TWO RENOVATED PUBLIC BUILDINGS WITH RENEWABLE ENERGY TECHNOLOGIES

Karin Buvik
SINTEF Building and Infrastructure, Architecture and Building Technology, Alfred Getz vei 3, 7465 Trondheim, Norway, Karin.J.Buvik@sintef.no

Kirsten Engelund Thomsen
Danish Building Research Institute, Aalborg University, Dr. Neergaards Vej 15, 2970 Hoersholm, Denmark ket@sbi.dk

Ove Mørck
Cenergia Energy Consultants, Herlev Hovedgade 195, 2730 Herlev, Denmark , ocm@cenergia.dk

Summary

Within the project *Bringing Retrofit Innovation to Application in Public Buildings* (BRITA in PuBs) eight demonstration public buildings were retrofitted. The project was part of the EU Eco-buildings programme. The aim of the project was to further increase the market penetration of innovative and effective retrofit solutions to improve energy efficiency and to implement renewable energy technologies. BRITA in PuBs was finalised in 2008. Two of the demonstration buildings are reported in this paper:

- Borgen Community Centre in Norway (conversion from school to community centre)
- Proevehallen in Denmark (conversion from industrial building to cultural centre)

Borgen Community Centre is located in a suburban area in Asker close to Oslo, the capital of Norway. The Borgen School was built in 1970 and has now been retrofitted and converted into the Borgen Community Centre, a centre for the whole neighbourhood. The main building contains a secondary school and facilities for health-care services and leisure-time arrangements. The design strategies, the energy-saving measures, energy savings and costs are described.

Proevehallen (the test hall) is located on the outskirts of Copenhagen, the capital of Denmark. Constructed in the 1930s, Proevehallen was an open factory building consisting of one large hall that has now been retrofitted and converted into a cultural centre. The energy consumption and the economy are reported. The design, installations, solar PV and solar thermal system and the building management system are described.

The two buildings showed demonstrated that by introducing appropriate energy conservation concepts and renewable energy technologies into retrofitting projects, the resulting energy standard can be considerably higher than required by the current building regulations at reasonable costs and payback time.

Keywords: public buildings, energy savings, retrofitting, eco-buildings, CO_2 reduction

1 Aim of the demonstration buildings in the BRITA in PuBs project

The overall aim of the EU project *Bringing Retrofit Innovation to Application in Public Buildings* (BRITA in PuBs) was to increase the market penetration of retrofit solutions for energy efficiency. Eight public buildings of different types were chosen as demonstration buildings to boost awareness of eco-buildings in groups of differing age and social origin. The general aim of the demonstration buildings was to halve the purchased energy demand for heating, ventilation, cooling and domestic hot water, and to improve comfort and indoor climate substantially, at moderate additional costs.

2 Borgen Community Centre in Norway

2.1 Conversion from school to community centre

The old Borgen School in the municipality of Asker, built in 1970, has been retrofitted and converted into the Borgen Community Centre, a place for the whole neighbourhood. The retrofitting of the main building was comprehensive, making the building suited for new working methods in the school and for a diversity of activities as a result of new tenants in from the neighbourhood. In addition to a secondary school there are now facilities for health-care services and leisure-time arrangements. A large part of the building is accessible and suitable for various groups in the local community.

The renewed building consists of 4,000 m^2 of retrofitted areas and 2,000 m^2 of new constructions.

2.2 Pre-project phase

For the pre-project phase of the Borgen Community Centre, an accompanying research and development project was initiated to assist the goal setting and planning. SINTEF, a Norwegian research institute, was the facilitator of this R&D project, and researchers from SINTEF and the Norwegian University of Science and Technology (NTNU) were involved as expert advisers on environmental issues [Buvik 2008].

The sustainable retrofit did not have a purely technical focus; instead a more integrated approach was used, combining building design and energy technologies, also including more «soft issues» such as user involvement in the planning process and social issues. In order to create a vibrant local community and meet the need for more efficient use of resources, a joint location and a coordinated use of facilities were emphasised.

At the early stage, the researchers' role was to provide input for discussions about plan layout and functionality as well as input to discussions about environmental issues. Next followed analyses of various solutions that ended with a building programme where statements of ambitions and intentions were put into specific terms:

- Compared with standard practice, the school section should be space efficient and suitable for various groups in the local community.
- In accordance with the Norwegian assessment method «EcoProfile», the building and the outdoor space should obtain the best quality classes.
- Purchased energy consumption should be halved, and indoor climate should be considerably improved.

2.3 Design phase

In the design phase, the researchers contributed to co-optimising a large number of parameters and assessed how different building layouts, building structures and building envelope designs would influence the indoor climate and the energy used for heating, cooling, ventilation and lighting.

2.3.1 Strategy for energy design

In aiming to reduce the consumption of energy, a five-step strategy was applied:

1. Reducing heat losses
2. Reducing electricity consumption
3. Utilising solar energy
4. Controlling and displaying energy consumption
5. Selecting energy source

In other words: the starting point was application of energy efficient measures to reduce energy demand, and then meet the remaining demand with an energy supply system utilising renewable energy sources.

Step 1. *Reducing heat losses* generally deals with building shape, zoning of room categories and area efficiency. Well insulated and airtight building envelopes without cold bridges, and efficient heat recovery of ventilation air are crucial for reducing heat losses. At Borgen the following measures were applied: Insulation of envelope, replacement of windows, and heat recovery.

Step 2. *Reducing electricity consumption* in general deals with the exploitation of daylight, low pressure drops in the ventilation system, reduction in need for cooling by utilising thermal mass in combination with night cooling and efficient solar shading, plus energy efficient lighting and equipment. At Borgen the following measures were applied: New daylighting openings, new hybrid and natural ventilation systems, thermal mass, solar shading, and efficient lighting.

Step 3. *Utilising solar energy* in general deals with optimum window orientation, thermal mass activation, solar collectors, and photovoltaics. At Borgen solar collectors and photovoltaics were estimated to be too expensive. Measures concerning solar gains were focused on materials with a high thermal mass capacity in walls (bricks) and floors (concrete).

Step 4. *Controlling and displaying energy use* deals with smart house technologies in general; i.e. demand control of heating, ventilation, lighting and equipment, and feedback to users on consumption. At Borgen the following measures were applied: Building Energy Management System (BEMS) providing demand control of heating, ventilation and lighting, and feedback and reminders to users, to assist their manual control.

Step 5. *Selecting energy source*, deals with heat pumps, district heating, firewood, gas, and electricity with regard to renewable energy in Norway. At Borgen the chosen solution was a water-based heat pump, harvesting heat from the ground for space heating, preheating of ventilation air and domestic hot water. Under normal conditions the geothermal heat is enough, and the old oil burners are used only a few days during winter.

2.3.2 Environmental assessments

A simplified environmental assessment was performed during the design phase [Andresen]. The assessment was based on the Norwegian EcoProfile method [Stiftelsen

Byggsertifisering]. EcoProfile classifies a building based on three main criteria: Exterior environment, resources, and indoor climate. These main criteria have many sub-criteria. The criteria are assessed on three levels: Level 1 is «low environmental load», Level 2 is «medium environmental load » and Level 3 is «high environmental load».

Due to the fact that the EcoProfile method is primarily developed for assessing existing dwellings and office buildings, some adjustments to the method had to be made in order to make it suitable for school buildings still in the design phase. The assessment was carried out by researchers, who also elaborated a focus list for the next design phase.

Fig. 1 Main building before retrofitting. Photo: B. Matusiak.

Fig. 2 Before retrofitting. The old building was poorly ventilated and had minimum daylight. Photo: B. Matusiak.

Fig. 3 After retrofitting. New daylight openings in the roof and new façades. Air inlet tower and heat recovery unit (roof top) are seen in the picture. Architects: Hus Arkitekter AS. Photo: J. Rolland.

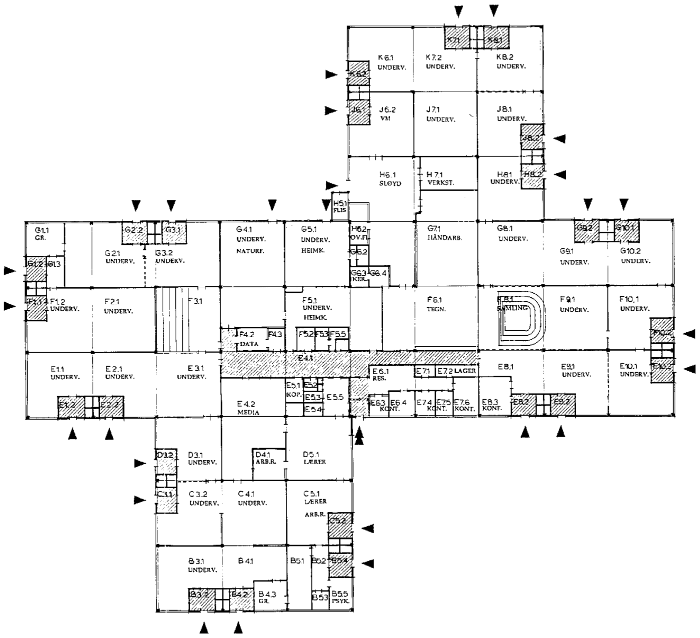


Fig. 4 Plan layout before retrofitting. Classrooms with outdoor communication areas. The old building was not suited for modern working methods nor for cultural and social activities.

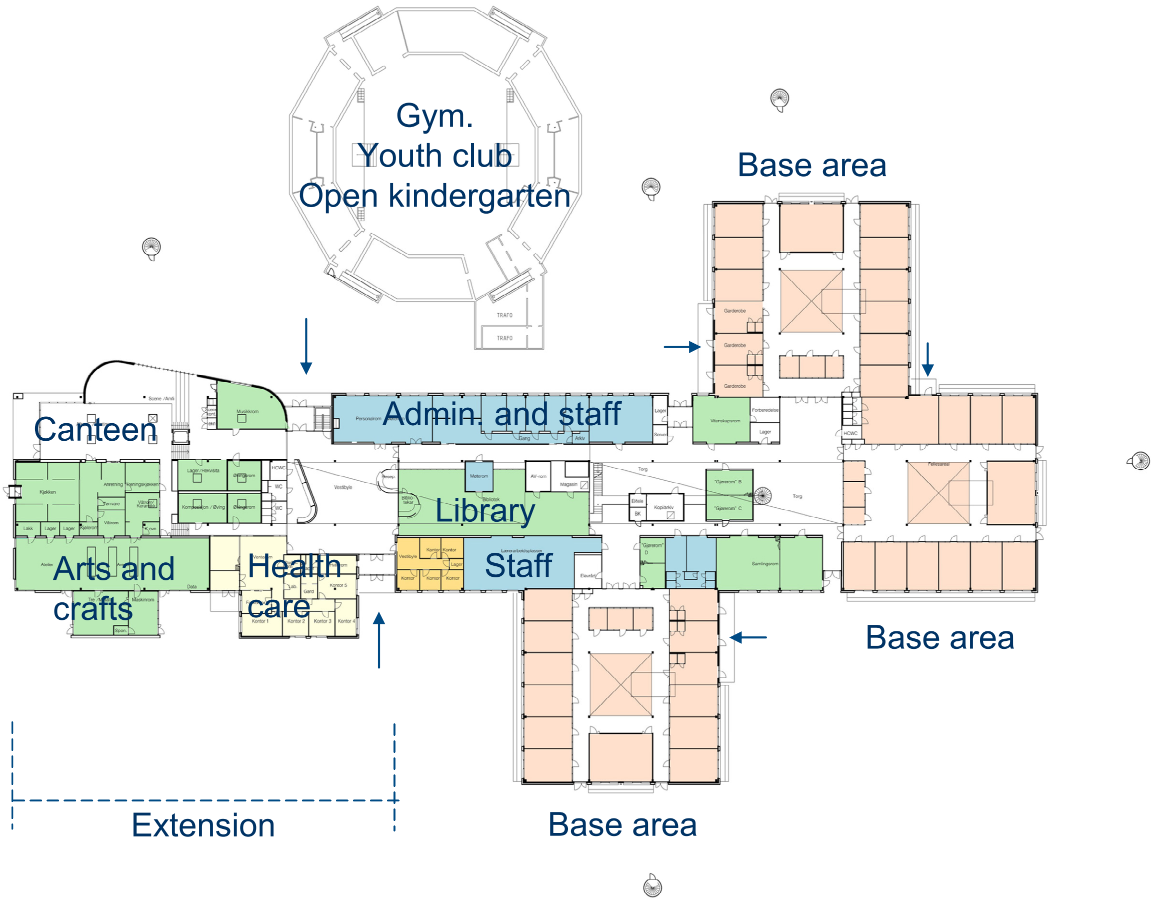


Fig. 5 Plan layout after retrofitting. The building contains a secondary school, local library and health care services. At the disposal of the community there are kitchens and canteen, workshops, offices and meeting rooms.

2.4 Reused constructions and materials

The following elements from the old building were reused: the basement, pipes, floor and roof construction. Due to new regulations on snow loads, the roof construction had to be strengthened. The roof surface had to be replaced and that allowed for daylighting openings. The intention was to reuse the bricks from the old exterior walls, but it turned out to be too expensive to clean the bricks for reusing.

Fig. 6 Indoor communication area before retrofit. Photo: B. Matusiak

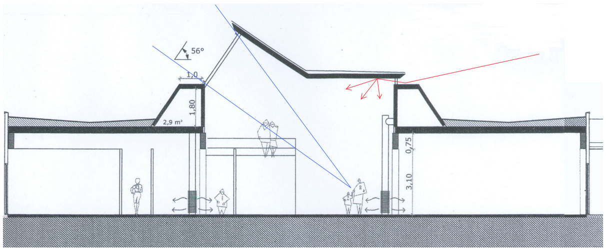


Fig. 8 Daylighting study from the design phase. Illustration: B. Matusiak [Matusiak]

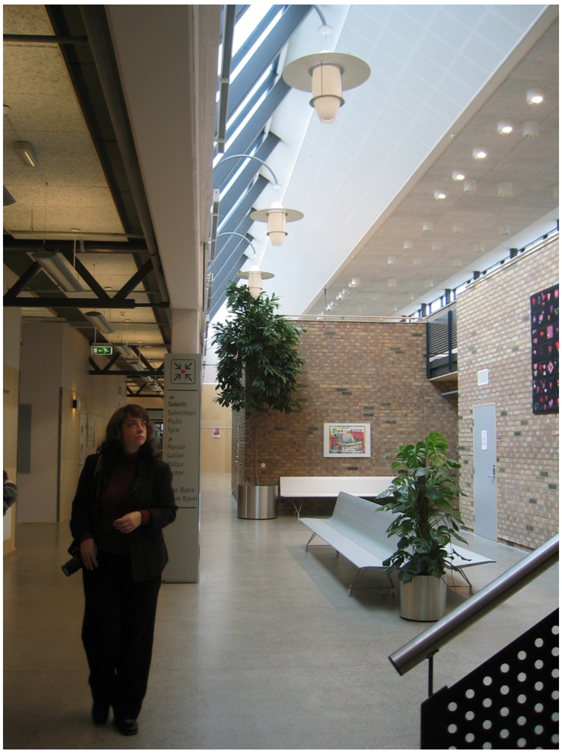


Fig. 7 Indoor communication area after retrofit. Photo: K. Buvik.

2.5 Measured energy consumption

The purchased energy consumption before retrofitting was 280 kWh/m^{2}a. Energy consumption has been monitored daily since the retrofitted building was opened. Measurements for 2007 (normalised) showed 102 kWh/m^{2}a.

2.6 Costs and payback time

Tab. 1 Additional costs compared with conventional building

Elements	**NOK**	**EURO**
Building-integrated ventilation constructions	3.800.000	463.415
Specially designed ventilations elements	930.000	113.415
Sensors for ventilation control (CO2)	372.000	45.366
Heat recovery systems	254.200	31.000
BEMS	750.000	91.463
Planning and project administration	700.000	85.366
SUM	**6.806.200**	**830.025**

Tab. 2 Total costs

	NOK	EURO
Total project costs	183.000.000	22.317.073

Payback time for additional costs compared with conventional building was calculated to approximately 9.5 years, which was considered very satisfactory. Asker Municipality had negotiated a very favourable energy price at the time. However, the contract would expire a few years later, it was expected that the price would increase considerably, which in turn will reduce payback time accordingly.

2.7 Users satisfaction

Statement from the municipality (Stein Grimstad, head of project department): «Borgen Community Centre stands as a very successful project, representing a major contribution to improve environment and indoor climate. I register with pleasure that our goal of reducing energy consumption by at least 50 % has been achieved by a good margin. Our experience with the technical principles applied to the building represents a good foundation for future buildings in our municipality. The building has also been awarded a prize for being an environmental friendly building, and the response from the users are very positive.»

2.8 Lessons learnt

2.8.1 Ventilation

Constructing underground culverts along existing buildings is complicated and expensive. Other solutions should be searched for.

2.8.2 Sensors

IR sensors for light regulation combined with burglar alarm have caused problems, because unwanted light hits the sensor and triggers the alarm. These should be separate systems.

2.8.3 Training of building operating staff

Extensive and complicated BEMS system requires a long testing and adjustment period. Technical personnel should be trained before the building is opened.

In the beginning there were some problems regulating and adjusting the heat supply to some parts of the building. As a consequence, the operation of technical installations was not optimal. Borgen Community Centre has an advanced BEMS system with a large number of sensors and automatic valves, pumps, fans etc. It should therefore be expected to spend some time on refining the BEMS software and educating facility managers in optimising operation.

A two-day training course was conducted for the building operating staff of Asker Municipality at the Borgen Community Centre. The training course was financed by the EC, as part of the BRITA in PuBs project. It is the intention that the local authorities should give similar courses in other building activities.

3 Proevehallen

3.1 Conversion from old factory building to cultural centre

One of the main challenges in this project was to show how energy efficient solutions could be used when converting an old factory building into a modern low energy and multifunctional cultural building. The site is located in an old industrial district, which is being completely reshaped and modernised. The building, Proevehallen ('The test hall') was part of an industrial complex for porcelain production. Constructed in the 1930s, Proevehallen is an old building containing one large hall . It is approx 18 m, the same height as that of a 5-floor building. The building was uninsulated, had windows with one layer of glazing and no heating or ventilation system. The ventilation was obtained by opening the windows. The building had not been used in several years before the retrofit, so there is no information concerning earlier energy consumption.

There are about 3000 similar buildings across Europe. The site is located in an urban area called Valby located in Copenhagen.

Fig. 9 Proevehallen before the retrofit

3.2 Energy-saving measures

The main retrofit measures were:

- External insulation of the brick walls
- Natural ventilation of the upper floor. The windows are demand-controlled with respect to CO_2 and temperature
- Mechanical ventilation of the lower floors including an efficient air-to-air heat exchanger controlled by CO_2 and temperature sensors
- Solar cells (PV) on the gable wall
- Solar cells/thermal (PV/T) to deliver heat to a heat pump. The return flow of the heat pump to cool the PV system, which would increase the efficiency of the system
- Installation of a Building Energy Management Systems (BEMS).

Fig. 10 Proevehallen after retrofit

After retrofitting, the building has three floors. The volume is 15,700 m^3, and the floor area is 1809 m^2 as opposed to the original 765 m^2.

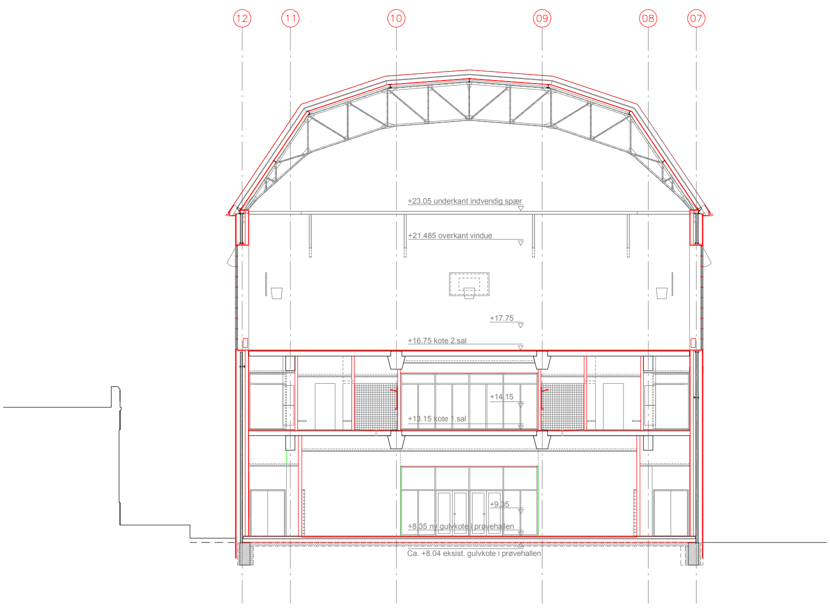


Fig. 11 Cross section of the renovated Proevehallen

It was decided to insulate the wall externally which was the optimal way to minimise the thermal bridges. The U-values before retrofit were very poor as seen in the table below.

Tab. 3 Building construction data

	Before retrofit U-value [W/m^{2}K]	After retrofit U-value [W/m^{2}K]
Walls	**1.6**	**0.18**
Roof	**3.1**	**0.13**
Windows	**6.0**	**1.56**
Doors	**6.0**	**1.56**

The building was ventilated by a combination of natural ventilation – of the upper floor – and mechanical ventilation of the lower floors, which included bathroom and toilets. The upper parts of the high windows were used for natural ventilation of the upper floor. As the openings were placed high above the floor, the incoming air was mixed with the indoor air – thus reducing the risks of cold draughts. Natural ventilation was required only when the gym on the upper floor was used by people generating heat that had to be vented out, so that preheating and heat recovery was not needed for this air exchange. The windows were demand-controlled with respect to CO_2 and temperature.

An efficient air-to-air heat exchanger was used for the mechanically ventilated part of the building. This balanced ventilation system kept the ventilation for the toilets at a minimum and supplied additional ventilation when CO_2, humidity (in the bathrooms) and temperature sensors demanded additional air exchange.

Based on the use of the naturally ventilated upper floor and the efficient heat exchanger in the mechanical ventilation system, solar preheating of air could not be justified in terms of economy. The benefit and costs of solar preheating of ventilation air had not been explicitly calculated and shown in the original proposal, so this modification did not mean any changes for these calculations [Cittero].

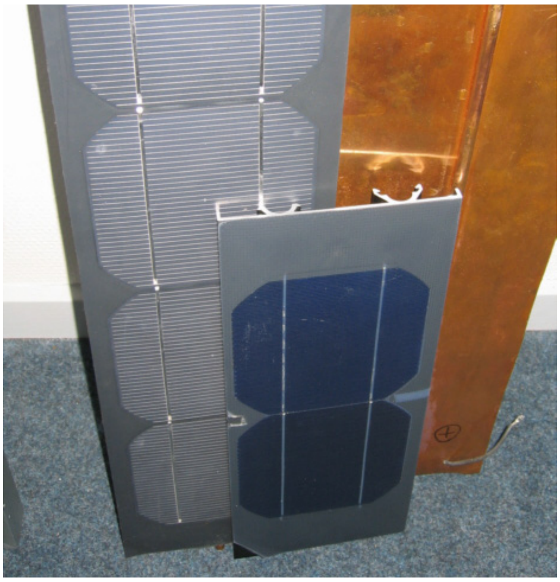


Fig. 12 PV/T panel with pipes behind the solar cells with liquid, cooling the solar cells by means of a heat pump

In the original proposal, a 25 kWp PV array was to be mounted on the roof of Proevehallen. In the design phase, it turned out that the roof was constructed as a so-called “minimal-construction” and could not take the additional weight of the PV array.

Therefore, it was decided to place the array on the south gable wall – however by maintaining the artistic expression, there was only space enough for 19 kWp PV arrays. Consequently, a combined solar collector/ solar cell panel was planned instead of the originally intended solar heating system and the remaining part of the PV array (6 out of 25 kWp) placed here.

The basic heating system selected for Proevehallen was a standard hydronic radiator system. The piping was insulated according to Danish Standard specifications. The air supply in the mechanical ventilation system was preheated - if needed - by a heating coil. This was also supplied from the hydronic system. The additional feature was the control system. The BEMS was designed and installed to control the heating and ventilation systems. This ensured optimal control of the building and thus saved energy compared with simpler or manually controlled systems. BEMS was also used to record energy consumption and data on temperature, CO_2, humidity plus external weather conditions that could be used for analysis of indoor comfort, air quality and energy consumption.

3.3 Measured energy consumption

The calculated energy consumption for heating before renovation (minus hot water) was 132 kWh/m^2 per year. The expected consumption after renovation was 64.8 kWh/m^2 per year, and both the measured and the normalised consumption due to heating degree days are even smaller. The monitored energy space heating was nearly 18 % lower than the expected.

The resulting electricity consumption is shown in the table below. The national benchmark for electricity is 62.7 kWh/m^2 per year, and the predicted electricity demand is 47.8 kWh/m^2. This meant that the measured electricity demand was 22.5 kWh/m^2 higher than expected. However, the explanation for this is straightforward: Proevehallen had become a real success as a local cultural centre and it was used far more than anticipated for theatre plays and concert performances, which consumed high amounts of electricity for spotlights, amplifiers, etc. The very low figure for the electricity consumption of the ventilation system showed that energy-efficient fans worked as expected. It was more difficult to evaluate the effect of the BEMS system.

Tab. 4 Measured electricity consumption

	Electricity consumption [kWh/m^2 per year]	**Electricity consumption [kWh per year]**
Total electricity	70.3	127,000
Electricity consumed ventilation system	3.14	5,680
Electricity consumed for lighting	67.16	121,320
Primary Energy (Total electricity x 2.5)	175	317,500

The average hot water consumption was 1.00 m^3/day from August 2007 until May 2008 with a slight increase during the period. That corresponded to 0.20 m^3/m^{2}a and a total of 365 m^3 per year for the whole building.

The estimated reference hot water consumption (national benchmark) was 1.13 m^3/m^2 per year and the estimated target was 0.88 m^3/m^2 per year based on estimated savings of 0.25 m^3/m^2 per year. This meant that the monitored hot water consumption was far below the target. This was the reason why it was not profitable to use the solar heat from the PV/T modules by the heat pump.

3.4 Costs and payback time

The table below shows the savings for electricity and hot water minus the actual costs, as the effect of these were difficult to decide. The actual payback time was higher than expected, because the electricity and water savings, which have a very low payback period, were taken out. The figures in parentheses show the situation if these savings were taken into account.

Tab. 5 Costs and payback time. (A price of 0.54 DKK/kWh for heating and 2.10 DKK /kWh for electricity are used). One € equals 7.5 DKK

Total expected costs [1000 DKK]	**Actual extra costs [1000 DKK]**	**Expected savings [1000 DKK/year]**	**Actual savings [1000 DKK/year]**	**Expected payback [year]**	**Actual payback [year]**
3,218	2,914 (3117)	231	112 (197)	13.9	26 (16)

3.5 Lessons learnt

The calculated energy consumption has become half of what if would have been if the energy savings introduced through the Brita in PuBs project had not been carried out. In Proevehallen the use of the building was completely changed and also the interior of the building was changed. The estimates of electricity and water consumption were prepared by the design engineering company based on some key-figures for "similar" buildings in Denmark. It turned out that the energy-saving concept worked as expected, maintaining a satisfactory thermal indoor climate. However, now and then difficulties may arise due to the capacity of the mechanical ventilations system, which for reasons of economy was not constructed in an optimal way.

The main impression is that by pushing and trying hard enough you can move “what is possible” quite a bit further than what is first indicated by building designers and contractors. For example, the finding of the architect that the minimal construction of the roof had already been strengthened, so it could actually support the weight of the additional insulation. In addition, the competition between the window manufacturers made it possible to come up with quite low U-values for the whole window area even when taking into account the rather small individual glazing areas. Another example is the BEMS, which at first was considered too expensive, but was installed in the end.

4 Additional research work in the BRITA in PuBs project

Besides the demonstration building, the main research tasks consisted of socio-economic research exploring barriers for not choosing energy efficient solutions in public buildings, research of different financial strategies, development of Design Guidelines, an E-learning tool and a quality-check toolbox. Below some of the research work is described briefly, but further information is given on the website.

4.1 Socio-economic research

One of the main goals of the BRITA project was to increase the use of innovative energy saving measures and renewable energy technologies. Answers and conclusions from interviews with public administrations helped to formulate more specific questions, and by asking a larger number of persons, a better statistical analysis could be performed. These main questions and answers were translated into the different national languages and placed on the website of the BRITA in PuBs project.

The following conclusions were drawn from the socio-economic research: When searching for information, the Internet seems to be very popular, both Google and specific sites were mentioned. Magazines were also mentioned as a good source of information, but the time for reading them is limited. Seminars are informative, but it was often mentioned that there was neither time nor funds to attend.

It showed that the information needed during the decision phase concerned investment costs, energy savings, a general overview of each solution proposed with experience from other projects and its benefits/limitations. Both information about the technical possibilities as well as economic information had to be provided to politicians and to the technical personnel. The information must be easy to find and retrieve, easy to understand and easy to apply. The best way to provide information seemed to be newsletters and the use of the Internet. Most of the countries preferred the information in their own language.

4.2 Economic research to provide insights in different financing strategies

An important issue to be determined within the project was to find what different financial mechanisms/strategies existed in the participating countries and whether they could be transferred to other countries if they did exist,. Although in most cases funding came from the state, either at a national or at a regional level, there were some instances of private funding for low-energy retrofitting of public buildings, either through a bank or through a third-party financing (t.p.f.) mechanism. A t.p.f. mechanism is typically sponsored by energy supply companies, which propose and implement a series of energy-saving measures for public buildings that can be paid back over an agreed period of years just by the operating costs saved by the project. Although this is a rather new possibility, mentioned only by a few countries (Germany, Denmark and Greece), it certainly has a lot of advantages for the low-energy retrofitting of public buildings throughout the EU.

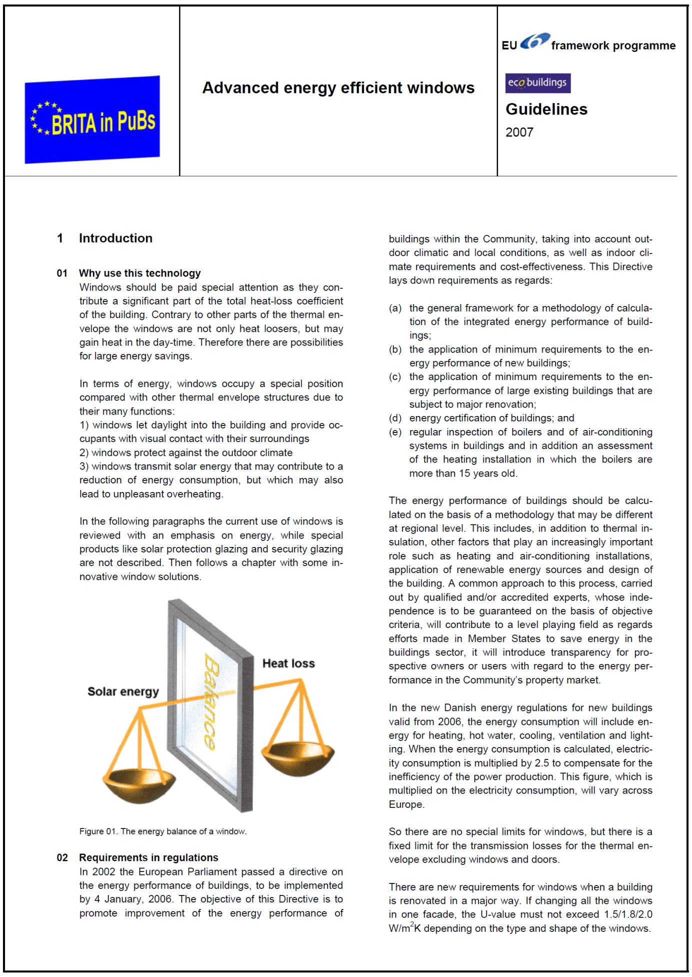
The possibility of internal allocation of funds by a public enterprise, in order to apply energy-efficient retrofitting measures to its own buildings is also quite promising. In fact the initial fund is always replenished by the energy savings from the measures implemented – as is the case with t.p.f. projects too. Specific, often state-funded, programmes exist in most countries for the financing of low energy public buildings. These are used for demonstrating the energy efficiency as well as other advantages like indoor comfort, clean operation, low operating costs and aesthetics of selected innovative technologies. In these cases, like in the demonstration buildings, the project was funded by a combination of public subsidies and grants coming from different sources, including the EU. Implementation procedures are usually public calls for tender.

A monitoring period follows the implementation of the project and dissemination of the results is quite important for public opinion. Finally many countries offer quite ambitious programmes of PV integration in buildings. In this case it is interesting to note that there is often a subsidised price for electricity produced by renewables if supplied to the public grid. This may act as an extra incentive for public buildings, as the amount of electricity supplied, if measured at this special prize, can constitute a considerable asset for a public building, which can be used for many other needs.

4.3 Design Guidelines

In the last decade, the use of "clean" technologies in the building sector industry and natural and passive techniques for the heating, ventilation, lighting and air conditioning of buildings have become more widespread throughout Europe. However, many problems still exist during the design phase of major refurbishment. One of the main barriers in advanced building retrofit is connected with the difficulty of designers to identify reliable design tools and guidelines for dimensioning advanced building-integrated solutions for air conditioning, for evaluating building energy, environmental and economic performances and for assessing the environmental impact of products comprising life-cycle assessments (LCAs). These barriers still exist in spite of the existence of many guidelines and assessment methods with varying degrees of complexity and applicability at different design stages.

The aim of developing Design Guidelines as part of the BRITA in PuBs project was to provide both the building designers and the energy managers with an integrated approach consisting of a comprehensive set of connectable and reliable tools. This will help them choose the appropriate strategies and demonstrate their convenience to the decision-makers in the public sector, so that energy efficient and environmentally conscious practices can be successfully implemented and become part of the mainstream for retrofitted buildings in the end.


BRITA in PuBs

Advanced energy efficient windows

EU framework programme

eco buildings

Guidelines

2007

1 Introduction

01 Why use this technology

Windows should be paid special attention as they contribute a significant part of the total heat-loss coefficient of the building. Contrary to other parts of the thermal envelope the windows are not only heat loosers, but may gain heat in the day-time. Therefore there are possibilities for large energy savings.

In terms of energy, windows occupy a special position compared with other thermal envelope structures due to their many functions:
1) windows let daylight into the building and provide occupants with visual contact with their surroundings
2) windows protect against the outdoor climate
3) windows transmit solar energy that may contribute to a reduction of energy consumption, but which may also lead to unpleasant overheating.

In the following paragraphs the current use of windows is reviewed with an emphasis on energy, while special products like solar protection glazing and security glazing are not described. Then follows a chapter with some innovative window solutions.

Figure 01. The energy balance of a window.

02 Requirements in regulations

In 2002 the European Parliament passed a directive on the energy performance of buildings, to be implemented by 4 January, 2006. The objective of this Directive is to promote improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness. This Directive lays down requirements as regards:

(a) the general framework for a methodology of calculation of the integrated energy performance of buildings;
(b) the application of minimum requirements to the energy performance of new buildings;
(c) the application of minimum requirements to the energy performance of large existing buildings that are subject to major renovation;
(d) energy certification of buildings; and
(e) regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old.

The energy performance of buildings should be calculated on the basis of a methodology that may be different at regional level. This includes, in addition to thermal insulation, other factors that play an increasingly important role such as heating and air-conditioning installations, application of renewable energy sources and design of the building. A common approach to this process, carried out by qualified and/or accredited experts, whose independence is to be guaranteed on the basis of objective criteria, will contribute to a level playing field as regards efforts made in Member States to save energy in the buildings sector, it will introduce transparency for prospective owners or users with regard to the energy performance in the Community's property market.

In the new Danish energy regulations for new buildings valid from 2006, the energy consumption will include energy for heating, hot water, cooling, ventilation and lighting. When the energy consumption is calculated, electricity consumption is multiplied by 2.5 to compensate for the inefficiency of the power production. This figure, which is multiplied on the electricity consumption, will vary across Europe.

So there are no special limits for windows, but there is a fixed limit for the transmission losses for the thermal envelope excluding windows and doors.

There are new requirements for windows when a building is renovated in a major way. If changing all the windows in one facade, the U-value must not exceed 1.5/1.8/2.0 W/m^2K depending on the type and shape of the windows.

Fig. 13 Examples of first page of a Design Guideline

4.4 BIT – Internet information tool

The analysis of earlier studies on restraints has shown that new technologies are rarely applied due to the decisions-makers' lack of knowledge . Yet those with reliable information on innovative technologies tend to realise these technologies more often. Therefore, it is important to provide them with databases including advantages and disadvantages of retrofit technology and practical experience with realised projects. The BIT – BRITA in PuBs Information Tool – includes identification of new retrofit technologies and new building technologies applicable when retrofitting buildings. It is also a presentation of the demonstration buildings in a standardised format in the information tool including lessons learnt and how to improve cost-efficiency. The tool is structured to allow a multilingual conversion. The database structure permits easy change to other languages. Useful links in the different participating countries and central contact persons for governmental support like national energy agencies are also part of the tool.

5 Conclusions

So far, there is little demand in the market for buildings of a better standard than that required in the codes. But a steadily increasing number of building developers are interested in enhancing their competences, show their abilities and be ready when the market demand occurs.

Generally speaking, it seems that actors in the building market are not very willing to change their way of working. The traditional way of planning and building is most often preferred. Among architects, consultants and entrepreneurs there is a lack of know-how about heightened energy standards and eco-buildings. This lack of know-how leads to worries about growing costs and unacceptable payback time. It also leads to worries about building damages and poor indoor climate. So far, most producers do not want to go for heightened standards while there is little demand from buyers.

Demonstration buildings can uncover the barriers to getting started. When knowing the barriers, authorities should create targeted incentives to help building actors to speed up knowledge accumulation relating to buildings.

Another important task is to disseminate to the building actors that future codes will require very energy-efficient buildings. Other drivers, like energy labelling and certificates, and customers' increasing environmental concern, will also contribute to a growing market. Thus the actors should build their competence and be ready for coming requirements and demand.

5.1 From research to application

There are three main phases in sustainable building:

1. In the introduction phase, international cooperation is needed to uncover the lack of knowledge and bridge the gap.
2. In the growth phase regional demonstration is needed. Public buildings are especially well suited for demonstration purposes, as they may have a large impact at the social level, and enhanced visibility of the results is to be expected.
3. In the volume phase, we need knowledge accumulation relating to buildings and step-by-step intensification of regulations.

Fig. 14 Three main phases in sustainable building

The two demonstration buildings, presented in this paper, will hopefully give a signal to start the growth phase in the regions where they are located.

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