the apartment is characterised by the sum of the air volumes extracted from the rooms mentioned above. These volumes, regardless of the ventilation type, should be at least:

-	for kitchens with external windows, using gas or coal cookers	70 m^3/h
-	for kitchens with outer windows, using electric cookers:	30 m^3/h
-	in apartments for up to 3 people	50 m^3/h
-	in apartments for more than 3 people	
-	for kitchens without external windows, or for kitchen recesses with electric cookers	50 m^3/h
-	for bathrooms (with or without toilet)	50 m^3/h
-	for separate toilets	30 m^3/h
-	for an auxiliary room, without windows	15 m^3/h
-	for rooms divided from the other rooms with air exhaust by more than 2 doors or for rooms located on upper level in multi-storey single family house or multi-storey apartment in multifamily house.	30 m^3/h

Kitchens without external windows, fitted with gas cookers, should have mechanical exhaust ventilation: the extracted airflow should be at lest 70 m^3/h.

Buildings of up to 9 stories may use passive stack ventilation or mechanical ventilation. Higher buildings should have mechanical exhaust or mechanical supply-exhaust ventilation. Mechanical ventilation should operate 24 hours a day. During the night (e.g. between 10.00 p.m. and 6.00 a.m.) the ventilation airflows given above may be reduced to values ensuring 20 m^3/h per person.

In public utility buildings ventilation requirements are defined by the minimum ventilation rates (outdoor air) per person:

-	for rooms permanently or temporarily occupied by people	20 m^3/h per person.
-	for public buildings where smoking is allowed	30 m^3/h per person
-	for kindergartens, infants day nursery	15 m^3/h per child
-	for air conditioned rooms or rooms with not openable windows	30 m^3/h per person
-	for air conditioned rooms or rooms with not openable windows where smoking is allowed	50 m^3/h per person

If in ventilated room other sources of pollution than a man are present, the ventilation rate should be evaluated on the basis of other requirements.

It should be noted that in Poland smoking outside clearly marked smoking areas in all public places is forbidden.

As ventilation system parameters other than ventilation intensity also influence indoor environment "Technical criteria to be met by built structures and their localisation" specifies a lot of additional requirements for ventilation installation. Only the most important are described below.

Air re-circulation can be used when the designation of ventilated spaces is not associated with presence of bacteria causing illnesses, with emission of substances harmful to humans' health or with unpleasant odours and requirements for minimum outdoor air are met. In health care building re-circulation requires special permission of local sanitary inspector.

In case of mechanical ventilation supply-exhaust or air conditioning systems with air volume at least 10000 m^3 heat recovery from the exhaust is obligatory. Devices used for this purpose should have solutions minimising air leakage between air streams to:

- 0.25% of exhaust air in case of plate heat exchanger and or heat pipes exchanger,
- 5% of exhaust air in case of rotary wheel exchangers,

all of the above with respect to pressure difference of 400 Pa.

Devices used in mechanical ventilation systems and air-conditioning systems should be protected against the pollutants in outdoor air and in special cases in re-circulated air by effective air filtration:

- heat exchangers, cooling coils, and heat recovery devices: filters at least class G4,
- humidifiers: filters at least class F6.

Typical ducts in mechanical ventilation systems and air conditioning systems should fulfil criteria for the class A of airtightness (table A4.9). In case of ventilation ducts in high pressure installations as well as in case of overpressured parts of the exhaust installations that remove polluted air containing substances harmful to humans health or flammable substances and if there is a possibility of its leakage into the spaces designated for permanent occupation, the ducts should fulfil criteria for the class B of airtightness (table A4.9).

Table A4.9. Permissible values of the duct leakage coefficient

Test overpressure in the duct, Pa	Dust leakage coefficient	
	class A, $m^3/(m^2 \cdot h)$	class B, $m^3/(m^2 \cdot h)$
400	≤ 4.78	≤ 1.59
1000	-	≤ 2.89

Set of 14 conditions describes the location of air intake and exhaust from mechanical systems. Group of other requirements state that duct systems as well as all devices should have easy access necessary for proper maintenance including cleaning.

A4.2.4 Thermal comfort

In many countries requirements for thermal comfort are based on the different indices described in Standards belonging to the ergonomics group. In Poland such standards also exists:

- PN-85/N-08013 Ergonomics. Moderate thermal environments. Determination of the PMV and PPD indices and specification of the thermal comfort.
- PN-87/N-08009 Ergonomics. Cold environments. Method of approval of negative thermal stress based on WCI and IREQ
- PN-85/N-08011 Ergonomics. Hot environments. Estimation of the heat stress on working man, based on the WBGT index (wet bulb globe temperature).
- PN-87/N-08016 Ergonomics. Thermal environments. Instruments and methods for physical quantities.

but they are not used for designing and for verification in construction process.

In practice in heated spaces only one parameter of thermal comfort is considered, indoor air temperature. Designing temperatures set forth by “Technical criteria to be met by built structures and their localisation” are presented in table A4.10.

Table A4.10. Designing temperatures of spaces in buildings

Designing temperatures	Destination or description of spaces utilisation	Examples of rooms

*)		
1	2	3
+5°C	spaces not intended for occupation by people industrial during operation of stand by heating systems (if technological conditions allow)	Stores without permanent staff, individual garages, parking halls (without repairs), battery rooms, machinery rooms, elevator shafts
+8°C	spaces without heat gains and with single occupation by people in motion with outdoor clothes is not longer than 1 h,	Stairways in residential buildings
	spaces with heat gains from technological devices, lightning system etc. over 25 W per 1 cubic meter of the space	Compressor rooms, pump stations, smithy, steel temper halls, heat processing halls
+12°C	spaces without heat gains, intended for permanent occupation in outdoor clothes, or for users working permanently with energetic loss over 300 W	Stores and depots with rooms permanent staff, entrance halls waiting rooms in show rooms without cloak-room
	spaces with heat gains from technological devices, lightning system etc. from 10 to 25 W per 1 cubic meter of the space	shops for physical work with energetic loss above 300 W, battery charging rooms, cooling systems machinery rooms, markets, fish shop, butchery
+16°C	spaces without heat gains intended for permanent occupation: in outdoor clothes in sitting or standing position,	Showrooms without cloak rooms, public toilets, outdoor clothes cloak rooms, processing halls, gymnasiums
	spaces intended for permanent occupation without outdoor clothes or for users working permanently with energetic loss up to 300 W	individual kitchens equipped with coal kitchen stoves
	spaces with heat gains from technological devices, lightning system etc. less than 10 W per 1 cubic meter of the space	
+20°C	spaces intended for permanent occupation without outdoor clothes, users do not permanently work physically	Rooms for living, halls, individual kitchens equipped with gas or electrical cookers, office rooms, meeting rooms
+24°C	intended for undressing and or rooms used without cloths	Bathrooms, cloak rooms for undressing, showers, swimming pools, rooms for medical examination with undressing of patients, nursery rooms for children in kindergartens, operating theatres
*) It is allowed to select other designing temperatures for heated spaces than defined in the table if it is result of technology requirements.		

Thermal comfort in mechanically ventilated or air-conditioned spaces is the subject of the Polish Standard PN-78/B-03421 “Ventilation and Air conditioning. The Standard introduces concept of “optimal” and “permissible” conditions for both winter and summer. Physical activity plays the role of basic criterion for parameters selection. It is estimated by summing the total heat loss depending on the body position and additional heat loss depending on the type of physical activity (table A4.11). Physical activity is categorised in three groups:

- low < 200 W,
- medium - 200÷300 W,
- high > 300 W.

Table A4.11. Estimation of mans physical activity

Total heat loss depending on the body position		Additional heat loss depending on the type of physical activity			
Body position	Total energy lose [W]	Type of work	using hand	1 arm	2 arms
Sitting	120	Light work	30	60	120
Standing	140	Medium work	50	90	150
Moving	240	Heavy work	60	120	180

Table A4.12. Calculation indoor air parameters for the winter period

Physical activity	Air temperature	Relative humidity		Maximum air speed
		Optimal	Permissible	
	°C	%	%	m/s
Low	20÷22	40÷60	30	0.2
Medium	18÷20			0.2
High	15÷18			0.3

Table A4.13. Calculation indoor air parameters for the summer period

Physical activity	Optimal conditions		Permissible conditions			Maximum air speed
	Air temperature	Relative humidity	Temperature in case when heat gains for 1 m2 of the floor of room or working zone are		Relative humidity	
			below 50 W/m^2	above 50 W/m^2		
	°C	%	°C	°C	%	m/s
Low	23÷26	40÷55	t_z+3	t_z+5	70	0.3
Medium	20÷23	40÷60				0.4
High	18÷21	40÷60				0.6

Designing conditions for indoor air according to PN-78/B-03421 are presented in tables A4.12 (winter) and A4.13 (summer). Important remarks for tables 20 and 21.

- In case of no possibility of humidification in winter it is allowed to not meet the permissible minimum value and to take into calculation values resulting from outdoor conditions and room moisture balance
- Permissible values of temperature in summer may be taken into account only when there is no possibility to cool the air. One should no select the values between optimal and permissible. Symbol t_z denotes outdoor air temperature according to Polish Standard PN-76/B-03430.
- In case of selecting indoor air temperature from the "optimal" range permissible values of relative humidity should be selected respectively: for the temperature 26 °C – not above 55%, and for 23 °C not above 65% relative humidity (not according to the permissible values).
- Because of necessity of taking into account the heat radiation, indoor temperature for winter may be selected only when mean temperature of inner surfaces of envelope components $\tau_{p\,śr}$, is not less than 2 °C from minimum indoor temperature associated with specific physical activity. If this condition is not fulfilled the case require individual evaluation if indoor temperature. Mean temperature of inner surfaces of envelope components $\tau_{p\,śr}$ is calculated using equation.

$$\tau_{p\,śr} = \frac{\sum\left(F_i \cdot \tau_{p\,i}\right)}{\sum F_i}, \text{ [°C]} \quad (1)$$

where:

$\tau_{p\,i}$ temperature of inner surfaces of envelope component, [°C]

F_i surface area, [m^2]

A4.2.5 Daylighting, artificial lighting and solar penetration

Traditionally, the polish requirements to daylighting in buildings were based on the glazing ratio i.e. the ratio of the glazing area (between frames) to the floor area in rooms. In the current polish recommendations the requirement to the glazing ratio is still present: in rooms intended for the long-term occupation the ratio should be at least 1:8, in other rooms in which daylight is needed because of their function at least 1:12. In the requirements formulated by The Ministry of Education a special recommendation refers to classrooms: the glazing ratio should be within the range 1:4 ÷ 1:5.

In addition to the glazing ratio, which ensures the minimum need for daylight from the overcast sky, the minimum time of sunlight penetration in buildings is required. In rooms intended for collective presence of children in nurseries, kindergartens and schools, the solar penetration time should be at least 3 hours at the equinox (21 march and 21 September) in the time period 8^{oo}-16^{oo}. Chemical and physical labs as well as fine art classrooms are excluded from this demand. The requirement to minimum 3 hours solar penetration refers also to residential buildings for the period 7^{oo}-17^{oo}. In multi-room apartments it is allowed to meet this requirement in at least one occupation room. In downtown areas it is even allowed to reduce the required solar penetration time to 1,5 h.

The more specific requirements concerning daylighting of interiors are defined in the Polish Standard PN-71/B-02380. The main lighting parameters determining luminous environment are: daylight factor and uniformity.

For sidelighting minimum daylight factor is required. For skylighting and mixed lighting (sidelighting and skylighting) average daylight factor and uniformity are required. The required daylight factors are given in table A.4.14. Classification of interiors, concerning categories of visual task, is enclosed in the appendixes of the Standard (app. 2 ÷ app. 3).

For skylighting and mixed lighting uniformity, defined as the ratio of minimum to maximum daylight factor at the working plane, should be: at least 0,3 for less demanding tasks (III and IV category of visual task); at least 0,5 for more demanding tasks (I and II category of visual task).

Table A.4.14 The levels of daylight factors

Category of visual task	Type of activity	Sidelighting DF_{min}	Skylighting and mixed DF_{ave}
I	Except. hard visual task	3,5 ÷ 4	10
II	Very hard visual task	2 ÷ 3	7
III	Hard visual task	1,5 ÷ 2	5
IV	Moderate visual task	1 ÷ 1,2	3
V	Limited visual task	0,5 ÷ 0,8	2
VI	General orientation without discrimination of details	0,25 ÷ 0,4	1

The requirements regarding artificial lighting, defined in "Technical criteria to be met by built structures and their localisation", refer to performance [DzU RP Nr 75, 2002].

§ 59.1. Artificial lighting of the rooms designated for man occupation should meet user's needs and meet the criteria set forth by the Polish Standard..

2. General artificial lighting of the rooms designated for permanent man occupation should ensure proper usage conditions at all areas.

3. Artificial lighting of adjacent rooms designated for permanent man occupation and for communication should not have differences in illuminance that may cause discomfort glare in the case of moving between the rooms.

The more specific requirements concerning artificial lighting of interiors are defined in the Polish Standard PN-84/E-02033. The main lighting parameters determining luminous environment are: illuminance and uniformity at the working plane, luminance distribution, glare, correlated colour temperature, colour rendering index and flicker.

The average illuminance at the working plane should not be less than the values given in table 23. The original table gives also examples of the room or jobs and tasks. The standard describes also conditions when average illuminance should be increased or decreased. Detailed requirements concerning illuminance levels, and also glare, are enclosed in the appendixes of the Standard PN-84/E-02033 (app. 1 ÷ app. 9), for different room types or activities.

Uniformity at the working plane, defined as the ratio of minimum to average illuminance at the work plane, during long-term work should be at least 0,65 while during short-term work and in communication zones at least 0,4. The ratio between the mean illuminance at a working plane and at planes adjacent to it (not being a work area) or between adjacent rooms should not exceed 5:1.

Useful reflectances of the main room surfaces (ceiling, walls, floor) and illuminance ratios (average walls illuminance / average working plane illuminance; average ceiling illuminance / average working plane illuminance) are given to provide relatively uniform luminance distribution in interiors.

Maximum luminaire luminance at some angles, minimum shielding angles and luminaire height above working plane are required to fulfil glare requirements. Ways of limiting reflected glare on the working plane and on the immediate surranding are given too.

Regarding minimum average illuminance at the working plane, light sources should have, given in the Standard, correlated colour temperatures. Regarding type of activity, light sources should have, given in the Standard, colour rendering index. Ways of limiting flicker are given too.

Table A.4.15 The levels of illuminance at the working plane and their application.

Minimum average illuminance lx	Type of activity or interior
10	General orientation in rooms
20	Orientation in rooms with recognition of objects of middle size like face features
50	Short presence, performance of simple tasks
100	Permanent work and casual tasks with low visual requirements
200	Work with limited visual requirements
300	Work with moderate visual requirements
500	Work with high visual requirements
750	Long term and hard visual work
1000	Long term and exceptional hard visual work

A4.2.6 Acoustics

Just like other parameters regarding the indoor environment, the ordinance "Technical criteria to be met by built structures and their localisation" includes a general acoustic requirement that refer to performance.

§ 323. 1. Building and connected devices should be designed and constructed in such a way that noise level, for which users and people in neighbourhood may be exposed, would not be harmful and allow them work, rest and sleep in satisfactory conditions.

In a number of detailed requirements the ordinance addresses the set of 24 Polish Standards devoted to acoustics that covers: vocabulary, requirements, assessment method, devices and laboratory test methods. The detailed acoustic requirements in buildings are described in the Polish Standard PN-87/B-02151 that consist of 3 parts:

- PN-87/B-02151/01 "Building acoustics. Noise protection of apartments in buildings. General requirements and technical means of noise control".
- PN-87/B-02151/02 "Building acoustics. Noise protection of apartments in buildings. Permissible values of sound level.
- PN-87/B-02151/03 "Building acoustics. Noise protection of apartments in buildings. Sound insulation in buildings and building elements. Requirements.

Table A4.16. The examples of permissible values of sound level in different types of spaces in dB.

Space designation	Permissible equivalent sound level from all sources dB		Permissible sound level from technical equipment of the building and other devices inside and outside the building			
			Average sound level (in case of steady noise) or equivalent sound level (in case of non steady noise), dB		Maximum sound level (in case of non steady noise) dB	
	Day	Night	Day	Night	Day	Night
Rooms in residential buildings	40	30	35	25	40	30
Kitchen, bathroom and WC	45	40	40	40	45	45
Classrooms (excluding technology labs)	40	-	35	-	40	-
Rooms for mental work with high concentration	35	-	30	-	35	-
Administrative rooms without noise sources	40	-	35	-	40	-
Administrative rooms with noise sources	45	-	40	-	45	-