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Any intelligent fool
can make things bigger and more complex….

it takes a touch of genius
– and a lot of courage –
to move in the opposite direction.

Albert Einstein

FOREWORD

Regarding the history of architecture and the built environment, the strong impact of social development and the related technological progress on design is clearly evident and undisputed. As a consequence of industrialisation, new materials were developed and applied on a large scale. Traditional forms of construction were changed and, in the 20th century, the “international style” became predominant. With this Modern Architecture more comfortable dwelling standards were invented – not only in the prominent, detached villas from Mies van der Rohe and le Corbusier but also in the growing number of housing developments and estates for the working population. The new materials and rising standards were based on innovative manufacturing methods and mass-production and on the wide scale exploitation of energy sources and the growing networks for its distribution.

In the Western Hemisphere the “modern way of life” became more and more common until, in the 1970s, the first energy crisis indicated that a basic change was necessary in order to take into account the consequences of this development – for example, high energy bills and possible effects on the climate.

Against the background of a growing world population the ECOBUILDINGS concept represents a real attempt to maintain a high standard of living while applying sustainable methods of construction and use of energy. Europe already has its towns and cities so that the highest potential for energy efficient technology lies in holistic retrofit and continuous R&D to develop new technologies and materials that make energy efficiency in buildings -- and our life -- more simple in the future.

M. Kratz

Research policies and strategies

Priorities for National R&D Projects

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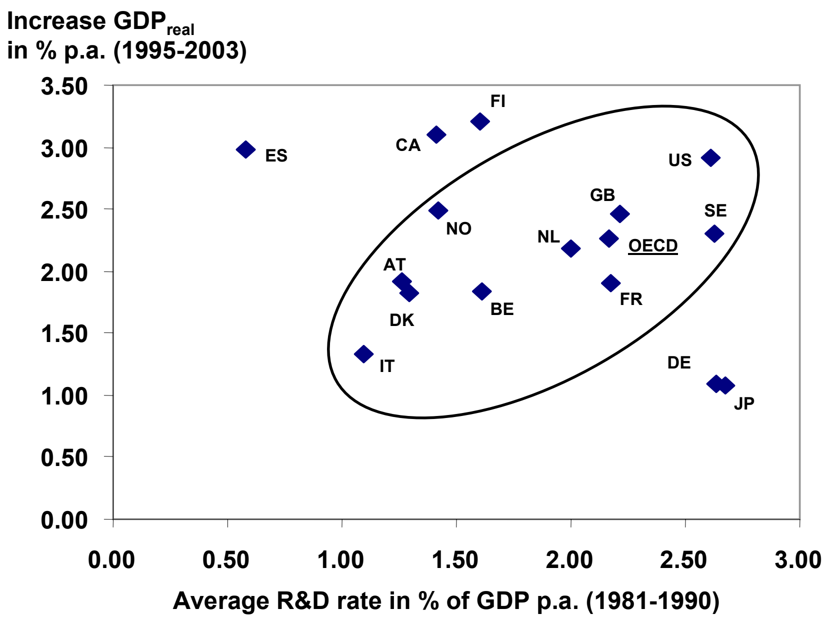
1 Introduction

R&D is fundamental for innovation and technological progress. Without R&D it is not possible to ensure economic welfare and prosperity. Investment in R&D is one of the important ingredients for economic growth and employment. Looking closer at this issue it is interesting to note that there are substantial differences regarding the link between R&D expenditures and economic activity in different nations (Fig. 1). Statistics of the OECD show that the productivity of the “Research-Euro” seems to be much higher in countries such as Finland, Canada or Spain compared to countries such as Germany or Japan.

Fig. 1: R&D investments and economic activity



The principle of a positive correlation between R&D and economic growth can be transferred to other sectors. One of the basic ideas of Energy Policy is that more expenditure on energy R&D will lead to a more sustainable energy system in the future. Unfortunately, there are also uncertainties regarding the impact of R&D investments. One cannot expect that each “Research-Euro” will have the same positive impact towards a more secure, competitive and environmentally-friendly energy system in the future. This perspective illustrates the need for priority setting and in particular the importance of two political decisions: to which fields should the public R&D money go and who should decide about the R&D investment process.

2 Energy Technologies in Perspective

The German Government has just presented its new Energy Research Programme “Innovation and New Energy Technologies” (June 2005). To identify the priorities for R&D projects the programme followed the advice of the famous Prussian general Gneisenau (1760-1831): “It is not wise to ride on the battlefield in all directions at the same time”.

Consequently, Germany is pursuing a dual strategy, namely: targeted support for selected "key technologies" with appropriate funds and "broad-based technology funding" at a lower level of financing. This parallel approach ensures that, in addition to the necessary success in technology fields essential for the energy future, new products, processes and developments can be continuously integrated into the funding process.

Germany’s energy R&D concentrates in particular on the following fields:

- Modern power plant technologies on the basis of coal and gas (including CO_2 capture and storage),
- photovoltaics and off-shore wind,
- fuel cells and hydrogen as secondary energy carrier and energy storage systems,
- technologies for energy optimized buildings, and
- technologies for using biomass for energy purposes.

In addition, the German Government's funding policy comprises the fields of energy-saving technologies in industry, other renewable technologies such as solar heating, geothermal power and hydropower, nuclear safety and repository research, the development of nuclear fusion as a source of energy as well as system analysis and dissemination of information. It is important to note that the Energy Research Programme provides sufficient flexibility and takes precautions to re-allocate funds, if necessary, as soon as new data are available and other options for a breakthrough in the energy sector towards a sustainable energy supply should become apparent. Overall the German Government is making about € 1.7 billion available for R&D in modern energy technologies from 2005 to 2008.

3 Shared Responsibilities for R&D

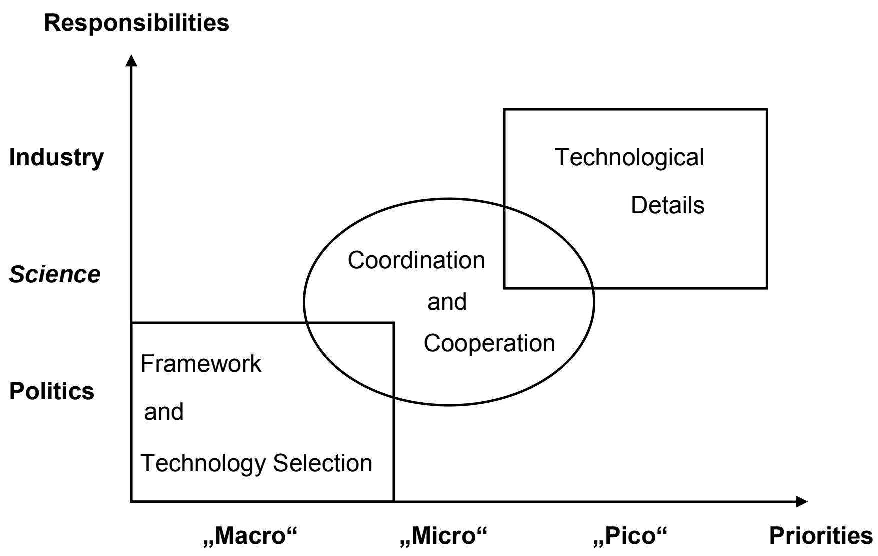
Industry, science and policy-makers have shared responsibilities for promoting R&D in the energy sector:

- Primarily, R&D is a task for business enterprises. This clear responsibility of industry results from our understanding of the general superiority of the processes of the free market economy. Industry has better incentives for effective R&D work. Industry is the main beneficiary of research findings. Industry knows best the strengths and weaknesses of the technologies and, in a competitive market, it must act in a particularly circumspect manner.
- The government has the job of creating a productive environment for innovation and technological progress. And the government has the task to provide funds for a selection of innovative technologies which are important for the society's energy future, but which cannot be dealt with adequately by industrial research and development work as a result of the high risks involved.

The process of priority setting for public funds is itself a complex and interactive exercise involving many players, representing politics, industry and science (Fig. 2). Politics identify the principal areas for research and define the selection of technologies on which the funds should be concentrated (macro-priorities).

Industry is responsible for the details in the technology development (micro- and pico-priorities). Finally, science has to contribute to all stages of the priority setting process.

Fig. 2: The Process of Priority Setting



The effectiveness of energy R&D rests on the cooperation between the different players. Cooperation between politics, industry and science is important in particular in order to ensure that support measures are focused on the concrete needs of the markets and the requirements of the economy. On the other side, one has to avoid that this approach develops into a full scale “command and control” approach. Elements of competition must be maintained in order to exploit the scope for optimization, and to help new approaches achieve a breakthrough faster. Finally, the division of labour between national and European research must be optimized with the aim of avoiding duplication of efforts and focusing resources in the EU on projects with a clear "European dimension".

4 A new Priority: Energy Efficient Buildings

Major priorities for future funding in the area of energy R&D are "energy efficiency" and "renewable energies". Within these two areas, technologies and processes for energy-optimized buildings are of special interest. The buildings' sector has a great technical and, to some extent, economic potential that can be exploited for energy savings. Rational use of energy, efficient supply systems and the utilization of solar energy can help to significantly reduce the demand for fossil energy – without any loss of convenience.

Germany is pursuing a parallel strategy for energy optimization in the field of "new buildings" and in "improving the energy performance of existing buildings". In the case of new buildings, the goal is to reduce by half the primary energy requirements, i.e. the energy necessary for space heating, heating domestic water, ventilation, air conditioning and lighting, as well as auxiliary power in comparison to the present state of the art. The long-term objectives are zero-emission buildings.

Future funding policy in the area of Energy Efficient Buildings will concentrate on the following details:

- implementation of the results of R&D in demonstration projects with the aim of examining the various elements with respect to their efficiency, applicability in practice and future marketability, and also the transferability of R&D findings to the training of planners, architects and craftsmen,
- continuation of R&D work on promising materials, components and systems for the construction of buildings and for technical equipment; this includes further energy improvements to the external envelope also combined with the use of solar energy via the façade and windows as well as innovative ideas for heat generation and distribution,
- further development of the "distributed" supply of buildings with heating and cooling services from local heat and district heat produced by the cogeneration of heat and power, from industrial waste heat, environmental energy and biomass; this also involves the modernization and adaptation of older networks as well as the testing of novel structures,

- development and testing of promising techniques for short- and longer-term heat and cold storage systems for heating and air conditioning,
- optimization of the associated measuring and control technology for efficient plant operation making use of modern communication technologies,
- transfer of suitable techniques to applications in the refurbishment of old buildings.

Literature

Bundesministerium für Wirtschaft und Arbeit (2005), Innovation und neue Energietechnologien - Das 5. Energieforschungsprogramm der Bundesregierung (www.bmwa.bund.de)

RETROFIT OF RESIDENTIAL PANEL BUILDINGS – THE SOLANOVA ADVENTURE

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Overview

SOLANOVA is supported within the European Commission's Fifth Framework Programme, target action "Eco-Buildings". SOLANOVA's full title already summarizes its overall objectives: "Solar-supported, integrated eco-efficient renovation of large residential buildings and heat-supply-systems".
In the new Eastern European member states an urgent need can be observed for the renovation of facades and supply systems of large panel buildings. State-supported programs are just beginning but only aim at comparatively low standards, i.e. the EU's significantly higher objectives regarding energy savings, environmental protection and sustainable development are counteracted and thus delayed for the next three decades. With the EU's financial support, renovation concepts can be developed and applied in a demonstration project to set an example. SOLANOVA

- for the first time consequently applies the philosophy of the state of the art available for new buildings (space heat demand 15-30 kWh/m^{2}a),
- pushes this standard forward to question the low-energy standard (space heat demand of 60 kWh/m^{2}a), as feasible aspiration level for renovation
- brakes the development towards the foreseen doubling of electric climate control until 2010 by providing for passive cooling,
- enables convenient application of low-exergy heating systems that integrate high-efficient solar thermal panels by immensely diminishing the heat demand
- is designed eco-efficiently and user-oriented and thus matches the highest ranking objective of a sustainable development.

The reduction of energy consumption by a factor of almost 10 triggers significant effects on the energy supply systems. Therefore the development of building renovation and seasonally adjusted heating systems should be done in an integrated approach to reach optimised results.
In new buildings, extraordinarily low energy consumption is realized by consequently avoiding thermal bridges and by using controlled ventilation with heat recovery, the same should be done in the case of renovations.
Several retrofit options have been designed. The evaluation of these options has been realized by applying a life-cycle approach, i.e. inputs are accumulated and balanced throughout the whole life-cycle from the mining of the resources, via the manufacturing and the use until the deconstruction ("from cradle to grave"). Based upon this, the reduced consumption of resources and other environmental effects is balanced against investment and operation costs within a process of eco-efficient optimisation (life-cycle-engineering).

The process of eco-efficient optimisation which takes place in several loops is illustrated in Figure 1.

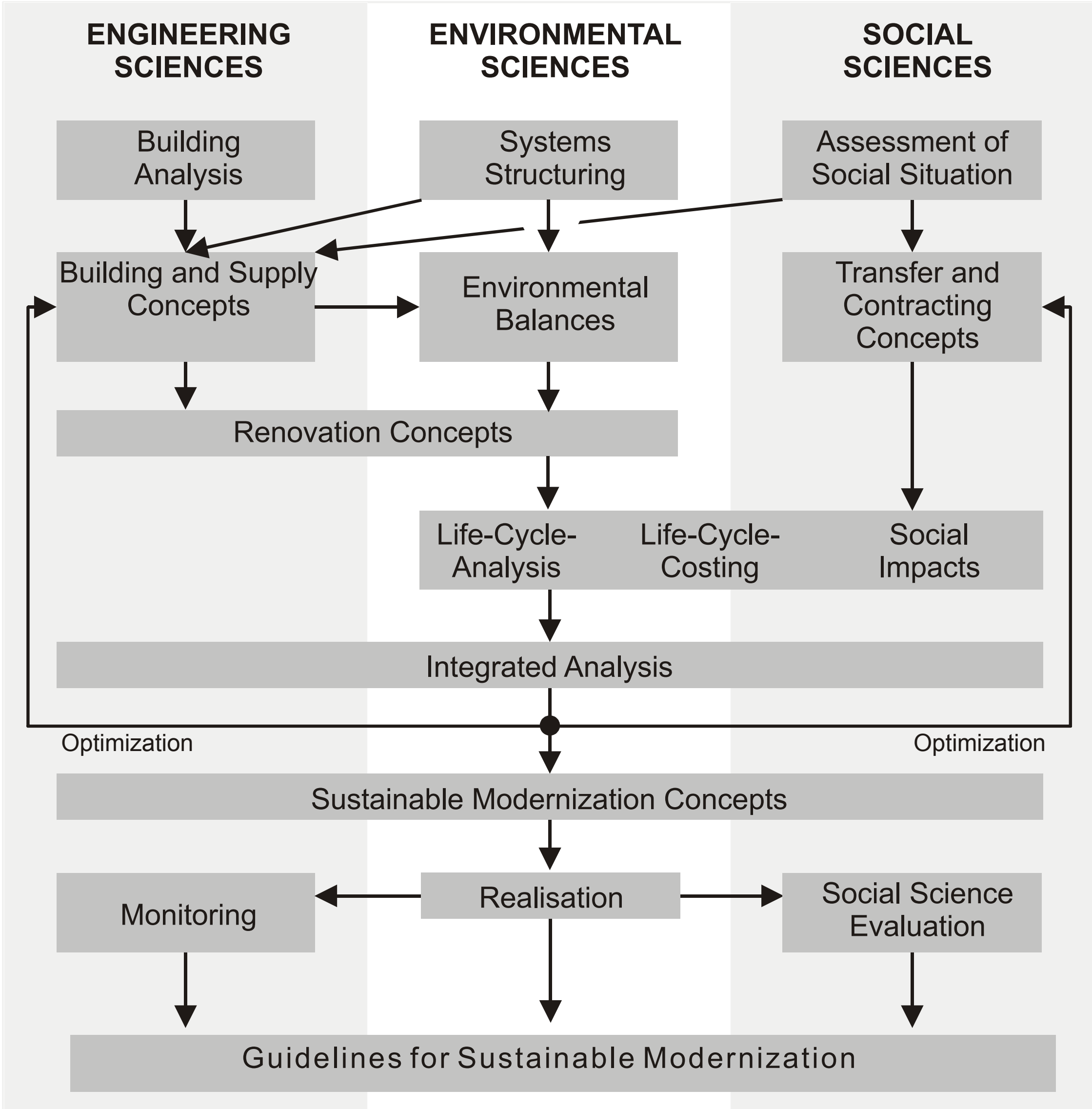

Figure 1 - SOLANOVA's process of eco-efficient optimisation

The accompanying social research focuses on the dwellers' needs, their satisfaction with the indoor climate as well as on their behaviour before and after the renovation. Long-term social effects will also be looked upon. The results have been and will be exploited for the user-oriented design of the final concept for renovation or optimised information strategies respectively.

The way towards a stepwise renovation of whole residential quarters should be founded on practical experience. This is the reason why it makes sense to set an example by means of demonstration. The climatic conditions in Hungary with cold winters and hot summers provide for adequate test conditions.

Based on the practical experience gathered from the implementation phases and the achieved results on energetic, economic, ecological and social level a manual for an eco-efficient, user-oriented renovation will be created. Research results in the fields of building physics and supply systems will result in a software-supported "Passive House Renovation Package".
The reconstructed building will show evidence for the "Factor 10" standard being a feasible option for renovation. The evaluation of the technical monitoring, the cost of reconstruction and the accompanying social research lead to applicable quantitative and qualitative results from the implemented measures. Based on this safe ground a stepwise renovation of whole panel-building districts can be conducted.

SOLANOVA – The steps so far

Design and Construction

Without doubt the team went through several loops of optimisation till finishing the tender documents in summer of 2004. The high aspiration level of the project got very clear to all members when it turned out to be almost impossible to find only one construction company daring to put something into practice which has never been done before in Eastern Europe within a budget which does not allow for „first time", „uncertainty" or whatever else supplements. Even after having found a general constructor willing to join the SOLANOVA adventure "utmost patience" has been one of the most wanted virtues for all participants. Only by the start of February 2005 all financing sources could be called „safe". During this half-year delay, the prices had been risen to a level which created too high a risk for the general constructor to immediately start the construction. Thus another loop of techno-economic optimisation, hard decisions as well as tough negotiations became necessary until finally the main obstacles had been removed by middle of March, 2005.
Finally the reconstruction started in May 2005, now having "time" as the major limitation. As the project ends in December 2006, the team and the EC longed for having at least one complete heating season and one complete summer season within the project duration. As in highly insulated buildings the heating season starts somewhat later, it was agreed, that finishing the building till the end of October 2005 would provide for achieving this objective. After having settled this question another

unexpected round of complications started about the ventilation system between June and August. Having been the main object of discussion, negotiations, misunderstandings and quarrels during the whole project – which mainly resulted from a mismatch of long-time experience in the field of conventional ventilation and housing on the one hand and missing experience in ultra-low-energy housing and adequate ventilation on the other hand -, this time an existing agreement about the design of the ventilation system and parts of the tender for the ventilation system were simply ignored by some of the partners, and the ventilation designer and the project coordinator had quite a hard time to "turn back" the clock to a compromise, which could be called almost "technical equivalent" and which was accepted by all partners in the last second which allowed to keep the deadlines.
On October 25, 2005 the technical handover of the building took place. This means, the major works have been carried out, the building is in operation and a list of deficiencies was elaborated which have to be fixed by the general constructor within 30 days.

The following pictures illustrate the transformation of the building:

Figure 2 – SOLANOVA-Demo-Building Façade Before and After Retrofit

The most decisive "variable" for the project success – the dwellers

One of the main SOLANOVA challenges should be mentioned which had to be accepted and solved in an optimal fashion: refurbishment in occupied state. The best technology won't spread only because of its objective quality but because of its subjective quality. This means, the user must be convinced about the product's quality and not the engineer. During a renovation in occupied state the user is part of the manufacturing process. His perception of this process will inextinguishably determine his subjective evaluation of the final result – the product, the renovated building. If something is judged to be acceptable or not, largely depends on the local context and culture. Therefore project participants from abroad should try to get a feeling for the local situation and habits. Processes being regarded "normal" or "acceptable" in one country might get the opposite evaluation in another country. Luckily the mood of the dwellers is still very positive after the delay and all the interventions which they had to endure during the past months.

But the technical realisation is only one step in a series of steps for disseminating the news. After having finished the realisation, there are several steps of education and dissemination aiming at bringing the good SOLANOVA news to the relevant market players and thus fostering a quick dissemination to avoid as many lost opportunities as possible. Even if the engineers and other technical experts have a positive evaluation of the building, the most important thing is that it gets a positive evaluation of the people living inside – a fact which – quite surprisingly – has been neglected in the past very often.

The behaviour and well-being of the dwellers is a function of personal variables and variables of their environment. Buildings belongs to the artificial environment where they spent more than 90% of their life, therefore this has a decisive impact on their well-being and behaviour. The dwellers should come to a point, where they consider the "updated" technical surrounding as a comfortable, integral part of their life and not as something exterior, strange and unknown. On the day of the technical handover, more than four hours have been spent to inform and teach the dwellers about the new devices. The teaching took place within the flat and it focused on answering questions like "What do I have to do, if …" instead of holding a lecture

about the principles of ultra-low-energy houses. Some more “optimising” loops are going to be made to achieve a close link between the dwellers and the building.
A comprehensive monitoring of the “objective” parameters like energy consumption, indoor temperatures and humidities will reveal, if the high expectations will be met or not.

Conclusion

SOLANOVA is a first time attempt to establish an ultra-low-energy standard in the retrofit of large residential buildings in the new member states. The basic concept is neither restricted to panel buildings nor to a certain size of buildings. This is due to the fact, that the criterion “replication potential” enjoyed a very high priority throughout the design. By integrating the dwellers’ opinion right from the beginning into the design process major mistakes can be avoided – in the SOLANOVA this meant avoiding an overwhelming focus on the building’s performance in winter, as after the first survey the summer turned out to be of at least equal importance for the dwellers.
The monitoring will deliver “hard facts” and “soft facts”, i.e. physical units and dwellers’ opinions. By the end of 2006 the evaluation of the results will show if SOLANOVA may fulfil its dedication as a blueprint for the just starting reconstructions in Eastern Europe.

The Energy Performance of Buildings Directive

THE ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE – OVERVIEW ON THE IMPLEMENTATION IN THE EU MEMBER STATES

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The policy context

Under the Directive on the Energy Performance of Buildings[1]:

1. Member States will develop an integrated methodology for calculating the energy performance of a building (Article 3);
2. Member States will set minimum energy performance requirements on all new buildings and on large existing buildings undergoing major refurbishment (over 1000m²) (Article 4);
3. Energy certificates will be required when buildings are new, sold or rented (Article 7);
4. All large public buildings will be required to display this certificate (Article 7.3); and
5. Boilers and air-conditioning systems over a certain size will be inspected regularly (Article 8 and 9).

The Directive entered into force on 4th January 2003 (2002/91/EC). Member States must implement the measures set out in the Directive by 4th January 2006. They may apply for an additional 3 years because of a lack of qualified experts.

This Directive is a key element of the EU's strategy to meet its Kyoto Protocol commitments. Buildings account for 40 % of the energy consumed in the EU and research shows that more than 1/5 of this energy could be saved by applying tougher standards on buildings.

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[1] Directive 2002/91 of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, OJ L 1, of 4.1.2003, p. 65

A regulatory Committee has been established by the Directive – the Energy Demand Management Committee. The Committee is tasked with updating the annex of the Directive (which sets out the issues that should be covered by the methodology); and assisting the Commission in evaluating the impact of the Directive and in making proposals for additional energy efficiency measures in buildings. Before the implementation date, this Committee will discuss progress in implementation and share good practice.

At the meeting of the Energy Demand Management Committee on 19th March 2004, it was decided to set up two sub-groups; the first to monitor the work of the European Committee for Standardisation (CEN) to develop the methodology to calculate the energy performance of a building; and the second to undertake the energy certification of the Berlaymont building.

Additionally in the frame of the EIE SAVE projects, a discussion and experience exchange platform is created by the EPBD Concerted Action project. Representatives from almost all member states share their experiences during the implementation phase on the fields of certification process, experts training, assessment methods and inspection procedures.

Besides the implementation processes in all member states are still under development - and therefore no official report from the member states is available - this overview can only reflect a snapshot from the different information platforms above and has no claim of completeness.

The certification process

Although Member States have to implement this and the other measures of the Directive until January 2006, the recent refurbishment of the Berlaymont Building offered an excellent and timely opportunity for the Commission to lead the way by undertaking an energy certification process for its newly refurbished headquarters, the Berlaymont Building.

Austria, France, Germany, Netherlands, Poland and Portugal have agreed to participate in the Berlaymont Working Group and to issue their own certificates and/or analyse the building, and have appointed experts. These Member State experts used their own calculation methods to determine the energy performance of the Berlaymont Building.

The Commission considers that a prominent display of energy certificates from a number of European countries will highlight the European nature of this building and attract media attention. *Bruxelles-Capitale* will eventually be the responsible authority to ensure that the Berlaymont and other public buildings in its jurisdiction comply with the Directive. Representatives from *Bruxelles-Capitale* were involved in the project but have not applied its own system for certification since it was still under development.

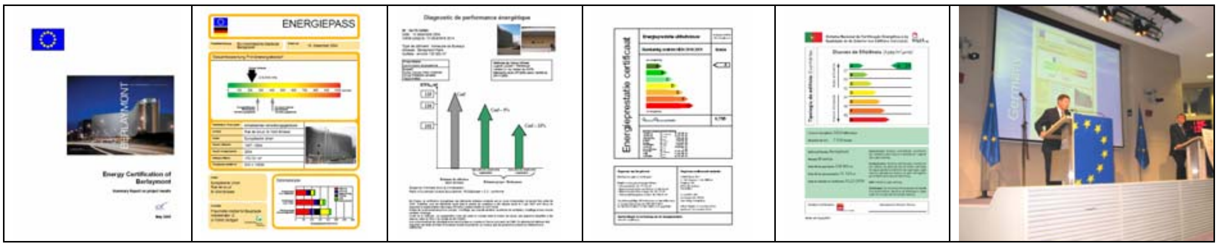
This project offers a practical way to tackle the difficulties that may arise in certifying existing buildings more generally and to give Member States the opportunity to work together by piloting their methods for certification.

The main goals of this project were to:

- Make a public statement of commitment by the Commission on the importance of reducing energy consumption in buildings through the provision of an energy performance certificate.
- For Member States to pilot their method on a complex building and to learn from the other methods of certification.
- Raise the awareness of the Energy Performance of Buildings Directive and that Member States are required to introduce these new measures by January 2006.

This project is primarily an awareness raising, information-sharing and public relations exercise. It was not the intention to produce highly accurate and detailed energy performance certificates, or to compare the results from the different energy certificates. The overriding priority was that the energy certificates are available when the building is fully occupied and operational, since the key purpose of the project is to publicise the Buildings Directive.

The text of the Directive also calls for recommendations on the cost-effective improvement of the energy performance of the building (Article 7.2), but this is not within the scope of this project.



Picture 1: Official report and energy certificates for the EU Headquarters “The Berlaymont Building” from Germany, France, Netherlands and Portugal presented at a press conference (right) by the EU Energy Commissar

The result of this common activity is shown in figure 1. It can be summarised, that only a few member states have had already in summer 2005 a procedure for non-residential buildings, which could be applied at the Berlaymont Building and that the realised certificates have no uniform layout, but comparable declarations.

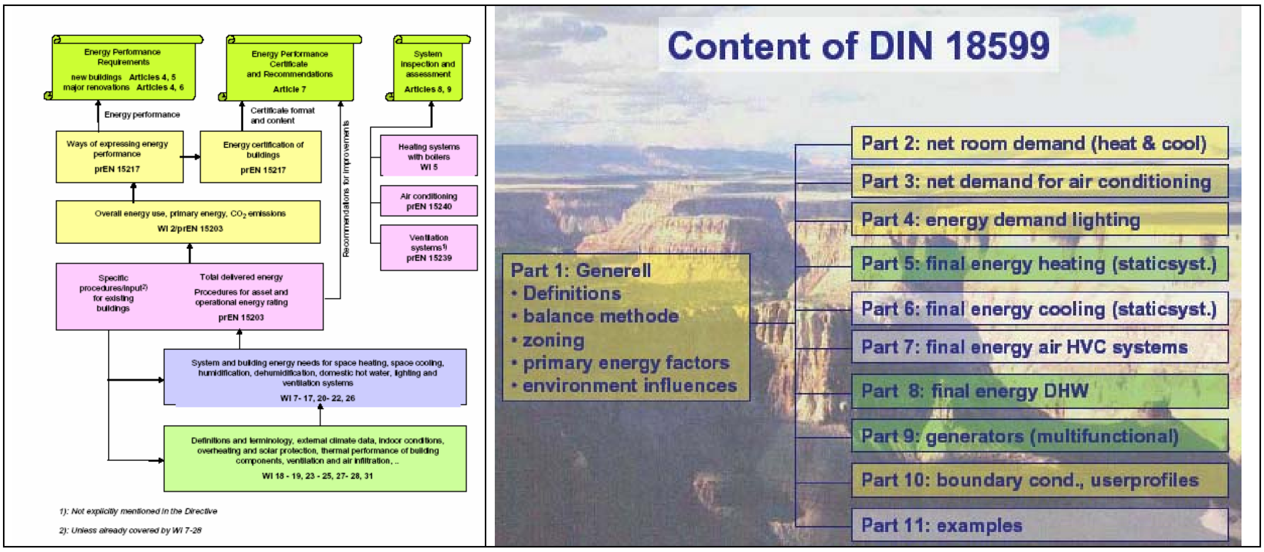
The certification process

The Directive requires several different measures to achieve prudent and rational use of energy resources and to reduce the environmental impact of the energy use in buildings. This is to be accomplished by increased energy efficiency in both new and existing buildings. One tool for this will be the application by Member States of minimum requirements on the energy performance of new buildings and for large existing buildings that are subject to major renovation (EPBD Articles 4, 5 and 6). Other tools will be energy certification of buildings (Article 7) and inspection of boilers and air-conditioning systems (Articles 8 and 9). A basic requirement of measures in Articles 4, 5, 6 and 7 is the existence of a general framework for a methodology of calculation of the total energy performance of buildings, as set out in Article 3 and the Annex to the Directive.

CEN got contracted by a mandate from the Commission to develop a set of European Standards (EN´s) that are intended to support the EPBD by providing calculation methods and associated material to obtain the overall energy performance of a building. A series of 31 work items are defined in the mandate in which more than 40 new standards from the involved 5 Technical Committees of CEN will be developed. Additionally is given a procedure in an umbrella document, set up by a Coordination Group of the CEN Management Committee, how to handle the full set of standards according to the Articles of the EPBD.

Most of the standards are in the stage of a prEN and get just comments from the national Standardisation Committees in an enquiry process. More than 2500 pages have to be reviewed from the mirror committees in the Member States. The time schedule in the mandate of the Commission (final standards end of 2005) has to be extended, because of time lacks in different work items and general revise comments by some Member States.

Depending on this situation, most of the Member States developed their own procedure taking into account the discussion in the CEN working groups. The assessment methods in the Member States which will be implemented in the first stage differ a lot from each other. The developed calculation methods differ in time steps (seasonal, monthly, hourly) and simplification levels (algorithms, default values, benchmarks). In picture 2 is shown the structure in the umbrella document on connection of the different work items and an exemplary structure of the calculation procedure chosen in a Member State (Germany).



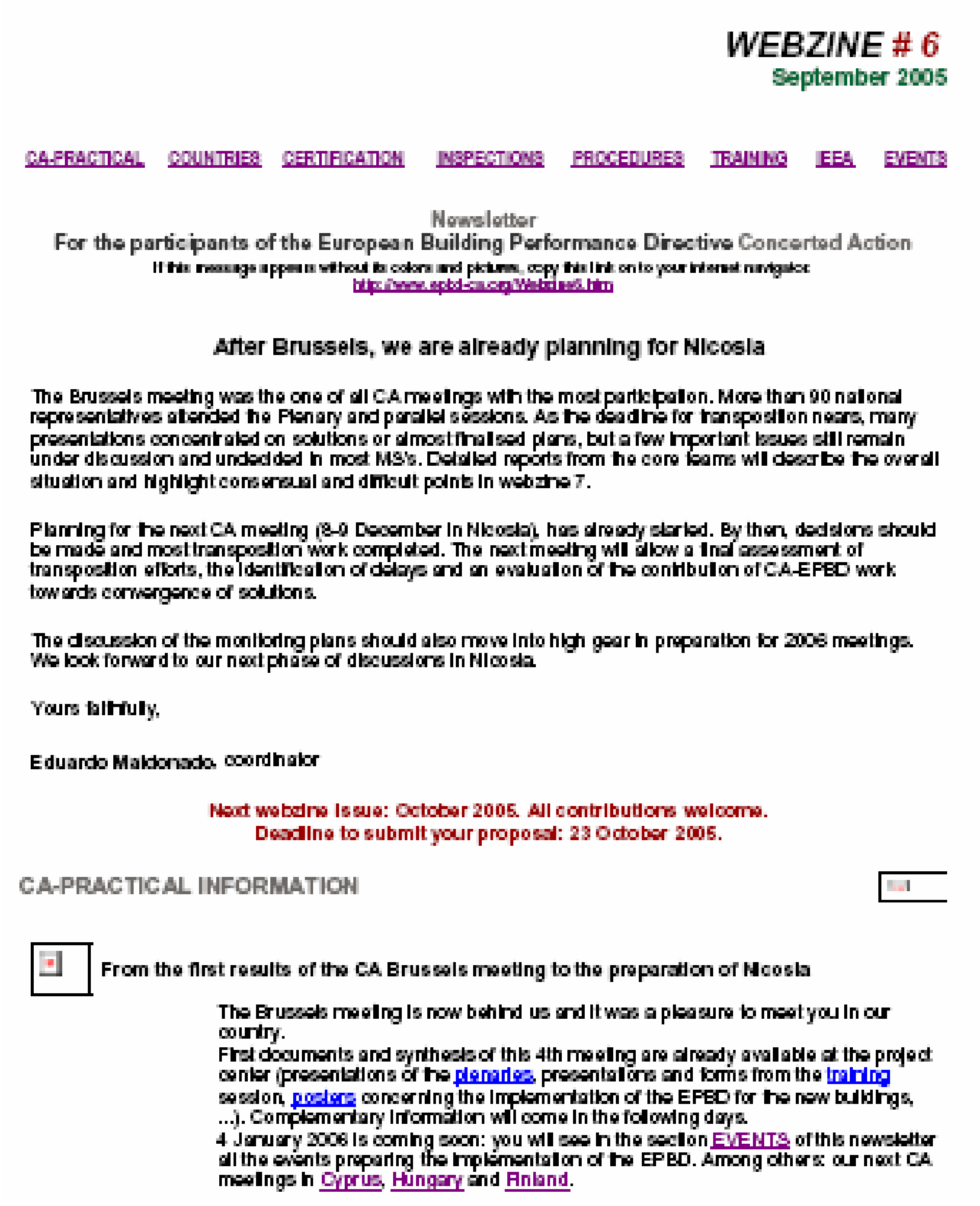
Picture 2: Structure of the CEN assessment procedure to perform the EPBD and the chosen procedure in one of the Member States

The implementation status in the Member States

In the EPBD Concerted Action project the policy makers and implementation teams of the 25 Member States exchange information and experiences on the actual problems in the implementation process. The actual status of the Member States was presented in Brussels at a conference in September. The overview could be summarised as follows:

- 22 countries will have national procedures, 3 regional ones
- all countries covers procedures for new and existing buildings
- all countries have finished a procedure for residential and 21 countries are still working on a procedure for non-residential buildings
- 19 countries use asset rating, 7 benchmark systems, 7 operational rating
- 9 countries referred to national standards, 12 published in ordinances
- 7 countries planned to implement CEN standards fully, 5 partly, 10 in a pragmatic way
- 2 countries are ready with all documents, 11 have draft versions , 12 are still not ready.

The EPBD Concerted Action project developed a newsletter service, which reflects the ongoing process in the Member States very well. In a so-called webzine the implementation teams report monthly about the actual status and supporting activities. The webzine can be viewed under http://www.epbd-ca.org.



WEBZINE # 6
September 2005

CA-PRACTICAL COUNTRIES CERTIFICATION INSPECTIONS PROCEDURES TRAINING IEEA EVENTS

Newsletter
For the participants of the European Building Performance Directive Concerted Action
If this message appears without its colors and pictures, copy this link on to your internet navigator:
http://www.epbd-ca.org/Webzine6.htm

After Brussels, we are already planning for Nicosia

The Brussels meeting was the one of all CA meetings with the most participation. More than 90 national representatives attended the Plenary and parallel sessions. As the deadline for transposition nears, many presentations concentrated on solutions or almost finalised plans, but a few important issues still remain under discussion and undecided in most MS's. Detailed reports from the core teams will describe the overall situation and highlight consensual and difficult points in webzine 7.

Planning for the next CA meeting (8-9 December in Nicosia), has already started. By then, decisions should be made and most transposition work completed. The next meeting will allow a final assessment of transposition efforts, the identification of delays and an evaluation of the contribution of CA-EPBD work towards convergence of solutions.

The discussion of the monitoring plans should also move into high gear in preparation for 2006 meetings. We look forward to our next phase of discussions in Nicosia.

Yours faithfully,

Eduardo Maldonado, coordinator

Next webzine issue: October 2005. All contributions welcome.
Deadline to submit your proposal: 23 October 2005.

CA-PRACTICAL INFORMATION

From the first results of the CA Brussels meeting to the preparation of Nicosia

The Brussels meeting is now behind us and it was a pleasure to meet you in our country.
First documents and synthesis of this 4th meeting are already available at the project center (presentations of the plenaries, presentations and forms from the training session, posters concerning the implementation of the EPBD for the new buildings, ...). Complementary information will come in the following days.
4 January 2006 is coming soon: you will see in the section EVENTS of this newsletter all the events preparing the implementation of the EPBD. Among others: our next CA meetings in Cyprus, Hungary and Finland.

Picture 3: Screenshot of the Webzine of the Concerted Action project

More information

www.brita-in-pubs.com (website of BRITA in PuBs)
www.ecobuildings.info (website of eco-buildings programme)
www.epbd-ca.org (website of the concerted action project)

Transposition of the EU Energy Performance of Buildings Directive

– Amendment of the Energy Conservation Regulations and Energy Certification –

Baudirektor Dipl.-Ing. Hans-Dieter Hegner

Federal Ministry of Transport, Building and Housing, Berlin

EC Directive 2002/91/EC on the Energy Performance of Buildings has to be transposed into national legislation by January 2006 [1]. To this end, the Federal Government wishes to amend comprehensively the legislation governing energy conservation (Energy Conservation Act, Energy Conservation Regulations [3], [6]). The amended Energy Conservation Act entered into force on 8 September 2005 [4]. This Act gives the Federal Government a wider basis of authorization to transpose the Directive. It now has to lay down details in the Energy Conservation Regulations. This paper describes how far deliberations have progressed at the working level, especially concerning the technical possibilities as regards energy certification. A departmental draft of new, evolved Energy Conservation Regulations (2006) had not yet been tabled when the paper was prepared.

1. Evolving the Energy Conservation Regulations to transpose the Directive

The objectives pursued by the EU Energy Performance of Buildings Directive are almost the same as those pursued by the Energy Conservation Regulations. The main objectives are:

- to use the whole building method for assessing the energy performance of buildings;
- to improve the energy efficiency of the building stock;
- to provide transparent information for consumers;
- information and requirements as regards improving the energy efficiency of technical equipment in buildings.

With the entry into force of the Energy Conservation Regulations in 2002, the Federal Republic of Germany laid the groundwork on many key issues. Requirements in the Directive for national standards for the energy efficiency of new and existing buildings have already been implemented by the Energy Conservation Regulations. In addition, the Regulations make it mandatory to implement the whole building method (joint assessment of the building envelope and services). In addition, the requirement for the regular inspection of boilers is already being implemented in Germany by the mandatory checks stipulated by the First Federal Immission Control Regulations, the provisions of the current Heating Systems Regulations governing dimensions, the requirement to decommission old systems stipulated by the Energy Conservation Regulations and by numerous incentive measures.

On several points, however, the Directive goes beyond national legislation. For this reason, national energy conservation law has to be adapted in some places. in particular, this concerns the following:

- incorporating the energy demand of lighting and air conditioning systems in the non-residential sector;
- introducing mandatory energy certification for existing buildings (when being sold or let);
- displaying “energy plaques” on buildings with frequent public access;
- regularly inspecting air conditioning systems.

The requirement for material changes will be implemented in the Energy Conservation Regulations. The Energy Conservation Act will also have to be amended where this is necessary given the objectives of the Directive and the strategy to implement it (especially because of energy certification in the building stock and the inclusion of lighting and air-conditioning systems).

There will be little change as far as residential buildings are concerned. The requirements introduced in 2002 and the methodology will not be altered. On the other hand, a new special procedure will be required in the Energy Conservation Regulations 2006 to address the category of non-residential buildings. The methodology of the Energy Conservation Regulations 2002/2004 is inadequate for this category of buildings. To take built-in lighting and air-conditioning systems into consideration, it will be necessary to refer to new technical rules. To integrate the shares of energy demand accounted for by lighting and air-conditioning systems into the energy performance calculation, the necessary technical regulations have had to be extensively revised and adapted. In many case, this involved entering uncharted territory (standardized monthly energy balance for the building fabric and services, assessment of the summer performance of buildings, use of daylight, et al.). Given the need for a whole-building approach, this work has been carried out by an interdisciplinary DIN working group (Civil Engineering, Building Services Plant and Lighting) and is summarized in DIN Standard V 18599 “Assessing the Energy Performance of Buildings”. The advantages of this standard over the planned European standards are that it has already been published (July 2005), that all its parts are dovetailed and that it is of a much smaller size than the 31 planned European standards, which will probably not be available until 2007. The new approaches described in this standard will apply to new and existing non-residential buildings when the Energy Conservation Regulations 2006 enter into force.

When the Energy Conservation Regulations 2006 enter into force, energy certification of existing buildings will also be progressively introduced. The Directive states that energy certification is required when buildings are constructed, sold or rented out. In addition, it makes it mandatory to display energy certificates in a prominent place in buildings

- in which public services are provided,
- which are open to the public, and

- which have a total floor area exceeding 1,000 m^2.

This obligation is not contingent on the building being sold or let, and is thus a clear instruction to “public authorities” to set a good example.

Energy performance is to be calculated and shown on the certificate. Reference is made here to the criteria listed in the Annex to the Directive, which describe in great detail the building and its services. If this performance is to be expressed in a single indicator, this will have to be done with end-use energy or primary energy.

The Directive states that energy performance certification will normally be done for the whole building. In addition, it makes provision for stating the energy performance for parts of the building, blocks or even individual apartments. In Germany, thermal envelopes as well as heating, ventilation and air conditioning systems are designed not per apartment but per building. Thus, in Germany, energy certification should, in principle, relate to the building on the whole.

2. New requirement methodology for non-residential buildings

Non-residential buildings have to meet widely varying requirements regarding their use. For this reason, a primary energy requirement solely as a function of the surface to volume ratio is not an appropriate means to achieve the objective. Rather, the future requirement to be met by a non-residential building has to be defined as a function of its use criteria. The operation of an indoor swimming pool requires a considerable amount of energy for hot water heating and ventilation, whereas office blocks can be constructed without hot water and mechanical ventilation. For this reason, the introduction of a “reference building method” has been suggested for the non-residential sector. In this method, the requirement for a specific building is no longer based on a curve dependent on the surface to volume ratio, but on a calculation of the exact geometrical dimensions of the building.

The main requirement variable will continue to be the annual primary energy demand, which is calculated using the following equation:

$$\mathbf{Q_{P,max} = Q_{P,heat,max} + Q_{P,vent,max} + Q_{P,HW,max} + Q_{P,\,light,max} + Q_{P,cool,max}}$$

The value is to be calculated zone-by-zone – based on the same geometry and mixture of uses as the future actual building – and the values for each zone added up. For the incorporation of a balance share according to the aforementioned equation, there are limits that ensure that “minor conditionings” are not taken into account.

To calculate the benchmark and actual values, marginal conditions relating to the climate and use have to be taken into account. For this purpose, the profiles in DIN Standard V 18599-10 will be used. They are the “standard profiles” (e.g. monthly outdoor temperatures, solar radiation, hot water demand, recommended indoor temperature, hours of use, e.g. use of offices, etc.) This is designed to prevent a situation where the performance of buildings is “improved” by manipulating the marginal conditions (e.g. by reducing the hours of use or indoor temperature). Over 30 profiles are available. If a specific use cannot be captured with the profiles, it should be possible to create a customized profile based on the state of the art (studies, etc.) or to use a similar “standard profile”. Depending on the use, different shares of energy may be effective in individual zones. Before the calculation is carried out, therefore, the building will have to be divided into use zones (e.g. office use, meeting rooms, canteen, circulation areas). Zones that account for less than three percent of the total reference area of the building may be counted as part of another zone that differs least from the zone in question in terms of the marginal conditions to be applied. The energy demand for each of the zones will then be calculated on the basis of the concrete conditions relating to the building fabric and services. There may be widely differing requirements and actual conditions in the individual zones. The figures for all the zones will subsequently be added up.

For calculating the benchmark values of the individual shares of energy, the Energy Conservation Regulations 2006 will stipulate marginal conditions for requirements (e.g. thermal insulation value, configurations of services, etc.), taking the uses in the corresponding building categories into account. The actual value will then be calculated on the basis of the final design and compared with the benchmark value: $\mathbf{Q_{P,max} \geq Q_{P,ACTUAL}}$

3. Energy certification – the new focus of the Energy Conservation Regulations 2006

Article 7 of European Directive 2002/91/EC of 16 December 2002 on the energy performance of buildings states that, when buildings are constructed, sold or rented out, an energy performance certificate must be made available [1]. In addition, it states that energy certificates must be displayed on public buildings.

According to the Directive, a benchmark representing the energy performance of the building has to be stated. To improve consumer-convience and transparency, information on reference values is also to be provided. The objective pursued by the Council and European Parliament in formulating the Directive was to make consumers more aware of the need for energy efficiency of buildings and to encourage energy conservation measures. As energy costs rise, tenants or buyers of buildings should be provided with better information on the service charges they will face. On the other hand, this will also create incentives for investors to operate on the market with properties that have a high level of energy efficiency. Modernization work is often carried out too slowly and inadequately. The Directive thus states that the certificate shall be accompanied by recommendations for the cost-effective improvement of the energy efficiency of the building, if this is deemed advisable from an economic point of view. This requirement of the Directive is mandatory.

According to the Directive, it is in principle possible to prepare energy certificates on the basis of calculations of demand or on the basis of metered consumption. This can be derived from Article 2, which states that the energy performance of a building is the amount of energy actually consumed or estimated. A calculation of demand is prepared for the climate and use under normative conditions. It could also be called “calculated consumption”. The great advantage of this method is that it produces a very neutral assessment of buildings. Different users do not affect the outcome. In this way, it is possible not only to assess but also to compare the quality of buildings.

At the same time, the calculation is also a diagnosis of the building. Any deficiencies will be identified and described.

Metered consumption captures not only the actual energy efficiency of the building but also, in particular, individual user behaviour and climatic influences. These influences can totally mask the true energy efficiency of a building. In case of doubt, an empty building would have the highest level of energy efficiency. The discussions about correct user behaviour (e.g. checking and setting the services properly) are interesting and necessary, but cannot replace the determination of energy efficiency quality, as called for by the Directive. Neutralization of the climate effects is always necessary for comparative studies. A diagnosis of the building and proposals for its modernization are not possible with consumption benchmarks.

The obligation to display certificates on public buildings, as well as the energy certification of non-residential buildings when they are rented out (e.g. new retail outlets in a shopping centre), will present many owners, and especially the public sector, with great problems in quickly issuing the certificates. The need to issue certificates quickly should be “staggered”, and solutions should be provided that minimize the work involved.

What options are available for providing relevant information?

4. Energy certificates based on calculations of demand

The calculation rules that already exist for the residential sector can be used for calculating demand in new buildings and for assessing existing buildings. For the collection of data in the building stock, it is planned to specify “simplified flat-rate” benchmarks. When new buildings are constructed and existing buildings modernized, a certificate of demand will have to be issued, as in the past.

Likewise, it will also be possible, under certain conditions, to offer consumption certificates for existing residential buildings.

The energy certificates are to be accompanied by recommendations for measures to modernize the building in question that experience has shown to be cost-effective. As a rule, they can be given if a limit value is exceeded (e.g. 140 % of the value in the Energy Conservation Regulations). The consumption certificate may then result in a demand analysis being carried out. These recommendations are not necessary in the case of new or refurbished buildings.

For non-residential buildings, too, it will be possible to issue either consumption certificates or certificates of demand. Now that the technical rules for the non-residential sector have been finalized in DIN Standard 18599 (published in July by Beuth-Verlag), energy certificates can be issued on the basis of this standard.

The basic parameters used to calculate energy performance will be the primary and end-use energy demand and the thermal transmittance of the thermal envelope. Primary energy is regarded as a good characteristic and was introduced by the current Energy Conservation Regulations. However, if it is viewed in isolation, it can often lead to wrong conclusions being drawn. For instance, although the use of wood pellet boilers results in a favourable primary energy value, there may still be a high end-use energy demand, which will be presented to the user in the form of high service charges. The use of systems with good primary energy efficiency must not mask the service charges that are likely. Both the primary energy demand (as an environmental indicator) and the end-use energy demand must be displayed in a prominent place. In addition, the values must be explained. In particular, it must be pointed out that the demand assumes standardized marginal conditions and that the value cannot be used to order next year's energy supply but merely allows a comparison between buildings. If appropriate, demand should be declared as "standard consumption" (as for cars).

Both primary and end-use energy demand are to be clearly shown. In addition, the calculation of demand can be used to make specific proposals for modernization. Showing the shares of demand accounted for by energy in non-residential buildings makes it possible to identify where investment is advisable. It is envisaged that the energy certificate will use standardized forms, as stipulated by the Energy Conservation Regulations. A proposal will be published with the departmental draft of the Energy Conservation Regulations 2006. An initial test was carried out in a European Community project. The calculation rules of various EU Member States were used for the project at the European Commission's headquarters in Brussels and energy certificates were issued.

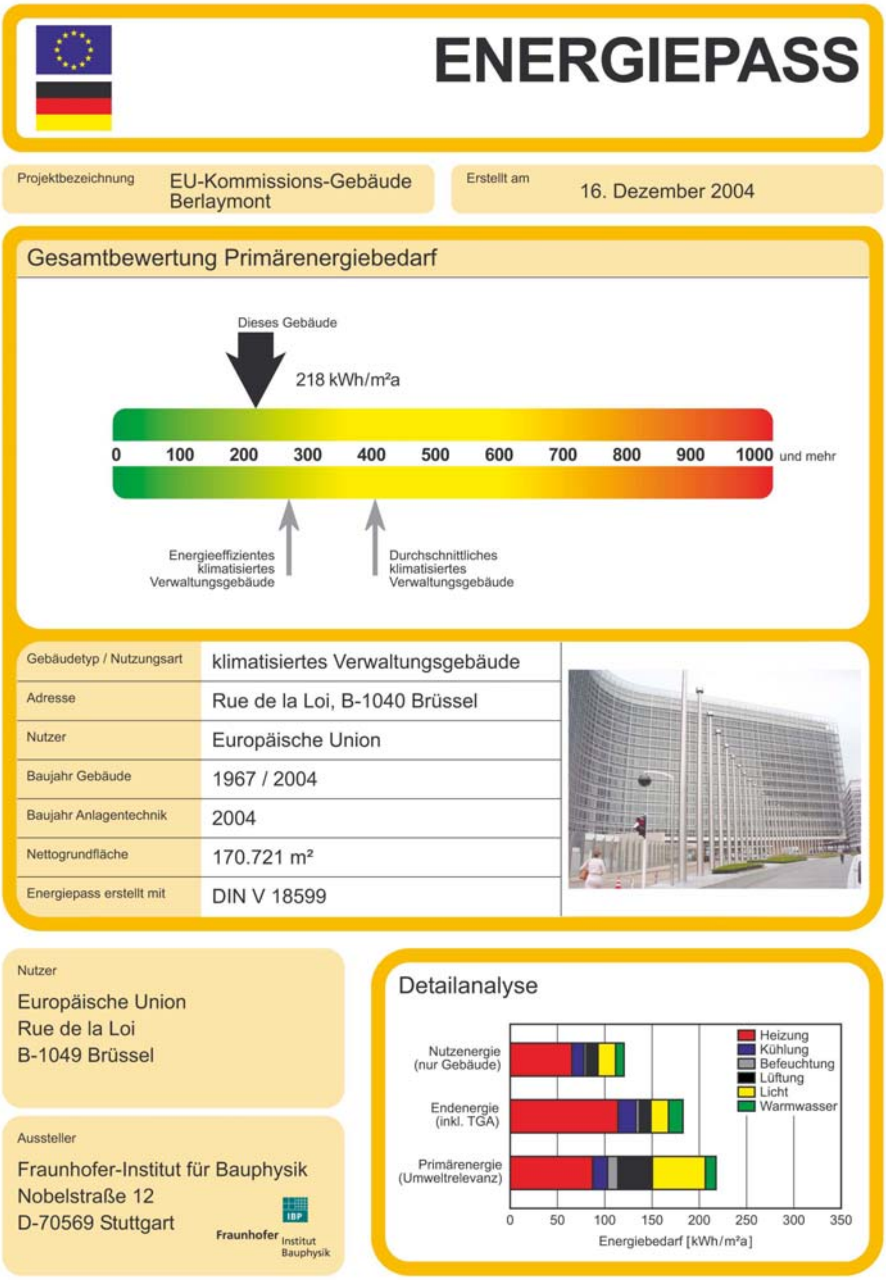


Figure 1: *Energy performance certificate issued by the Fraunhofer Institute of Structural Physics for the Berlaymont building in Brussels (Assessment of total primary energy demand, this building: 218 kWh/m^{2}a, Average air-conditioned office building: 400 kWh/m^{2}a, Energy efficient air-conditioned office building: 250 kWh/m^{2}a, Net floor area 170,721 m^2, Energy certificate issued on the basis of DIN V 18599)*

5. Energy certification based on consumption benchmarking

In the case of residential buildings, energy consumption benchmarks are to be determined using energy consumption data calculated for a whole building within the framework of the invoicing of heating costs under the Heating Costs Regulations.

Benchmarks are to be determined for the concrete accounting period on which the weather adjustments are also based. Electricity (e.g. for auxiliary power) is not to be taken into account in the case of residential buildings.

A description of the energy performance of non-residential buildings requires that the measurement of consumption takes into account both the energy consumed for heating and hot water and the energy consumed for lighting, ventilation and air conditioning systems, and auxiliary power (e.g. for pumps). This means that both energy consumption attributable to heating and electricity consumption have to be analyzed.

Heating consumption benchmarks are to be determined using consumption data calculated for a whole building for one year within the framework of the measurement of heating consumption or within the framework of the invoicing of heating costs under the Heating Costs Regulations. Benchmarks are to be determined for the concrete accounting period on which the weather adjustments are also based. The data must be climate adjusted. If the heating consumption of the building includes components that are not dependent on the weather (e.g. hot water heating or other consumption not dependent on the weather), the calculated heating consumption must be split, before the weather adjustment is made, into the portion that is dependent on the weather (heating energy) and the portion that is not dependent on the weather (hot water heating). The following equation is used for the weather adjustment for the heating energy component of heating consumption for a federal mean:

$$E_{V,H,Fed} = f_{climate} \cdot E_{V,H}$$

where

$E_{V,H,Fed}$ is the weather adjusted proportion of heating consumption (heating energy) for a building in kWh/a
$E_{V,H}$ is the weather dependent proportion of heating consumption (heating energy) for a building in kWh/a
$f_{climate}$ is the climate factor, calculated as described in VDI 3807-1

This value is placed in relation to the usable floor space and can then be stated in the energy certificate. For comparison purposes, consumption data from buildings in the same building category can be used. In the case of residential buildings, comparison is also possible with 140 % values from model calculations.

Benchmarks for non-residential buildings are currently being derived from statistical surveys carried out by the Federal Government and the federal states. Non-residential buildings are to be classified by groups or types of buildings in accordance with the Standard Classification System for Structures of the Standing Conference of the Federal State Ministers responsible for building.

Electricity consumption benchmarks for non-residential buildings are to be determined using energy consumption data calculated for a whole building for one year within the framework of the invoicing of electricity costs or the measurement of electricity consumption. The accounting period should be the same as that used for determining heating consumption. It is here, however, that the shortcomings of consumption measurement become apparent. In many cases, the electricity consumption determined includes significantly more than the shares accounted for by lighting, ventilation and air conditioning systems, and auxiliary power. Energy used for manufacturing, computer centres, lifts, special uses, etc. distort the building-related electricity consumption. Solutions therefore have to be sought for making the data more objective (by adjusting them if necessary) or for explaining them. In addition, reference values from statistics for corresponding building categories should be shown here, too.

Since it is not possible to derive any information on modernization from consumption values, ways should be sought of implementing this requirement of the Directive. One possibility would be to define a requirement that if the reference value is considerably exceeded, the calculation should be carried out on the basis of DIN V 18599, in order to state the scope for improving energy efficiency. Appropriate regulations still have to be coordinated.

6. Looking ahead

The first step in the process of adapting and amending energy conservation legislation to implement the EU Directive on the Energy Performance of Buildings was the adoption of the Energy Conservation (Second Amendment) Act by the lower and upper houses of the German Parliament [12]. The departmental draft for the Energy Conservation Regulations 2006 will be published by the new Federal Government in the near future.

It will contain detailed rules governing energy certification as well as transitional periods. Under the new Regulations, both the demand-based and the consumption-based methods are to be possible in both the residential and non-residential sectors. The appropriate engineering conditions have been created with the publication of DIN V 18599 and various draft technical guidelines.

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Ecobuilding approaches

BRINGING RETROFIT INNOVATIONS TO APPLICATION IN PUBLIC BUILDINGS – BRITA IN PUBS

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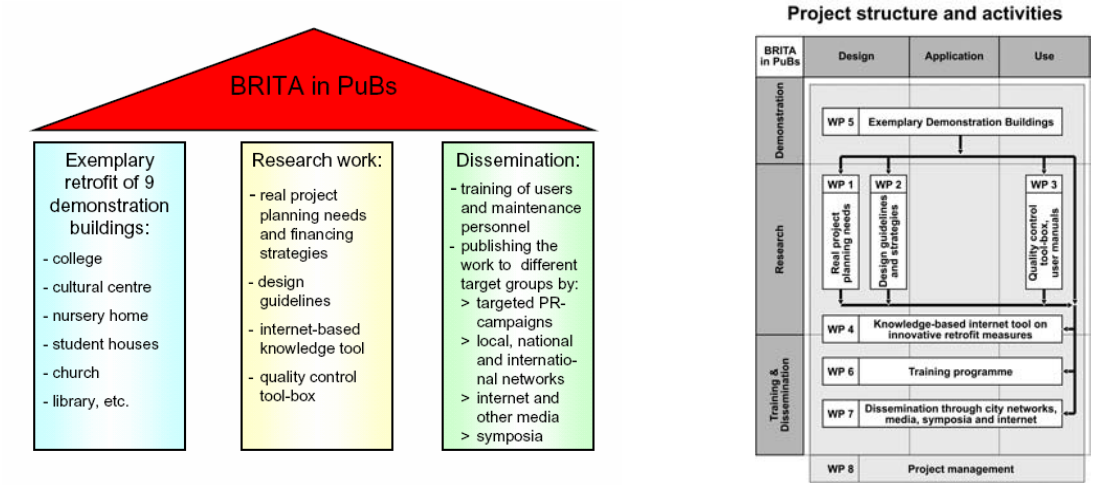
Introduction

The BRITA in PuBs project on Eco-buildings aims to increase the market penetration of innovative and effective retrofit solutions to improve energy efficiency and implement renewables, with moderate additional costs. In the first place, this will be realised by the exemplary retrofit of a group of demonstration public buildings in the participating European regions (North, Central, South, East). By choosing public buildings of different types such as colleges, cultural centres, nursery homes, student houses, churches etc. for implementing the measures it will be easier to reach groups of differing age and social origin. Public buildings can be used as engines to heighten awareness and sensitise society on energy conservation.

Secondly, the research work packages will include the socio-economic research such as the identification of real project-planning needs and financing strategies, the assessment of design guidelines, the development of an internet-based knowledge tool on retrofit measures and case studies and a quality control-tool box to secure a good long-term performance of the building and the systems.

The third main pillar of the BRITA in PuBs project is dissemination. This is divided into a minor part, the training of users and maintenance personnel, and a larger section on publishing the research and demonstration work to different target groups. This is organized by a combination of targeted PR-campaigns and using local, national and international networks such as Energie Cités, the internet and other media, and arrangement and participation in symposia and conferences.



Picture 1: Structure of the Eco-Buildings project BRITA in PuBs.

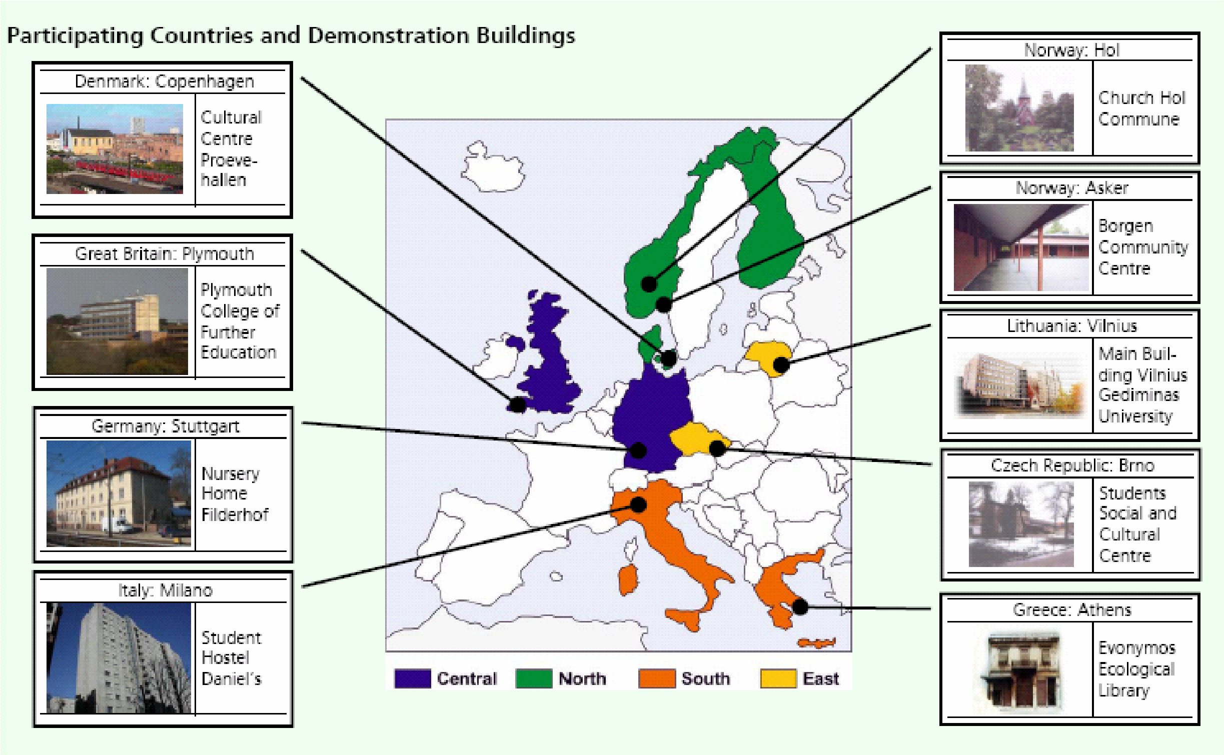
The project is organised geographically by regions and vertically by incorporating the owners of the public buildings, the research team of architects and engineers and the project dissemination networks. The project is managed via biannual meetings, a steering committee and four subtasks on design, implementation, use and dissemination. A general assembly decides on finance and project alterations, which are prepared for discussion by the steering committee

The project emphasises

Exemplary retrofit measures at selected public buildings

The objective of this activity is demonstrating the implementation of innovative energy saving renovation technologies in public buildings. Different public building types with relevance to the energy consumption in Europe are chosen for this project to cover the whole public building sector. The buildings are located in all 4 regions (North, South, Central and East) in Europe in which the project is active.

The technology applications includes measures at the building envelope like improved insulation and high efficient windows, advanced ventilation concepts like hybrid systems, integrated supply technologies like combined heat and power units, energy-efficient lighting and integrated solar applications.



Picture 2: The demonstration buildings of the eco-buildings project BRITA in PuBs

The activities on 7 of 9 buildings are going regularly: some of them are still in the advanced design phase, others are already in the building phase and in three of them the building works are almost completed and the evaluation phase has started.

Research work

As shown in picture 1, the BRITA in PuBs covers 4 research activities:

Real project planning needs and financial strategies

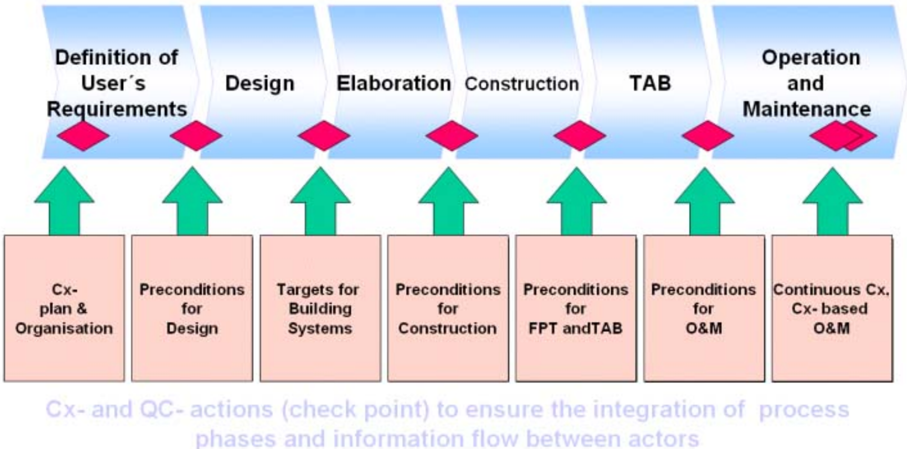
The objectives of this activities in the BRITA in PuBs project are to analyse the critical path in a public administration for decisions concerning the introduction in building renovation projects of renewable energy and energy conservation technologies and to identify and assess successful financial mechanisms for public authorities. The project analysed the existing literature databases and worked out a questionnaire for interviews with stakeholders.

Guidelines and tools for choosing the right design strategies

The aim of this work is to support the design stage with tools and data. Looking on the different types of buildings and the different strategies and technologies used in the demo buildings, the project group decided that the best way to arrange this activity is to divide by technology and then for each topic to give an overview on what kind of buildings these would be suitable for.

Quality control box

In this activity the project group will develop a concept from design to post construction life long management, using BEMS/REMS-type procedures and using prevailing methods. A toolbox will be developed in electronic/internet-based form and be structured according to the major building project stages.



Picture 3: The planned structure of the quality toolbox of the Eco-Buildings project BRITA in PuBs

Knowledge based information tool of innovative retrofit measures

The analysis of earlier studies on restraints has shown that new technologies are rarely applied because of a lack of knowledge at the decision makers. Yet those of them, having reliable information on innovative technologies tend to realise these technologies more often. Therefore it is important to provide them with profound data bases including advantages and disadvantages of retrofit technology and practical experience with realised projects. This project activity extends an existing database with technology and experiences out of the research and demonstration projects with special respect to gained results from synergy effects of different technologies.

Picture 4: Parts of the IEA Annex 36 ECA (left) will be used for the BRITA in PuBs tool (right)

An α-version of the tool is available soon. This will include some of the first parts of the case studies and the first revised chapters of the retrofit measures.

Dissemination

As shown in picture 1, the BRITA in PuBs covers 2 main dissemination activities:

Training and e-learning programme

The activities aim at informing, helping to develop a consciousness and therefore improving the user's behaviour on energy questions. Furthermore instruments of e-learning/distance learning shall be enhanced and used to distribute knowledge.

The user behaviour has a strong influence on the energy performance of buildings, it can increase or decrease the energy consumption for heating and lighting by more than 50 %. Additionally it can influence the indoor comfort. A change to a better user behaviour is a no-cost measure for the building owner and will therefore be supported by them. For each target group (occupants like pupils and teachers or office workers/care-takers and maintenance personnel/administration) a simple blackboard information sheet will be developed specifically, which informs on positive and negative influence possibilities to the energy consumption and indoor comfort of buildings. Slogans on blackboards could be:

„a sustainable building starts with the user“ ***or*** **„an intelligent building management system, is just as intelligent as the care-taker and the maintenance personnel dealing with it“.**

Internet platforms designed for the academic and general education in several countries e.g. ”Multimediales Lernnetz Bauphysik” shall be used in the project. The project results can herewith made available for the target groups and the knowledge be transferred to different countries. A possible example for the contribution of BRITA in PuBs to the e-learning would be to create a virtual experiment like showing the influence of user behaviour on the energy consumption and indoor air-quality.

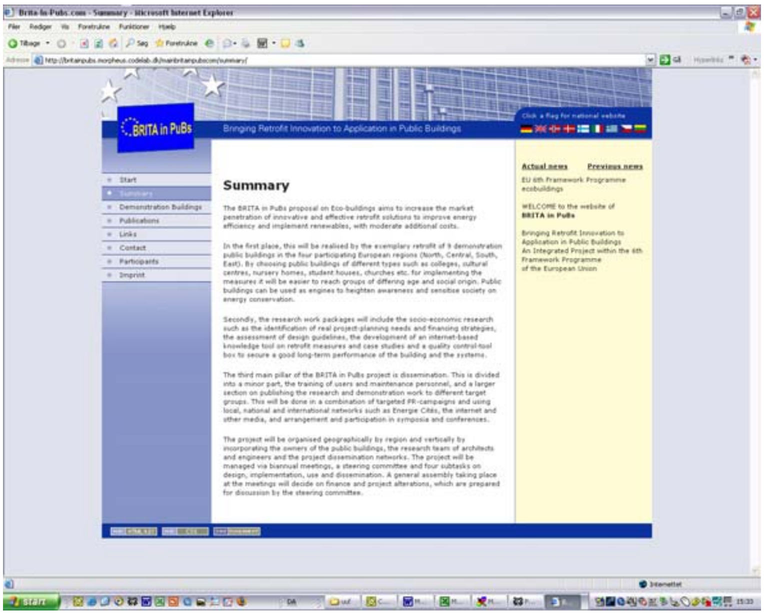
Common and project related dissemination

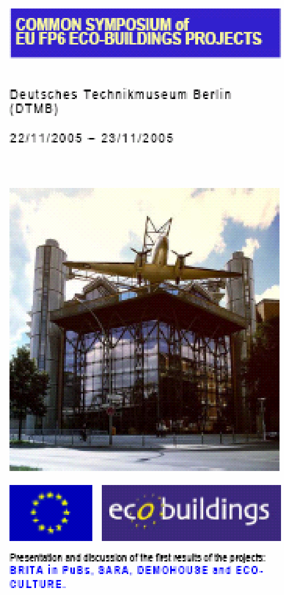
The dissemination activities are directed to public decision-makers (key local political and administrative decision-makers at different hierarchic levels) and how they can bring retrofit innovation technologies for energy saving or renewable energy supply into application in public buildings. The key to this motivation is to convey knowledge about technical possibilities of energy saving and renewable technologies paired with practical and economical experience from the BRITA in PuBs project to the public decision-makers and thereby assure the replication of the demonstrated cost-efficient measures. The explicit goal is to make the innovative sustainable building renovation issues an integrated part of decision-making.

Additional objectives are to:

- creation of an internet communication platform for information-exchange (www.brita-in-pubs.com)
- contribute to continuous education of professionals involved in the building process through the whole life cycle from design, via construction and commissioning to everyday use.
- help to establish benchmarks and performance indicators
- bring design guidelines to the attention of authorities and building professionals
- accelerate the general market penetration of innovative technologies for energy efficiency and renewable utilisation in buildings.
- creating awareness at the public of the communities by involvement of local city networks like AGENDA 21

The 4 eco-building projects started common activities and developed a common eco-building website, a newsletter, posters and report layouts. The different eco-building projects are sharing the work – the BRITA-in-PuBs project is supplying a standard poster format and is organising the first joint symposium in Berlin. The Coordinators are also joining at least one meeting of the other projects and once a year a joint coordinator meeting.





Picture 5: Screenshot of the BRITA in PuBs website and the announcement of the first common ECO-BUILDINGS symposium in Berlin.

More information

www.brita-in-pubs.com (website of BRITA in PuBs)

www.ecobuildings.info (website of eco-buildings programme)

SUSTAINABLE ARCHITECTURE APLIED TO REPLICABLE PUBLIC ACCESS BUILDINGS – SARA, WWW.SARA-PROJECT.NET

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Introduction

SARA aims to construct sustainable, cost effective, high energy performance, public-access eco-buildings that are immediately replicable at large scale in many locations. The eco-buildings will be equipped with sustainable energy technologies integrated by an innovative architectural approach and combined monitoring and building management systems (BMS).

SARA involves the demonstration of 7 highly sustainable and replicable Public-access buildings in 6 EC Member States (Austria, France, Italy, Slovenia, Spain and the UK) and 1 New Independent State (Uzbekistan). An important German research centre is also involved. In total there are 15 participants in the project.

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.

The demonstration sites include integrated project planning, active and passive solar design, low energy construction, including sustainable materials and components and including renewable energy technology and building energy management systems.

The buildings will surpass the requirements of the European Directive on Energy Performance in Buildings and the project is committed to achieving energy savings of 30% with an overcost of no more than 5% compared to conventional public buildings in each country. The overcosts in each building will be due to the use of more environmentally sustainable architectural practices and techniques, energy efficient installations, use of renewable energy sources, and automated energy management systems. All of these innovations are market ready and replicable in other buildings.

SARA will successfully implement interdisciplinary, integrated, sustainable energy actions on a Europe-wide scale. The results will be monitored and disseminated in order to contribute to future similar actions through replicability, promoting energy sustainability in buildings. The replicability of the Eco-buildings will be corroborated by facilitating useful information from the SARA experience to the main market actors through particular SARA initiatives and through common activities in collaboration with the other "Eco-buildings" contracts of the EC (see: www.ecobuildings.info).

Content - Work performed and results achieved to date (October 2005)

The project has now concluded the first year of its four year duration and the project is proceeding according to plan. The precise construction calendar varies between buildings as indicated in the table on the following page.

In addition to the eco-building progress and international management of the consortium, collaborative work performed has focussed on the following areas:

- Design advice and consultation
- Establishing common standards and minimum requirements for Building Management Systems (BMS), monitoring via BMS and integration with or incorporation of public interpretation facilities
- Research on how to certificate building energy performance once constructed

- Development of dissemination and training tools and materials.

The results achieved so far are:

- A report updating the energy design specifications of each building
- Reports defining standards for BMS based monitoring, public interface
- Detailed consultation regarding energy performance of each building design and optimisation of some buildings as a consequence (also detailed in reports).
- An information bulletin for consortium coordination
- Agreements on dissemination of all Eco-buildings projects.
- A web site for external promotion and internal communication.

SARA's second year, looking ahead

SARA's second year will see construction work start on all remaining sites. At the same time, systems will be developed to integrate output from the building management systems (BMS) and comparative information to provide energy performance indicators available to the public via the project web site. The challenges here are to enable fluid and compatible communication between various systems and to present the information in an intelligible, comparable, accessible and attractive way. Rapid prototyping will be carried out using test systems and the buildings already completed in order to have definitive solutions ready as the rest of the buildings come "on-line".

This innovative part of the project is seen as a vital contribution to achieving SARA's full demonstration potential. It is also an exciting way of exploiting the rapidly developing possibilities offered by information and communications technology. More details will be provided by Ursula Eicker in a separate contribution to the symposium.

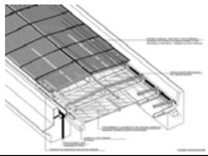
Eco-building	State of progress (October 2005)	Photos / images
Office and Laboratory building. Sinabelkirchen (Austria)	Work on site is now ready to start, pending administrative matters. All construction work is now expected in 2006.	
Primary School, La Tour de Salvagny, France	Construction finished. PV ready for grid connection.	 
Cultural Centre - *refurb*. Napoli (Italy)	All plans approved by ministry of culture and heritage. Completion expected by May 2007.	  
Health Centre, Barcelona Spain,	Construction work is now in progress. Foundations work is complete and the concrete based structure is being constructed.	  September 2005 December 2006:
Supermarket Ljubljana (Slovenia)	The project for building permission is finished and the executive project will be finished by the end of 2005. Construction is expected March 2006 – Dec. 2006.	
University Services Building Southampton (UK)	Construction finished. All systems operational. Building to be inaugurated 9/05	  
Community centre,- *refurb* Bukara, (Uzbekistan)	Refurbishment of existing structure on-going. Final energy strategy design to be completed once this is finished. Construction will start before May 2006.	 

Table 1 : Summary of SARA Eco-buildings progress and plans.

Focus on the Southampton University Eco-building

This is the first SARA eco-building to be completed and information is offered below to give a clearer indication of the scope of the project by means of a specific example.

Basic characteristics	"One stop shop" for student's administrative needs (recruitment & admission, graduation office, accommodation, fees and loans, etc.)		
Useful floor area	2600 m^2 (new building); 2000 m^2 (existing building)		
Energy (Between types 2 & 3 of BREEAM Energy Efficiency Best Practice Guide)	Standard Building	Eco-building	Saving
Demand (kWh/m^2/yr)	278	170	108 (39%)
Renewables contribution (kWh/yr)	0	12,500	
Water usage	Reduction by 1,830 m^3/yr relative to standard building		
Time schedule	Start of construction: 10th May 2004, Completion: 16th May 2005		

Table 2. Southampton University Eco-buildings vital statistics

The building aims to demonstrate a high level of innovation in planning and architecture. It is **a three storey structure with basement** and is physically attached to the existing administration office building on a triangular shaped site.

It provides a large, accessible, attractive space, able to accommodate large numbers of visitors at peak periods. It consists of a reception area, seating, customer service desks, computer work stations, events space and display space.

Passive solar design is used to give priority to the use of natural light and natural ventilation, complemented by a minimum of additional lighting and mechanical ventilation to maintain comfort levels.

Air conditioning is not provided, but free cooling by means of exposed structural mass, and ground cooling from low-level air displacement units in the atrium combine with opening ventilation panels alongside each double-glazed fixed window, to provide **occupiers** with a comfortable environment, over which they can directly influence a **degree of control**.

The 11.3kWp Atrium integrated Photovoltaic system is expected to generate up to a third of the power consumed in the new office floor area, and provide solar shading.

The design of the pitch and orientation of the larger glazed roof included PV considerations.

The vertical atrium roofing elements include mechanically controlled natural ventilation systems, which, like all services and environmental readings are continuously monitored by a

Building Management System (BMS). Uniquely, much of this data will be made publicly available via the internet as part of the SARA project.

All aspects of the building are designed to minimize environmental impact. This includes energy and water usage and construction materials, and incorporates use of grey water systems.

Expected final results and conclusions

The principal end result of the project will be the demonstration of high energy performance in the buildings themselves. The fact that the project coincides with the implementation at national and regional levels of the European Directive on Energy Performance in buildings is no accident: the expected impact is the exploitation of their replication potential of the Eco-buildings by making their performance standard rather than exceptional in a wide range of public access buildings through political or commercial interest and commitment to the demonstrated results. The secondary expected result that will be more difficult to measure is the dissemination effect on the public who access the buildings. It is hoped that the demonstration example will raise awareness of the value and importance of improving energy performance in buildings in Europe and lead to changes in habits and perceptions. More details can be found on the project web site: **www.sara-project.net**

Acknowledgements
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DEMOHOUSE: DESIGN AND MANAGEMENT OPTIONS FOR HOUSING

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Introduction

Since the renewal of the existing building stock is about 2% per year there exists an enormous potential for improving energy savings and introduction of renewables in connection to the needs for rehabilitation of existing building areas in Europe, both in the "EU15" - countries and -even more-in the new EU member states.

The idea of the DEMOHOUSE project, which involves seven countries: Austria, Denmark, Greece, Hungary, the Netherlands, Poland and Spain, is to focus on introducing healthy, cost effective, energy effective and sustainable renovation and rehabilitation in Europe, an area which there will be a very large demand for in the coming years in connection to aims of improving the economic and social development in Europe. The aim of the project is to develop minimum standards and recommendations in connection to the above themes and to agree on actual quality agreements in this field.

Compared to construction of completely new houses, the traditional possibilities for improvement of energy efficiency and sustainability of existing houses are limited. In the first place technical barriers must be mentioned: an existing building has its physical restrictions. Furthermore, there could be socio-economic barriers: tenants are not always willing or capable to pay a higher rent as a consequence of investments in energy conservation measures, if the costs are not compensated by savings on energy costs or substantial improvement of comfort. And last but not least: to organise the implementation of energy conservation measures in existing buildings is much more difficult, compared to raising the energy efficiency standard in new to build buildings.

Energy Conservation and Renovation

In practice, energy conservation and sustainability measures are relatively easily implemented if they are combined with renovation or major overhaul. However, research in for instance the Netherlands has pointed out that energy conservation measures in renovation and maintenance projects are not always the optimal ones, seen from the perspective of cost-effect ratio. Furthermore, sustainability is seldom considered, so that the gains on the one side can result in losses on the other (with respect to embodied energy of materials, unnecessary replacements of components and lack of life cycle approach in design and construction).

It is not that we do not know how to improve energy performance and sustainability in existing buildings. As can be seen from the reports of projects carried out within various EU programmes, IEA tasks, national programmes and private initiatives, a lot of theoretical and practice oriented research on innovative techniques and processes for energy efficiency, energy conservation, renewable energy and sustainability, all with respect to buildings, has been done already. However, only few of the results of previous work have been implemented in practice in a substantial way. Though so far no research investigating the reasons of not implementing these results are known, several reasons are imaginable.

In the first place, the problem of high costs can be mentioned. The costs of demonstration projects are necessarily high. This is why these projects mostly get financial support within the framework of the EU or national demonstration programmes. In order to bring the costs down, a larger scale of implementation is necessary. But this is again blocked by the high costs...

In the second place, there is probably a lack of knowledge about the further possibilities of demonstrated techniques. Newly developed solutions are not always applicable ‘as is’ in other situations, but must be picked up by architects and consultants for adaptation, further development and application. In case of renovation, demonstrated techniques have to be optimised for very specific situations.

In the third place, the organisational and financial structure of large housing companies might be not the most appropriate for large-scale implementation of new developments. In addition, the social aspects of renovation make renovation in itself a complex process, which offers limited openings for demonstration of, and experiments with new developments.

Reference Projects, Pilot Projects and Theme Groups

How does the DEMOHOUSE project deal with the problems mentioned above?

For each of the participating countries a Pilot project and a Reference project have been defined. The Pilot project will be the actual demonstration project, where the recommendations of the investigations and research will be implemented where possible (this is due to the fact that a 6th framework project on the one hand and renovation projects in practice on the other have their own project dynamics, which are not always matching). 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 and national standards. The selected Reference housing complexes will be analysed on possibilities for improving the energy performance with at least 30% above the usual standards. In principle, the savings on energy costs must cover the extra capital costs of the energy conservation measures. As a straightforward pay back analysis might not always be the right approach for energy conservation measures in renovation processes, new financial and management models could be necessary to reach this goal.

Based on the best practices within and outside the country concerned, solutions will be proposed. In order to judge the suitability and applicability of these techniques and solutions, the reference housing complexes and the pilot projects will be subject to further thematic analyses, i.e. energy (energy efficiency, implementation of renewable energy and passive solar design), sustainability, socio-economic aspects, building technology & building physics, indoor environment and maintenance. The analyses will be carried out by various "theme groups", consisting of project partners, specialised in the themes concerned, from at least two different countries.

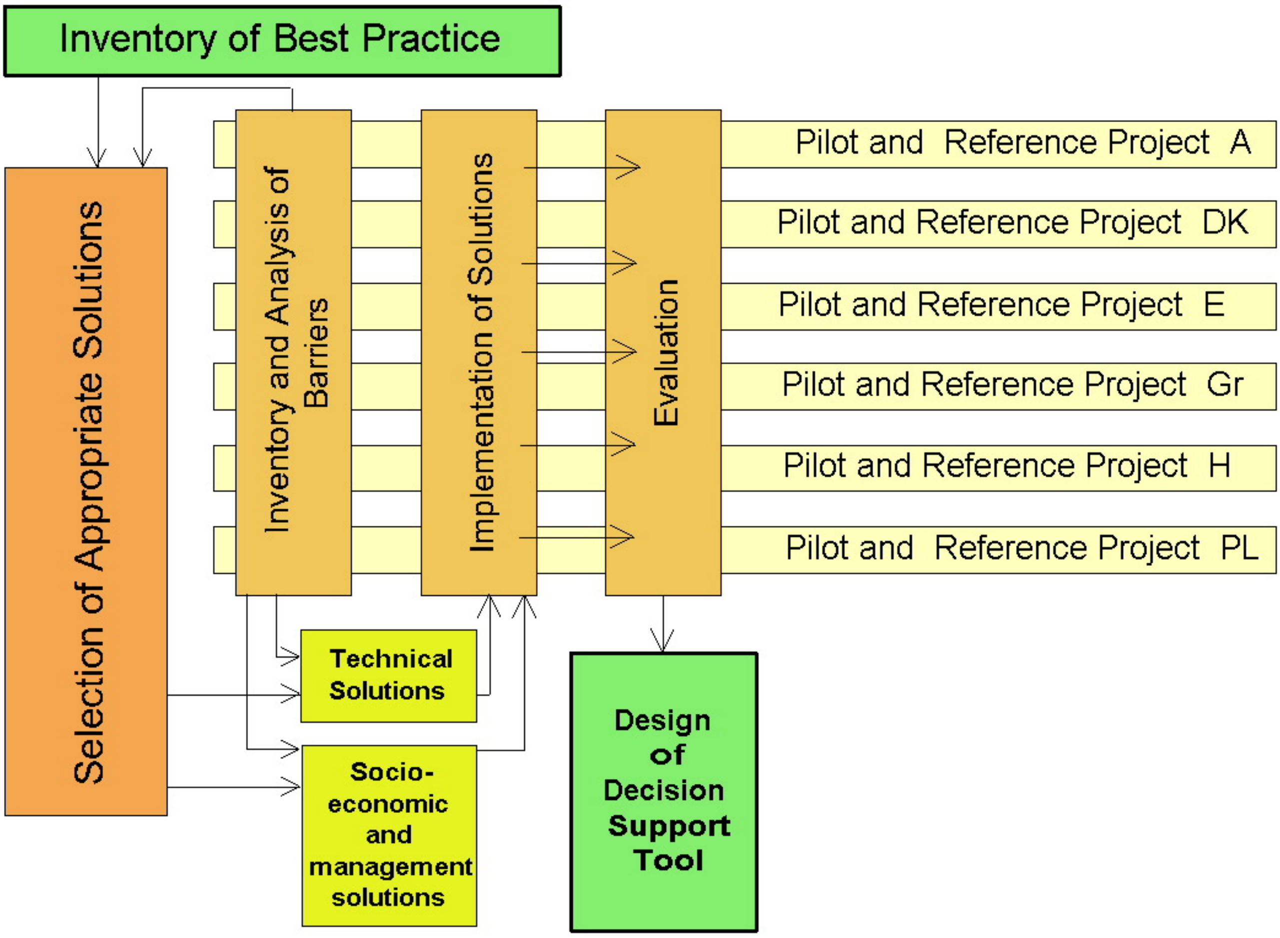
The outcomes of the analyses will be confronted with the above-mentioned techniques and solutions that will be modified when and where necessary. The techniques and solutions will be ranked according to effectiveness, being the maximum of CO_2 reduction per invested Euro. This is not only the CO_2 reduction gained by reduction of energy use for heating and domestic hot water, but also CO_2

reduction gained by minimising the embodied energy of building products and constructions. Where possible, the selected solutions will be implemented in the Pilot projects.

In order to remove the financial and organisational barriers to large-scale implementation of new renovation technologies, not only the design of the projects will be improved, but also new management approaches and new financing models will be developed and demonstrated. These management approaches will assess the sustainability aspect of future maintenance measures, whilst new financing models will help to ease implementation of energy efficiency measures in renovation processes.

Structure of the Project and expected results

The main structure of the project is summarised by the figure below.



Basically, the project starts with identification, description and analysis of the reference projects, one per participating country (with exception of the Netherlands: after the withdrawal of an originally intended demonstration project it was not able to get a new project in) *(Inventory and Analysis of Barriers)*.

Within the renovation processes, the reference projects will usually be adapted to the energy performance standards that are in force. The energy performance and the environmental load of the reference project before and after renovation/maintenance will be calculated. This is also the case in the Greek project, which is not a renovation but a new housing estate, where the proposed improvements will be compared to the project like it would be made “as usual’.

It is here that the "theme groups" start their work. Starting from their analyses, an inventory will be made of possible suitable solutions, both technical and organisational, from Best Practice and demonstration projects *(Inventory of Best Practice).* Important in this stage is the cross fertilisation between the participating countries, which may lead to common or less common solutions that have already been implemented and that can be applied in other countries.

Apart from possible existing solutions, new solutions will be generated in the phase *Selection of Appropriate Solutions.* The proposed measures will be ranked according to effectiveness (CO_2 reduction per Euro invested), CO_2 reduction related to sustainability (embodied energy, use of materials, possibilities for recycling, durability), the applicability of the techniques/solutions without adaptations, and to the contribution of the technique/solution to the increase of renewable energy in the built environment.

In the next stage the solutions will be integrated into a technical design for the pilot projects *(Technical Solutions)*.

Also suggestions for a new management approach and/or new socio-economic approaches will be developed where necessary, in close co-operation with the concerned housing company/companies *(Socio-economic and Management Solutions)*. The expected solutions focus on strategies to overcome socio-economic barriers and on management protocols during the life cycle of the pilot projects. The solutions link the problems and chances of all demonstration projects in the different countries and define new strategies for:

- Policy making on refurbishment and on energy conservation by housing institutions or co-operatives;
- Agreements between parties on ambitions and contributions;
- Financial instruments;
- Regulations and directives from the EU and regional governments.

The solutions –both the technical and the socio-economic solutions- will be implemented in the Pilot complexes as far as possible *(Implementation of Solutions)* and an evaluation will be made, focused on effectiveness with regard to energy and environment, costs and social aspects, by means of:

- Carrying out well designed sensitivity studies in order to assist designers to investigate the specific impact and performance of a parameter, component, system or a combination of them, in a building and adapt its/their design accordingly, and
- Calculating the specific and global energy and environmental efficiency and performance of the final design of a building, in order to compare with initial targets, existing consumption data and finally classify it according to a rating scheme.

Thus, the simulation / evaluation task should:

- Provide designers with the appropriate inputs for any kind of evaluations.
- Assist designers to carry out sensitivity studies to improve their design.
- Assist designers and evaluation teams to calculate the specific and global efficiency of the buildings.
- Provide designers and engineers with statistical energy data for relative energy and environmental classification of their building.
- Provide participants with an accurate rating / classification methodology, involving a homogenisation procedure for cross comparisons.
- Improve the life cycle cost and performance of each building

The material outcome of the project is a decision support tool for housing companies, municipalities, architects, building contractors and building material suppliers *(Design of Decision Support Tool).* Besides, the tool will also contain useful information to energy agencies, national and European associations of professionals in the building, housing and energy sectors, universities and Technical Colleges. The tool, in the form of a CD ROM and downloadable from the Internet for free, consists of:

- decision support models on energy conservation measures, applicability of renewable energy and maintenance management in the housing sector;
- examples of best practice in well defined, specific contexts, which may form a lead for energy efficient and sustainable renovation of the housing complex concerned;
- an overview of technical measures, listed according to CO_2 reduction per invested Euro, CO_2 reduction related to sustainability (embodied energy, use of materials, possibilities for recycling, durability), the applicability of the techniques/solutions without adaptations, the contribution of the technique/solution to the increase of renewable energy in the built environment;
- examples of appropriate financial models, management and policy approach for affordable energy efficient renovation;
- an overview of pilot projects in relation to reference projects;
- an overview of appropriate tools for evaluation of energy saving measures;
- performance indicators of energy efficiency, to meet the European Directive on Energy Performance in Buildings (EPBD).
- a maintenance planning and control tool, in order to guarantee as much as possible that the implemented measures will function in a proper way during the remaining life time of the building.

Concluding remark

DEMOHOUSE is an ambitious project, which has started one year ago. It is clear already that the discrepancy between project planning and day-to-day reality of renovation will not ease the project process. However, due to the enthusiasm of all the partners the project has good prospect to reach its goals.

ECO-CULTURE
DEMONSTRATION AND DISSEMINATION OF ECO-CONCEPTS FOR HIGH-PERFORMING EUROPEAN CULTURAL BUILDINGS

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Introduction

This project addresses demonstration of energy-efficient technologies integrated into three high-performing cultural ECO-buildings:

- The Danish Royal Theatre, Copenhagen, Denmark
- The Amsterdam Library, Amsterdam, The Netherlands
- The New Opera House, Oslo, Norway.

The construction of the buildings is ongoing and will be finalised in 2008. Results will be published at www.cowiprojects.com/ecoculture.

Project Goals

The overall energy objectives of the ECO-CULTURE buildings are:

- To reduce the energy consumption and CO_2 emission related to cooling by 75-80%;
- To reduce the heat consumption and related CO_2 emission by 35-50%;

- To reduce the energy for ventilation and related CO_2 emission by 35-50%;
- To use renewables; sea water, ground water and solar energy;
- To use intelligent control for maximised utilisation of the used technologies.

To disseminate the used ECO concepts of the high-performing cultural buildings as there is a need for increased awareness of ways to improve the environmental performance of this type of buildings throughout Europe and beyond.

Royal Playhouse theater, Copenhagen

The playhouse will accommodate a large stage with a seated capacity of 750 and with a smaller, flexible stage with a seated capacity of 250. A combined rehearsal auditorium and intimate stage will seat 100.
The Playhouse will open in 2008.

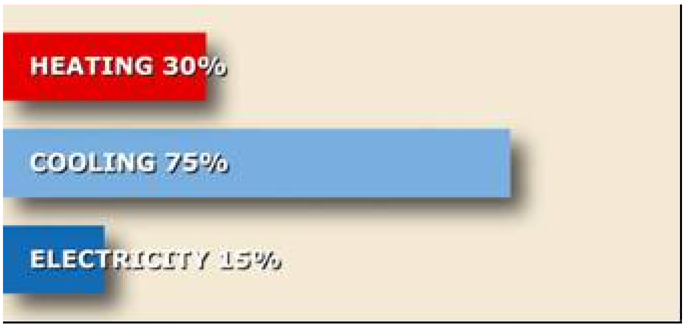
Demonstrated technologies

The demonstrated technologies in the ECO-culture project are:

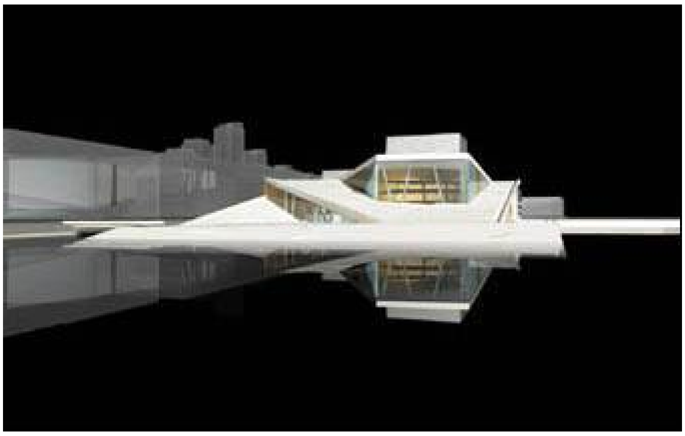
- Integrated 'climate belt' energy storage using thermoactive slabs;
- Optimised heat pump and seawater cooling;
- Optimised and intelligent controlled ventilation system, including BeMS;
- Environmental-friendly building materials - environmental-friendly concrete ("green concrete").

Energy objectives

The expected energy savings for heating, cooling and electricity consumption:



Opera House, Olso



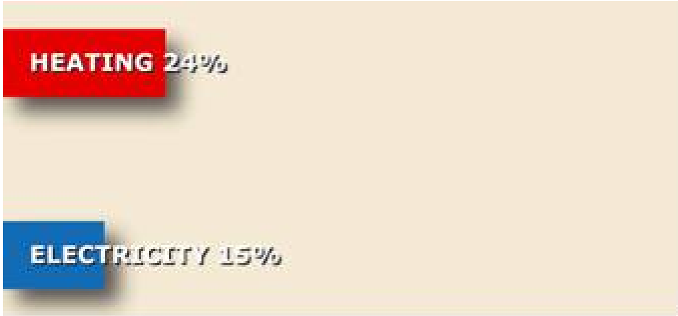
The Opera House will accommodate a large stage with a seated capacity of 1350 and with a smaller, flexible stage with a seated capacity of 400. The Opera House will open in 2008.

Demonstrated technologies

The demonstrated technologies are:

- Demand-controlled and energy-efficient distribution of ventilation, including humidity control;
- Control strategies for glass façade, light, ventilation, heating and cooling to improve use of daylight and passive heating and cooling;
- A south facing glass façade with solar cells.

Energy objectives



The expected energy savings for heating, cooling and electricity consumption.

The Amsterdam Public Library

Introduction

The Oosterdokseiland (Eastern Dock Island) lies to the east of Amsterdam's Central Station and borders on the historic city centre. The island is a component of the large-scale project to develop the Zuidelijke IJoever (the south bank of the IJ inlet). The shift of port functions westward from this part of the city has presented new opportunities to support city-centre functions. Amsterdam wants to transform the area into an intensive urban area, providing residential, commercial, recreational and public functions in as mixed an environment as possible. It can therefore accommodate functions that are forced to leave the city centre because of a lack of space. These principles are reflected in the Oosterdokseiland Zuiddeel urban plan that was released in January 2002. A tract of land covering approximately 48000 m^2 on the south side of the Oosterdokseiland is being transformed into a new urban area with a built programme of about 225.000 m^2. The new main branch of the Openbare Bibliotheek (public library) and the Conservatorium (Amsterdam

Conservatory) will be located here. Towards the east, the plots become wider, allowing for large-scale buildings such as the conservatory and the library.

The design for the new Public Library on the Oosterdokseiland is by architect Jo Coenen. The future user (and commissioner) was closely involved with devising the plans during the workshops. The architect's sketches are a record of a complex quest to find the ideal solution. Coenen's methodology is intensive and exploratory. Pursuing this from the very start, every design was used to learn something and to rationalize why changes were needed in order to arrive at an ideal variant. Even while travelling in Malaysia, he sent faxes with new sketches to the bureau in the Netherlands. Large, rough models were made of every interesting design.

A central underground system for Long Term Energy Storage (LTEO) will deliver air conditioning and heat to the buildings at the desired temperatures.

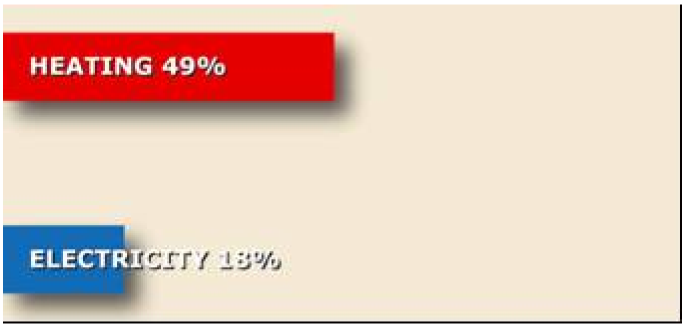
The library will be opened in 2007.

Demonstrated technologies

The demonstrated technologies in the Eco-Culture project are:

- Long-term energy storage (LTEO) in an aquifer (technology 1);
- Renewable energy systems: Solar Façade and Roof (technology 2);
- Controlled ventilation (technology 3);
- BEMS (technology 4).

Energy objectives



The expected energy savings for heating, cooling and electricity consumption.

The project partners

COWI A/S, Denmark	(Project coordinator)
The Royal Danish Theatre, Denmark	(Building owner)
Gemeente Amsterdam, The Netherlands	(Building owner)
Ecofys bv, The Netherlands	(Consultant)
Statsbygg, Norway	(Building owner)
Erichsen & Horgen AS, Norway	(Consultant)

Applied Ecobuildings: The German Museum of Technology Berlin

THE GERMAN MUSEUM OF TECHNOLOGY IN BERLIN – A CASE STORY ABOUT ENERGY EFFICIENCY

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Abstract

A low energy strategy with special emphasis on daylighting was developed and realised for the new building of the German Museum of Technology in Berlin. The main goal was to demonstrate the energy saving potential in large public buildings. The approach was to fully exploit the passive building characteristics in order to reduce interior systems and running costs. Boundary conditions of the interior climate were defined in order to conserve exhibits and to sustain thermal comfort. A key issue was to abandon active cooling and conventional dehumidification within the HVAC system. At present the building is monitored. Performance parameters and systems settings are continuously tracked and optimised.

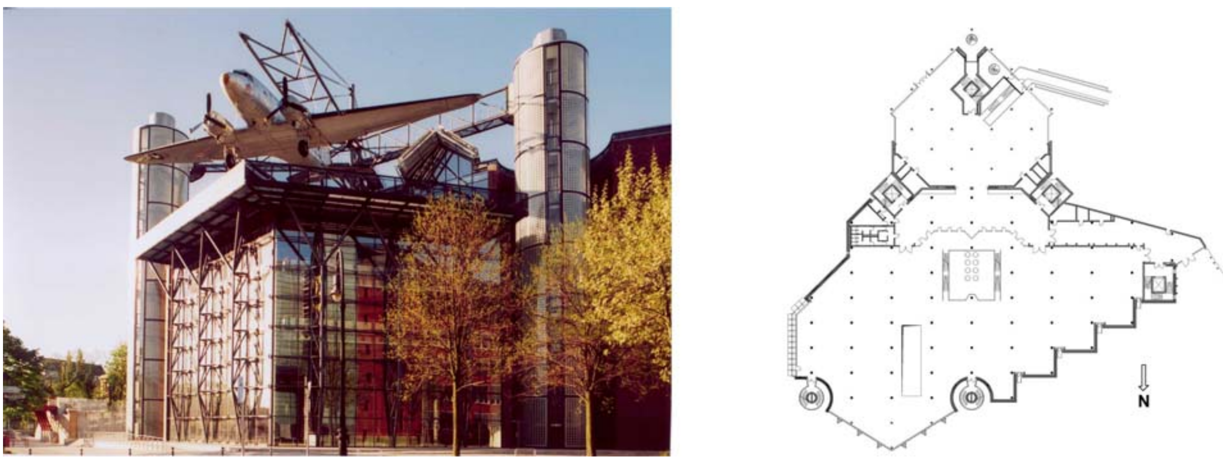

Figure 3 - Photograph of North Façade with Douglas C-47 "Rosinenbomber" (left), floor plan of entrance level (right)

Design of a new building for the German Museum of Technology in Berlin

The German Museum of Technology is located on the ground of the former Anhalter goods station in the centre of Berlin. The premises of the station were refurbished for museum purposes and the site was converted into a museums park.

The new building was placed at the northern tip of the museums park adjacent to the 'Landwehr' channel. The extension provides about 20 000 m² of usable floor space. Exhibition areas have been placed in the northern part as a measure to protect exhibits from direct sunlight. The service wing is oriented to the museums park in the south. The opening indexes of 18% in the exhibition building and of 31% in the service wing reflect the different design attitudes regarding protection and openness. Table 1 gives an overview of building data.

	Actors
Architecture:	Architect partnership MVT
Assignor of contract:	City of Berlin (1st phase), CommerzLeasing (2nd phase)
General contractor:	ARGE DTM, STRABAG (lead)
User:	German Museum of Technology Berlin
Research:	Institut für Bau-, Umwelt- und Solarforschung (IBUS) Fraunhofer Institute for Building Physics (IBP) Technical University of Berlin
Project Management:	Projektträger Jülich (PTJ)
Funding:	Senat von Berlin, Bundesministerium für Wirtschaft und Arbeit
	Project Data
Location:	Trebbiner Straße 9, 10963 Berlin-Kreuzberg
Time frame:	1987 (start planning) – 2001 (construction) – 2005 (opening)
Volume (gross):	158 968 m³
Floor space:	29 936 m² (gross), 27 023 m² (net floor area)
Building costs:	70 800 000 € (2617 €/m^2_{NGF})
	Construction
Foundation:	Water impermeable tanking with concrete
Basement:	Non-metallic fireproof construction
Supporting walls:	Concrete
Column/girder/slabs:	Composite units of steel and concrete
Exterior walls:	Cavity external masonry wall (not load bearing)
Facades:	Steel-glass construction
Interior walls:	Masonry of foamed slag concrete bricks
Roof:	Non-ventilated flat roof with planting
	Performance indicators
Mean U-Value:	0,52 W/m²K
Compactness:	0,12 /m
Specific heat loss:	0,43 W/m^2_{NGF}K (NGF: Net floor area)
Solar aperture:	3% (reference: net floor area)
Opening index	18% (exhibition), 31% (services)

Table 1: Building Data

Both departments - navigation and aviation - have two stories of different height. Each floor provides an open plan exhibition space of about 2 500 m², in total the building shows a continuous exhibition area of approximately 12 000 m². The architectural design interprets construction elements as exhibits hence leaving most of the structure and systems exposed and unfinished. The service building includes a restaurant, a library, an entrance area and workshops with 8 000 m² of usable floor space.

Energy Concept

Figure 4: Exposition of thermal mass and interior installations (left), construction detail to avoid thermal bridges (middle), seasonal shading of skylights (right)

The architects already had developed the design scheme when it was decided to optimise the building. Therefore the first step in optimization was to analyse the design proposal in terms of energy efficiency.

The initial design incorporated positive elements, such as a compact shape and a double layer foundation that could be used to precondition supply air. But it had also less favourable aspects, such as the exposure of structural elements penetrating the thermal envelope or deep floor plans that could hardly be supplied with daylight. The architects proved to be open to all proposals regarding energy efficiency as long as the cornerstones of design were left untouched. For example the proposal to have skylights facing north-south rather than east-west was not adopted, because it did not harmonize with the notion of space that the architects had in mind. The avoidance of thermal bridges in the construction of the double leaf brick façade on the other hand was supported. Here brackets could be avoided by stressing the brick layer.

	Heating	Cooling	Lighting	electric consumption of building systems
Improvement of the heat insulating capacity	■	■		
Use of solar gains	■			
Floor heating in perimeter areas	■			
Double foundation to precondition supply air	■	■		
Occupancy responsive ventilation	■	■		■
Heat recovery	■			
Operable skylights		■		■
Daylighting	■	■	■	
Daylight responsive controls		■	■	
Glazing free of iron oxide	■		■	
Solar shading		■		
Use of hygroscopic materials		■		
Activation of thermal mass	■	■		

Table 2: Energy efficiency measures

The strategy to bring about the specified indoor climate with minimum energy use was defined with extensive simulations. Table 2 lists the most important energy efficiency measures.

Measures to improve the building skin include an enhancement of the U-value of facades, the optimisation of the construction, and air-tightness. The increase of temperature on the interior side of the facades allows a feeling of comfort even at a room air temperature of 18°C. The use of triple glazing with a U-value of 0,7 W/m²K was among the most important improvements of the building skin.

The double foundation that originally had been designed for waterproofing the archives was integrated in the ventilation scheme of the museum. Measures to protect the building from overheating in the summer are of particular importance since the air handling units include no artificial cooling and dehumidification. Further elements of the passive cooling strategy include the activation of thermal masses, operable rooflights and a user responsive ventilation rate. A detailed description of the energy concept can be found in [1].

Requirements for conservation

Since the exhibits in a museum have to be conserved for long periods, the requirements on indoor climate are more severe in museums than in other building types. Specific requirements depend on the type of exhibits. The level and the variation in moisture and temperature are most crucial with respect to indoor climate. As a rule of thumb slow changes with a low amplitude are tolerable, sharp variations have to be avoided.

In conventional museums the HVAC system is designed to maintain the indoor climate at the expense of high energy consumption. The abandonment of dehumidification and artificial cooling in the new building of the technical museum permits air temperature and moisture to float freely in summer.

Additionally to preconditioning supply air the use of hygroscopic materials in the interior – foamed slag concrete bricks and wooden pavement – contributes to balance the relative air moisture within a band of 45% and 55%. Despite the use of effective solar shading and other passive cooling measures the air temperature rises to 27°C in warm summer periods within the given boundary conditions.

In museum projects that have higher requirements regarding interior climate compared to a technical museum the abandonment of artificial cooling and dehumidification may not be likely - however passive measures can contribute significantly to decrease energy use in these buildings as well.

Daylighting

All daylight areas in the museum have been simulated thoroughly under the artificial sky. The layout of rooflights as well as daylighting systems in facades have been optimised.

On the eastern facade for instance, the concern was to develop a system that does not affect the view to the outside but provides thermal shading and protection from glare - additionally redirecting daylight. Large horizontal louvers were introduced in the rhythm of the floor slabs. An inner translucent acrylic wing was combined with an outer wing of perforated sheet metal. According to the sun position and the tilt angle of the lamella the amount of daylight can be varied without affecting the depth of the daylit zone. Contrasts in the facade area are mediated to provide visual comfort.

Further elements of the daylighting strategy are daylight responsive controls for electric light and in some cases for daylighting systems as well.

The depth of floor spaces initiated the idea of demonstrating possibilities of lightguiding daylighting systems along the way of visitors to the exhibition areas. Three systems have been installed: Daylight luminaires, a sun-duct and a sun tracking mirror.

Figure 5: Redirected Sunlight on concrete wall (left), engine of Junkers ’52 illuminated with sun tracking mirror (middle), exhibition at east façade (right)

Construction phase

From the first sketch it took 14 years to the completion of the building. The construction activities stopped several times. After the shell was completed, the project organisation shifted from a conventional financial scheme to a leasing model. All building characteristics that impacted the energy efficiency had to be fixed in the bill of quantities. The leasing model showed to be quite inflexible once the contract was signed. During the construction phase the research partners attended project meetings and surveyed the construction. All relevant product specifications were checked. The prototypes of daylighting systems were realised directly under the responsibility of the research team. A detailed documentation of the construction can be found in [2].

Monitoring & Operation

After the building was completed, the installation of exhibitions started. The assumptions of the energy concept were given as design advice to the exhibition designer. The settings of the Building Energy Management system as well as performance parameters are continuously tracked and optimized. A data acquisition system started in 2002 recording data on energy consumption and indoor climate. Since the opening of the exhibition of aviation in April 2005 the building is fully occupied. Hence since then the data show the real building performance. Monitoring will continue until 2007.

Literature

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Ecobuilding design

A Common Evaluation Protocol for Buildings.

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1. Introduction

The present paper aims to present the common evaluation protocol for buildings developed in the frame of the DEMOHOUSE project of the European Commission.

A large variety of technical innovations regarding the energy design and the control systems are to be implemented in the retrofitting, conversion or new erection of the buildings involved in this project. Especially innovative is the integrated approach and combination of energy efficient technologies with comprehensive interventions on the building itself on the basis of scientific research and simulations.

The energy designs of the buildings addressed in this project incorporate various upgrading measures, most of which will be integrated in the majority of the buildings and are also highly replicable in similar buildings in Europe, thus improving the following:

- **Microclimate** - through the appropriate use of shading, plantation, water surfaces etc. in order to decrease the temperature of the area surrounding the building and thus reduce each building's cooling requirements.
- **Building's Envelope** - by improving insulation, glazing, optimising natural ventilation and daylighting techniques through appropriate design and using advanced materials and components in its construction, in order to reduce the thermal losses of the building.
- **Energy Systems** - used for heating (i.e. heat recovery), cooling (i.e. use of ceiling fans, night ventilation, exposed mass strategies), ventilation (i.e. demand control ventilation) and artificial lighting (i.e. improved luminaires and lighting devices, use of task lighting, daylight compensation) purposes, in order to improve the efficiency of the incorporated systems and decrease the specific energy requirements in each sector.

- **Control Strategies** including use of BEMS, distribution / demand control strategies, intelligent control etc. in order to optimize the performance of the various installed innovative systems and adjust properly their operation according to the building requirements.

For the reduction of energy requirements of the buildings and the improvement of indoor comfort, a **common evaluation - simulation methodology** is required in order to efficiently integrate energy saving and control strategies in each building's design. By doing so, the homogeneity of the calculation methods / results that is used to evaluate and predict the impact of the interventions on each building's performance is secured, while it is possible to make comparisons on the efficiency of specific measures under various design approaches and environmental conditions, as this will be monitored through the appropriate mechanisms and protocol.

2. Evaluation – Simulation Methodology

The evaluation of the scenarios for each building, is done by using exact simulation techniques. Energy calculations - simulations have two main objectives:

- To carry out well designed sensitivity studies in order to assist designers to investigate the specific impact and performance of a parameter, component, system or a combination of them, in a building and adapt its/their design accordingly
- To calculate the specific and global energy and environmental efficiency and performance of the final design of a building, in order to compare with initial targets, existing consumption data and finally classify it according to a rating scheme.

The simulation / evaluation tasks aims to optimize the design by calculating the specific and overall performance of a building considering all the major subsystems and in particular:

1. The outdoor environment defining the microclimate
2. The building envelope

3. The indoor environment
4. The active systems and mainly the HVAC system as well as the lighting and
5. The control - management system.

The evaluation methodology permits to homogenize the specific as well as the global energy consumption of buildings, and then compare them with a common reference traditional building. Each considered energy conservation scenario or package of measures are rated under the same base, thus direct comparisons are possible. The method permits to consider not only energy but other environmental quality parameters like comfort and indoor air quality as well, while cost and other financial aspects can be taken into account as well.

Thus, a full and relatively low cost evaluation protocol is defined for all buildings, that permit to assess and better understand the performance of the specific phenomena, techniques and systems as well as the global energy and environmental quality of the building.

The two main objectives of the simulation documentation and output format are:

- To form the basis of a reporting format which makes it easy to compare various retrofitting measures, scenarios and packages in terms of energy consumption, indoor environment and costs in different climatic regions.
- It should be easy to use for the participants of the DEMOHOUSE project.

These objectives have been met by a pre-produced input file with a schematic layout which simply has to be filled in with figures and text.

In general the reporting format is aiming for results on key figure level i.e. annual energy consumption for heating, cooling ventilation, equipment, lighting and the sum of thermal and electrical energy. It was considered best to split the annual figures into monthly figures for retrofit scenarios and packages. In addition it was decided not to split the main energy consuming building services further e.g. not to split the energy consumption for artificial lighting into energy consumption for task lighting and general lighting.

The reporting format for each building contains two sections. In the first section, all the technical details concerning the measures package / scenario improvements are presented in accordance with the matrix of incorporated features and aspects. In particular :

Microclimate, Building Envelope, Energy Systems, Space Heating, Space Cooling, Ventilation, Artificial Lighting, Control Systems, and other Measures.

In the second section scenarios and packages are reported in a more comprehensive level with for example energy results on monthly basis, accumulated frequency curves for indoor temperatures and economic figures to assess the viability of the investment. In particular:

- Part A, is concerned with basic data valid for the examined measures package / scenario for each building. For example data on the existing / new building, on simulation tools and models, data on the requirements influencing the energy consumption and the indoor comfort levels, etc. These data have to be reported once per building study.

- Part B, is a summary of the calculated energy results (kWh/ m^2) - key figures concerning the whole building. In particular the specific energy needs for heating, cooling, lighting, ventilation, humidification and dehumidification, have to be reported on a monthly basis for all the zones of the building. Thermal comfort results like maximum and minimum temperatures are reported. Each study building is evaluated under operational control conditions. Visual comfort and indoor quality simulation results are also reported.

- Part C, includes the results of simple financial analysis. Economic values for each specific energy cost are given, as well as saved energy costs, saved running costs, capital costs and subsequently simple pay back period estimations.

To better describe the dynamic performance of the building, the energy signature of each building has to be given. The energy signature offers information on the necessary energy to be spent under specific ambient temperature conditions. (See figure below).

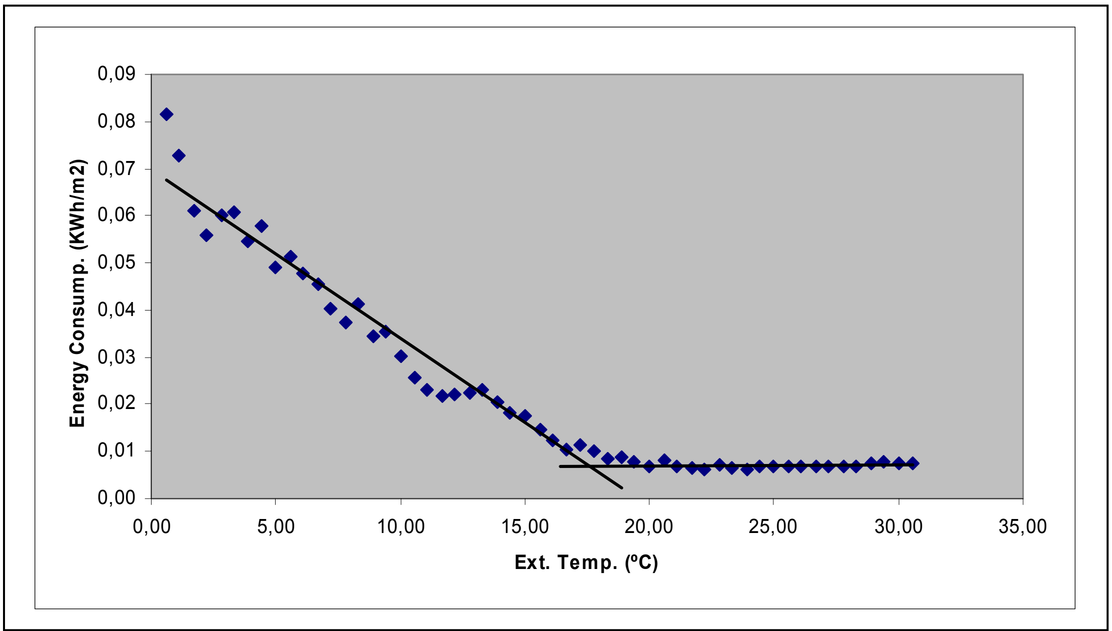

Figure 1. Relationship between energy consumption and the ambient climatic conditions (external temperature). Energy signature

3. Environmental Issues

The common evaluation protocol includes aspects related to the sustainability of buildings. The specific aspects considered by the method include:

- Water, seawater and rainwater
- Materials and constructions
- Waste
- Energy, and
- Building and urban development area. Methods for sustainable development and sustainable urban management.

A full questionnaire has been prepared for all the participants. The „Green Build“questionnaire is based on the Danish developed Green Build Tool, which works as an „energy and environmental point system“. It has for example been used in the EU „Energie“ supported project, „Green Solar Regions“, where it was used in connection to a new urban development project with individual houses and apartment blocks for around 800 inhabitants in the municipality of Glostrup in Denmark.

The Green Build questionnaire is part of the so-called Green Build tool, which shall make it possible for European municipalities to assess and compare their individual environmental performance. It is here possible to work with the questionnaire concerning sustainable building measures in general. It can also be used by municipal authorities and builders who want to document sustainability in their own building and planning projects.

The answering of the questionnaire is divided into two phases. One phase for what is the intention to do and another phase is telling what is the aim to do just before the building project starts when the final economy is known.

Phase 1 is thus what the building owner intends to do with his building from the beginning.

Phase 2 is about what the builder intents to do just before the building project starts, when the economy is known. Can e.g. be delivered to the municipality in connection to the application for a building permit.

When energy and environmental points are attached to the questionnaire, then the achieved number of energy and environmental “points” in 6-7 different areas can be used to identity a rating between A and M which can be compared to aimed at local standards. To motivate sustainability measures and improved financing based on achieved point levels can be an efficient promotion tool.

The questionnaire is filled in by ticking off the questions which [are intended] / [will be fulfilled]. For example regarding energy savings. If the energy consumption is below for example 32 kWh/m2 all 3 lines should be ticked off as shown below:

Energy consumption for heating is below 46 kWh/m2

Energy consumption for heating is below 40 kWh/m2

Energy consumption for heating is below 35 kWh/m2

In other words: The fully filled in questionnaire will be a picture showing the degree of agreement between the original intentions and real facts in the project that will be realized.

BIT – THE BRITA IN PUBS INFORMATION TOOL FOR PUBLIC DECISION MAKERS

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Introduction

If we look at the building stock and the energy consumption for heating, cooling, ventilation and lighting in Europe with the focus on energy-efficient buildings, mostly built after 1980, we have to realise that these buildings represent about 20 % of the building stock but only 5 % of the energy consumption. In order to meet the objectives of the Kyoto Protocol we have to concentrate on improving the energy-unefficient building stock. The aim of improving the situation and of boosting the significance of energy conservation as one of the set-up of goals of decision makers in retrofit projects must be realised by increasing the knowledge of energy-efficient retrofit technologies and their intelligent application. One of the best ways to do that is to present best practice examples to show that the improvement of the comfort as the primary aim can be achieved together with measures for energy savings. Another promising way is to give the decision makers and their technical staff simple-to-use tools at hand that will support them in the first planning phase to make the right decisions towards energy saving retrofit measures. The 6th Framework Programme Integrated Project “Bringing Retrofit Innovation to Application - BRITA in PuBs” covers both approaches, the demonstration of retrofit projects and the computer tool for the first planning phase. The work package 4 in BRITA in PuBs deals with the development of a knowledge based information tool for public decision makers including the documentation of innovative cost-efficient retrofit measures in the participating 9 countries. This tool is be based on the work of the IEA ECBCS Annex 36, which resulted in the ECA tool, the Energy Concept Adviser.

Summary of IEA ECBCS Annex 36

The IEA ECBCS Annex 36 dealt with the energy efficient retrofit of educational buildings. Researchers from 10 participating countries from Europe and the US were collecting information on retrofit measures and case studies and were developing an energy concept adviser for technical retrofit measures. This internet-based computer tool for decision-makers is the main outcome of the annex. One of the most important inputs to the tool is the collection and assessment of case studies, which was also presented in a specific report.

The Energy Concept Adviser tool

Picture 1 shows the title page of the computer tool.The Energy Concept Adviser consists of the following main parts:

Problem related recommendations

Here the decision maker can receive proposals for solutions to specific problems in the buildings administered by him. The problems are sorted into groups: high energy consumptions for heating and electricity, high water consumptions, bad indoor air quality, untight building envelope, high humidity or mould problems, damages at different building or HVAC components, heat-start or control problems as well as asbetos in building components. For each solution payback times and best times for starting the retrofit are given. Additionally links to case studies with similar problems and to the detailed descriptions of suitable retrofit measures are provided.

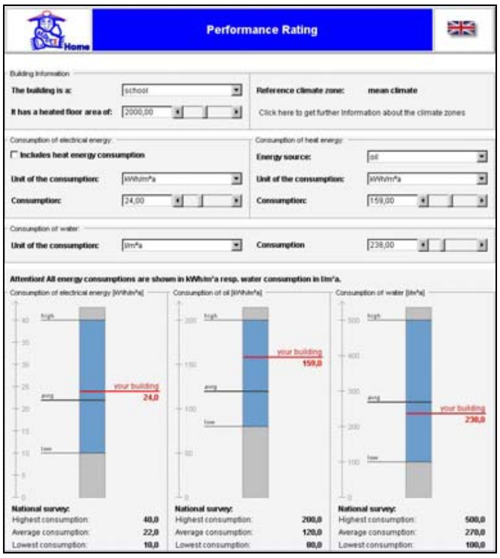
Collection of case studies and retrofit measures

The database of retrofitted case study buildings and the description of suitable retrofit measures is created as matrix (see picture 1). The user is provided with information on more than 30 case studies and various retrofit measures. The case studies can be sorted according to country, and age. The retrofit measures include measures at the building envelope, the HVAC system, the lighting system, protection against overheating and no-cost measures such as further education of users, caretakers, etc. All information can be printed as pdf-report.

Picture 2: Titel page of the Energy Concept Adviser (left) and matrix as entrance to the information on case studies and retrofit measures (right).

Performance Rating

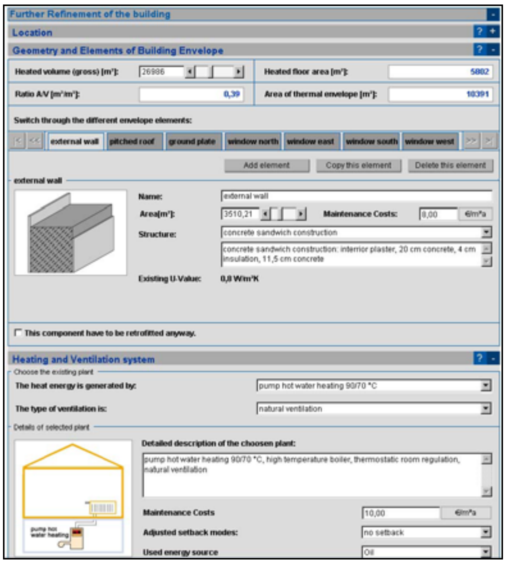
The user provides the input of the energy consumption for heating, electricity and the water consumption of a specific building. The programme then assesses these characteristic values by comparing them to the average national consumptions of the user country that are based on national studies, see picture 2.

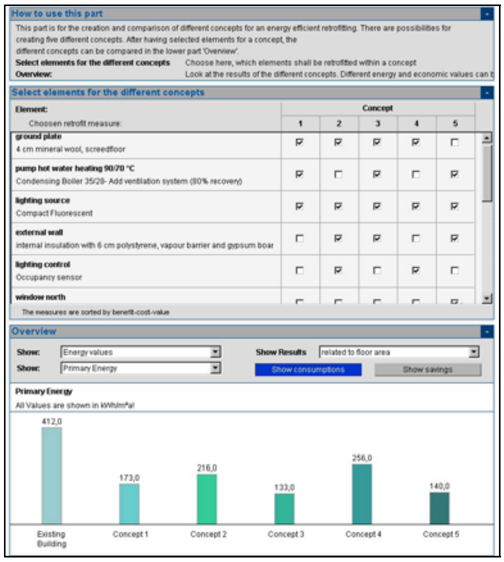


Picture 2: Comparison of the energy consumption of a specific building to the national average within the performance rating part of the ECA.

Retrofit Concept Development

This core part of the tool supports the user with an assessment method on energy savings and the necessary investments and running costs for various retrofit measures. The starting point is either a typology building suitable to the own building, or the adaptation of the geometry and systems default values to the real building. Picture 3 shows on the left the adaptation user-interface of the building envelope and the heating and ventilation system.





Picture 3: Adaptation of the building envelope data and the heating and ventilation system to the existing status of the own building (left) and presentation of the results of several retrofit concepts (right).

After defining the existing status, first single retrofit measures for each building and system component are assessed financially and according to the energy savings. The next step is to combine the best measures at each component to up to 5 retrofit concepts that are compared against each other. Picture 3 contains on the right a screenshot of the presentation of the results of several retrofit concepts.

How to acquire the Energy Concept Adviser?

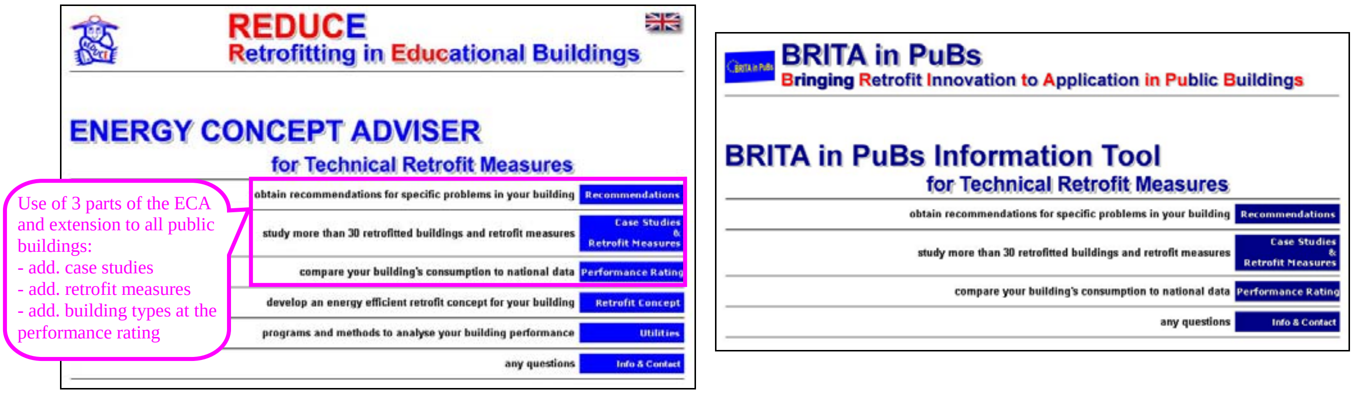
The Energy Concept Adviser is currently in English language at www.annex36.com available, but can be additionally ordered as free of charge CD-Rom at Fraunhofer Institute of Building Physics (to order at: Fraunhofer-Institut für Bauphysik, Mr. Hans Erhorn, Nobelstr. 12, D-70569 Stuttgart, fax: +49-711-970-3399). The translation to German was realised within the last months, the German tool is available at www.annex36.de or at order at Fraunhofer-Institut für Bauphysik. For information on the translation to other languages please contact your national representative as listed on the international website.

Further development of the ECA within BRITA in PuBs

The BRITA in PuBs project aims to increase the market penetration of innovative and effective retrofit solutions to improve energy efficiency and implement renewables, with moderate additional costs. In the first place, this will be realised by the exemplary retrofit of 9 demonstration public buildings in the four participating European regions (North, Central, South, East). The research work packages will include the further development of an internet-based knowledge tool on retrofit measures and case studies.

Planned work in BRITA in PuBs

BRITA in PuBs will use the first 3 parts of the Energy Concept Adviser and extend the case studies by the demonstration buildings of the project as well as refine the retrofit measure chapters including information on innovative retrofit technologies. Picture 4 on the left shows which parts of the ECA will be used in the BRITA in PuBs work. On the right is the draft of the navigator of the new BIT tool.



Picture 4: Parts of the ECA that will be used for the BRITA in PuBs tool (left) draft of the navigator of the new BIT tool (right).

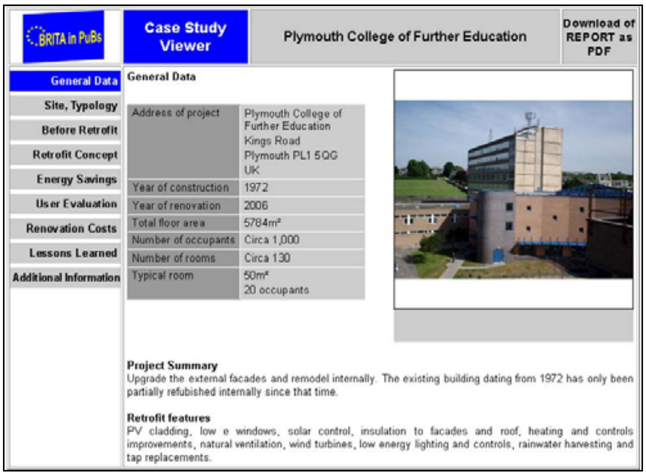
The buildings to be included are the nursery home Filderhof in Stuttgart (Germany), the Plymouth College of Further Education (United Kingdom), a church in Hol (Norway), the Borgen Community Centre (Norway), Proevehallen Cultural Centre in Copenhagen (Denmark), Evonymos Ecological Library in Athens (Greece), students social and cultural centre “Brewery” in Brno (Czech Republic) and the main building at the Vilnius Gediminas University (Lithuania).

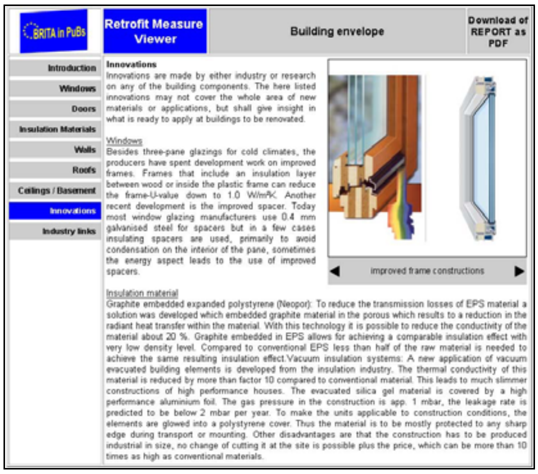
The list of retrofit measures that are planned to be described in the tool is:

Building envelope: introduction (insulation, thermal bridges, air-tightness), windows (frames, glazing, U-value, g-Value), doors (draught sealing, insulation), insulation materials and systems (thermal conductivity), walls (interior/exterior, thermal composite system, overcladding, solar walls), roof (between the rafters, below or above the rafters), ceilings/basement (post-insulation, thermal bridges), innovations (three pane glazing, improved spacers, improved frames, improved insulation material)
Heating systems: introduction, heating, domestic hot water, energy sources, control systems, innovations
Ventilation systems: introduction, natural ventilation, mechanical ventilation, hybrid ventilation, control and information, innovations
Solar control & cooling systems: introduction, shading and glare protection, cooling systems, air-conditioning, control systems, innovations
Lighting & electrical appliances: introduction, lighting systems, electrical appliances, daylighting technics, control systems, innovations
Management: introduction, energy auditing, commissioning, education and training, non-investment, innovations
Renewables: introduction, solar thermal, PV, heat pumps (ground source, air-air, air-water, sea water-water), urban wind turbines, biomass heating, (hydrogen), innovations

Actual status of the work

For the month 18 (end of October 2005) of the BRITA in PuBs project an α-version of the tool is planned. This will include some of the first parts of the case studies and the first revised chapters of the retrofit measures. At the same time the working group is collecting benchmark input for the performance rating of the different public building types. Picture 5 shows on the left a screenshot of one of the case studies already incorperated in the tool and on the right the revised retrofit measure building envelope.





Picture 5: Screenshots of the α-version of the BIT with case study PCFE on the left and retrofit measures building envelope, part innovations on the right.

Literature

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Ecobuilding realisation

DESIGN IS NOT A STRAIGHT LINE: CHALLENGES IN ECOBUILDINGS

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Introduction

It is well known that the design of an ecobuilding can not be considered as a routine task: for its own nature, ecobuilding is a building that works in a closer contact with the environment. Exploitation of natural phenomena as natural ventilation, daylighting, passive cooling and heating, integration of Renewable Energy Sources in a framework of an energy efficient building envelope and of energy efficient building energy systems, are the main characteristics of a building that aims to be defined “ecobuilding”. In doing this task, designers have then to take into account that interactions between building and climate, building and plants, plants and users and users and building, often present problems that can’t be solved with common procedures. Integrated approach is then a prerequisite of ecobuildings design and cooperation between architects and engineers has to be closer. A recursive design procedure is often a necessity: what was considered solved in a previous round can change during the following round, or, even more frequently, the solution of a problem opens another problem.

This aspect is evident in new buildings design process but becomes even more important in developing energy saving concepts and during the detailed design phase of a retrofit intervention on an existing building: real situation of some aspects (only two examples taken from “lessons learned” of BRITA in PuBs project: structural conditions, constraints from local and antiquarian authorities) is rarely well known at the beginning of planning phase. In some cases real situation become evident when the design phase is at an advanced stage, and part of the work already done has to be cancelled.

Can, in this context, the design process of an ecobuilding be compared to a straight line?

Problems or challenges?

Looking at outcomes of BRITA in PuBs project design phase, some interesting considerations can be done. Walking through the experiences reported by design teams of these demo buildings it is possible to notice that arising problems in design phase of ecobuildings were, in some cases, the opportunity to explore alternative solutions, and in some cases the first and most obvious solution wouldn't have been the best one.

Of course this approach should require flexibility, open mind and decisional rapidity in all the partners involved: designers themselves first of all, building owners, authorities and, last but not least, bodies co-financing the intervention. In some cases "the barrier" was not to find the technical solution but achieve, in reasonable time, the approval of all these partners. Finding adequate technical solutions is, definitely, less time expensive and tiresome than convincing all the partners involved of the opportunity of choosing the new solution.

Financial challenges

*The first kind of challenge that ecobuilding designers has to face up, is the lack of funding. As well known, ecobuildings are, in general more expensive than conventional buildings. That problem has to be solved, evidently, in planning phase and the decision makers have to be convinced of the convenience of adopting such kind of solutions. That can have some influence in the design process: what was considered convenient at the beginning can be turned into not convenient. PCFE demoproject of Brita in PuBs reported, for instance, that "*The long payback period discourages the choice of such technologies unless grant funding is available to support investment.*" On the other hand dealing with public funding, bring some non negligible problems. Filderhof reported the necessity of "*a lot of coordination work to done with several partners of the project inside the city and especially with financial government. Thus the project times enlarges to five year from the earliest planning phase to now. To take into account of all partners is a very busy work”.

In some cases uncertainties and, or, delays of public funding availability prevent from the prosecution of participating in the project in a framework of strong time constraints, as happened for the Italian and (probably, at the time of writing these notes) the Greek buildings in BRITA in PuBs. The project lost, in this way, the possibilities of demonstrating solutions for reducing cooling loads in south Europe countries.

Actually the energy prices variability can strongly influence this kind of decisions: a considerable prices modification can intervene even during planning or design phase.

Economic factors may also influence the change of materials used for building parts. At Filderhof, the glazed part of atria roof was strongly reduced because financial problems. Designer had to react on the situations and transfer the planned PV system to the opaque roof parts.

Also the prices of materials or devices can significantly vary, luckily not always in wrong direction. In retrofitting the main building of Vilnius Gediminas Technical University, because of the financial shortages, the ventilation system was not foreseen to be refurbished. During the design phase it came out that price of windows chosen by designers were lower than foreseen in planning phase: this fact enabled the authorities of university to use saved money for partly funding the renovation of ventilation system (heat recovery system). Of course this fact opened another challenges: how funding the rest of the ventilation system? That required a second round of decisional process that involved VGTU authorities, builders and designers.

Challenges inherent with the design process

Most of challenges in the ecobuilding design process are inherent with the process itself. As mentioned above, to be defined “Ecobuilding”, buildings need integration of: renewable energy sources, energy efficient systems and efficient envelopes.

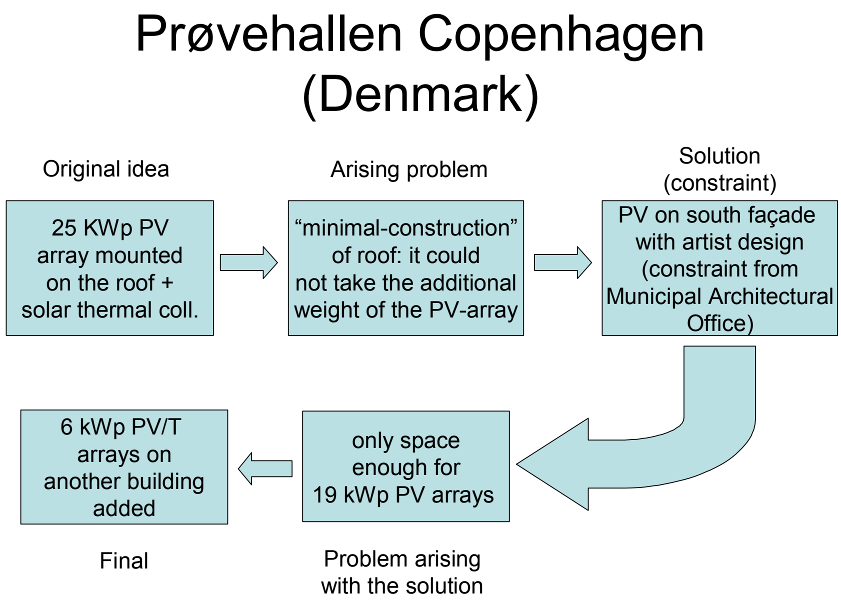
Design process of ecobuildings is then much more complex than design process of usual buildings, where different systems are less interconnected. Many variables

are, contemporarily, on the table. Many knowledge have to be exchanged between different actors.
Integrated approach is then a prerequisite of ecobuildings design and cooperation between architects and engineers has then to be closer than in conventional buildings: no one single designer has the knowledge of contemporarily managing all the aspects of design process of a conventional building; in case of ecobuilding this problem is even more evident. Interaction between architects, plants engineers, structural engineers, energy consultants, is, in this case, much more complicated than in conventional buildings. Most of plants of an ecobuilding have a lot of influence on architectural design also. Many components, related to natural ventilation, daylighting, RES exploitation and so on, have a strong characterization that greatly influences architectural design as well.
Design process becomes in this case necessarily iterative: architect and engineers have to take part in some rounds and this fact results to be time consuming.
Reliable design tool that allows a real integrated approach is still not available: a mix of tools have to be adopted. Importance of availability of reliable building modeling was reported by Plymouth College for Further Education Demoproject of BRITA:
"*Untested opinions and ideas are critical to the creative process, however the modeling of these ideas are essential. Time needs to be built in to the programme to facilitate sufficient analysis and testing of ideas, particularly when dealing with the constraints offered by an existing building. It is important to establish a model of the building to allow the rapid testing of ideas, as the most obvious concepts do not always offer the greatest benefit.*"
Benefit of integration of different purposes in one component was also reported: *"It is possible to integrate technologies to serve dual purposes (….).Careful consideration or all aspects of a project at the outset will permit such integration."*

Challenges in building structure

Working on existing building, especially when not recently built, often means not having, at the beginning of design phase, a clear vision of how the conditions of building and its structures are. Sometimes these aspects become clear during the works only, and very often modifications of the "design path" occur.

That was the case in Proevehallen demoproject in BRITA. Here (*Picture. 1*) is reported the “design path” of the location of a PV array. It was originally thought to be mounted on the roof of the building. At the beginning of works the “minimal construction” of the roof become evident. That had a list of consequences that involved many other aspects.

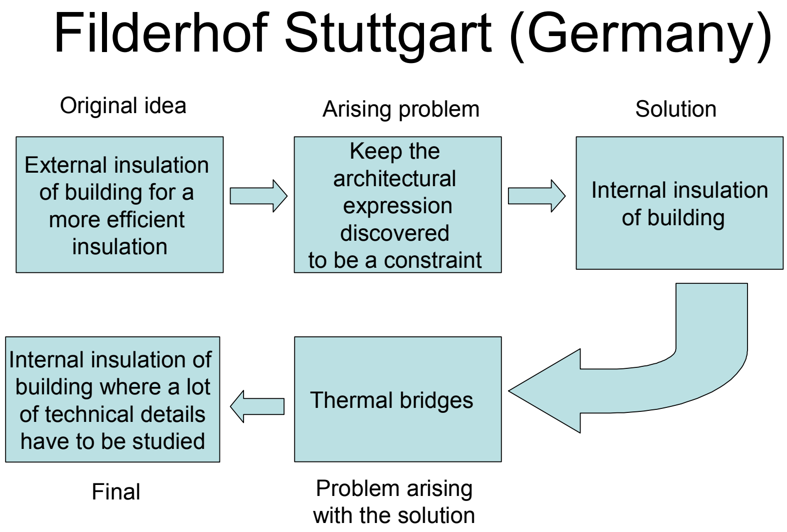


Picture. 3 - Design path of PV array location in Prøvehallen

Challenges with architectural influences and “listed buildings”

In case of existing buildings, considerable problems arise from the possibility that they are considered, or, even worse, they become during the design process, part of cultural heritage and for this reason they are listed.

In many cases, for this reason, it is not possible to intervene on envelopes, partly or substantially modifying the external aspect of the building. This fact has, obviously, a great impact on the possibility of an effective intervention on façade insulation, but also on the possibility of adopting RES systems that have, as well-known, a deep impact on the architectural aspects. In Brita project the design of 4 buildings had some consequences descending from this fact, or from the necessity of maintaining the architectural expression of the building. That was the case of Filderhof *(Picture. 2)* where architectural influences had a strong influence into the retrofit concept even though a building is not listed. In this case it caused the change from external insulation to internal insulation on the outside walls. This may lead to less energy savings and result in more planning work on details in order to prevent thermal bridges.



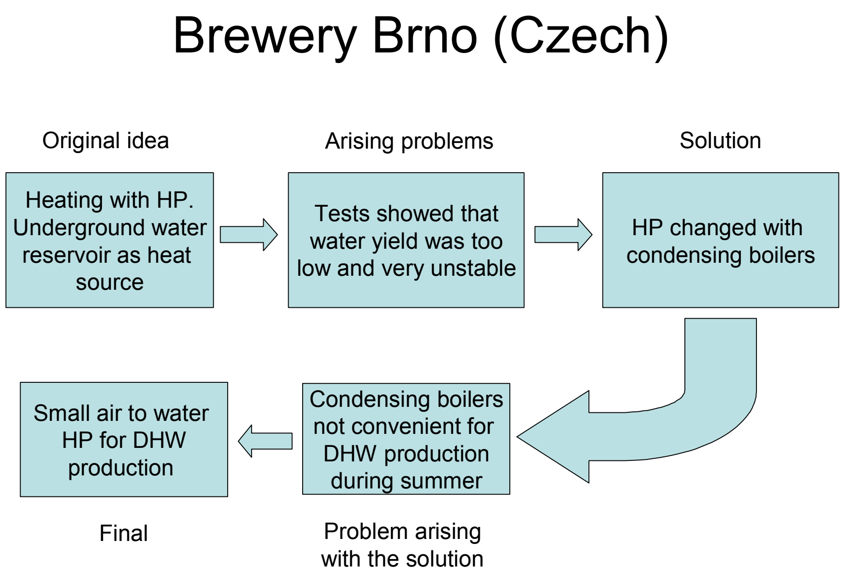
Picture. 2 - Design path of envelope insulation in Filderhof

Other listed buildings where the authorities had a strong influence on design path were:

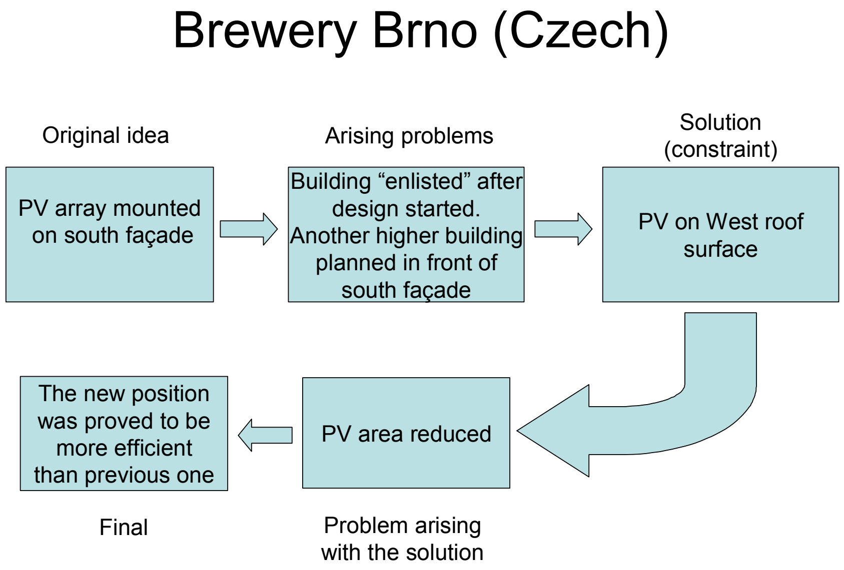
- Brewery in Brno, where the PV array had to be moved on the roof. *(Picture. 4)*
- Hol Church, where all the intervention on envelope (even if the insulation was foreseen to be mounted internally) and the design of solar air heating system (even if the solar collector was foreseen to be mounted at tens of meters from the building) required a continuous check of the authorities.
- Prøvehallen in Copenhagen, where the architectural aspects forced the designers to giving up the design of air preheating systems integrated in the windows.

Challenges for uncertainty or modifications of boundary conditions

At the beginning of planning phase of the retrofit of a building that have to be converted in a ecobuilding, the boundary conditions are not always well known or they can be modified during the design process. The case of Brewery building in Brno is in this sense exemplary. In this building the original idea was to have heat pumps exploiting a underground water reservoir as heat source. A deepened analysis of the situation showed that the water yield was too low and very unstable. That fact forced the designers in giving up the original idea *(Picture. 3).*



Picture. 3 - Design path of heating plant in Brewery



Picture. 4 - Design path of PV array in Brewery

Other examples of how the boundary conditions can change and modifying the design of a building are reported in *Picture. 4.*

In Brewery building of Brno Technical University, the decision of building a new, higher building close to the south façade of the building to be retrofitted, forced the design team to find an alternative solution for mounting the foreseen PV arrays. In this case the design team was very close to give up the idea of mounting PV panels on the building, because this "challenges" was combined also with a constraint coming from architectural authorities that decided to list the building as architectural heritage when the design phase was at an advanced stage already.

Conclusions

The analysis of the design paths of all the buildings involved in BRITA in PuBs, showed that the task of changing an existing non energy efficient building in an ecobuilding is everything but a simple task.

Difficulties of designing an ecobuilding are summed to the fact of working on an existing building, where the possibility of dealing with uncertainties and unforeseen events is much higher than what can happen in a new building. All the parts involved in the process of retrofitting an existing building (owners, decision makers, designers, funding bodies) should have clearly in mind this fact, and have to be

ready in changing their mind and looking at the necessity of exploring and adopting alternative solutions not as an exception but as a rule.
Exploring alternative solutions with reliable calculation tools was reported as a must: that allows to evaluate quickly untested opinions and ideas.
In general, the probability of having the necessity of changing the initial plan has to be considered as an opportunity: in many cases the necessity of modifying the original idea was the way if discovering a more efficient solution. On the other hand, one of the main task of “energy consultant” is convincing owners and architect in the convenience and in the feasibility of some ideas: the most reported answers from them are “It is too expensive” or “it is not feasible”; pushing and trying harder was proved to be effective in changing this mind.
What is important for all the partners involved in this kind of projects is, in any case, to have clear in mind what is the final target, to be conscious of difficulties but not use them as excuses for giving up the project and make everything is possible for achieving that goal.

Acknowledgments

The author acknowledges all designers of retrofit interventions realized in BRITA in PuBs project for their contributions:

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INTEGRATION OF RENEWABLES, WIND TURBINES ON THE ROOF OF PLYMOUTH COLLEGE OF FURTHER EDUCATION

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1 Introduction

1.1 Plymouth College of Further Education is situated in the South West of England.

1.2 This talk shares our experience of installing two 6KWp wind turbines on the roof of one of our buildings called Innovation Centre.

1.3 I am the college's Facilities Manager; therefore speak as a user rather than expert in environmental technologies.

2 Background

2.1 The Innovation Centre is a new building opened in 2001 and amounts to about 2400m^2 in floor area. A significant aim for its design was to include a wind range of good environmental design and technologies but at an average construction cost for the class of building. This was achieved.

2.2 Being an exposed location with the main prevailing winds coming from the South West, we wanted to integrate wind turbines into the building.

South West outlook

The turbines would be an inspiration in themselves but also attract attention to our exemplar building.

2.3 The feasibility of including turbines to the roof of the new building was explored but could not proceed due to a lack of funding.

2.4 The only preparatory works included were stub columns to the roof should funding for the scheme come available.

Roof without turbines

2.5 The process of obtaining planning consent was also taken forward but this was altered to work with a local small business who was seeking a location for their prototype turbines. They were designing a turbine specifically for roof mounting. Unfortunately this collaboration came to nothing.

3 Funding

3.1 The first successful grant sources was through BRITA in PuBs. The wind turbines fit into a much larger scheme that includes the refurbishment of the adjacent tower block. The works will include cladding two facades with photo voltaics.

Tower Block with Innovation Centre in foreground

3.2 We obtained part funding from the regional electrical supplier called EDF Energy.

3.3 Working with Sustainable Energy Installations, a further grant was obtained from Department of Trade and Industry through their "Clearskies" programme. SEI went on to do the design and installation of the turbines.

4 Turbine Design and Installation

4.1 The scheme is based around turbines from a Scottish company called Proven and their unit WT6000 6KW. These have the following details: -

Cut in speed	2.5 meters/sec
Rated wind speed	12 meters/sec
Above 12m/s blade pitch adjusts to maintain 200 rpm	
Number blades	3 flexible
Rotor diameter	5.6 meters
Generator	direct drive (no gear box)
Mast	self supporting/tilt down providing 9m hub height


Proven WT6000 6KW Turbine

4.2 Output has been projected at 33800KWh/yr. Assessed from manufacturer's data and the wind speed assessment for the site from ETSU. This provided average wind speed of 6.0m/s. At current electricity costs this saves the college € pa.

4.3 Turbines connected into the power supply for the building through invertors. Due to the base demand for the overall Kings Road site, no electricity will be exported.


Electrical Invertors

4.4 Total cost of installation as quoted by SEI € . This is now subject to an increase due to problems in forming the winching points. Likely additional costs € . These figures exclude expenditure at the time for the construction of the Innovation Centre.

4.5 Installation took place on 25th to 27th October 2005. This was delayed from the summer by Proven being busy and the difficulties in forming satisfactory winching points.

Installation underway

4.6 SEI obtained both Planning Consent and Building Regulation Approved without difficulty. This may have been helped by the previous application for the college.

5 The experience so far

5.1 Obtaining the funding was a long drawn out business. The Senior Management of the college was only keen on the project with substantial external funding.

5.2 Finding designers and installers experienced in putting such turbines on buildings is not easy in the UK.

5.3 We had been warned about vibration. The turbines are mounted on buffers but the steel framed building does experience minor vibration which increases with wind speed. This has caused some disquiet to occupiers although the amount of vibration is not significant.

Turbine Mounts

5.4 We were not prepared for the significance of shadow flicker. This only affects a few places in the college but we not found an easy solution as yet.

5.5 Community complaints have been received but have been few so far. They mainly seem to come from an idea that we should have consulted them before installation. The local authority consults neighbours before granting planning consent. Also the college had received periodic press coverage in the few years leading up to the installation.

5.6 The winching points were a great irritation. To obtain a good structural fixing meant breaking into the roof to explore the structure and later to install the winch points. This involved disturbing a specialist roof covering, which very few companies within the UK are able to repair.

5.7 At the time of writing, actual output would suggest an annual electrical generation of only 20000KWh. Proven have already stated the springs that control the blade feathering can be changed to suit local wind conditions. But stronger feathering springs mean more structural vibration.

6 Conclusions

6.1 The payback period amounts to 25yrs or more. This will improve if commercial electricity supply prices continued to rise at 30%+ pa. Although a long established technology, to broaden its use, particularly in urban environments, means some people expensively leading the way. Grants are therefore essential. Also one Renewables Obligation certificate that enables electricity supplies to buy capacity to help achieve their obligation must be improved.

6.2 To do a retro fit installation you must have full design calculations for your structure.

6.3 Vibration must be considered although it should be less significant for a reinforced concrete frame.

6.4 Do not underestimate the disturbing effect of shadow flicker.

6.5 Experience among designers and installers is very limited when using such technologies in an innovative way. Experience may cost you.

6.6 Vertical axis turbines would be a better solution for roof maintaining but the market needs to drive into production units with a decent output.

6.7 Horizontal axis turbines have a presence which can enhance the architecture of your building and provide a strong corporate image.

Picture of Innovation Centre

BORGEN COMMUNITY CENTRE

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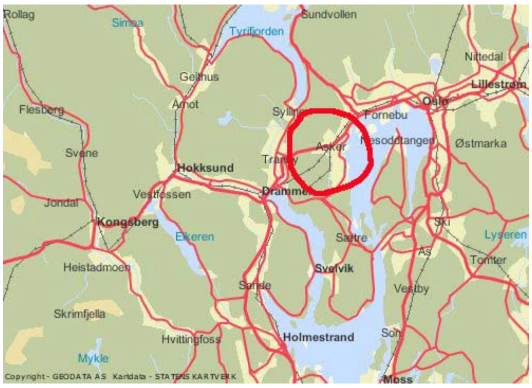
General information

1.1 Location

Borgen Community Centre is located in an open suburban area approximately 2 kms from the centre of Asker, a municipality with about 50.000 inhabitants. Asker is situated about 20 kms southwest of Oslo, the capitol of Norway.



1.2 Building type

Borgen consists of a 5 parallel secondary school, kindergarten, youth activity centre, health care, dental services and rooms dedicated to private organisations. The centre also comprises the dodecahedron shaped school gymnasium and the nearby newly built Vardåsen church. The church is not part of the Brita project.

1.3 History

Borgen was originally built as a combined elementary and secondary school. Completed in 1971, it had modern design with open, flexible plans and decentralized entrances. The design was based on the teaching concepts of the late sixties. However, over the years new needs lead to more parting walls and less openness. By the end of the nineties the building was generally in poor condition and in need of a comprehensive rehabilitation.

2 Status before retrofit

2.1 Construction

The building envelope suffered from insufficient insulation, air leakages in both windows and walls and extensive damages on brick cladding. The roof elements did not meet new requirements to snow loads and needed to be replaced. Internal walls would have to be replaced to allow flexible solutions that would meet the requirements of the school as well as the local community.

2.2 Technical installations

The building was heated with electrical resistance heaters mounted underneath the windows. Ventilation was based on a decentralized system with five ventilation units placed on the roof above each of the main building sections. The units were equipped with heat recovery systems, but had low capacity and efficiency. There was no cooling.

2.3 Energy

Insufficient insulation and poor building conditions resulted in high total energy consumption with an average of 280 kWh/m2a.

3 Retrofit aspirations

3.1 Building

- Space efficiency
- Flexibility that allows multiple use of the building
- Optimize thermal insulation
- Windows with high quality double glazing

3.2 Heating

- Utilise renewable energy resources (heat pump)
- Solar energy collectors
- Use building material with high thermal capacity (even out temperature variations throughout the day)

3.3 Ventilation

- Reduce electric energy for ventilation fans by using natural driving forces - buoyancy and wind
- Air rate regulated according to actual needs (temperature, relative humidity and CO2)
- Heat recovery systems

3.4 Lighting

- Active use of daylight
- Automatic control of artificial light (sensors for daylight and motion)

3.5 BEMS

- Optional automatic or manual control of all functions
- Energy meters for monitoring total consumption in relation to outside temperature
- Energy monitoring of different sections of the building

3.6 Energy saving

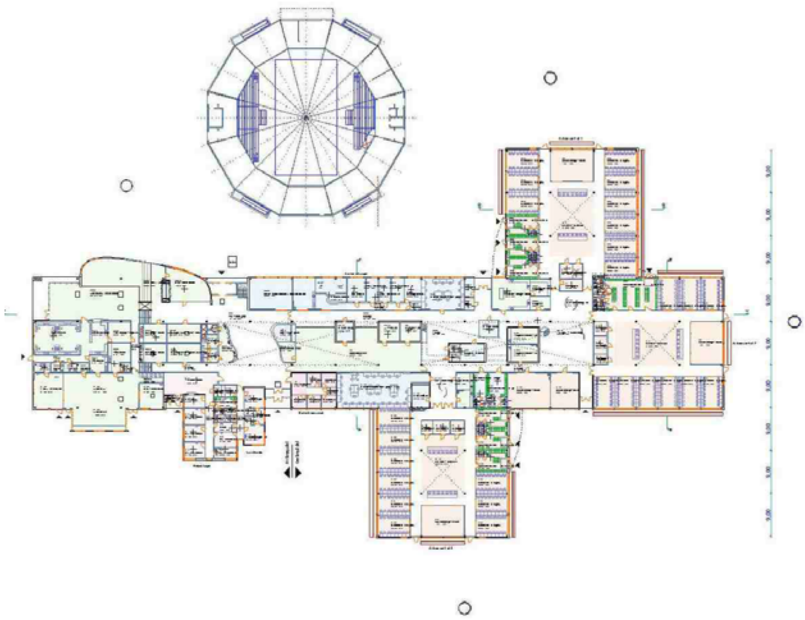
Reduce energy consumption by 50% or better.

National Benchmark for total energy consumption	220 kWh/m²/a	
	Budget for Borgen	
	Energy kWh/m²/a	Power W/m²
Space heating	29	30
Heating ventilation air	20	41
Water heating	13	10
Fans and pumps	15	6
Lighting	23	14
Equipment	11	8
Cooling	0	0
Total	**111**	
Old school building	**280**	
Anticipated saving	**169**	

4 Project

4.1 Building constructions

The main objective was to turn the building into a modern local community centre with emphasis on *environment, resources and indoor climate*. The building itself was a challenge with its deep areas with poor daylight condition and the general state of the building envelope. All internal walls had to be replaced to allow flexible solutions that would meet the requirements of the school as well as the local community.



4.1.1 Roof

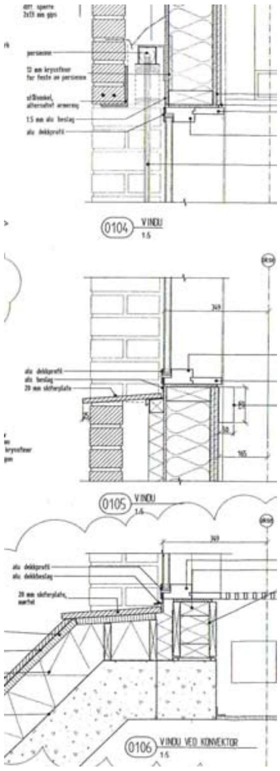
In order to meet the new requirements for snow loads, roof elements were replaced. Central areas were lifted to allow daylight into the building. Underlying structure was strengthened with steel trusses between the pillars, which had sufficient capacity. Roof insulation was increased to an average thickness of 300 mm which resulted in a U-value of 0,13 W/m2K.

4.1.2 External walls

A complete rehabilitation of the walls was calculated and turned out to be more expensive than replacing them with completely new walls. Walls were rebuilt with 8″ wood framework and brick cladding. Inside was covered with two layers of plasterboards. 200 mm insulation gives a U-value of 0.2 W/m2K which is within Norwegian requirements. An extra increase in insulation thickness would be expensive and would yield poor energy benefit.

4.1.3 Windows

New windows have wooden frames with outside aluminum cladding. Glass is high quality double glazing with low emissive coating. Theoretical U-value is 1,1 W/m2K which is well below the national requirements of 1,6.



4.1.4 Floors

Existing floor slabs were given a new 100 mm insulation layer underneath a new 100 mm concrete floor slab. Some areas were covered with oak floorboards, but the greater part was grated and waxed to give a robust surface with high thermal capacity. The insulation layer was also used to lay new water pipes and electric cables.

4.2 Heating

To optimize the use of renewable energy, a geothermal heat pump was chosen. Heat is pumped from the ground from 44 150 m deep energy wells. During the summer it could provide cooling by pumping excess heat back into the ground and thus "recharging" the wells. Depending on the interest rate and electric energy prices, payback time was calculated to 10 to 13 years. Since then interest rate has gone down and energy prices up, and payback time is expected to become a lot shorter. The heat pump produces low temperature hot water, 45 to 50˚ C. Heat is distributed by water to radiators under the windows. It is also used to preheat DHW to about 40˚C and the temperature is then lifted to 75˚C by electric heating.

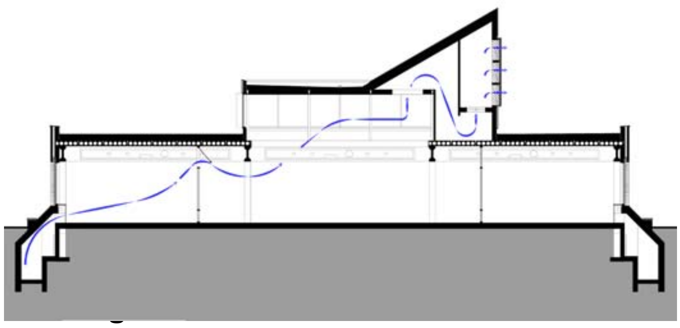
Two oil boilers are installed as a backup system, and they have sufficient capacity to heat the building and supply hot water if the heat pump is out of function. The heat pump is dimensioned for 60% of total needs. Under normal conditions this is enough

and the oil burners will kick in only a few days during the winter. The energy plant also supplies hot water for heating to the nearby Vardåsen church.
Studies were also made for solar PV´s, solar energy collectors and double facades. The conclusion was that no reliable and cost effective system was yet on the market and the idea was abandoned.

4.3 Ventilation

The main ventilation is based on a natural hybrid system with inlet towers and underground culverts for fresh air supply. Since we had an existing building, culverts had to be built outside along the foundations. They would normally have been under the building, but this was not possible in our case. This does not give the culverts optimal length, and it was necessary to install backup fans to ensure air transport during period with low thermal force i.e. during warm periods in the summer. Inlet towers were placed about 14 – 15 meters from the building and the connecting culvert was designed to give room for backup fans, filters and preheating battery. From the culvert air is let into the room through specially designed grids that allow people to stay close without feeling a draught Air flow through each room is regulated by electrically operated windows in the wall towards the central area. The opening (and the air flow) is regulated by temperature and CO_2 sensors in each room and thereby adjusted to the actual needs. Exhaust towers located over the central area in each base, are equipped with fans that are activated when natural driving forces are insufficient. Heat recovery systems supply heat to the preheating units in the culverts. To benefit from wind forces a special shutter system was developed to ensure that wind always helps evacuate the air and never build up a counter pressure that could reduce or stop the natural air flow.

4.4



The ventilation culverts are cooled from the ground, and their massive concrete construction supplies enough thermal mass to even out temperature changes during the day. Ventilation is automatically run during night to cool the building when this is needed. The use of building materials with high thermal capacity then helps to keep the temperature throughout the day. The lower fresh air temperature also helps keeping room temperature at the recommended 20 to 21°C. The heat pump is not used to provide active cooling, but the circulation pumps can be used to transport excess heat into the energy well and thus cool the building.
The school kitchen, wardrobes and toilets have mechanical exhaust systems, and the health centre and administration offices have traditional balanced ventilation systems.

4.5 Lighting

The shape of the building made it necessary to improve daylight conditions. The large skylight is facing north at an angle that does not let direct sunlight and heat into the long central section of the building, but greatly increases the level of daylight. The narrow window facing south also contributes without letting in too much heat. The raised windows in the central section of the base areas do the same, but shutters had to be used to prevent unwanted heat.

To optimize the effect of daylight, all artificial lights are adjustable and regulated by light sensors. In addition, light is also regulated by motion sensors that will turn the light on when someone enters the room, if conditions require so. When a room is left empty, the light will automatically be turned off after a preset time lapse. The IR-sensors also serve as detectors for the burglar alarm during the night.

4.6 Solar thermal collectors

The Borgen project is participating in a group developing and testing a prototype solar collector, based on a glass construction and liquid heat medium. The idea is that collectors can become building integrated elements in roof or wall constructions. Preliminary studies of potential energy gain under different solar conditions and different locations indicate temperatures from approximately 22 to 43°C for the southern Norway region. Naturally, results improve as one moves south, but the low sun in the winter also give good results for vertical collectors. The project group hopes to obtain higher temperatures with improved glass constructions and better heat medium. Production of domestic hot water will require a heat pump to raise the temperature to a level where legionella problems are avoided. This may not be a problem with closed circuits for room heating only.

Plans are to have design ready for a prototype in February 2006 and the first prototype ready for installation at Borgen by mid April. The effects will be monitored during a test period of one year and the results will be used in the development of the final production unit.

4.7 ACC windows

The same group is also engaged in the development of a wooden window with a sash that may be turned 180 degrees in the frame. The sealed glass unit has one solar absorbing glass and one glass with low emissive coating. This will give increased solar gains during the heating season with the solar absorbing glass facing inwards, and reduction of unwanted heat during the summer when the absorbing glass is facing outwards.

Preliminary design for window frames and sashes have been completed. A prototype for the special hinges is produced and details concerning the wind tight sealing have been designed. A prototype of the ACC window will hopefully be ready for installation along with the solar collector next spring.

4.8 BEMS

A Satchwell Sigma BEMS system is installed at Borgen. It has been prepared for OPC protocol, but the server has not been installed yet. All functions can be controlled and monitored from operation terminals in the building and at the operation centre in the municipality of Asker. The BEMS provides fully automatic registration of energy consumption on hourly bases. Energy supplied to the church is registered separately. The system allows registration of total energy consumption as well as electric power used for ventilation, heating (heat pump), electric lighting etc in relation to outdoor temperature.

5 Literature

Barbara Matusiak, 18.03.2005, Daylight conditions at the Borgen Community Centre

Inger Andresen and Anne Grete Hestnes, 09.03.2005, Environmental assessment for the redevelopment of Borgen Community Centre

WEB-BASED NEGOTIATION DECISION SUPPORT SYSTEM FOR HEATING SYSTEMS

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Abstract. The authors of this paper participated in the project Framework 6 “Brita In PuBs“. During this project an analysis of database of best practice, intelligent (neural networks, expert and decision support systems) and e-business systems for heating systems that were developed by researchers from various countries assisted the authors to create one of their own Web-based Negotiation Decision Support System for Heating Systems. Above systems are described in the paper.

Heating Systems: Intelligent and e-Business Systems

The major players in a heating systems field can use neural networks, expert and decision support systems, e-business, best practice, etc.

Different expert systems for heating systems [1-7] today generally serve to relieve a ‘human’ professional of some of the difficult but clearly formulated tasks. The description of these systems [1-7] is follows.

An expert system has been developed for troubleshooting a solar heating system located on a university campus. The expert system employs both heuristic and generic knowledge to diagnose the abnormal behaviors that are observed in the solar heating system. The heuristic and generic diagnostic knowledge were acquired from the designer of, and textbooks on, the solar heating system. The expert system was implemented in G2 Diagnostic Assistant (GDA) and can be used for troubleshooting other similar solar heating systems [1].

T. Lakshminarayana, M. D. Murty [2] describe an online rule based expert system tool that allows continuous process monitoring, diagnosis and expert advice in case of a potential problem. The tool also allows experts to create, modify and improve the knowledge base as new situations arise and new knowledge is accumulated.

Diagnosing problems in feed water heating system of a thermal power plant by using appropriate domain knowledge is presented as an example. This on-line expert system was developed for use in thermal power plants along with any DCS.
A new ultrasonic sensor system in fluid-filled tubes is reported. The system is a solution for transmitting information without the installation of cables, which in some cases will be very difficult and expensive. The described ultrasonic sensor system for energy saving has been developed and demonstrated by an EC project in cooperation with industry and the University of Paderborn. Bitzer and Lamotte [4] particularly discusses those parts undertaken by the latter. They analysed existing single-room controlled heating systems and selected suitable buildings for the new ultrasonic system. In addition, computer programs for calculation of energy saving and for ultrasonic transmission in fluid-filled tubes will be realized. An expert system is used for the simulation program of the ultrasonic transmission [4].
Clements et. al [5] describe the development of a real-time dynamic simulator that is configurable to simulate a variety of commercial/residential combined space heating and domestic hot water systems. The simulation allows the designer the ability to test different physical configurations under various operating conditions and to optimize a system design for specific operating requirements. The simulator was built using the G2 expert system shell which is a product of the Gensym Corporation.
The goal of Smart Home Technologies [6] is to automate decisions in a smart home environment with a single inhabitant. For this purpose was developed a rule based decision system that automates lights and the AC/ heating system, and that operates a security guard robot to check for intruders in the home. To implement the decision maker can use CLIPS, an expert system shell that permits him to build a rule-based decision system.
Residential Energy Efficiency software [7] shows effective ways to reduce home energy consumption. Topics include insulation, windows, doors, weather-stripping, and caulking. The expert system feature allows users to calculate how much they will save by making their homes more energy efficient. After you enter information about your home and the energy-saving changes you intend to make, the program uses local utility and climate data to calculate your savings in money, energy, and reduction of pollutants. This program shows effective ways to reduce home energy consumption. Topics include insulation, windows, doors, weather-stripping, and

caulking. The expert system feature allows users to calculate how much they will save by making their homes more energy efficient. After you enter information about your home and the energy-saving changes you intend to make, the program uses local utility and climate data to calculate your savings in money, energy, and reduction of pollutants [7].

Neural network is a method of computing that tries to copy the way the human brain works. Artificial neural networks are widely accepted as a technology offering an alternative way to tackle complex and ill-defined problems. They can learn from examples, are fault tolerant in the sense that they are able to handle noisy and incomplete data, are able to deal with non-linear problems and, once trained, can perform prediction and generalisation at high speed. They have been used in diverse applications in control, robotics, pattern recognition, forecasting, medicine, power systems, manufacturing, optimisation, signal processing and social/psychological sciences. They are particularly useful in system modelling such as in implementing complex mappings and system identification [12]. The different stakeholders can use various purpose neural networks [8-20] for heating systems. These systems are described below.

An artificial neural network (ANN)-based controller for hydronic heating plants of buildings is presented. The controller has forecasting capabilities: it includes a meteorological module, forecasting the ambient temperature and solar irradiance, an indoor temperature predictor module, a supply temperature predictor module and an optimizing module for the water supply temperature. All ANN modules are based on the Feed Forward Back Propagation (FFBP) model. The operation of the controller has been tested experimentally, on a real-scale office building during real operating conditions. The operation results were compared to those of a conventional controller. The performance was also assessed via numerical simulation. The detailed thermal simulation tool for solar systems and buildings TRNSYS was used. Both experimental and numerical results showed that the expected percentage of energy savings with respect to a conventional controller is of about 15% under North European weather conditions [8].

Yang and Kim [10] present an application of the artificial neural network (ANN) in a building system. The objective of this study is to develop an optimized ANN model to predict the time of room air temperature descending. In this study, a program for predicting room air temperature and an ANN program based on back-propagation learning were developed, and learning data for 27 spaces were collected through simulation using systems of experimental design for predicting room air temperature. ANN was trained and the ANN model having the optimized values of learning rate, moment, bias, number of hidden layer, and number of neurons of hidden layer was presented and its performance on predicting the descent time to desired room air temperature was evaluated. The results showed that the optimized ANN can predict the time of room air temperature descending with relative accuracy.

Yang et. al [11] present an application of the artificial neural network (ANN) in a building control system. The objective of this study is to develop an optimized ANN model to determine the optimal start time for a heating system in a building. For this, programs for predicting the room air temperature and the learning of the ANN model based on back propagation learning were developed, and learning data for various building conditions were collected through program simulation for predicting the room air temperature using systems of experimental design. Then, the optimized ANN model was presented through learning of the ANN, and its performance to determine the optimal start time was evaluated.

Kalogirou [12] presents various applications of neural networks mainly in renewable energy problems in a thematic rather than a chronological or any other order. Artificial neural networks have been used by the author in the field of solar energy; for modelling and design of a solar steam generating plant, for the estimation of a parabolic trough collector intercept factor and local concentration ratio and for the modelling and performance prediction of solar water heating systems. They have also been used for the estimation of heating loads of buildings, for the prediction of air flow in a naturally ventilated test room and for the prediction of the energy consumption of a passive solar building. In all those models a multiple hidden layer architecture has been used. Errors reported in these models are well within acceptable limits, which clearly suggest that artificial neural networks can be used for modelling in other fields of renewable energy production and use. The work of other researchers in the field of renewable energy and other energy systems is also reported. This includes the use of artificial neural networks in solar radiation and wind speed prediction, photovoltaic systems, building services systems and load forecasting and prediction [12].

Artificial neural networks (ANN's) are more and more widely used in energy management processes. ANN's can be very useful in optimizing the energy demand of buildings, especially of those of high thermal inertia. These include the so-called solar buildings. For those buildings, a controller able to forecast not only the energy demand but also the weather conditions can lead to energy savings while maintaining thermal comfort. Argiriou et. al [14] such an ANN controller is proposed. It consists of a meteorological module, forecasting the ambient temperature and solar irradiance, the heating energy switch predictor module and the indoor temperature-defining module. The performance of the controller has been tested both experimentally and in a building thermal simulation environment. The results showed that the use of the proposed controller can lead to 7.5% annual energy savings in the case of a highly insulated passive solar test cell [14].
The objective of Kalogirou work [15] is to use Artificial Neural Networks (ANNs) for the long-term performance prediction of forced circulation type solar domestic water heating (SDWH) systems. ANNs have been used in diverse applications and they have been shown to be particularly useful in system modelling and for system identification. Three SDWH systems have been tested and modelled according to the procedures outlined in the standard ISO 9459-2 at three locations in Greece. Two ANNs have been trained using the monthly data produced by the modelling program supplied with the standard. Different networks were used due to the different natures of the output required in each case. The first network was trained to estimate the solar energy output of the system for a draw-off quantity equal to the storage tank capacity and the second network was trained to estimate the solar energy output of the system and the average quantity of hot water per month, at demand temperatures of 35 and 40°C. The data presented as input to both networks are similar to the data used in the program supplied with the standard. The statistical coefficient of multiple determination (R2-value) obtained for the training data set was equal to 0.9972 for the first network and equal to 0.9878 and 0.9973 for the second network for the two output parameters, solar energy output and hot water quantity, respectively. Other data, unknown to the network, were subsequently used to evaluate the accuracy of the prediction. Predictions with R2-values equal to 0.9945 for the first network and 0.9825 and 0.9910 for the second were obtained. The maximum percentage differences were 1.9 and 5.5% for the two networks

respectively. These results indicate that the proposed method can successfully be used for the prediction of the long-term performance of forced circulation water heating solar systems. The advantages of this approach compared to the conventional algorithmic methods are speed, simplicity, and the capacity of the network to learn from examples. This is done by embedding experiential knowledge in the network [15].

In a hydronic heating system, it is important to control the zone temperature with a certain degree of accuracy. The system consists of a space heating circuit with the ability to modulate both the fuel mass flow of the burner and the mass flow of hot water. The physical model of the system consists of a heating system, a distribution system and an environmental zone which are simulated by an eleventh order nonlinear system. The objective of the controller is to maintain the zone temperature as close as possible to a chosen setpoint and, at the same time, to maintain the temperature of the hot water below a maximum temperature which is usually 90°C. However, there are many problems in designing such a controller due to system uncertainties, saturation of the actuators and long system delay. To overcome the above nonlinearities, an adaptive controller has been designed using neural networks and evaluated with software simulations. Comparisons are made between the RMS of the zone temperature and the energy consumption of the system for a time period of two days by several neural networks with different architectures and learning laws [20].

Interested parties can use various purpose decision support systems for heating systems [25, etc.]. The decision support system (DSS) provides a framework through which decision-makers can obtain the necessary assistance needed for making decisions through an easy-to-use menu or command system. Generally, a DSS will provide help in formulating alternatives, accessing data, developing models and interpreting their results and by selecting options or analyzing the impacts of a selection. Also other decision support system definitions are used in practice:

- A highly flexible and interactive IT system designed to support decision making when the problem is not structured; an information system that utilizes decision models, a database, and a decision maker's own insights in an ad hoc, interactive analytical modeling process to reach a specific decision by a specific decision maker [21].

- A system that provides data, structured models and ad-hoc query tools to enable business decision development and analysis [22].
- Decision support systems are a class of computerized information systems that support decision making activities [23].
- An application primarily used to consolidate, summarize, or transform transaction data to support analytical reporting and trend analysis [24].

For example, L. Arvastson in his PhD Thesis “Stochastic Modeling and Operational Optimization in District Heating Systems” [25] describe operation of a district heating system. According to L. Arvastson [25] operation of a district heating system is accomplished via a sequence of decisions by the operators controlling the system. These decisions are based on expectations of conditions in the system that are not known at decision time. The operators could be helped by a decision support system that computes predictions of future system variables and suggests appropriate control actions given the available information. This thesis presents a new model that gives a both physical and stochastic description of a district heating system. The model describes both technical and economical information of the system that are important for the control decisions. It is easy to calculate predictions based on this model as well as performing simulations. The ambient temperature is the single most important explanatory variable for the heat demand in a district heating network. A model that can be used to calculate reliable temperature predictions are presented where the full advantage of both local measurements and forecasts from a meteorological institute are utilized. A heuristic approach to the operational optimization problem is presented and it is shown in simulations to be superior to a traditional control, based on a priority scheme. The operational optimization problem is a complex stochastic optimization problem and the heuristic approach gives a solution that can be calculate instantly. An online computer program, EnerPlan, is developed where the described models are used to calculate predictions and simulate alternative future scenarios. The program is currently used in the control room at the Heleneholm power plant in Malmö, Sweden [25].

The main functions of the most advanced Construction Products E-Business Systems are as follows:

- Construction product merchandising - construction products need identification; construction product presentations, pricing and personalized discounts, substitute products, search for the product or groups of products, finding of alternatives and formation of a comparable table/tables, construction product comparisons and buyer assistance for making construction product selections.

- Order management - execution of the orders application, selection of the form of payment, transfer of the order, payment for the order, receiving information about the state of a personal customer's account such as checking of availability of the required amount of money in account, checking of the order payment, shipping, inventory, and taxation; support for authorization, settlement, subscription renewals, partial billing, and credit payments.
- Fulfillment - deliver construction products with automated customer notification by faxes, e-mail, or secure Web pages; construction products receiving and verification. Reversible process: information is transferred to the server about the received construction products and an analysis of the results.
- Customer service - support customer service representatives with a set of tools for analyzing and resolving customer issues such as review of orders, payment history and billing information.
- Information exchange - announcement board, discussions forums, advertising, e-mail box, articles, other information, various announcements, notices, information of the market situation, market changes and future prospects, information bulletins and other updating information for the users' attention.

Best practise examples of Heating Systems

Large amount of information is stored and databases are created on the basis of which thousands of high quality experts pass on their experiences and expertise through the Internet. Different best practice definitions are used in practice:

- An activity or procedure that has produced outstanding results in another situation and could be adapted to improve effectiveness, efficiency, ecology, and/or innovativeness in another situation [26].
- A particular way of doing business that has a positive impact on one or more of the following: customer satisfaction, employee satisfaction, or financial results. Best practices involve top-level commitment, a linkage to strategic planning, process adaptations that reinforce desirable behaviors and outcomes for the

organization, and measurements to tie the initiatives to critical business practices [27].

- Learning how the best businesses in your field do those things which help them operate more effectively and efficiently, so becoming more profitable and competitive [28].
- Programs or services that research or expert opinions have shown to be effective [29].
- For any business process, there is a set of practices that have been established that result in the lowest cost for that process. As technology improves so do the business practices that utilize those improvements. Since technology is constantly evolving, there should be a periodic review of best practices and their application to your business processes [30].
- There are different best practice publications in heating systems field:
- Best Practice in New Housing - a practical guide. This guide is designed to help designers and builders achieve Best Practice levels of energy efficiency without carrying out a large number of detailed calculations. The Best Practice specification goes beyond the energy requirements of building regulations. Following the specification described in this guide should therefore make approval against building regulations a straightforward process [31].
- Domestic Heating: Solid Fuel Systems. This guide is designed to help installers, specifiers and purchasers of solid fuel appliances to choose the most appropriate system for their needs. It covers solid fuel appliances which contain a boiler providing hot water for the space heating and domestic hot water needs of the household. It also covers room heaters [32].
- Energy Efficient Loft Extensions. This guide is for designers, builders and homeowners contemplating loft conversions. It explains how to incorporate energy efficiency into the design and specification. Loft conversions are important; they can provide new, energy efficient accommodation and can also improve the overall energy efficiency of the houses [33].
- CHeSS – Central Heating System Specifications. CHeSS 2002 gives Basic and Best Practice specifications for the components of domestic wet central heating systems that are crucial to energy efficiency. "Basic" means sufficient to comply with the Building Regulations Part L1 and Building Standards (Scotland) Part J

which came into effect during 2002. " Best Practice" means the adoption of products and techniques that are already established in the marekt, cost-effective and able to save energy without incurring undue risks. This leaflet also includes reference tables to show typical SAP ratings, carbon indices, energy savings and fuel cost savings attributable to CHeSS [34].

- Domestic heating and hot water - choice of fuel and system type. The overall energy efficiency of domestic heating and hot water systems has a major impact on both running costs and carbon dioxide emissions. The efficiency of most heating and hot water products has increased in recent years but care must still be taken to choose the most appropriate system. This wide-ranging publication assists installers, specifiers and purchasers of domestic heating and hot water systems by providing guidance on selecting heating and hot water systems. The guide covers ducted warm air, solid fuel and electric heating and hot water systems, and individual appliances heating a single room [35].
- Domestic Energy Efficiency Primer. Written for trade professionals, building materials suppliers, and housing and energy advisers, this guide is designed to help you become familiar with energy efficiency measures, advise clients about reducing fuel bills, identify opportunities for installing energy efficiency measures alongside home improvements or repairs, and choose energy efficient solutions to building problems. The guide gives indicative costs and savings for different measures and house types, key information on measures, and information on grants, contacts and useful publications [36].
- Controls for domestic central heating and hot water. Installing effective controls has a major impact on the energy consumption of heating and hot water systems, whilst reducing running costs and lowering carbon dioxide emissions. This guide brings together information on controls for all domestic central heating systems supplied by mains gas, liquefied petroleum gas (LPG), oil, electricity and solid fuel. The guidance covers: the function of individual controls and their particular benefits, help on selecting controls, the minimum set to meet the requirements of the Building Regulations (2002) and recommended best practice, upgrading existing systems, advice on installation, commissioning of controls, energy-saving benefits, advice to householders and terminology [37].

- Best Practice in New Housing - a practical guide. This guide is designed to help designers and builders achieve Best Practice levels of energy efficiency without carrying out a large number of detailed calculations. The Best Practice specification goes beyond the energy requirements of building regulations. Following the specification described in this guide should therefore make approval against building regulations a straightforward process [38].
- Domestic central heating and hot water: systems with gas and oil-fired boilers - guidance for installers and specifiers. Endorsed by many of the leading trade organisations, this publication provides invaluable guidance on selecting boilers and heating systems to improve energy efficiency and to reduce running costs and carbon dioxide emissions. The guide brings together information on most of the different boiler types, describes the systems to which they should be fitted and outlines the issues to consider when choosing a boiler. Contents includes: boiler types; flues and ventilation; system choice; energy efficiency (including SEDBUK, SAP and the Benchmark scheme); annual running costs; and a boiler selection checklist provides a useful summary of the key points [39].
- Community Heating - a guide. Community Heating delivers heat to more than one building, dwelling or customer from a central source. This guide explains how housing management issues, technical questions and economic considerations impact on the use of Community Heating, and why they need to be taken into account at the design and development stages of refurbishment and regeneration projects. The guide also contains information about legal, insurance and environmental issues [40].

Advantages

Intelligent systems and database of best practice for heating have such advantages:

- Modeling of heating systems and its characteristics;
- Customers can fairly quickly find alternative products or services and make their best choices hours a day, all year round and from almost any location;
- Possibility to determine rational (according to technological, economical, qualitative, political, legal, cultural and health criteria) heating systems alternatives;

- Energy saving and CO2 emission reduction and thereby encouraging the market introduction in Europe;
- More technological, economical, legal and health information about products and services and related innovations/updates;
- Consumers receive the latest and detailed information;
- Maintenance and service can be analysed;
- Performance parametric analyses can be made and performance and performance trends can be established (predicted), etc.
- Users of can very quickly carry out a search according to technological, economical, qualitative, and other criteria;
- Users can use information/specifications and drawings retrieved from the database later in their activities;
- Acceleration of the process of delivery;
- E-Business increased competition on an international level which reduces prices of offered products and services;
- Easier access to new markets;
- Small-scale business people can offer their products and services worldwide;
- The companies working online can offer their customers better quality servicing and provide quick answers to all questions asked by the customers;

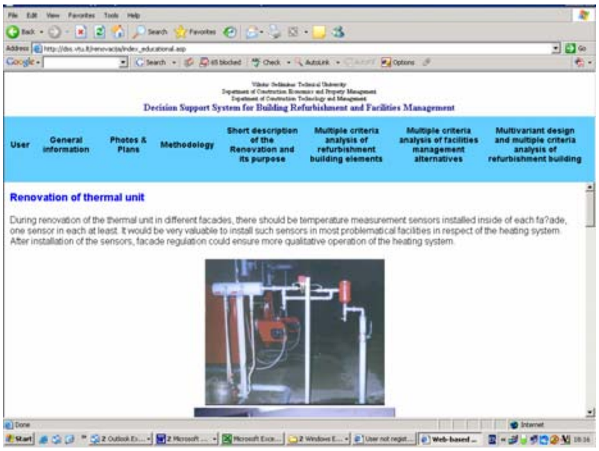
Web-based Negotiation Decision Support System for Heating Systems

During Brita in Pubs project an analysis of database of best practice, intelligent (neural networks, expert and decision support systems) and e-business systems for heating systems that were developed by researchers from various countries assisted the authors to create one of their own Web-based Negotiation Decision Support System for Heating Systems. Above systems are described in the paper.

NDSS-HS is a Web-based Negotiation Decision Support System for Heating System. The NDSS-HS consists of a Decision Support Subsystem (DSS-HS) and Expert Subsystem (ES-RE). DSS-HS consists of a database, a database management system, model-base, a model-base management system and a user interface.

Heating systems listings are an interface for a seller to post listings. The system provides forms for sellers to fill in information about their heating systems. Heating systems sellers wishing to present information on their objects must receive permission from DSS-HS administrator. Having this permission the broker inserts all the necessary information about heating systems under sale in the DSS-HS databases according to the system's requirements (i.e. system of criteria, values and weights of criteria). Access to the databases developed personally by sellers is provided only to the broker and to the DSS-HS administrator. At present the developed DSS-HS allows for the performance of the following five main functions: search for heating systems alternatives; finding out alternatives and making an initial negotiation table; analysis of alternatives; negotiations; determination of the most rational heating systems purchase variant. In order to throw more light on the DSS-HS, a more detailed description of some of the above-mentioned Subsystem functions follows.

A consumer may perform a search for heating systems alternatives from databases from different sellers. This is possible because the forms of data submissions are standardized at a specific level. Such standardization creates conditions that can be applied to special intelligent agents that are performing a search for the required heating systems in various databases, and the gathering information/knowledge.



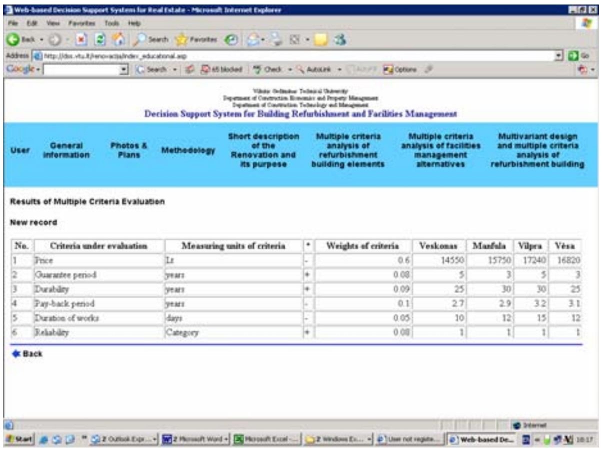
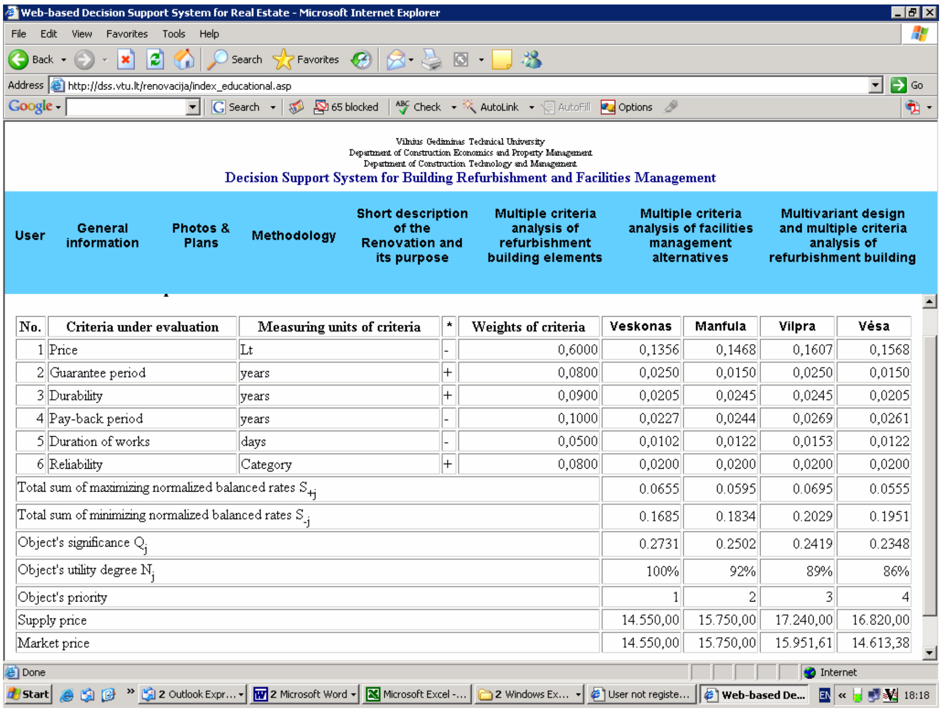


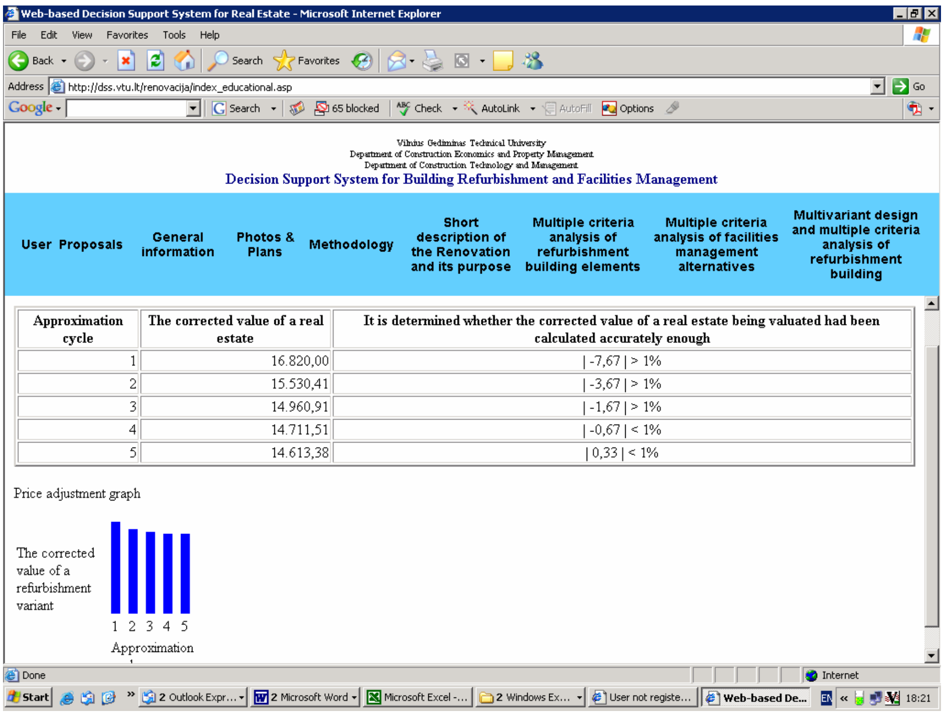
Fig. 1 - Search results for specific heating system can be submitted in: textual, photo/ video and graphical information on the heating systems (left); expert and quantitative description of the heating systems's alternatives (initial negotiation table) (right)

Consumers specify requirements and constraints and the system queries the information of specific heating systems from a number of online sellers. The system performs the tedious, time-consuming, and repetitive tasks of searching databases, retrieving and filtering information/knowledge, and delivering it back to the user. Search results for specific heating systems are submitted in a textual, photo/video and graphical information on the heating systems's alternatives and the initial negotiation table (see Fig. 1), which may include direct links to a Web page of sellers. When submitting such a display, the multiple criteria comparisons can become more effectively supported. By clicking the link "Expert and quantitative description of variants", the expert and quantitative description of heating systems' alternatives is presented (see Fig. 2). Each alternative described by the quantitative information (system of criteria, weights of criteria and values) has a number that coincides with the verbal and photographic information describing the mentioned alternative (see Fig. 2).



No.	Criteria under evaluation	Measuring units of criteria	*	Weights of criteria	Veskonas	Manfula	Vilpra	Vėsa
1	Price	Lt	-	0,6000	0,1356	0,1468	0,1607	0,1568
2	Guarantee period	years	+	0,0800	0,0250	0,0150	0,0250	0,0150
3	Durability	years	+	0,0900	0,0205	0,0245	0,0245	0,0205
4	Pay-back period	years	-	0,1000	0,0227	0,0244	0,0269	0,0261
5	Duration of works	days	-	0,0500	0,0102	0,0122	0,0153	0,0122
6	Reliability	Category	+	0,0800	0,0200	0,0200	0,0200	0,0200
Total sum of maximizing normalized balanced rates S_{+j}					0.0655	0.0595	0.0695	0.0555
Total sum of minimizing normalized balanced rates S_{-j}					0.1685	0.1834	0.2029	0.1951
Object's significance Q_j					0.2731	0.2502	0.2419	0.2348
Object's utility degree N_j					100%	92%	89%	86%
Object's priority					1	2	3	4
Supply price					14.550,00	15.750,00	17.240,00	16.820,00
Market price					14.550,00	15.750,00	15.951,61	14.613,38

Fig. 2 - Results of multiple criteria evaluation of the heating system's alternatives



Approximation cycle	The corrected value of a real estate	It is determined whether the corrected value of a real estate being valuated had been calculated accurately enough
1	16.820,00	| -7,67 | > 1%
2	15.530,41	| -3,67 | > 1%
3	14.960,91	| -1,67 | > 1%
4	14.711,51	| -0,67 | < 1%
5	14.613,38	| 0,33 | < 1%

Fig. 3 - Calculation of the market value: presentation of the market value's calculations in numerical form; presentation of the market value's calculations in graphic form

While going through the purchasing decision process a customer should examine a large number of alternatives, each of which is surrounded by a considerable amount of information/knowledge. Following on from the gathered information and knowledge, the multiple criteria analysis is then carried out. By using multiple criteria methods as was developed by the authors, the buyer (seller) determines the initial priority, utility degree and market value of the analyzed heating system's alternatives During this analysis. Clicking the link “Results of Multiple Criteria Evaluation”, the results of the multiple criteria evaluation of the private heating system's alternatives are thus demonstrated (see Fig. 2). In the lower part of the obtained result's matrix the calculated significance of the heating system's alternatives, their priority and utility degree are presented (see Fig. 2). The upper part of the obtained result's matrix shows the numbering of the heating system's alternatives (see Fig. 2). By clicking these blue underlined numbers it is possible to calculate the market value of a certain alternative (see Fig. 3). The table presented in Fig. 3 shows the iterations made during the calculation of the heating system's market value. The same information, only in graphical form is presented in Fig. 3.

A buyer performing a multi-criteria analysis of all heating systems alternatives selects the objects for starting the negotiations. For that purpose he/she marks (ticks a box with a mouse) the desirable negotiation objects. A negotiations e-mail are created by the Letter Writing Subsystem and sent to all heating systems sellers after the selection of the desired objects is made and then Send is clicked.

During negotiations the buyer and the seller with the help of DSS-HS may perform real calculations (the utility degree, market value and purchase priorities) of the heating systems. These calculations are performed on the basis of characteristics describing the heating system's alternatives obtained during negotiations (explicit and tacit criteria system, criteria values and weights). According to the results received, the final comparative table is then developed. Following on from the developed final comparative table the multiple criteria analysis and selection of the best heating systems buying version is carried out by using DSS-HS.

There are two main categories of rules and procedures in the Expert Subsystem:

Development of suggestions as to what sellers to use and for what reasons further negotiation should be carried out. With the help of the DSS-HS having determined the sequence of priority, the degree of utility and the market value of the heating systems, the rules of the expert's subsystem suggests what sellers to use and for what reasons further negotiation should be carried out.

Composition of comprehensively reasoned negotiation e-mail for each of the selected sellers. By using information inherited from the previous DSS-HS calculations and predefined rules and procedures, the expert's subsystem composes of negotiation e-mail for each of the selected sellers, where it reasonably suggests that the price of the heating systems should be decreased. The e-mail includes references to the calculations performed by DSS-HS.

Conclusions

The authors of this paper participated in the project Framework 6 "Brita In PuBs". One of Brita In PuBs goals (on the Lithuanian side) was to develop a Web-based Negotiation Decision Support System for Heating systems (NDSS-HS) which consists of a Decision Support Subsystem and an Expert's Subsystem and can create value in the following important ways: search for heating systems alternatives, find out alternatives and make an initial negotiation table, complete a multiple criteria analysis of alternatives, make negotiations based on real calculations, determine the most rational heating systems purchase variant, and complete an analysis of the loan alternatives offered by certain banks.

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Ecobuilding technologies

SOLAR ENERGY AND ARCHITECTURAL INTEGRATION

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Background and Focus

Solar energy in the building sector has a considerable potential. Three major approaches prevail : Passive solar, solar electric (PV) and solar thermal. My contribution focuses on two major issues : Building integration / aestetic integration (Picture 1). I will show examples of such integration but mainly show solar thermal air solutions.

Picture 1 - No need for promotion Campaigns ? Picture 2 - Roof Chaos

Solar thermal OR Solar Electric (PV)

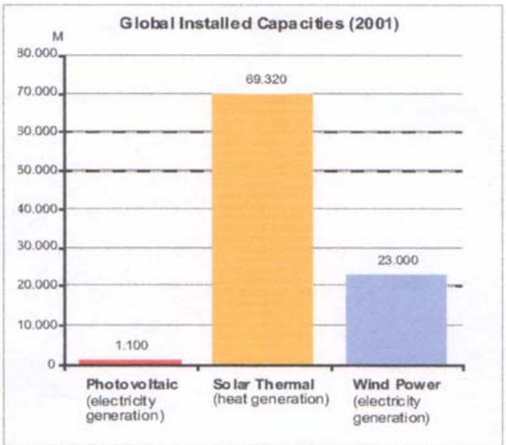
A lot of attention has over the past few years been given to solar electric.

Lately, however, larger solar thermal systems above the size of typical Domestic Hot Water (DHW) systems that roofs in southern Europe are packed with, have been given growing attention (Picture 2).

The reasons are :

- Heating constitutes a larger part of the energy bill than electricity – in most countries.
- Solar electric systems can generally speaking only supply approximately 100 Watt /m2 wall surface of usable energy.
- Solar thermal systems can supply 300 – 400 W/m2 wall surface, which is three times higher than solar PV (Picture 3).
- Solar thermal system costs are only a fraction of solar electric per installed Watt. That is one of the major reasons of the widespread use in so many countries.

When covering walls or roofs with solar collectors, we have to consider carefully that we get the most energy out of it per m2, so that we do not block the area for ever with a poor output.



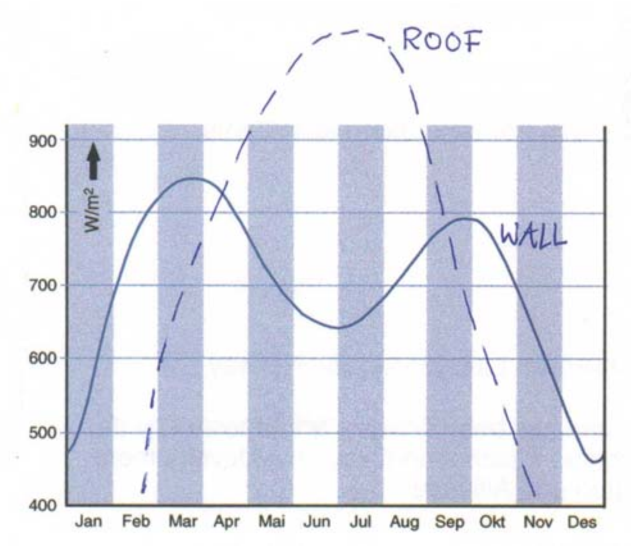
Picture 3 - Solar PV,Thermal,Wind

Orientation and Angle

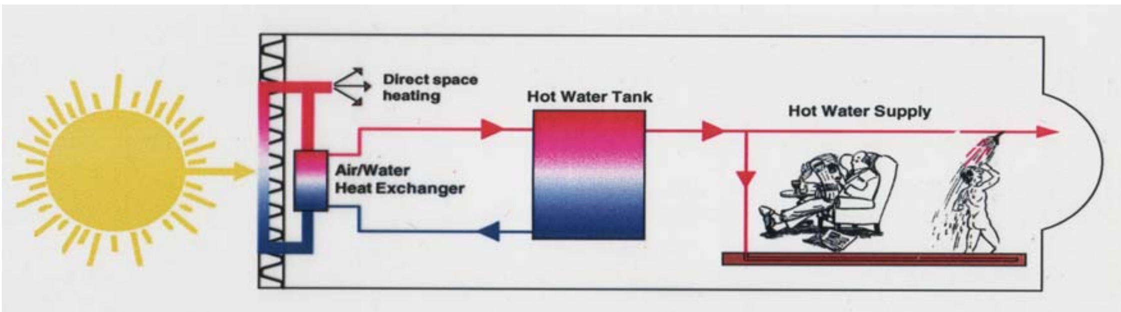
In most Mid- and North European locations, the orientation will be acceptable if the solar absorber faces South or 45 degrees East or West of South.

Angle is more a question of function – like DHW or space heating.

If the system is going to deliver both DHW (energy need all year round) and space heating, a good rule of thumb to find the angle to the horizontal, is latitude plus 10. If – on the other hand the system is only going to deliver space heating, which is in demand mainly autumn, winter and early spring, a vertical position is acceptable (Picture 4). Thermal space heating systems hence lead to wall integration, rather than roof integration.



Picture 4 Sunshine on Wall or Roof



Picture 5 Typical Air System

Colour in Solar architecture

Provided darker colours are used, the efficiency loss of using colours as opposed to the normally black matt colour used in solar thermal absorbers is very small.
It can easily be defended or compensated by increasing the area a little.

Solar Air Systems

Air has a lower mass than water, This can lead to more bulky constructions to move heated air as opposed to moving hot water, but air has other advantages :

- Air based solar systems do not freeze.
- Air systems do not leak and cause damage like a water system.
- Air systems do therefore not need to use defrost liquids like Glycol.

Bulkiness caused by deep air ducts in larger systems can be overcome if the air speed can be reduced. This reduces the efficiency (transfer of heat from absorber to point of energy need) but acceptable compromises can easily be struck.

Listed buildings and Solar energy

Most of the buildings that will surround us in 50 years are already built.
If we are going to reduce the energy need in the building stock, existing buildings will have to play a key role. But what do you do when you are practically not allowed to do anything because the building is listed ?

In the BRITA in PuBs project we have studied this challenge and tried to come up with solar thermal solutions that do not interfere with the building structurally on walls or roof – but at a distance. In some countries the regulations are very stringent and the antiquarian authorities demand a distance of 65 metres. This is normally though a point of departure for negotiation, depending on the individual site.

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INNOVATIONS IN BUILDING MANAGEMENT SYSTEMS

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Introduction

Control related problems significantly contribute to high energy consumption in office and commercial buildings. Today, building management systems (BMS) are commonly designed to control the technical building equipment in order to reach comfortable climatic conditions in the controlled spaces. This setpoint orientated control strategy does normally not contain any active supervisory instruments to control the energy consumption of the building. As a consequence, no error messages will occur as long as the setpoints are reached, sometimes even if in the worst case the cooling and heating system are working against each other. Furthermore, standard BMS control algorithms are only able to detect abrupt changes in the conditions of e.g. HVAC-Systems, but they do not offer significant fault detection and diagnostic information and are unable to detect gradual degradations in system performance (Buswell R.A. et. al., 2003 and others). On the other hand, dynamic simulation tools are so far only used during the planning phase for the building design and the dimensioning of the technical equipment like the heating and cooling system. Control algorithms are then well developed under consideration of simulation results and the planned equipment, but the implementation is later normally done by system engineers of the chosen BMS company. Due to information losses interpretation and implementation errors are nearly unavoidable and lead to suboptimal system control. To reduce such problems new strategies are required to directly implement well tested control algorithms from simulation programs into the building control system. During building operation the simulation tools can then e.g. be used in the energy management system for online simulation and control, e.g. to check the control actions and measurement data against the simulation results (Clarke, J.A. 2004; Gouda M.M. 2003; Hao, X. 2005 and others). Using the means of information technology, control and simulation actions can also take place at different locations, so that there are apart from usable software interfaces no additional requirements on site for the building automation system.

Innovations in building management systems

Energy consumption control

Building management systems are commonly used for the control of the building and its energy supply systems and only in some cases additionally for the monitoring of the cooling and heating energy consumption of the building. Since the energy consumption depends strongly on the outside conditions like temperature and solar irradiation, a simple monitoring provides no detailed information whether the system and the building control works properly and energy efficient. If a standard energy management system is installed, at least the yearly or even monthly energy consumptions of the building are compared to historical energy consumption data using degree day normalisation methods. However, since only historical data of long time periods are analysed, this is more a passive than a real active energy management tool.

Model based control

For the implementation of an active energy management system the monitoring data of the building and plant performance should be compared to predicted values in daily, hourly or even shorter time periods calculated by simulation models under consideration of the real operation conditions like weather data and time schedules for the utilisation of rooms or the building itself. Instead of a comparison of measured and predicted energy consumption, the models can also be used for the active control of the building and the heating, cooling and ventilation systems. Such applications are for example:

- Optimisation of heating up / cooling down periods after night time or weekend energy saving time or for partly used rooms under consideration of the internal building mass.

- Energy optimised strategies for the control of the sunshading system in order to increase solar gains and to prevent overheating under consideration of the building envelop properties und internal mass.
- Control of passive cooling systems during the night time using the ventilation system or automated window openings.
- Control of solar driven absorption /adsorption cooling systems using weather forecast data. Cooling of rooms below a certain setpoint (to e.g. 22 °C instead of 24°C) if the weather conditions are optimal for a solar cooling system.

For the implementation of such a model based control system, online simulation models of the building and the plants have to be developed and validated against measurement data. The main question which has to be considered and clarified is the necessary level of modelling detail to meet the required accuracy for the planned control implementation. Do we need in all cases dynamic models, how simple can a dynamic model be, which time steps are required for the planned control action etc.. In case of the building detailed static calculation methods according to DIN EN 832 or DIN V 18599 can be used for the calculation of the energy demand of the building in monthly or with small adjustments in the calculation methods even daily mean values. For shorter time periods in time steps of one hour the building dynamic caused by the internal mass has to be considered in order to reach comparable result for the cooling and heating energy demand. This requires more or less detailed dynamic building simulations. In a first approach a simple model, based on an extension of the steady state calculation methods, will be developed and tested.

Necessary communication infrastructure for the implementation of model based control systems

For the implementation of a model based control system a software interface to the installed BMS is required. The proposed system runs on a PC separately from or parallel to the BMS and can be located on site or centrally in the office of an energy management agency. In any case, the measured data and setpoints collected by the BMS need to be transferred to the model based control system. The possible solutions for the data transfer strongly depend on the installed BMS and the available interfaces. In the easiest case the BMS provides an interface which transfers the measured data directly on a DataSocket or OPC server. If the BMS provides only an interface which writes the measured data into a database on the PC, an additional database reader and writer software is necessary to read the necessary data from the database and write it on a DataSocket or OPC server. For the transfer of measured data to the online simulation models, a DataSocket or OPC client (reader) and a corresponding server have to be installed (software installation) on the PC which is connected to the BMS-System and to an internet/modem connection. DataSocket or OPC clients (reader and writer) have to be installed on a PC of the energy management agency as well. The reader client reads the necessary measurement date via internet or modem connection from the DataSocket or OPC server running on the PC who is directly connected to the BMS on site and passes them to the online simulation tools running on the PC of the energy management agency. The simulation results are then written back to the server running on the PC on site. Additionally, the calculated output performance is compared with the measured performance of the building. If the deviation between measurement and simulation exceeds a certain threshold, additional warning messages and control actions can be written back to the DataSocket or OPC Server running on the PC on site. DataSocket and OPC are provided by National Instruments amongst others.

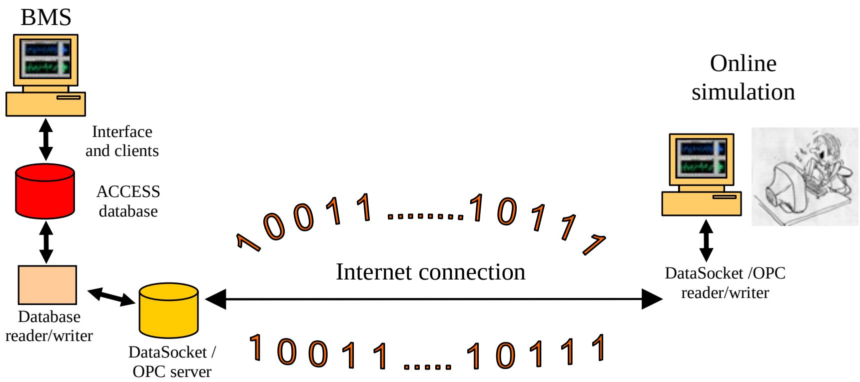

Fig. 1: Communication structure for model based fault detection scheme

Example projects

POLYCITY project

The POLYCITY project focuses on large scale urban development, where living and working areas are integrated to result in sustainable city quarters with short distance and low transport energy consumptions. POLYCITY comprises three projects, one in Torino, one in Stuttgart and one in Barcelona. The urban conversation project in Stuttgart Ostfildern, named as Scharnhauser Park covers 178 000 m² of newly constructed surface area for 10 000 people and provides high building standards combined with bio-mass co-generation. Apart from the project coordination the main task of the zafh.net research centre in Stuttgart is the development and implementation of a communal energy management system. These activities comprise the development of simulation tools for the supply (co-generation unit, absorption cooling systems) and demand side (buildings) and the development of necessary communication structures and interfaces to different types of building management systems. As a first implementation project the City hall of Ostfildern located within the Scharnhauser Park was chosen. This low energy standard building was completed end of 2003, is connected to the district heating system fed by the biomass co-generation unit and is mostly naturally ventilated without active cooling devices. During the first operation year 2004 the heating energy consumption of the building was manually read from the installed energy meters and documented every month. A model according to DIN EN 832 was developed to calculate the energy demand of the building for the same time period under consideration of the real weather data in monthly mean values. The results depicted in Fig. 2 show that the calculated energy demand exceeds the measured data significantly in the winter months (Dec, Jan and Feb) if a constant air exchange rate of 0.7 h^{-1} is used in the model. However, if the air exchange rate is reduced to a value of 0.4 h^{-1} the calculated energy demand fits quite well for the winter month but falls below the measured values in autumn and spring. This indicates that the real air exchange rate of the naturally ventilated building is related to the outside temperature, which should be considered in further models.

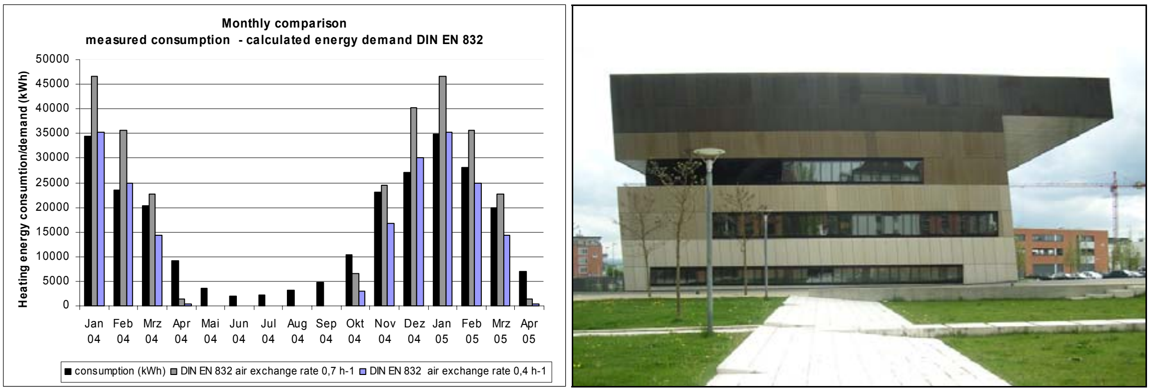

Fig. 2: Monthly comparison of measured and calculated energy consumption/demand

For the installation of an active energy management system additional models for the calculation of the heating energy demand of the building according to DIN V 18599 have been developed, which allow the static calculation of daily mean values. In order to reach comparable hourly mean values a simplified dynamic model is currently under development. These models will be used in an energy management tool which will be equipped with interfaces to the BMS of the building for the transfer of measured and calculated date and control actions via modem or internet connection. Since the installed Kieback & Peter BMS uses proprietary protocols and system software, software interfaces, OPC clients and an OPC server were developed by Kieback & Peter for the online data transfer. These software tools are installed on a separate PC which is directly connected to the PC of the BMS by a crossed CAT cable and network cards. The energy management tool runs on a different PC located at the zafh.net research centre Stuttgart. For the online data transfer between both locations OPC clients (reader and writer) are installed on the energy management PC which pass the measured data to the online simulation tool. A modem connection is used for the data transfer.

In order to test BMS systems at different level of integration, a simple microcontroller unit called smartbox produced by ennovatis with integrated modem and internet interface was additionally installed in the City hall and connected to the energy meters for heating and electricity. The software interface and clients for the data transfer from the smartbox to the energy management PC were developed by zafh.net. The implemented communication structures of both systems are shown in Fig. 3. The model based energy management tool will be tested for the following heating period, using different types of building models as described above.

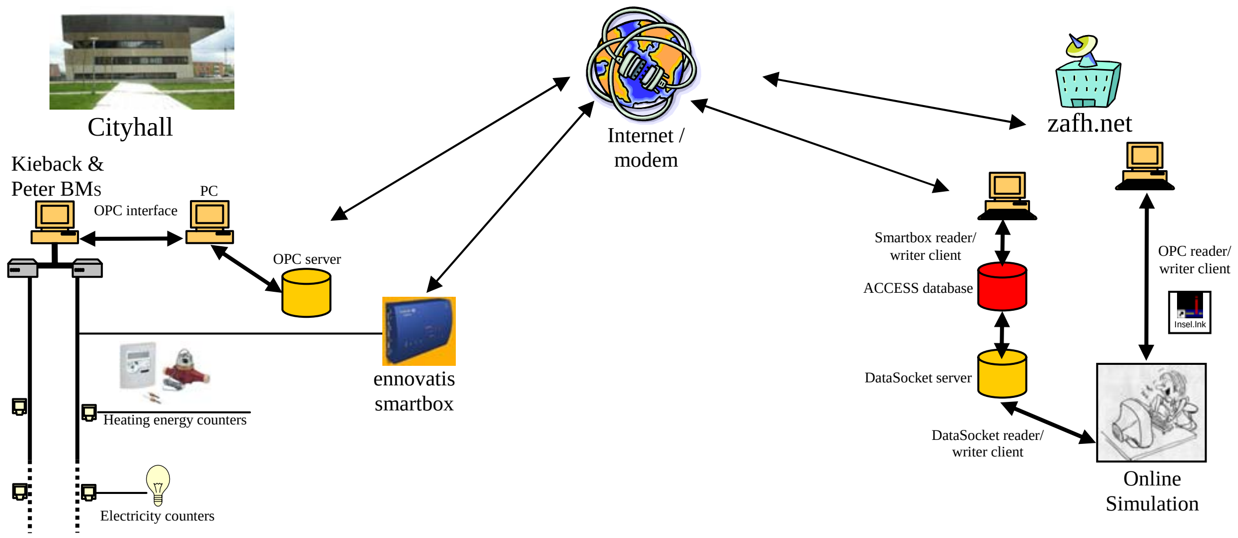

Fig. 3: Communication structure for the model based energy management system

SARA project

„Sustainable Architecture Applied to Replicable Public-Access Buildings"

The project SARA involves the demonstration of 7 sustainable buildings with different public functions, two training centres, one in France and one in Uzbekistan, a supermarket in Slovenia, a healthcare centre in Barcelona, an educational office building in the UK, a municipality office building in Italy and a office building with exhibition halls in Austria. Within the SARA project the main tasks of the zafh.net research centre in Stuttgart are the analysis and

improvement of the implemented BMS control strategies and the development and integration of intelligent online simulation tools. These simulation tools focus on the energy demand of the buildings and on parts of the integrated energy
supply equipment like PV-generators, ventilation and cooling systems, geothermal systems (heat pipes, earth collectors etc.). The communication structure necessary for the data transfer to the online simulation tools is quite similar to the PolyCity project. Interfaces to different types of BMS have to be developed together with the producers of the systems. The simulation models will run centrally on a zafh.net PC in Stuttgart with data transfer from/to the demonstrations sites via internet connection. The calculated energy demand/production from the online simulation tools will be used for the monitoring and shown in parallel to the real energy consumption/production. This will help to detect and improve hidden control mismatches or system faults. Furthermore, the online simulation tools will be used for the development and testing of new intelligent control strategies which are then implemented in the BMS. The development of more advanced online simulation tools with some active control tasks are planned for the ventilation and cooling system of the health care centre in Barcelona.

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LONG TERM MONITORING VIA INTERNET

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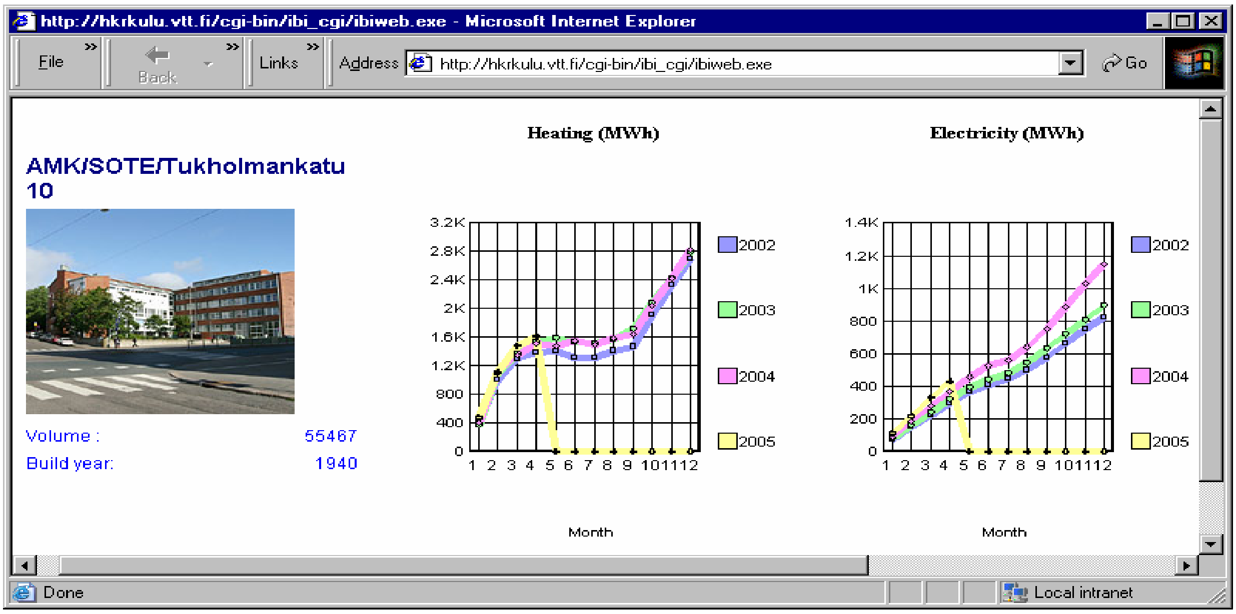
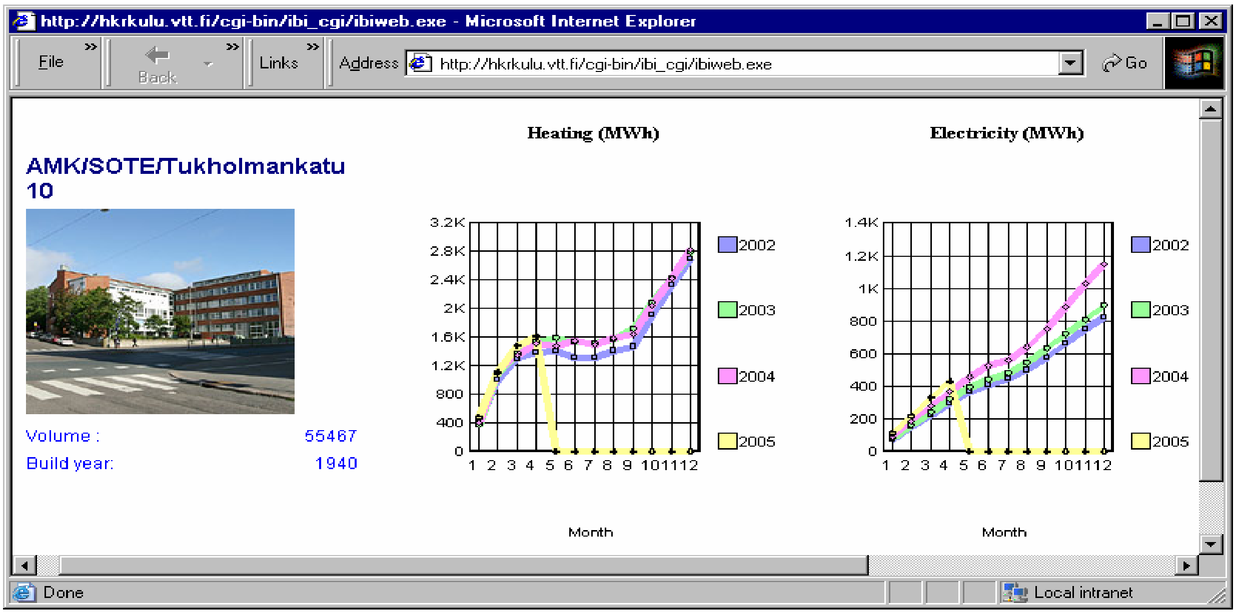
Introduction

The ongoing fast development of information and communication technologies (ICT) is rapidly changing our societies and everyday life all over the world. Today internet can be accessed almost anywhere, and www-based applications are becoming widespread. Internet is already the main platform for many public and private information services, business applications, entertainment etc. Internet technology offers new possibilities to develop solutions for the improved building energy efficiency as well. It provides a common digital infrastructure and communication platform for new type of applications and services, which can shift energy saving activities to the new era of information society.

Energy monitoring – Basis for everything

" What can´t be measured cannot be managed" - this phrase is more than valid also when building energy efficiency is discussed. Without reliable information on the energy and water consumption saving activities cannot be directed properly, not to say anything about assessing the influences of the saving measures already completed.



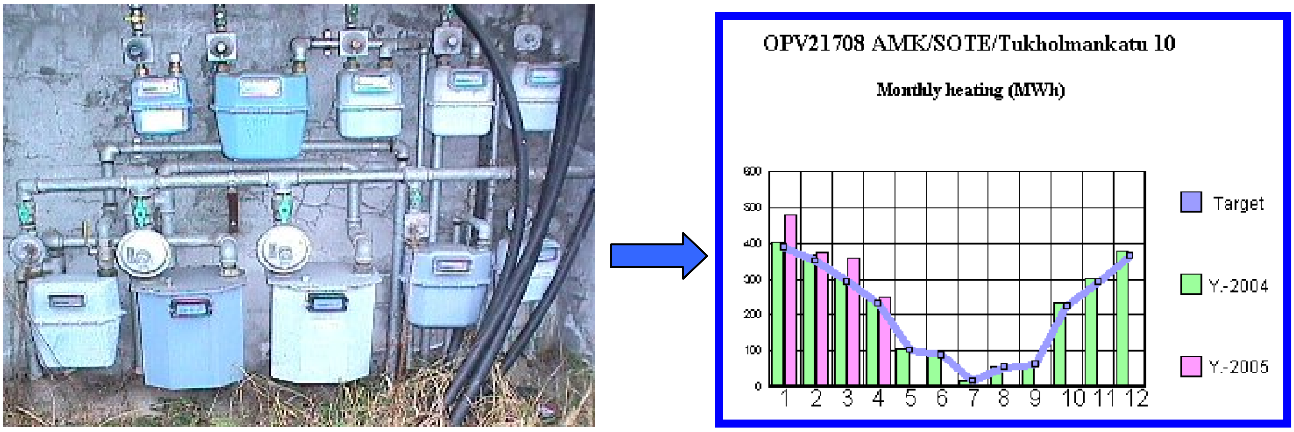


Picture 4. Monitoring results for a vocational high school. Accumulated monthly figures show clearly the continuous increase of electricity use

The first step on the way towards improved energy efficiency in buildings is the continuous and regular recording of actual energy and water usage. Comparing the yearly, monthly or daily consumption to the respective previous period gives already a lot of information about how the energy efficiency is varying and developing with time (picture 1). When major changes in daily operation or maintenance routines are made the impacts should be observable in consumption figures too. Conversely, remarkable changes in consumption figures lead us to search for the probable reasons if they are not self-evident. Based on this kind of feedback information offered by monitoring, the energy behaviour of the building can be understood better, and operational routines as well as planning of retrofits can be directed in a right way.

Existing utility meters – an undervalued source of data

When aiming at improved energy control and management in the majority of existing buildingstock, installation of new sensors, meters, automation systems etc. is not a realistic short-term option because of high costs. Existing utility meters (picture 2) can offer a sound basis for the monitoring activities however. The information needed in basic energy management is already available for almost every building. Until now this existing data source has been almost forgotten or at least undervalued. Compared to invoices, utility meters can offer more accurate information for energy control and saving. In addition to their wide existence (investments already done) another important benefit is that the accuracy and performance (maintenance) of utility meters is quite well guaranteed because of the economic interests of both the utility companies and the customers.



Picture 2. Existing utility meters offer sound basis for long term monitoring

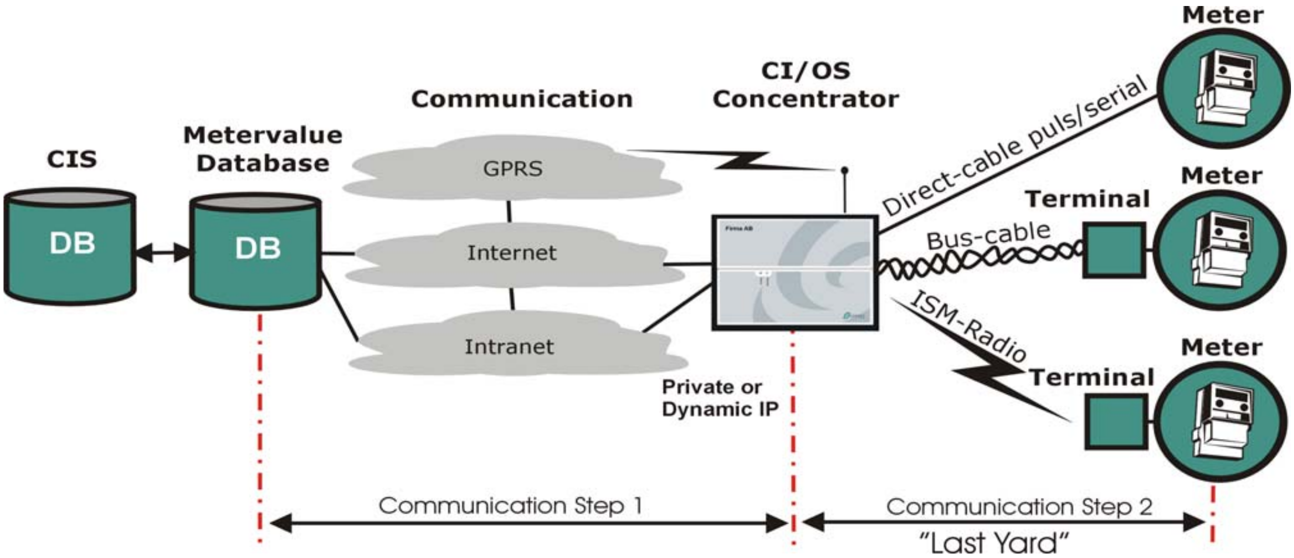
For the basic energy management the data accessed from utility meters is sufficient. In the long term energy control and management there is no need for the very accurate and short interval registration of consumption provided only by modern meter technology or proprietary equipment (dataloggers etc.). The so called whole building approach gives already enough information to achieve most of the important benefits of monitoring. The main disadvantage of this approach is of course, that it does not quantify the energy performance of the building itself, but rather the sum total of the quality of construction, behaviour of the occupants and efficiency of O&M functions. From the point of view of environment this can even be an advantage however. And the whole building consumption figures can always be complemented with temporary in situ measurements, when more accurate data is needed for energy auditing, commissioning etc. In many cases the installation of new "sub meters" is justified as well in order to get more accurate information about consumption pattern.

Internet offers new possibilities

Internet offers several possibilities to develop new type applications for energy control and management. Even manual monitoring activities and the whole building approach mentioned before can be raised on a new level. By utilising web based applications monitoring&targeting is possible via standard web browsers and no installations are needed on user side - access to internet is enough. For example service men of buildings can update their own data whenever they want from different location. The data is immediately available for analysing, comparisons etc. for everybody having access to the system. Even building occupants, tenants, owners etc. can easily get feedback not only on their own energy consumption but benchmarks with other similar cases as well. In this way e.g. energy and water consumption in hundreds of buildings owned by the city of Helsinki are controlled and monitored (pictures 1-2). Servicemen and O&M managers can get continuous feedback for their daily operations. Energy auditors and designers have always reliable and up to date information, when planning retrofits or other saving actions.

Towards automated data collection and diagnostics

Besides more or less manual updating of meter readings also more intelligent and automated data acquisition techniques are available on the market. Many so called automated meter reading (AMR) solutions have been developed based on both wireless and wired data transmission. On going deregulation of energy markets is boosting the use of these technologies and many European utilities have on going deployment projects in this field. Internet offers an open infrastructure for AMR as well. Finnish high-tech companies like Comsel System (http://www.comsel.com) for example offer solutions in this field but there is development in other European countries as well like e.g. Ennovatis in Germany (http://www.ennovatis.com).

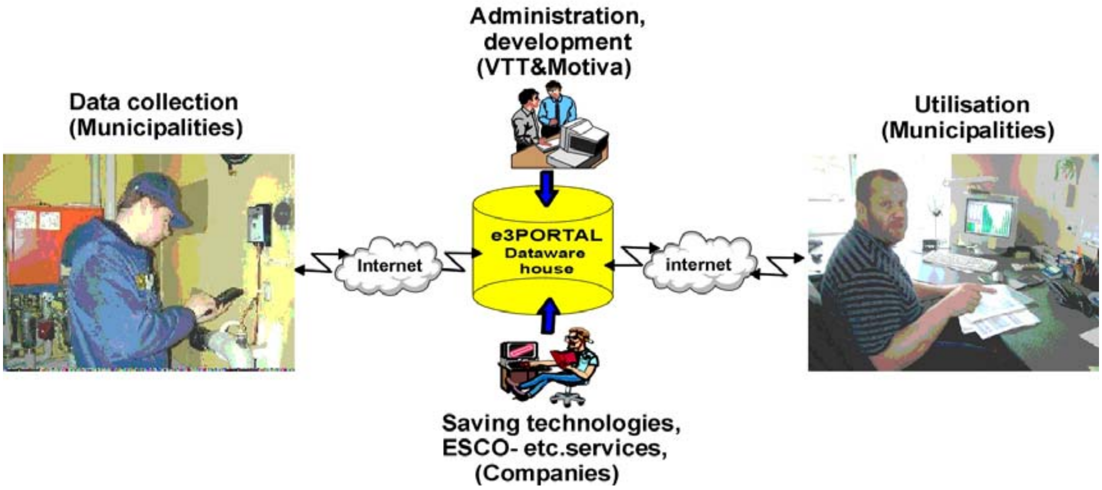


Picture 3. AMR solutions over Internet based on the I/O Server of Comsel System

Based on AMR consumption figures can be registered daily or hourly and automated meter reading solutions can be realised. In case of modern electricity meters even rate of sampling of milliseconds is available and data for so called NIALM-methods (Non Intrusive Appliance Load Monitoring) can be collected and quality analysis for electricity can be carried out as well. In the future data analysis and diagnostic routines will run on the background automatically and alarms will be generated and sent as short messages to mobile phones or as emails. Over internet real time consumption data as well as benchmarking reports based on long term figures are always available for the management, service companies, etc.

Portal solutions for benchmarking and certification

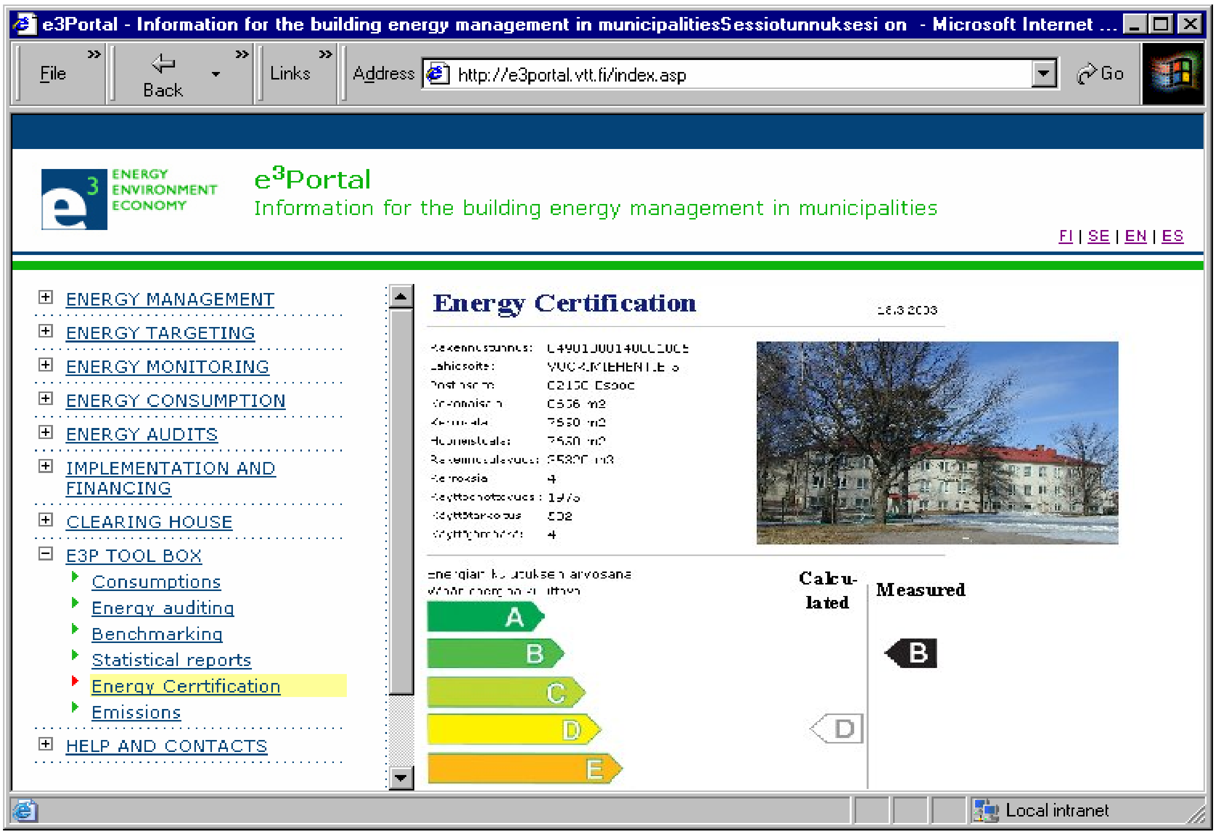
The effective management of building energy use requires the ability to set and review consumption targets, to monitor performance against the targets and to communicate the building performance to others. At VTT an internet-based information service for municipal building owners - called e3Portal - has been developed. Municipalities act as content provider by updating continuously the consumption figures and other information to the data warehouse of the portal. Building operators and other users can access the service over internet using only the standard web-browser (picture 4). Via benchmarking local actors can be motivated and best practice information can be disseminated. Sound basis for the participation of Escos and other companies has been created and in the future portal can offer platform for ebusiness type activities as well.



Picture 4. Internet portal for municipal buildings (http://e3portal.vtt.fi)

Via e3Portal the manager of a building for example can easily compare the energy consumption of his own building with the similar ones in the whole country. When planning improvements and designing saving concepts top ten lists of saving measures found in hundreds of similar buildings can be reported from portal´s data warehouse. Environmental load from building energy usage can be visualised and the real effects of local saving policies can be analysed. Information about successful saving measures and their real impacts can be delivered among municipalities. Portal supports in a new way the networking and best practice dissemination on local level but can be easily used in international collaboration as well.

In addition to the consumption data also information on energy saving technologies and products can be accessed via portal. Simple calculation tools for the asset rating of the energy performance will be included and results from the realised energy audits will be available as well. Portal offers also a good platform to test a new type of energy performance certification system. Based on internet technologies this kind of electrical "eCertification" (picture 5) could be implemented by minor resources and at least part of it (based on realised consumption figures) could be updated regularly.



Picture 5. Draft for an internet based eCertification of building energy performance

Conclusions

Modern ICT offers lot of possibilities for the development of new type applications and services, which can support the improvement of energy efficiency in buildings. Remarkable progress can be achieved already with quite simple tools and information based on the existing utility meters. Automated meter reading techniques will increase the available information dramatically and make real time fault detection and diagnostics possible. In the future internet will be the main platform for the new generation services and applications. Already now all European buildings could be involved in a common database consisting of information on building characteristics as well as long term monitoring data. Based on this an open platform for ebusiness type participation of companies could be created and an "eCertification" system for building energy performance could be implemented. In this way internet can support the transition of European energy efficiency policies to the new digital era.

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Annex

Deutsches Technikmuseum Berlin

an attractive location

for active visitors

The Deutsches Technikmuseum Berlin (DTMB) invites to an eventful and enjoyable journey of discovery through the cultural history of technology.

The museum occupies a historical industrial site dating back to 1874. The contemporary architecture of the new extension for the aviation and maritime collections fits perfectly into these surroundings to form a fascinating ensemble. The large museum park – containing two windmills, a water mill, a smithy and a brewery – is also an oasis of green.

On nearly 25.000 m², the museum presents a broad spectrum of old and new technology and demonstrates the various historical connections to culture and everyday life. Daily demonstrations, visitor activities and guided tours – as well as 250 experiments in the Spectrum Science Centre – make the DTMB an interactive learning experience.

INDEX OF AUTHORS

Ecobuildings

At present the building sector is responsible for more than 40% of EU energy consumption. There are technologies under development, which could substantially improve (up to 30%) the energy performance of buildings, reducing the conventional energy demand in new and existing buildings and substantially contributing to the reduction of energy intensity, through combined measures of rational use of energy and integration of renewable energy technologies.

The Eco-buildings concept is expected to be the meeting point of short-term development and demonstration in order to support legislative and regulatory measures for energy efficiency and enhanced use of renewable energy solutions within the building sector, which go beyond the Directive on the Energy Performance of Buildings.

The projects aim at a new approach for the design, construction and operation of new and/or refurbished buildings, which is based on the best combination of the double approach: to reduce substantially, and, if possible, to avoid the demand for heating, cooling and lighting and to supply the necessary heating, cooling and lighting in the most efficient way and based as far as possible on renewable energy sources and polygeneration.

Bundesministerium für Wirtschaft und Arbeit

eco buildings