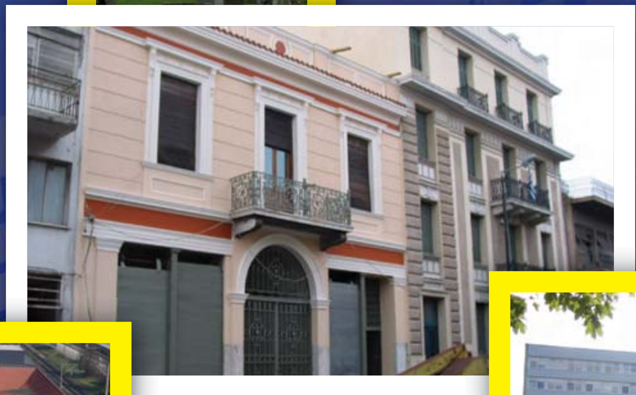
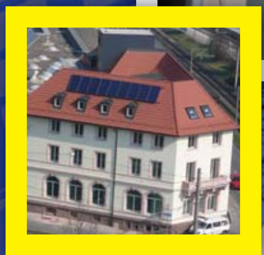
Bringing Retrofit Innovation to Application in Public Buildings

BRITA in PuBs




eco buildings

Public buildings as shining examples for a better energy efficiency in Europe

BRITA in PuBs

The Integrated Project (IP) of the European Commission BRITA in PuBs – Bringing Retrofit Innovation to Application in Public Buildings - has received funding from the EU 6th Framework Programme under the contract: TREN/04/FP6EN/S07.31038/503135

PROJECT-HOMEPAGE

www.brita-in-pubs.eu

PROJECT COORDINATOR AND EDITOR OF THIS BROCHURE

Hans Erhorn (hans.erhorn@ibp.fraunhofer.de)
Fraunhofer Institute of Building Physics (Fraunhofer-IBP)
Nobelstrasse 12
D-70569 Stuttgart
Germany
www.ibp.fraunhofer.de

EU PROJECT OFFICER

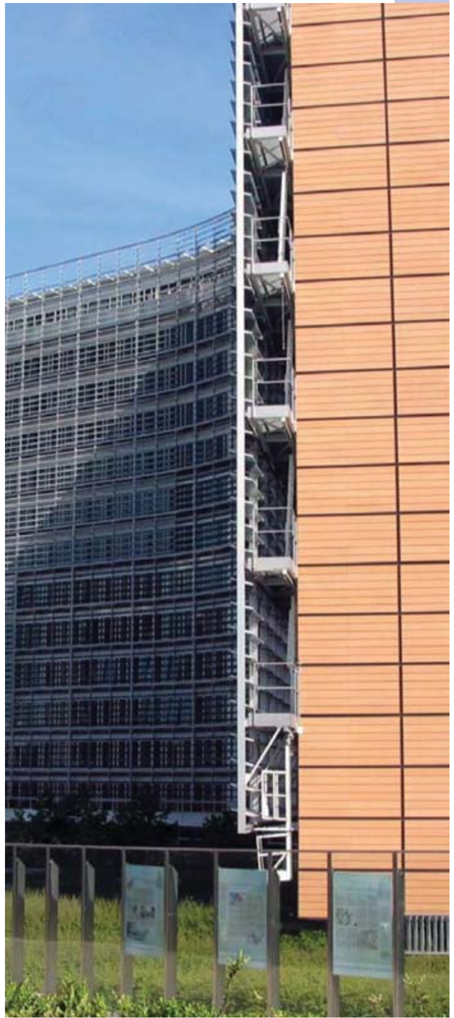
Jean-Marie Bemtgen, DG TREN

LAYOUT

Art Profound - marketing & communicatie /
Profound Groep, Bergen (N-H) The Netherlands

DISCLAIMER

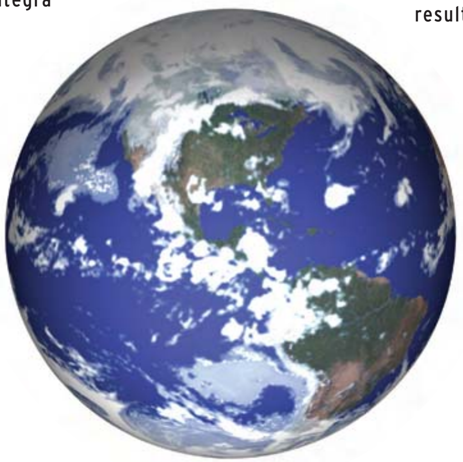
Content



Eco-Buildings: Answer to an immense challenge

The main challenge is immense: how to cope with dwindling fossil fuel reserves and climate change. The focus is often concentrated on the negative effects of traffic. Nothing wrong with that, however, other possibilities to cope with the problem are sometimes overlooked. Take the building industry. The possibilities here are impressive in number and effects. This sector is at present responsible for more than 40% of EU energy consumption. According to several studies and official EU policy documents, the sector offers the largest single potential for energy efficiency. Research shows that more than one-fifth of the present energy consumption and up to 30-45 MTons of CO_2/year could be saved by 2010 by applying more ambitious standards to new buildings and when refurbishing existing buildings, which represents a considerable contribution to meeting the Kyoto targets to which the EU is deeply committed. These efforts will also make an important contribution towards security of energy supply of the EU because, if nothing is done, the EU will be dependent on 70% from outside sources by 2030.

In the building sector there are technologies available and under development, which could substantially improve the energy performance in buildings. They reduce conventional energy demand in new and existing buildings and substantially contribute to reduce energy intensity, through combined measures of rational use of energy and integration of renewable energy technologies. A wide range of solutions, indication of the various possibilities as required in the European Performance of Buildings Directive (EPBD).



MEETING POINT

In order to create the meeting point of short-term development and demonstration to support legislative and regulatory measures for energy efficiency and enhanced use of renewable energy solutions within the building sector, the Eco-Buildings program was started. This initiative aims at a new approach for the design, construction and operation of new and refurbished buildings, based on the best combination of the double approach. On one hand the substantial reduction, and if possible, avoidance of the demand for heating, cooling and lighting. On the other hand supplying the necessary heating, cooling and lighting in the most efficient way and based as much as possible on renewable energy sources and polygeneration.

THE OBJECTIVES

The overall aim of the Eco-Buildings initiative is:

- Providing a clear and coherent platform to defend, promote and lobby for the consideration of energy performance of buildings from the first moment in the renovation and new design process, thus enabling cost effective, low-demand high quality buildings construction.
- Introduce the Eco-Buildings concept (as minimum requirement for the European building stock) in the EPBD, by promotion of cost-effective and energy efficient renovation and construction,, where possible with integrated Renewable Energy Systems (RES), based on information of successful examples, lessons learned, available products, systems and techniques.
- Identifying opportunities for (further) development of promising products, systems and techniques and to motivate manufacturers to start and/or continue these developments. Ultimately, success in the achievement of these aims will be measured by the ability of the project.
- Building a coherent voice for high performance/demand site management of buildings and a cohesive community of Eco-building actors, to be verified by analysing resultant change at the end of the project.

THE EUROPEAN PERSPECTIVE

The European Union is currently promoting a major effort to improve the energy efficiency of its buildings. The efforts to improve the energy efficiency in the buildings have a long-standing history in terms of EU legislative initiatives.

A new additional legislative policy has been agreed and has become EU law in 2006. The Proposal for the Directive on energy end-use efficiency and energy services sets up ambitious goals for the buildings sector when it established that member states should prepare energy plans to reduce energy consumption by 1 % per year over a period of nine years, as well as setting up energy-efficiency criteria in their public procurement of goods and services. Without a major promotion of energy efficiency in the new and existing buildings, the EU member states will certainly find it very difficult if not impossible to meet these targets. The Green Paper on Energy Efficiency, 'Doing more with less', published by the EC in 2005, builds upon existing initiatives and describes a new more challenging view for the goals and policies for the EU in this area, once again clearly indicating the need for more efficient buildings and a more aggressive attitude by member states and all the stakeholders. The Sustainable Energy Europe Campaign for 2005-2008, launched by the European Commission, has also set far reaching goals as part of that 'very low energy' houses (i.e., 'Eco-buildings') that should be built or retrofitted.

The Berlaymont Building in Brussels; Head Quarter of the European Commission. The building was energy retrofitted beyond national requirements – an Eco-Building.

Eco-Buildings, the four projects

The 4 Eco-Buildings projects within the 6FP started under the same call and therefore also roughly at the same time. Their project phase runs from 2004 to 2008. The demonstration projects concentrate on different building types, from new buildings to existing buildings, from large cultural buildings to social housings or public buildings. Also the research work is quite different. However besides a general information exchange (mainly via the coordinators) the work plan in all projects foresees a common dissemination task. Main parts of this task are a website portal for all 4 projects (www.ecobuildings.info), common posters, an Eco-Buildings newsletter and a high quality brochure including all demonstration projects. Additionally the project BRITA in PuBs has organised the first Common Eco-Buildings Symposium in Berlin in November 2005 with presentations from all projects and many interesting discussions (Kratz, Erhorn, 2005). Another Eco-Buildings Symposium is planned for April 7/8 2008. The figure on the left shows the actual Eco-Buildings poster.

BRITA IN PUBS

The BRITA in PuBs project (Bringing Retrofit Innovation To Application in Public Buildings) aims at increasing the market penetration of innovative and effective retrofit solutions to improve energy efficiency and implement renewables, with moderate additional costs. This is realised by the exemplary retrofit of 8 demonstration public buildings in the four participating European regions (North, Central, South, East). The general aim of the retrofits at the demonstration buildings is to reduce the primary energy demand for heating, ventilation, cooling and domestic hot water by factor 2 and at the same time to improve the user satisfaction by also factor 2. Additionally, research work (including socio-economic research) and training and dissemination work (based on the results of the demonstration projects) have been undertaken.

DEMOHOUSE

The aim of the project is to develop minimum standards and recommendations in connection to healthy, cost effective, energy efficient and sustainable rehabilitation and to facilitate implementation through the development of a "Decision Support Tool". In 6 participating countries, a pilot project and a reference project was defined. Besides the demonstration buildings, the project will produce the following results: A common evaluation protocol and a state-of-the-art-in-renovation report.

ECO-CULTURE

The ECO-Culture project addresses demonstration of energy efficient technologies integrated into three high-performing cultural Eco-Buildings. Focus is on investigations, demonstration and testing of technologies which have been selected out of the integrated ECO-concepts as being especially innovative and contributing to further development.

SARA

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 are equipped with advanced 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 EU Member States and 1 additional country. 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.

The BRITA in PuBs project

The BRITA in PuBs project (Bringing Retrofit Innovation To Application in Public Buildings) aims at increasing 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 is realised by the exemplary retrofit of 8 demonstration public buildings in the four participating European regions (North, Central, South, East). By choosing public buildings of different types such as colleges, cultural centres, nursery homes, churches etc. for implementing the measures it is easier to reach groups of differing age and social origin. Public buildings are used as engines to heighten awareness and sensitise society on energy conservation.

Secondly, the research work packages include 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 training and dissemination work contains blackboard information sheets, an Eco-buildings e-learning module, architectural student courses and a facility managers training based on the results of the demonstration projects.

The project website (www.brita-in-pubs.eu) contains a building diary with updated information on the status of the demonstration projects. The photographs on the right showed the current status of the buildings.

The general aim of the retrofits at the demonstration buildings is to reduce the primary energy demand for heating, ventilation, cooling and domestic hot water by factor 2 and at the same time to improve the user satisfaction by also factor 2. The latter is analysed by user comfort questionnaires. All buildings will be monitored for at least one year.

DEMONSTRATION BUILDINGS IN THE BRITA IN PUBS PROJECT

Stuttgart

Plymouth

Asker

Hagafos

Copenhagen

Athens

Brno

Vilnius

The Pilots

Filderhof, Stuttgart, Germany

Typology	Nursing Home
Total floor area	Before: 2,875 m² After: 2,131 m²
Responsible project partner	Office for Environmental Protection, Department for Energy Management Juergen.Goerres@stuttgart.de www.stuttgart.de/energie

Summary

The Filderhof demonstration project, a nursing home, was renovated and enlarged by an extension. Since the energy consumption of the building was very high in comparison to the public building stock of Stuttgart, the city decided to do an energy retrofit, too. Besides, a new heating plant being an energy improvement of the building envelope was part of the retrofit. The windows were changed, the walls insulated, a new heating system with solar plant and combined heat and power unit has been installed, the lighting system have completely been rebuilt and a PV-plant was erected. Between the existing building and the new building an atrium was constructed. The planning process of the energy retrofit measures started in 2004. The construction phase started at the end of 2005 and was finished in May 2007. The monitoring period started in April 2007.

The project, the challenges

The challenge in this project was to show how the primary energy demand in an old nursing home can be reduced by minimum 50 % without changing the historical view.

"Our demonstration projects are well suited to serve as best practice examples both for our municipality and for external planners and facility managers in Stuttgart and throughout Germany. We also present these projects at congresses to disseminate our best practice with others."

Deputy Mayor Matthias Hahn, Urban Design and Environment of Stuttgart, in his speech on the 3rd EnSan-Symposium

Context

The Filderhof is located in an urban area in the south of Stuttgart. On the south side of the building is a local railway station '(Stuttgart-) Vaihingen'. On the west, north and east side is a small park/garden situated around the site. The building was originally built as a hotel in 1890, got an extension in 1952 and since 1967 it has been used as a nursing home for old people and people with dementia. It consists of 4 storeys and has a total net floor area of 2,875 m^2.

BUILDING CONSTRUCTION

The external walls of the Filderhof were made of bricks and partially of natural stones with mortar. The wall thickness ranges between 24 and 40 cm. In most rooms the external walls were different. Because of its age, the walls, the roof, the upper ceiling and the cellar ceiling had no insulation. Though the old windows had double glass, they had a bad U-value and an insufficient noise protection against the train that drives past the Filderhof. Almost all of the old heating pipes, which are located in the external walls, were not insulated. The building was ventilated solely by the windows.
The U-values are assumed in the following table.
The exterior facade has many historical elements (the balcony, the frame of the entrance door and the architrave block of the building)

Structural unit	U-value [W/m^{2}K]
Windows	3.0
Walls	1.4
Roof	1.0
Upper ceiling	2.0
Cellar ceiling	1.9

which are worth to be kept. That's why no external insulation has been used.
The photos below show the state of the building before retrofit.

HEATING, VENTILATION, COOLING, LIGHTING SYSTEM

The heating system dated back from 1952, the boiler with a thermal heat power of 276 kW was replaced in 1988. The effectiveness of the furnace was only at 88 % and the heating system had an old control system. The preheated water flowed with 80 °C to the radiators.
The boiler system didn't work very efficiently because of the

South-West view (before)

Main entrance (before)

Upper ceiling (before)

dropping insulation and the missing measuring and control system. The ventilation was realised by opening the windows. No mechanical ventilation system was installed. A cooling system is not really necessary in the German climate.
The lighting system consists of energy saving fluorescent tubes and bulbs in the rooms and the traffic areas. It was controlled by manual switch on/off. The lighting system didn't work very efficiently and the power of the installed lighting system ran up to 12.5 W/m^2 for 300 lx.

Solutions

BUILDING CONSTRUCTION

All the windows and entrance doors were retrofitted. The new windows have high efficient triple-glasses with a U-value of 1.0 W/m²K and thermal spacers to minimize the thermal bridges at the edges. Furthermore they have a high noise protection, because of the trains passing by.

The original plan was to insulate the external walls from the outside with a composite insulation system (polystyrene insulation covered with plaster). But in order to maintain the architectural expression of the building, only internal insulation has been used in most parts of the old building. During the planning process ways to apply vacuum insulation were investigated. Unfortunately the vacuum insulation can not be applied in the project, since no system is suitable for such a building and the long term behaviour of these systems is still uncertain. Then the engineering team wanted to use a mineral insulation board (multipor), but the surface wasn't planar enough to stick the board on. That's why a mineral-fibre wool of various thickness has been used with an individual construction frame (aluminium profile frame planked with sheetrock).

Aluminium frame for the internal insulation

Internal insulation with vapour barrier

The internal insulation with the aluminium profiles frame was masked with a vapour barrier. Therefore a high quality control was necessary because water vapour may not infiltrate. Because of the internal insulation at the front walls a lot of technical details have to be solved in order to prevent thermal bridges. About 20 % of the front wall will get an external insulation.

To reduce the heat losses over the roof a 14 cm thick thermal insulation was fixed between the rafters. Additionally 5 cm insulation was fixed below the rafters. The upper ceiling of the building was insulated with 16 cm mineral fibre between the balks and insulation plates with 5 cm were laid on top of the ceiling. The use of some basement rooms changed, so they'll be heated now. Thus the thermal insulation had to be modified as well. The heated areas, which are used as kitchen and as dressing room, get insulation at the base floor and insides of the wall. In the other cellar rooms the ceiling is insulated.

Existing building and the extension building

In the rear side of the existing building an extension have been placed. With this construction, the whole complex is very compact after the rebuilding. The two buildings are connected with an atrium.

HEATING

The old heating system has completely been replaced. The new heating plant consists of two gas condensing boilers, a combined heat and power unit and a thermal solar plant. The new system temperature of the radiators is 60 °C flow and 40 °C return flow. The two gas condensing boilers have a thermal power of 150 kW each and the combined heat and power unit has a thermal power of 32 kW and 17 kW of electrical power.

Two gas condensing boilers

Combined heat and power unit

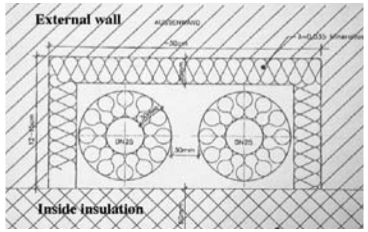
HEATING PIPES

Almost all of the old heating pipes were not insulated. Therefore the old pipes were completely removed in all external walls and the new heating pipes were placed into the existing slots in the external walls. In parts the distance from the pipes to the exterior surface (no external insulation) only amounts to 10 cm. Therefore additionally to the 30 mm insulation of the normal pipes another insulation board with 30 mm is attached into the slots. Thereby the heat losses were reduced.

VENTILATION

To transport the humidity away from the new bathrooms and to ventilate the kitchen rooms, two independent ventilation systems were installed. One ventilation system vents the kitchen rooms with up to 4,500 m³/h and the other plant exhausts the care bathrooms and restrooms in the old building with an air flow rate of 5,500 m³/h. The air outlets of the system are located in the corridors.

At the proposal time the ventilation system was planed with a heat recovery rate of 60 %. During the design phase the team decided for a system with a (much) better heat recovery rate of over 80 % for both ventilation systems. The ventilation systems are located in the cellar.



The new heating pipes (double insulation)

SOLAR THERMAL & SOLAR PV

Further more a thermal solar plant is realised for domestic hot water. The plant consists of 25 collectors, which are installed under an inclination of 45° on the retrofitted roof. The collectors have a surface of 60 m² and can provide thereby 32 % of the domestic hot water demand.

A photovoltaic system with a surface of 105 m² is installed. The maximum power of the plant amounts to 12.6 kWp and the 90 monocrystalline modules produce 12,615 kWh (estimated) per year. This means a reduction of the greenhouse gas CO_2 of around 8.7 Tons per year.


Thermal solar plant


Photovoltaic system

ELECTRICITY & LIGHTING SYSTEM

The team realised also measures to reduce the electricity consumption. The daylight use is improved and the nursing home got an energy efficient lighting system. The new motor of the elevator save around 40% of the electric energy consumption and the heating plant got energy efficient circulation pumps.

BEMS AND MONITORING

The Building Energy Management System (BEMS) has two components. First a conventional control system (saia control) was installed in the building. It regulates the water temperature of the heating system based on the outdoor temperature and the room temperature. Depending the amount of heat consumption, the control system will manage the energy source to be used: from the combined heat and power unit, from the condensing boilers, from the solar plant or from the storage tank. Finally the BEMS has to determine the moment that the storage tank has to be reloaded and when the combined heat and power unit needs to reduce power.

Additionally the Stuttgart's Energy Control Management (SECM) is used to control the daily energy consumption of the building. With this system, the energy managers in the office for environmental protection are informed automatically if the consumption is too high. The energy values are transferred over the telephone network. A special developed software visualizes the energy values into a PC. Thus a long-term controlling instrument is installed.

Energy data and additional results

Estimated savings:

Energy saving measures, heating	[kWh/m²a]	Total [kWh/a]
High-efficient windows	20	42,600
Insulation of opaque elements	80	167,400
Ventilation	39	82,500
Heating system	46	95,900
Solar thermal DHW	11	23,400
TOTAL HEATING ENERGY SAVINGS	196	411,800

Energy saving measures, electricity	[kWh/m²a]	Total [kWh/a]
Combined heat and power unit	37	78,800
Efficient lighting	10	21,300
Daylight transfer	3	6,400
PV-integration	6	12,615
TOTAL ELECTRICAL ENERGY SAVINGS	56	119,115

Economy

Energy saving measure/investment	Total costs [€]	Eligible costs [€]	Saving [€/a]	Pay-back period [a]
TOTAL	1,069,400	789,100	38,600	20

Energy costs used for the payback calculation:
Heating energy 44 €/MWh
Electrical energy 137 €/MWh
Fictitious feed into the grid 514 €/MWh

MEASUREMENTS AND EVALUATION

The measuring phase in the demo building started at the 1st April 2007.
Photovoltaic system:

	Input in to the power network [kWh]	Estimated power [kWh]	Global radiation [kWh/m²]
April 2007	1,721.4	1,326.8	185.4
May 2007	1,294.2	1,726.9	162.8

Evaluation:

	Area [m²]	Eligible costs [€]	Incurred costs [€]	Saving [€/a]	Pay-back period [a]
Solar thermal DHW	60	30,000	30,952	1,106	28
Daylight transfer	-	20,000	19,822	876	22
PV-integration	105	98,000	88,031	6,489	13

More significant measurements and evaluations are taking place.

First hand experiences

- Architectural influences may have a strong impact on the retrofit concept regardless whether a building is listed or not. In the case of Filderhof it caused the change from external insulation to internal insulation on the outside walls. This may lead to less energy savings and results in more planning work on details in order to prevent thermal bridges.
- Economic influences may change the material used for building parts. At Filderhof, the glazed atria roof has now only small glazed parts. The designer had to react on the situations and transfer the planned PV system to the opaque roof parts.
- The use of rooms in the cellar has to be carefully planned in order to keep the heated zone as compact as possible. However, the total space available and flexibility of usage are more important factors for the building owner than compactness and energy efficiency.
- The planning process over five years requires changes in the retrofit measures of a building. Therefore detailed information about the planned measures and the resulting energy savings at the proposal time of the EU project is not always possible. Necessary modifications at the retrofit measures have to be presented and elaborated at the Commission. This requires extra time in the planning process of the project.
- There is much coordination needed with several partners within the project, especially with the financial people of the local government. The project duration is has been stretched to five years from the earliest planning phase up to the end.

Hol Church, Hagafoss, Norway

Typology	Church building
Total floor area	555 m² gross area internal height: 20 m.
Responsible project partners	Sivilarkitekt Harald N. Røstvik AS Hol Church Council, Astri Tingstad, Telephone + 47 51861925

Summary

The Hol Church project has uncovered the big challenges to be met when dealing with a considerable part of such protected buildings in Europe. As these building will be remained for decades and centuries, they appear to be crucial with regard to the overall energy need reduction in the building stock. As long as we do not reduce the energy need in existing buildings, the overall energy need in European buildings will not decrease.

To achieve energy need reductions in existing buildings, AA restrictions (Antiquarian Authorities) should be reconsidered when renewing installations and innovative methods need to be applied in order to preserve this rich architectural heritage.
The Hol Church project shows that steadfastness and endurance coupled with innovation can lead to success.

The project, the challenges

The challenge in this project was to show how energy efficient solutions could be applied to a listed building under the authority of protective antiquarian wings, which means that in principle not any structural change will be allowed.

"If we are going to secure the future of coming generations, we must protect the environment. The church has a responsibility in this context and we will support work to stop negative environmental trends. We will show examples and shout, "it works". We will support all good forces and help provide politicians with courage to initiate necessary measures".

Laila Riksaasen Dahl
Bishop of Tunsberg in her New Year speech 2006

Context

The church, built in 1924, is located in a mountain valley in Norway's Southern part of the country; half way between Oslo and Bergen and only minutes from the popular winter ski resort Geilo. This church has a timber construction with steep roof indicating elements from the stave-church era. Its built on a stone foundation raising only slightly from the ground. It's extremely high interior of 20 metres equals the height of eight standard dwelling storeys, which is an energy challenge in itself since hot air rises and stay of comfort is hence a crucial element of this project.

The un-insulated timber floor was not covering a full-scale cellar, only a crawl space with varying height up to one meter. The timber roof construction and walls were also un-insulated. Windows and doors were not closing properly, had no gaskets and were letting extremely cold draughts into the building. All this caused considerable comfort problems and the energy need was high. Regardless of the energy being used, it often felt cold when the outdoor temperature fell down to minus 20-30 °C. No drawings of the church were made available to the project team. All studies, measurements and drawing plans needed had to be done on site. With the Antiquarian Authorities sitting 300 kilometres away in Oslo, and with low travelling budgets, proper communication really was a challenge.

Solutions

BUILDING CONSTRUCTION

After having received refusal from the Antiquarian Authorities (AA) for insulation works, appeals have led to compromises. The floor was insulated from below through the crawl space, which indeed was a difficult job. The details for the chosen insulation

method were worked out with the AA to avoid dampness leading to rotting of the construction.
A similar refusal/acceptance procedure was carried out for the flat part of the roof. Arguing that the existing ceiling, with a very dry sawdust covering, was a fire risk. Finally, the AA accepted that argument. The ceiling was insulated from above. This was also an extremely complicated work task, as bringing in materials could damage the church interior. Materials were instead crane-lifted into the building and through an upper window. The windows consist of two layers of glass with a 70 mm gap. The windows and doors were adjusted to close properly and they were equipped with rubber gaskets.

HEATING

The existing heating system was a typical Norwegian one. Due to the huge hydropower production, electric resistance heating is common. The system has a total capacity of 70 kW and heaters are positioned under the benches.
Due to the draughts, it took three days to reach a comfortable temperature in wintertime. This happened every time again with typical activities like approximately 21 services a year, 15 funerals, 5 weddings and 10 choir and other cultural events. The solar radiation normally gained passively through windows does not help either, since the church has only very small windows.

The heating solutions sought, can be split into three main categories:

- Insulation reducing heat loss through the envelope, coupled with improved gaskets to avoid drafts from windows and doors. This has proven to be comfort level raise without it necessarily having a huge impact on energy need since the system before the retrofit was going full speed and still not managing to raise the comfort level to an acceptable level.

- A vertical two metres high, 75 cm diameter round air canon of 4,200 m^3/hour (drawing only 160 W) ' shoots' unheated air upwards to replace the heated air under the ceiling. This process is normally started an hour before the service and it moves the warm air under the ceiling down to where people are seated. It has proven to be an efficient comfort measure that improves the feeling of comfort.

- In this region of Norway, when it is cold, it is normally sunny and not windy. There is also a lot of white reflective snow in this region. That's why an air based solar thermal system has been selected.

SOLAR THERMAL

An air based solar thermal system has been developed at a distance from the building. Since the AA has to approve everything within a radius of 65 metres of the church, this installment was fully rejected, even through the appeal round. The only solution was to appeal to the Bishop, who has the authority to overrule the AA.
The compromise was to reduce the height of the solar thermal system to 6 metres. Which also reduces the area and to increase the distance from the church to the absorber to 15 metres.
The vertical system is connected to the church through an earth-sheltered insulated duct bringing heated air to the church and sucking air from the church in a similar duct returning to the solar absorber. The air is moved through the solar absorber and from the absorber to the church by two small fans connected to a solar PV system that starts, stops and regulates air speed depending on how bright the sunshine is. It is in other words an autonomous and self-regulating system.

SOLAR PV

A minor solar PV system was initially planned. However, the confrontation with the restrictions from the AA have led to rethink this kind of solution for several reasons:

- The contribution per m^2 is small compared to solar thermal which delivers 3-4 times more energy per m^2 absorber at a lower cost.
- The cost of PV is high which leads to a high payback time (90 years).
- The AA would probably not allow the system to be implemented unless it was located at a minimum of 65 metres from the church wall.

A final decision about this issue is now being taken.

BEMS

Since the church has a very simple energy system, a complicated Building Energy Management System (BEMS) was not necessary to control the heating systems. Instead, a close dialogue, analysis and discussions with the caretaker has proved to be valuable in taking measures, checking routines and improving routines while continuously supporting the caretaker. It was the underlying philosophy for this project. To assure optimum control of the building and thus save energy, a continuous process of dialogue between the planners and the caretaker has proved to be fruitful. This even resulted in a considerable awareness level that in itself turned out to lower energy bills.
In order to bridge the huge distance between the caretaker's home and the church (25 km) an automated 'Ring the church warm' system has been installed. Before, the caretaker always had to drive to the church each time to turn the heat on, days before a major church activity took place. Or when the caretaker stayed elsewhere, the heat was turned on even some days


Air "canon"


One meter high crawlspace


Double windows with gaskets


Actual interior

before. By installing the new 'Ring the church warm' system, this was no longer necessary. It saved not only valuable heating days, but also reduced the energy consumption caused by the trips to and from the church, 51 times a year. Additional energy savings: 51 trips x 25 km x 2 = 2550 km, means annual petrol energy saving of approximately 255 litres and CO_2 emissions of half a ton (500 kilos) a year.

USER SURVEY

A user survey under the regular Sunday church service visitors during the winter of 2006/2007 illustrated the increased comfort level:
"Have you noticed improvements in the indoor climate since last winter as regards draught, temperature etc."

- Much better 55 %
- A little better 35 %
- No improvement 10 %

Energy data and additional results

These are the assumed savings calculated at the project initialisation phase:

Energy saving measures, heating	[kWh/m²a]	Total [kWh/a]
Improved insulation, roof, floors, windows	48	27,115
Solar thermal heating system	15	8,000
TOTAL HEATING ENERGY SAVINGS	63	35,115

Energy saving measures, electricity	[kWh/m²a]	Total [kWh/a]
Efficient lighting	5	2,700
Solar PV	5	2,700
TOTAL ELECTRICITY ENERGY SAVINGS	10	5,400

Economy

Energy saving measure/ investment/ savings/ payback	Total costs [€]	Saving [€/a]	Pay-back period [a]
TOTAL	136,700	6,100	22

Assumed energy costs used for the payback calculation:
Electricity: 0.15 Euro/kWh (1.20 NOK/kWh)

MEASUREMENTS AND EVALUATION

All costs for the energy savings measures are within and some below budget. Although the final bills have not been received as yet it is clear that there will not be a cost overrun. Measurements were started 1st May 2007 and data are being registered every month. The one year monitoring result will hence be available immediately as the last month, April 2008, is ending.

First hand experiences

- Existing, listed buildings are part of an architectural heritage that is well protected by the state through Antiquarian Authorities. They have an important job at protecting the valuable listed buildings and groups of buildings. This important job often is in conflict with the equally important job of reducing the energy need in existing buildings.
- The processes described above are time- and resource demanding. One should be prepared for several rounds before an approval is possible – if ever.
- In this instance, had it not been for the Bishop overruling the AA, there would have been no solar thermal system.
- A motivated client and a motivated caretaker is a crucial element towards success.
- Awareness building with the caretaker is showing positive energy need reducing results.
- As the project developed the local energy utility Ustekveikja decided, contrary to our predictions, that the cost of electricity shall fall instead of rise. Whilst the electricity costs in Norway have risen over the last years and is now in the region of our predictions that is being used for our payback period calculations, Ustekveikja have reduced the costs of electricity down to between 1/2 to 1/3 of the average market price in the winter, for the inhabitants in the region as a gesture to them. Through this, Ustekveikja argues that the inhabitants in this way get their share of the valuable local hydropower plants. This undermines energy efficiency measures and the introduction of renewables as the savings are reduced and payback time increases. It is also contrary to the trends in all other parts of Europe and in Norway.
- PV (solar electricity) is normally more costly per m² installed modules compared to solar thermal. One m² PV also delivers only 1/3 of the energy delivered by the same m2 solar thermal. PV payback time is so long that it brings up the overall payback time for the total building project to an unnecessary high level.

City College, Plymouth, United Kingdom

Typology	Education
Total floor area	5,794 m²
Responsible project partner	City College Plymouth: www.cityplym.ac.uk Gilbert Snook: gsnook@cityplym.ac.uk

Overview of the complex

Summary

As part of the overall refurbishment of the building the following low energy technologies are proposed; PV cladding, low-e windows, solar control, insulation façades and roof, heating and control improvements, natural ventilation, wind turbines, low energy lighting and controls, rainwater harvesting and tap replacements.

The project, the challenges

The challenge of this project was to upgrade the external façades and remodel internally to modernise the building but adopting a whole range of energy saving technologies. The existing building dating from 1972 had only been partially refurbished since that time. As a result it has a dated feeling suffering severe solar gain, drafts and inadequate heating. The aim of the project was to have a significant impact on the large student population that passes through the college. The college has over 29,000 separate enrolments representing over 6,000 fulltime equivalent students. The refurbishment will demonstrate and create a lead with regard to energy saving technology.

"I find it inspiring to see the wind turbines turning when I arrive in the morning. Although they only make a small contribution to our energy needs, it was very much a 'pilot' project. As City College Plymouth designs its new buildings, we will be incorporating a lot more 'green' design principles and practices."

Viv Gillespie
Principal of the City College Plymouth

Context

Plymouth has a temperate climate avoiding the extremes of temperature experienced in many other parts of Europe. The site itself is exposed to the sea together with the prevailing wind from the southwest. The site used to be a railway station and marshalling yards which was redeveloped at a time when the railway system in the UK was being cut back. The building was erected in 1972 having a reinforced concrete frame and non insulated cavity wall construction, and single glazed vertical sliding windows. The flat roof now has many mobile telephone installations.

BUILDING CONSTRUCTION

The building was erected using simple cavity wall construction and single glazed windows, all of which results in very low insulation values. The existing walling is typical of its time with an outer face of bricks and a 50 mm cavity with no insulation. Concrete blocks form the inner skin of the walls. Existing windows are single glazed in metal frames.

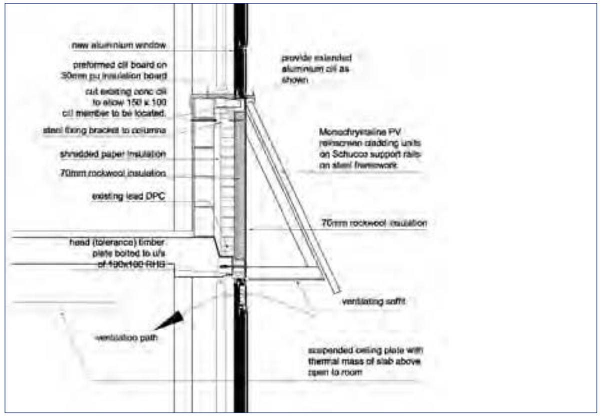
The heating comes from a significantly oversized boiler installation and relies on parameter convection units. These have poor controls. Ventilation is mainly passive using the openable windows although in many instances these are extremely drafty and difficult to operate. There is an only limited area of cooling in the building to the computer server rooms. The lighting installation has been upgraded in recent years incorporating low energy light units and some automatic control systems. There are still many areas of more old fashioned fluorescent lighting.

There is an advanced computer control system already used at the site called Satchwell 2800 Plus that this now requires updating. Building problems include overheating and rapid cooling with significant air leakage into the building. The building façades are suffering erosion due to their exposed positions. The windows are difficult to operate and are a Health & Safety hazard. The roof has been patched and needs an increase in its insulation thickness. With regard to the water installation some improvements have been made including waterless urinals but there is significant scope for further improvements to the ageing installations.

Solutions

BUILDING CONSTRUCTION

A holistic retrofit concept is developed, but not yet realized. This includes the upgrade of the external façades to significantly reduce energy loss. The remodelling internally to create a modern environment using innovative measures to control heating, cooling and lighting and the working environment. More specifically, new thermally broken double glazed, reversible window units including solar glare control and sealed to reduce infiltration gain. This would provide improved U-values of 1.2 W/m²K. The window system would be



The new window units at a glance

combined with a new cladding which on the south and west façades will include PV's amounting to 83 kWp. These PV's would be arranged on the west façade to include solar shading.
More traditional cladding will be used to the north and east façades and all façades will have a significant increase in insulation values.

Water use in the building would be reduced by maintaining the use of waterless urinals, the introduction of rain water harvesting for toilet flushing and the use of spray taps.

HEATING

This would be upgraded with three high efficiency modulating boilers, sized so that two boilers can serve 66 % of the total maximum heat demand to allow for servicing. Heat emitters will be replaced with high efficiency radiators served from a zoned distribution system. Zoning will allow the east and west elevations to run independently and on a floor by floor basis. Heating would be further improved by the addition of a combined heat and power unit. This would be based on a micro turbine with an electrical output of approximately 80 kWp. This would be run constantly from late September to early April, 24 hrs a day and the heat produced circulated around the building to reduce warm up times and to improve general thermal comfort. It is also intended to supplement the domestic hot water system through the addition of solar thermal units.

VENTILATION

Room ventilation will be based on natural system. High level louvers in each room will provide the inlet and outlet air for the ventilation strategy. The upgraded BMS controls will open the louvers at night to permit night time cooling and by day to maintain the required air change rates and comfort. Opening windows will also be included. Stairwell ventilation will be achieved by a natural stack effect and this will also assist in ventilation of corridors. There will be no mechanical cooling unless absolutely unavoidable e.g. computer server rooms. Also, as previously indicated, to help control internal temperature the external PV cladding will act as solar shading to reduce the solar gains by more than 50 %.

WIND TURBINES

Two 6 kW wind turbines have been installed adjacent to the Tower Block to help reduce energy demand of the site.

LIGHTING

Where practical, to be provided by natural daylight enhanced by the large window areas to be provided. High frequency electronic controlled gear and T5 lamps are to be provided in all rooms. Lighting will include automatic controlled both by occupancy and light levels. All lighting will be locally metered.

Energy data and additional results

Energy saving measures, heating, cooling, ventilation	[kWh/m²a]
Low-e windows	30
Improved façade design	20
Improved insulation of façades	15
Improved insulation of roof	8
Improved heating and control systems	35
TOTAL HEATING ENERGY SAVINGS	108

Energy saving measures, electricity	[kWh/m²a]
Low energy light fittings	7
Lighting controls	7
Window design to reduce lighting need	10
Passive cross ventilation	35
TOTAL HEATING ENERGY SAVINGS	59

BEMS AND MONITORING

The building energy management system (BEMS) will be upgraded to Satchwell Sigma System which is a network based system providing much more effective system control.

	Estimated annual energy consumption [kWh/m²a]		Annual saving	
	Before refurbishment (2004/05)	After refurbishment (2005/06)	[kWh/m²a]	[%]
Space and Water Heating	207	99	108	52
Electricity (without renewables)	112	53	59	53
Electricity (with 80kWp PV)	112	44.5	67.5	60
Electricity (with 2 x 6kW wind turbines and 80kW PV)	112	41.5	70.5	63
TOTALS (WITHOUT PV)	319	152	167	52
TOTALS (WITH PV)	319	143.5	175.5	55
TOTALS (WITH PV AND WIND)	319	140.5	178.5	56

Measurements and evaluation

A thorough user evaluation took place before the renovation but due to changing circumstances the main works have not progressed therefore post occupancy evaluation is not available.

With regard to the wind turbines, these have already been installed. Preliminary power output results have been disappointing and the situation is still being investigated but in summary the results are as follows:

- Target output for 2 kWp peak wind turbine 33,800 kWh/a.
- Actual output from first year 5,750 kWh.

The poor output seems to result from a combination of the following factors:

1. The wind conditions encountered during that particular year, which had more northerlies than normal.
2. Likely over estimation of the power output to be achieved not properly taking into account the wind disruption factor caused by the presence of the Tower Block adjacent to the turbine installation.
3. Poor performance by the installer and manufacturer to resolve problems with the turbine breaking systems.
4. Increased downtime caused by shadow flicker although this has mainly occurred during non windy periods therefore of less significance.

More significant monitoring is taking place in the second year of operation to identify more precisely the reasons behind the poor performance of these wind turbines.

First hand experiences

Examples of this experience are:

- Untested opinions and ideas are critical to the creative process; however, the modelling of these ideas is essential. Time needs to be built into the programme to facilitate sufficient analysis and testing of these 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

The building in its actual state

most obvious concepts do not always offer the greatest benefit. For example, the proposed vertical louvers under the PV array to the western elevation. Modelling showed a good saving from solar gain but the additional cost was unacceptable to the client.
- The long payback period discourages the choice of some technologies unless funding is available to support the investment.
- Consultants are often very inexperienced with regard to certain technologies for example wind turbines, which in this case are mounted upon a roof structure. Obvious design issues then get left and interrupt the construction process. Also lack of familiarity with low energy technologies mean they are seen as optional extras.
- An alternative and more adventurous solution should always be considered as they can have positive benefits if properly researched, proved and implemented. Example here is with regard to the possibility of 24hr running of the CHP system to provide background heating to the main building.
- It is possible to integrate technologies to serve dual purposes. In the case of this building the PV arrays are also serving as solar shading. Careful consideration of all aspects of the project at the outset will permit such integration.
- The goal for all designers is that the services concept should always start from a desire to consume zero energy and only add what is required to make the building function. It is not acceptable to use established benchmarks for similar buildings at the starting point as this can stifle innovation and lead to tried and tested solutions coming to the fore. This should apply to all projects and not just those seeking to be specifically energy saving.
- Better control of services can save considerable quantities of energy; this should be covered with high quality commissioning procedures and concise training of the client in the best use of the system. Poorly trained people will not use systems effectively and energy consumption will suffer as a result. The introduction of thorough sub meeting linked to BMS is essential to allow for efficient management of utilities.
- There is an education process required at the hand over stage to ensure the building owner understands the advantages and or limitations of any installed systems and maybe an expectation of systems will perform to provide results that are outside design parameters. This needs to be clearly explained such that the end views are brought in to the process at an early stage. Close liaison with the client and the end users through the design process is of a great advantage in connection with this.
- Many low energy technologies are currently produced by small businesses. These businesses struggle to provide good customer service when experiencing high demand. The use of businesses within the same region as the development is strongly recommended.

Borgen Community Centre, Asker, Norway

Typology	School building	
Total floor area	Ground floor	5,590 m^2
	Basem/culvert	1,549 m^2
	Gymnasium	1,910 m^2
Responsible project partners	Asker Municipality / Åke Larson Construction AS (coordination) HUS arkitekter Trondheim AS (architect) Ing. Seim & Hultgreen AS (building physics) Dagfinn H. Jørgensen AS (heating) Elconsultteam AS Drammen (electric installations) ENSI Rådgivning AS (monitoring)	

Overall view of the building

Summary

The Borgen demonstration project has proven that innovative energy solutions as thermal heat pump, hybrid/natural ventilation and active use of daylight in combination with increased insulation and high quality windows have substantially reduced energy consumption at a reasonable cost and a payback time of slightly over 10 years.

The project, the challenges

The challenge was to implement a comprehensive renovation of a combined elementary/secondary school building built in 1971, transforming it into a secondary school incorporated in a local community centre. The overall goals were:

1. Best possible quality classification for: environment - resources - indoor climate.
2. Reduce total energy consumption for heating, ventilation and lighting by 50% or better.
3. Utilize renewable energy resources.

Altitude	164 m above sea level
Mean annual temperature	5.2 °C
Mean winter temperature	-4.2 °C
Climate description	Temperate TRY average 1961-1990

The school, consisting of approximately 130 separate rooms, accommodates 360 students and 54 teachers.

Borgen Community Centre stands as a very successful project, representing a major contribution to improve environment, resources 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.

Stein Grimstad
Head of Project Department, Asker Municipality

The original state

Context

Borgen Community Centre is located in an open suburban area approximately 2 km from the centre of Asker, which is situated 20 km southwest of Oslo.

BUILDING CONSTRUCTION

Prefab concrete pillars and beams carrying a roof structure of U-shaped insulated concrete elements. The building had concrete foundations secured to underlying rock and concrete slab floors with vinyl covering. Outer walls were made with 4" wood framework and brick cladding. Wooden windows had standard double glazing. Internal walls were also made with wood framework and plasterboards on both sides.

HEATING AND VENTILATION

The building had electric heating with resistance heaters 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. Fresh air was filtered and preheated with electric heaters before it was distributed to the building. Used air went through a heat recovery system before it was exhausted. The units had low capacity and efficiency, and there was no cooling.

PROBLEMS AND DAMAGES

The building was generally in poor condition with 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

New roof elements

Structural unit	U-value [kWh/m²K]	
	Before retrofit	After retrofit
Windows	Approx. 2.0	1.1
Walls	Approx. 0.35	0.2
Roof	Approx. 0.6	0.13
Floor	Approx. 0.3	0.15

replaced. This would enable opening roof areas to let daylight into the dark central areas of the building and also increase roof insulation. The main structure had to be strengthened with steel trusses. Rehabilitation of the walls would be more expensive than replacing them with completely new walls. Window area could then easily be increased as well as insulation thickness.

Solutions

BUILDING CONSTRUCTION

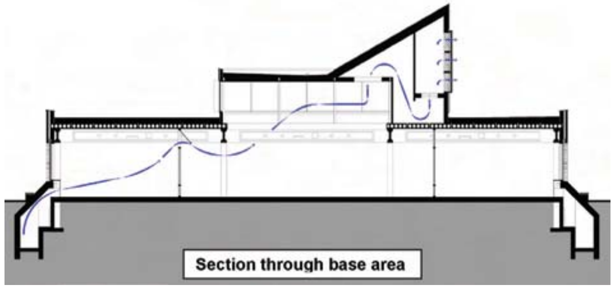
The concept was to reuse all construction elements that could satisfy Norwegian building requirements: foundations, prefab concrete pillars and beams, concrete floor slabs, drainage and sewage pipes.
In order to meet the new requirements for snow loads, roof elements were replaced. Central areas were 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. 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. New windows have wooden frames with outside aluminium 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. 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.
To provide enough floor space to meet the revised school and community centre needs, an extension of approximately 2,000 m² had to be added.

HEATING

To optimise the use of renewable energy, a geothermal heat pump was chosen. Heat is pumped from 44 energy wells in the ground, average depth about 150 m. 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 domestic hot water (DHW) to about 40 °C and the temperature is then lifted to 75 °C by electric heating. When using heat pumps, it is mandatory to have a backup system, and two oil boilers are installed. Together 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 to 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 supply hot water for heating to the nearby Vardåsen church, which is part of the local community centre but not part of the BRITA project. There is no active cooling, but excess heat is used to charge the energy wells during the summer.

VENTILATION

The main ventilation is based on a natural hybrid system which is designed and built according to the recommendations from The SINTEF Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology. Since this was an



Ventilation structure

existing building, air culverts had to be built outside along the foundations. 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. The massive construction of the culverts helps to cool the air in the summer and preheat during winter. From the culvert air is let into the room through specially designed grids that allow people to stay very close without feeling a draught. Air flow is regulated by temperature and CO_2 sensors in each room and adjusted to the actual need. Exhaust towers are equipped with fans that are activated when natural driving forces are insufficient. A heat recovery system supplies heat to the preheating unit in the culverts. During warm periods the system is run during the night to cool the building.

LIGHTING

The shape of the building made it necessary to improve daylight conditions. Central areas of the roof were raised to install windows and skylights. The large skylight facing north at an angle that does not let direct sunlight and heat into the building, greatly increases the level of daylight in the central area. The result is the same in

Light and good air

the base area, but shutters had to be used to prevent unwanted heat. To optimize the effect of daylight, all electrical lights are adjustable and automatically regulated by light sensors.

BEMS AND MONOTORING

An advanced Building Energy Management System (BEMS) has been installed to control the heating and ventilation systems. This will assure optimal control of the building and save energy compared to a normal manual control system. Automatic control nodes monitor consumption from oil and electricity meters and energy meters in the heat pump circuits. Results are sent by GSM to a server where facility managers can keep up with energy use.

Energy data and additional results

Estimated consumption:

	[kWh/m²a]	Total [kWh/a]
Space heating	29	262,420
Heating ventilation air	20	180,980
Water heating	13	117,635
Fans and pumps	15	135,735
Lighting	23	208,125
Equipment	11	99,540
TOTAL ENERGY CONSUMPTION	111	1,004,435

Estimated saving:

	[kWh/m²a]	Total [kWh/a]
Total consumption old building	280	2,533,715
Total consumption renovated building	111	1,004,435
TOTAL ENERGY SAVING	169	1,529,280

To be able to estimate the effect of our investments, it was necessary to use the same area for both the old and the renovated building. The share of the energy savings for the old part of the renovated building is approximately 169 x 5,970 = 1,008,930 kWh/a

Economy

Energy saving measure/ investment/ savings/ payback	Total costs [€]	Saving [€/a]	Pay-back period [a]
TOTAL	1,015,000	100,893	10

Energy costs used for the payback calculation:
Electric/oil: 0.1 Euro/kWh (0.8 NOK/kWh)

MEASUREMENTS AND EVALUATION

Monitored energy consumption during almost two years show that we have reached our goals and that consumption in fact is a little lower than calculated.

Building part	Monitored total energy consumption [kWh/m²a]		
	Before retrofitting	After retrofitting	
	(2004/05)	(2005/06)	(2006/07)
5,970 m²	280	-	-
9,049 m²	-	108	107

A four week air quality survey was carried out from January 8th to February 2nd 2007. During the survey period each base had different climate control:

- Base A: Temperature alone.
- Base B: CO_2 alone.
- Base C: CO_2 and temperature.

The results were a bit surprising. The different air flow regulations had minor effects. The overall impression is that the students experience of air quality and temperature to a large extent is psychological. In many cases there seem to be a link between temperature and air quality: low temperature results in poor air quality judgment even though CO_2 value is very good. Likewise, comfortable temperatures often result in a good air quality judgment even if CO_2 value is high. Comfort temperature varies among the students. The set temperature of 21 °C is defined as comfortable by some and too cold by others, who need 22 to 23 °C to be satisfied. Outdoor temperature also has some bearing on the perception of room temperature. Cold weather produces lower indoor temperature results even though actual temperature is fine.

First hand experiences

- Problems with sound carried from one room to another through ventilation culverts. Special care needs to be taken in the planning process to provide sound barriers.
- Building underground culverts along existing constructions is difficult and expensive. Natural ventilation with underground culverts is probably most suitable in new buildings, where they can be incorporated in the basement/foundations. For retrofit, other solutions should be considered, for instance fresh air inlet through double facades or through special convectors under the windows.
- Moisture from rain and snow enters the system from the air inlet towers and has caused lower part of the wall enclosing the filter unit to become moist. Too short distance from inlet tower to the filter- and heat recovery housing, use of wrong materials and the lack of a properly slanted floor towards the drain, has resulted in development of some fungus. Design should focus on preventing water from entering ventilations culverts.
- IR sensors for light regulation combined with burglar alarm has caused problems because unwanted light hits the sensor and triggers the alarm. These should be separate systems.
- Extensive and complicated BEMS requires a long testing and adjustment period.
- Technical personnel should be educated during the building period to get acquainted with the technical installations before the building is opened.
- Some problems with heat delivery to the nearby church. The two systems were planned and designed separately and the problems arose as a result of poor coordination in the planning period. Extra measures had to be taken to solve the problem.

Social Centre Brewery, Brno, Czech Republic

Typology	Before: brewery, malt house, warehouse; After: social and cultural centre
Total floor area	Before: 2,300 m^2 After: 2,660 m^2
Responsible project partners	Brno University of Technology (BUT) Prof. Miroslav Jicha: jicha@fme.vutbr.cz Pavel Charvat: charvat@fme.vutbr.cz

Summary

Decision makers in urban planning very often have to decide between demolishing and retrofitting of old buildings. The demonstration building Brewery is an example that an 18th century industrial-type building can be retrofitted into a 21st century social and culture centre. The retrofit design, however, is not a straight line and a good result can finally be achieved by iterative approach rather than adherence to the original plan.

The project, the challenges

The Brewery is the oldest building in the BRITA in PuBs demonstration project, dating back from 1769. The retrofitting of very old buildings, which involves the change of use, can be full of surprises. No drawings of a building are usually available at the beginning and some energy saving measures suggested at an early stage of retrofit design may not eventually be applicable. Success can therefore only be achieved by a flexible, iterative approach.

"Ancient Brewery was a part of historical monastery and its manor. Brewery was in 2005 enlisted as a national heritage and this made the retrofit very complicated, requiring a unique design and construction works. Advanced and energy saving technologies for heating and ventilation, namely in boarding and lodging parts implemented into Brewery increased its value and as we expect, will reduce substantially operational costs. Brewery becomes a precious stone of a newly developed campus of the Faculty of information technologies of Brno University of Technology."

Zdeněk Bouša
Vice-Dean for Development, Faculty of Information Technologies, Brno University of Technology

Context

The Brewery is an old industrial-type building in a historical area of the city of Brno. The Brewery and some other buildings in the area have been retrofitted for the use of the Faculty of Information Technologies of the Brno University of Technology. The name Brewery refers to the purpose that the building was originally used for, however, it only served as a warehouse in the recent past. The retrofitting of the Brewery involved a complete change of use. The industrial-type building had to be transformed into a modern social and culture centre for students and academics. Many building structures had to be rebuilt or reinforced during the retrofit and all the building systems had to be designed from scratch.

BUILDING CONSTRUCTION

The oldest part of the Brewery was built in the second half of the 18th century. A stone with a date of 1769 was discovered during the retrofit in one of the columns supporting the vaulted ceilings on the ground floor. The building has been rebuilt and extended several times during more than 200 years of its history.

The retrofitted building consists of two parts; a four-storey part with many structures dating back to the eighteen century and a two-storey part that was built later. Another two storey part of the building was torn down just before the retrofit. There were no existing drawings available for the project and entire documentation had to be prepared from scratch.

The brewery after retrofitting

Solutions

BUILDING CONSTRUCTION

The Brewery has heavy, one meter thick brick walls and the foundation pressure exceeded nominal bearing capacity of soil. The foundations were in a really bad condition and their reinforcement was necessary in order to avoid a demolition order. When the reinforcement of the foundations and load bearing structures was completed the energy saving measures could be applied. New windows with the glazing U-value of 1.1 W/m^{2}K replaced the old ones. Some external walls were thermally insulated with 100 mm of mineral wool. The floors adjacent to the ground were insulated with 60 mm of polystyrene, and the ceilings under the unheated lofts with 160 mm of mineral wool. The roof of the two-storey building was insulated with 160 mm of mineral wool. Guest rooms were built in the attic increasing the floor area of the building from 2,300 m^2 to 2,660 m^2.

HEATING AND COOLING

A hydronic heating system with different types of radiators and convectors is installed in the building. The wall mounted radiators are used in most of the rooms. Floor convectors placed in grill covered cavities are used in some rooms in order not to disturb the historical appearance of the rooms. Air handling units of the mechanical ventilation system are fitted with heating and cooling coils (water-to-air heat exchangers) and they can be used for heating and cooling. Since the building has a tremendous heat storage mass the mechanical ventilation systems can be employed for night cooling. A heating plant with two condensing gas boilers provides hot water for the heating system and air-handling units. A cooling plant with two chillers prepares chilled water for the cooling loop. A VRV air conditioning system is installed in the guest rooms. The VRV system can be used for both cooling and heating. The external units of the VRV system are located in the attic, so as not to disturb the visual aspect of the building. The units draw the outside air in through the openings in the facade and blow it out through the outlets (chimneys) on the roof.

New glazing...

VENTILATION

Both balanced mechanical ventilation with heat recovery and hybrid ventilation are used in the building. The mechanical ventilation systems are used in cafeterias, kitchens, clubs and multipurpose rooms where high air change rates are required. The hybrid ventilation system with the demand control based on air quality sensors is used in the guest rooms where the ventilation demand varies significantly over the time and from room to room. The pictures show the air supply inlets of the hybrid ventilation systems installed in the window frames.

SOLAR PV

A grid connected PV system with the peak output of 13 kW is installed on the roof. The system consists of 132 monocrystalline modules. The main objective of incorporating the PV system into the energy retrofit measures was the reduction of the load to the power grid in summer months when mechanical cooling is needed. A good match between the output of the PV system and the cooling loads is expected due to the orientation of the system.

...and hybrid ventilation

BEMS AND MONITORING

The Building Energy Management System (BEMS) is integrated into the Building Management System (BMS) of the whole campus of the Faculty of Information Technologies. It is possible, with this approach, to use information that is not directly linked to energy management for energy management purposes (e.g. information about occupancy from the access system can be used in control of heating and cooling). The BMS monitors numbers of parameters related to the performance of the building and building equipment. Since the BMS also incorporates a security system, CCTV, fire alarm and other services it is possible to limit access of different users to certain information.

Grid connected PV system

BRITA in PuBs


Air intakes and exhausts of the VRV air-conditioning system

Energy data and additional results

Energy saving measures, heating	[kWh/m²a]	Total [kWh/a]
Low temperature heating – condensing boilers	39.1	104,100
Energy efficient ventilation	33.4	88,750
Improved insulation of the building envelope	21.0	56,000
Low-e windows	28.1	74,750
BEMS	13.3	35,500
Individual control of heating	8.0	21,400
TOTAL HEATING ENERGY SAVINGS	142.9	380,500

Energy saving measures, electricity	[kWh/m²a]	Total [kWh/a]
BEMS	3.4	9,000
PV-cells, 13 kWp	5.3	14,000
Heat pump for DHW	1.5	3,900
TOTAL ELECTRICITY ENERGY SAVINGS	10.2	26,900

Economy

Energy saving measure/ investment/ savings/ payback	Total costs [€]	Saving [€/a]	Pay-back period [a]
TOTAL	515,000	31,730	16

Energy costs used for the payback calculation:
Thermal: 0.062 Euro/kWh (1.75 CZK/kWh)
Electric: 0.11 Euro/kWh (3.10 CZK/kWh)
Electric PV: 0.48 Euro/kWh (13.40 CZK/kWh)

The law (180/2005 Sb.) on support of the power production from renewable energy sources came into force in 2005 in the Czech Republic. The law introduces minimum purchasing prices of electricity from renewable energy sources and the obligation of power grid owners to purchase such electricity. The minimum purchasing price is guaranteed for the time period of 15 years from the commissioning of the plant. The minimum purchasing price of electricity produced by the plants converting solar energy to electricity (plants commissioned in 2006) is 13.4 CZK/kWh (0.48 EUR/kWh). As a consequence the payback time of the PV installations supplying electricity to the power grid is significantly shorter.

First hand experiences

Examples of this experience are:

- Application of Building Management Systems brings a potential of significant energy savings even in the retrofit of a very old building.
- Monitoring of occupancy, while being an effective energy saving measure, is not easy to implement in a cost-effective way.
- Even a very old building in a really bad condition can be retrofitted in a way to exceed the requirements of the contemporary building codes. The cost of a retrofit being only a fraction of what a new building with similar parameters would cost.


The brewery in its original state

Cultural Centre Proevehallen, Copenhagen, Denmark

Proevehallen in its new state

Typology	Before: factory building After: cultural centre
Total floor area	Before: 765 m^2 After: 2,300 m^2
Responsible project partners	Cenergia Energy Consultants, The Municipality of Copenhagen (UUF)

Summary

The Proevehallen demonstration project proves that introducing the right concept of energy conservation measures and renewable energy integration into a renovation project can bring the resulting building up to an energy standard that is considerable better than current building regulations at reasonable costs and payback time.

The project, the challenges

The challenge in this project was to show how energy efficient solutions can be used in turning an old factory building into a modern low energy and multifunctional cultural house.

"Copenhagen is devoted to fighting the climate change and welcome the opportunity to use a prominent building as a lighthouse to demonstrate the importance of introducing energy efficient retrofit measures for a renovation project of a public building. Our vision for Copenhagen is to become the worlds EcoMetropole by 2015. Copenhagen will assume a global responsibility by taking the lead in reducing CO_2 emissions. To obtain our goal we have to look into energy efficiency and savings in all aspects of the city planning. I hope that the good experiences from Prøvehallen will encourage and inspire other building owners, public as well as private, to look into the possibilities of increasing the use of energy efficiency savings and renewable energy in coming building renovation projects."

Klaus Bondam
Mayor of Technical and Environmental Administration of Copenhagen

Context

The site, built in 1930, is located in an urban area called Valby, located in Copenhagen. The site is an old industrial area, which is being completely reshaped, modernised and made into a new neighbourhood with its own identity. The building, Proevehallen ('The test hall') was together with the building, Ovnhallen, right next to it, part of an industrial complex for porcelain production. In Ovnhallen the porcelain was manufactured and in Proevehallen porcelain-isolators for the high voltage electricity distribution lines were tested. Proevehallen is an old open hall building constructed in 1930'ies in 1 floor. However, the height of the building is the same as that of a 5 floor building.

BUILDING CONSTRUCTION

Proevehallen had not been used for a number of years. It was an empty hall with height of 18 m. Due to its original purpose it had been built as a minimal construction with no insulation in walls and windows and simple single glass metal frame windows. In the renovation process 2 new floors had to be fitted in, and insulation and new windows had to be installed. The building had been unheated and ventilated solely by the port opening and the windows, so also complete heating and ventilation systems had to be designed and installed. As there was no energy consumption before retrofit to compare to the energy saving design had to compare to the existing requirements in the Danish building regulations and estimate the savings compared to a building renovated to these requirements. Complying with the requirements in the building regulations was not a requirement for the renovation as it was valid only for new buildings.

There were no existing drawings available for the project. Below the two photos show the state of the building before retrofit.

Solutions

BUILDING CONSTRUCTION

Originally it was the intention to insulate the external walls on the inside in order to maintain the architectural expression of the old brick walls. However, it turned out that for fire protection reasons (law and regulations) this would require

The original building

BRITA in PuBs

Proevehallen in it's original state

quite substantial and extremely costly treatments of the metal beam load supporting parts of the wall. Therefore it was decided to insulate the wall externally. This has no economical consequences to the project and from a technical point of view it is a clear advantage, as it is well known that external insulation is better at preventing thermal bridges than internal insulation.

HEATING

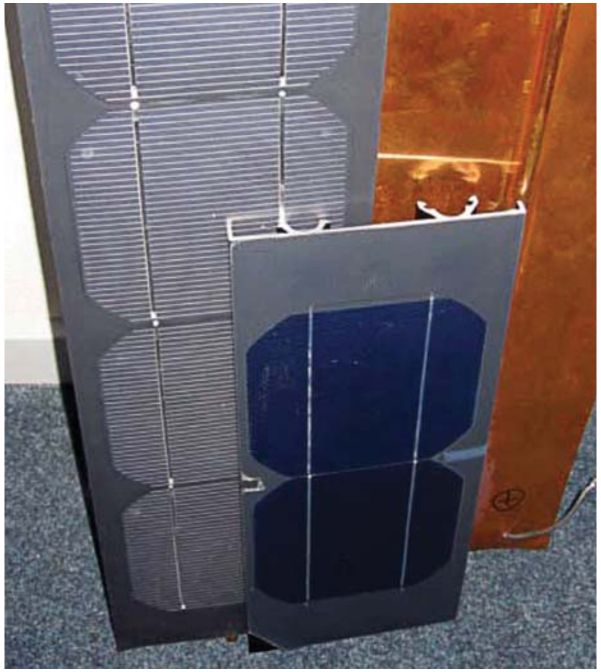
The basic heating system selected for Proevehallen is a standard hydronic radiator system. This is not a special energy saving measure of the project, so standard procedures for sizing the radiators, piping, pumps, etc. have been used. The piping has been isolated according to Danish standard specifications. The air supply in the mechanical ventilation system is preheated - if needed - by a heating coil. This is supplied also from the hydronic system. The monitoring of the heating energy consumption also includes this consumption.

VENTILATION

The building is ventilated by a combination of natural ventilation – of the upper floor – and mechanical ventilation of the lower floors where also a bathroom and toilets are located. The upper parts of the high windows are used for natural ventilation of the upper floor. As the openings are placed high above the ceiling the incoming air will be mixed with the indoor air – thus reducing the risks of cold draughts. This ventilation will be required only when the gym on the upper floor is used by people generating heat which has to vent out, so preheating and heat recovery is not needed for this air exchange. The windows will be demand-controlled according to CO_2 and temperature.

An efficient air-to-air heat exchanger is used for the mechanically ventilated part of the building. This balanced ventilation system keeps a minimum low ventilation for the

Upper floor and isolated roof



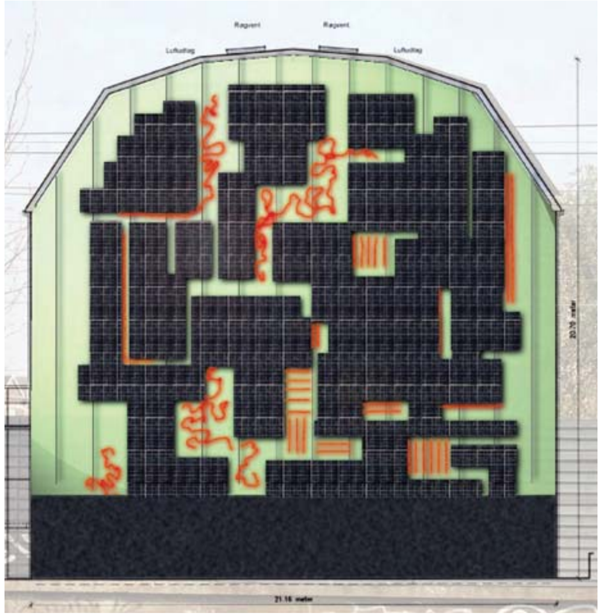
PV-T plant

toilets and it supplies additional ventilation when the CO_2, humidity (in the bathrooms) and temperature sensors indicate that there is a demand for additional air exchange.

With a naturally ventilated upper floor and an efficient heat exchanger in the mechanical ventilation system, there was no need for solar preheating of air. This modification will have no effect in calculations, since the benefit and costs of solar preheating of ventilation air has not been calculated and shown in the original proposal.

SOLAR PV & SOLAR PV/THERMAL (PV/T)

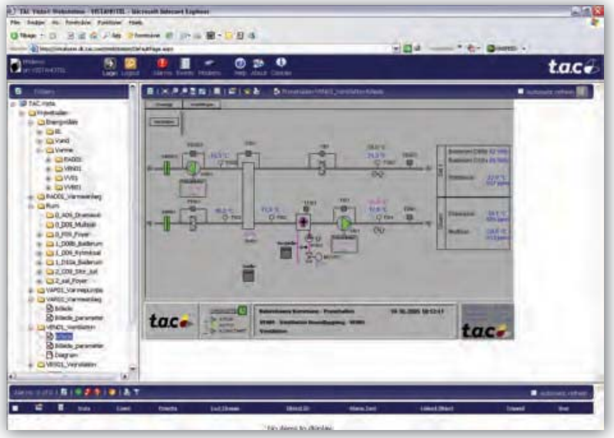
Two kinds of PV plants are installed at Proevehallen; One at the gable (19 kWp) which is made with an artistic expression and one innovative PV-T plant (6 kWp) which also delivers heat by cooling by a heat pump. The cooling raises the efficiency of the PVs. The produced electricity are used in the building or sold to the electricity grid.



'Artistic' PV on the gable

BEMS

A Building Energy Management System (BEMS) has been designed and installed to control the heating and ventilation systems. This will secure an optimal control of the building and thus save energy compared to less sophisticated or manual control systems.



BEMS

The system will also be used for capturing energy consumption and data about temperature, CO_2, humidity plus external weather conditions that can be used for analysis with respect to indoor comfort, air quality and energy consumptions.

Energy data and additional results

ESTIMATED SAVINGS

Energy saving measures, heating, cooling, ventilation	[kWh/m²a]	Total [kWh/a]
High efficient ventilation	47.2	118,000
Improved insulation of the façade	6.0	15,000
Low-e windows	8.0	20,000
Heat savings (lower water use)	9.2	23,000
BEMS	12.0	30,000
Combined PV and Thermal heating system	6.6	16,500
TOTAL HEATING ENERGY SAVINGS	89.0	222,500

Energy saving measures, electricity	[kWh/m²a]	Total [kWh/a]
High efficient fans in the ventilation	12.4	31,000
BEMS	4.0	10,000
Electrical output of PV/T cells	2.4	6,000
PV-cells, 19 kWp	6.4	16,000
TOTAL ELECTRICITY ENERGY SAVINGS	25.2	63,000

Water saving measures, toilets, showers, taps	[m³/a]
TOTAL	575

Economy

Energy saving measure/ investment/ savings/ payback	Total costs [€]	Saving [€/a]	Pay-back period [a]
TOTAL	426,749	30,623	14

Energy costs used for the payback calculation:
Thermal: 0.075 Euro/kWh (0.55 DKK/kWh)
Electric: 0.21 Euro/kWh (1.55 DKK/kWh)

The costs for the additional bearings for PV-panels on the gable wall was 2,119 Euro/kWp. These costs will be further increased because of artwork placing of the PV-panels. These additional costs are not included in the costs presented in the table – as they include other expenses, for example the fee to the artist. Furthermore this solution requires the use of new, totally black solar cells, at a higher cost than conventional solar cells.

First hand experiences

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.
The examples of this experience are:

- The finding of the architect that the minimal construction of the roof was already strengthened because of the crane, so it could actually carry the weight of the additional insulation.
- The competition between the window manufactures made it possible to come up with quite low U-values for the whole window even considering the rather small individual glazing areas.
- As always the first reaction from the contractors is that "this is too expensive". In the actual situation it was the BEMS system. But by negotiations it finally got through the process.

Evonymos Ecological Library, Athens, Greece

Typology	Before: residence and commercial use. After: ecological library and cultural centre
Total floor area	Before: 910 m² After: 1,000 m²
Responsible project partners	Energy and Environment Unit, NTUA (Euphrosyne Triantis, T. + 30 210 7721024; Moissis Kourouzidis, T. + 30 210 3316516) EuDiti Evonymos Ecological Library www.evonymos.org

Summary

The purpose of the project is to minimise energy needs with the use of energy efficiency measures and integration of solar technologies ensuring simultaneously thermal and visual comfort conditions both indoors and outdoors. Key feature of the retrofitting is the accommodation of energy efficiency and renewable energy systems (RES) and techniques in an integrated design without altering the facades of the building. The energy refurbishment design will follow the norms and restrictions foreseen by the General Building Code for listed buildings of this type.

The project, the challenges

The challenge in this project was to renovate a listed building, constructed in 1895 - 1905, using energy conservation and renewable energy systems. Besides it had to be converted into an ecological library devoted to demonstration, education, and dissemination of low energy and environment friendly technologies in building construction and renovation. This will include traditional and modern techniques of energy and water conservation, ecological building materials, renewable energy systems, and recycling of water, paper etc.

"We believe that a major step in reducing environmental pollution is the widespread use of low energy and ecological construction technologies, and especially in retrofitting of existing buildings. The renovation of Evonymos Ecological Library integrates energy conservation and renewable energy systems with traditional building techniques in a listed building, and as such it can serve as a pilot project for many similar buildings in Greece and in Europe."

Dimitrios Papadimoulis
Member of the European Parliament, Member of the Committee on the Environment, Public Health and Food Safety, Member of the Temporary Committee on Climate Change

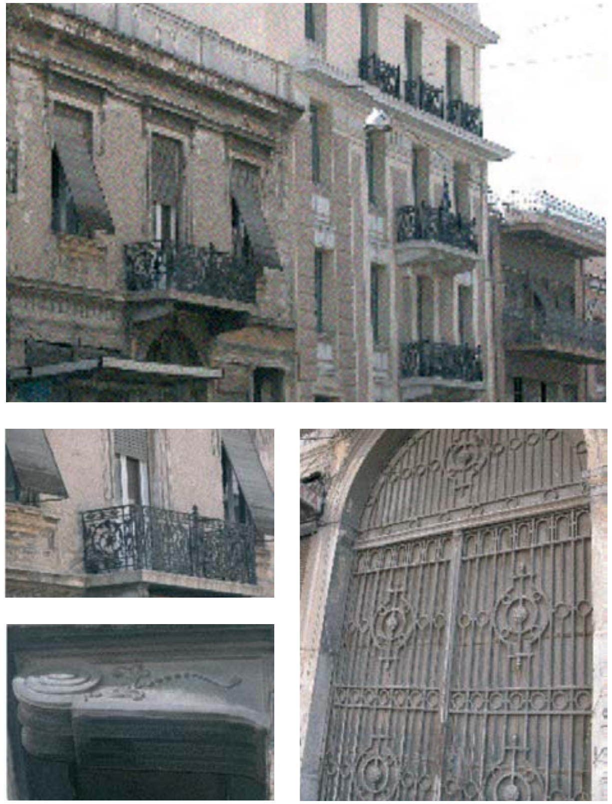
The new facade and the new patio with solar collector

Context

The building is located close to the central archaeological spaces in Athens, which are being united and enhanced by pedestrian roads. This location is ideal for dissemination purposes as the whole area is very popular and widely frequented by Athens citizens and visitors throughout the year.

CLIMATE CONDITIONS

Total annual sunshine hours	2,818
Annual heating degree days (18 °C)	1,110
Temperature in °C	
Winter average	11.6
Winter av. min	7.6
Summer average	25.1
Summer av. max	29.7



The building in its original state

BUILDING CONSTRUCTION

The existing building construction is characteristic of its era. It has 60 cm thick stone walls, and single pane 3.5 m high windows and balcony doors. Originally there was no insulation on walls and roofs and the building suffered from serious humidity problems. Currently it extends on three floors, a basement, and terrace. The ground floor housed commercial activities while the 1st floor originally a residence, is now used as a library.

The building has a total floor area of 910 m^2, to which two covered terraces will be added, bringing the total usable surface to 1,000 m^2 approximately. Another serious problem is the building facade which is gravely deteriorated and is in urgent need of renovation.

Initially the building was heated with portable small stoves burning liquid gas. The non-heated parts stayed quite cold. This gave rise to cold drafts and unpleasant cold zones that the users were exposed to when they circulated to non-heated areas. Furthermore, the temperature regime was strongly fluctuating with room door opening. During the very cold days the capacity of the stoves did not suffice to keep the internal temperature within comfort levels. Overall the space had strong thermal asymmetries and quite often was under-heated.

In summer, the heat absorbed by the high thermal mass during the day was not dissipated to the environment, since the building remained closed during the night, for safety reasons. Consequently the heat remained in the building elements causing overheating. Thus night ventilation is very beneficial for cooling off the building mass.

Solutions

BUILDING CONSTRUCTION

The interior of the building will be completely renovated. Key features of the renovation is the addition of new useful spaces, that is:

a) A mezzanine between the ground and 1st floor, in order to take advantage of the double height of the ground floor (nearly 6 m).
b) The conversion of an existing veranda on the first floor in to an open reading area.




The interior

c) The conversion of the terrace into a sitting area. The outdoor spaces will be designed to ensure high quality thermal and visual comfort for the users in all seasons.

ENERGY CONSERVATION

- External insulation of walls and roofs: 4 cm insulation thickness - all external architectural decorative elements will be dismounted for the placement of insulation and then replaced or reconstructed.
- Air tight low-e double glazing and night insulation (insulated aluminium rollers).
- Reduction of infiltration with window stripping and tight window frames.
- Shading varying according to the orientation of openings (horizontal, and vertical shades made of thin wooden openable fins).
- Shading of the South and Southwest façades with wooden pergolas supporting PV modules and sliding cloth shades.
- Ecologically treated wood.

HEATING

Renewable energy integration:

- Integration of two sunspaces on the verandas/terraces with openable vertical and tilted glazing to eliminate any increase of building cooling load.
- PVs integrated on the sunspace roofs as shading devices.
- Solar collectors for domestically heated water.

EFFICIENT ENERGY SUPPLY

- Gas fired water boiler system for heating, fuelled from the natural gas city network. The size of the boiler needed is 82 kW. A four-way valve is necessary at the boiler outlet to significantly lower the water temperature to the level needed by fan coil units (~45-50 °C). Pumps will be driven by Variable Frequency Drivers (VFD), to account for pressure changes due to opening/closing of local valves.

VENTILATION

- Hybrid efficient ventilation: ceiling fans and earth pipes.
- A centrifugal fan (fan section type) with VFD drivers will assist natural ventilation. It will be installed at the top of the main stairs of the building to reject used air.
- Innovative solar chimney / light duct elements.
- Night hybrid ventilation for the warm months.

BMS AND MONITORING

An intranet with PCs will be used for education and information purposes in order to present to students and visitors of the library the energy conservation and environmental systems used in the building and their operation. Most of the systems installed in the building will be controlled by a Building Management system (BMS).

The BMS serves 3 distinct purposes:

- Control HVAC, lighting, passive cooling, RES and other systems installed in the building, optimizing their performance.
- Collect system operation and energy consumption/production data for analysis and evaluation.
- Demonstrate the usefulness of the system itself, as well as the entire energy conscious design of the building.

The BMS will receive input and/or control the following:

System	Measurements & controls
Weather station	Temperature, solar radiation, humidity, lighting level, wind
Photovoltaic cells	Recorders, display
Boiler	Thermostats / valves, time
Heat pump	Thermostats / valves, time
Fan coil unit	Temperature, time, humidification
Air handling unit (meeting rooms)	Temperature, time, heat recovery
Fans / openings	CO_2 sensors, fans, openings, ambient conditions, time, motors
Lighting	Local dimmer sensors, occupancy sensors, time
Sunspace	Openings, shading, ambient conditions
Shading	Louvers (horizontal and vertical)
Glazing night thermal protection	Rollers (electric motors)
Fire protection	Fire sensors, alarms

It will be connected via LAN (Ethernet) to the computer system in the library, to be used for demonstration and teaching purposes.
It is planned to conduct a user survey among the library members in order to collect their opinion on comfort levels before and after renovation. Results will be evaluated in comparison to the monitoring data collected.

Energy data and additional results

ESTIMATED YEARLY SAVINGS

Heating energy saving	[kWh/m^{2}a]	Total [kWh/a]
	195	195,000

Electrical energy saving	[kWh/m^{2}a]	Total [kWh/a]
	4.2	4,234

Water saving					
Original measures	Original water savings		Modified measures	Modified water seavings	
	[m^3/m^2]	Total [m^3]		[m^3/m^2]	Total [m^3]
Two sanitary spaces	0.16	175	Addition of two more sanitary spaces to service the users	0.16	175

Economy

Measurements and evaluation will be available after completion of the project in May 2008.

Eligible costs [€]	Pay-back period [a]
484,370	23

First hand experiences

- It is often difficult to combine public financing procedures for the restoration of public buildings with the prerogatives of a research project. In the case of Evonymos project, the construction process has been greatly delayed because of the lengthy procedures involved in building restoration financing trough the Greek Ministry of Culture, to which the building belongs, as a listed building. The eligible part of the project would not have been completed in time if the project team had not secured the participation of private sponsors, such as STO AG-Dracopoulos O.E., Schneider Electric, Poseidon Monoprossopi Ltd and ISTO SA, who undertook financing and construction of different parts of the project, under the general management and coordination of Mr. Elias Louizos of ICS DUELL Ltd.

- Therefore, in addition to the challenge of integrating renewable and energy conservation systems to the traditional construction techniques of a listed building, this project has been innovative in terms of the combination of private and public sponsors in the retrofitting of a public building.

- Finally, it should be noted that the introduction of passive solar components into the retrofitting of a listed building should not be treated in an inflexible way or as remedy for all types of problems. Each building should be considered individually and passive solar features introduced into the overall design concept so that the best possible balance of thermal and visual comfort is achieved and the retrofitted building meets the occupants’ practical and aesthetic needs.

Main Building Vilnius Gediminas Technical University (VGTU), Vilnius, Lithuania

Main building Vilnius Gediminas Technical University (VGTU)

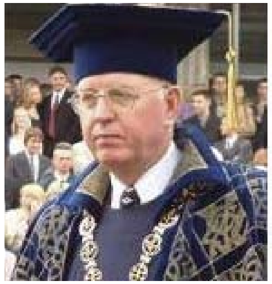
Typology	University education and research centre
Total floor area	8,484.20 m^2
Responsible project partner	Renovacijos projektai Ltd.

Summary

This demonstration project proves that by applying the methodology of multi-variant design and multiple criteria analysis of a building refurbishment more efficient building refurbishment can be realized.

The project, the challenges

The challenge in this project was to show how energy efficient solutions can be achieved in applying the methodology of multi-variant design and multiple criteria analysis of a building refurbishment by forming thousands of alternative versions. This methodology allowed to determine the strongest and weakest points of each the main building's of Vilnius Gediminas Technical University (VGTU) refurbishment project and its constituent parts.



"Every morning I look at the Main building of VGTU on my way to work and a feeling of admiration sweeps me: it has become so beautiful after refurbishment. It's sad that we could not refurbish other buildings of VGTU yet".

Prof. Dr. habil. Romualdas Ginevičius
Rector of Vilnius Gediminas Technical University

Context

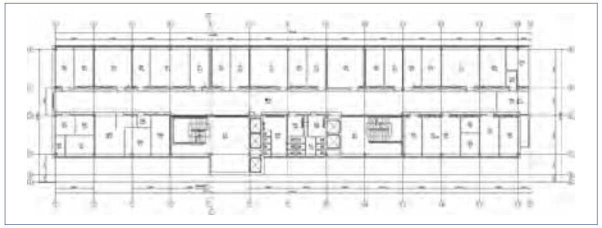
The site of the VGTU main building is in a suburb, nearby Vilnius university (VU), residential buildings and a forest.
Lithuanian climate is maritime/continental. The highest temperature in July is +30.1 °C, the lowest in January is -22.7 °C. The Lithuanian climate is temperate. From May to September daytime highs vary from about 14 °C to 22 °C, but between November and March it rarely gets above 4 °C. July and August, the warmest months, are also wet, with days of persistent showers. May, June and September are more comfortable, while late June can be thundery. Slush underfoot is something you have to cope with in autumn, when snow falls and melts. In spring, when the winter snow thaws. Average annual precipitation is 717 mm on the coast and 490 mm in the East.
Vilnius is located is the east of the country, 140-150 m above sea level. It has a mean annual temperature - 6.4 °C, the mean winter temperature -4 °C.

The rectangular building is a public one, the first one to see while approaching the university. The main details are:

- Length and width: 74.30 x 17.22 m.
- Floor area: 8,484.20 m^2.
- Number of storeys: 7.
- Number of occupants: 1,084.
- Number of rooms: 219.
- Several departments and lecture halls, with seating for 50 to 100 students.
- Average area per user: 7.83 m^2.
- Building date: 1971.

The substructure of the building was made from frame pillar with columns of the UK type. The walls of the building have a ferroconcrete frame and three-layer ferroconcrete panels (60/90/90 cm). The thermal transmittance of walls is U_w = 1.07 W/m^2K. During thirty years of exploitation, both sun and rainfall have had their impact on external sectors. On some places connection junctures of three-layer panels were already partly crumbled. Such sealing junctures were easily blowable and pervious to moisture. Juncture in damaged places of the external sectors was sealed with sealing material and filled up with a sealant.
There were drawings available for the project. The following two photos show the state of the building before retrofit.
The biggest part of the external sectors in the main facades was occupied by glass area. All window glass was placed in

The VGTU-building before retrofit.



Plan of 4th floor.

wooden or aluminium profile frameworks. The windows were very old: closing windows and lack of tightness were the biggest inconveniences. Current construction of the windows did not correspond to the modern window requirements and did not ensure proper inside comfort conditions. The thermal transmittance of existing windows was U_{wi} = 2.5 W/m^2K.
Lateral entrance doors in the building were old, unsealed and very insecure as well. The thermal transmittance of doors was U_d = 2.3 W/m^2K.
All roofs of the building were flat, and the covering was made from the roll. In October 2002, the roof was repaired.

After unwrinkling all blowholes and other roughness of the old covering, new hydro-isolating roofing was fit up. While renovating the roof, due to a shortage of financing, current old parapet tins were changed only in these places where they were very rusty. The thermal transmittance of roof was U_r = 0.8 W/m²K.

Structural unit	U-value [W/m²K]	
	Before retrofit	After retrofit
Windows	2.5	1.16
Walls	1.07	0.2
Roof	0.8	0.2
Doors	2.3	1.5

Solutions

BUILDING CONSTRUCTION

Keeping in mind that the building is now in use more than thirty years, the following measures have been suggested:

- Renovation of facades.
- Replacement of windows.
- Renovation of the roof.
- Replacement of entrance doors.
- A slight optimisation of the renovated thermal unit and complement of the automatic part.
- Renovation of the heating system.

The retrofit concept than looks as follows:

HEATING

It was suggested to carry out renovation of current morally and physically out-of-date heating system. It would include three stages:

1. A new, fully automated heating system, with automated compensation valves designed for the stands of the heating systems, new closing reinforcement, the installation of thermostatic valves for heating equipment, change of trunk pipelines and co-ordination of this part of the project.
2. Implementation of this heating system renovation.
3. Coordination and operation of the renovated heating system. This regards the heat effect.

During the partial renovation of the thermal unit, an electromagnetic indicator for heat and water quantity will be installed. With the help of the indicator the heat quantity, the quantity of flowing water, instantaneous debit, initial and recursive temperature, initial and final pressure is determined. Data of indicator may be transmitted by internet and the indicator managed by computer programs.

VENTILATION

Renovation of mechanical air supply/removal systems includes:

1. Replacement of the current ventilation system with at new one, fully automated. Ventilation should be mechanical, with 50-70 percent recuperation. In addition, new pipelines of air supply/removal and equipment will be installed.
2. Implementation of this air supply/removal systems renovation.
3. Installation and co-ordination of the new systems. This includes installation and co-ordination of the systems.

Energy data and additional results

ESTIMATED SAVINGS

Energy costs used for the payback calculation:

- Thermal: 36.14 €/MWh.
- Electric: 85.15 €/MWh.

Energy saving measures heating	[kWh/m²a]	Total [kWh/a]
High-efficient windows	26	220,589
Insulation of roofs and facades	27.9	236,672
Heating system	36	305,663
Ventilation system (heating recovery system)	42.2	297,000
TOTAL HEATING ENERGY SAVINGS	132.1	1,059,924

Energy saving measures/ investment/ savings/ pay-back	Total costs [€]	Saving [€/a]	Pay-back period [a]
TOTAL	462,000	40,840	11

Measurements and evaluations

The monitoring of the VGTU main building started in March 2006. The conclusions of an energy audit (performed in 2002) showed that 14-16 °C was the average temperature in premises during a heating season. The indoor air temperature increased by 2-4 degrees after replacement of windows, insulation of roof and renovation of the thermal unit. Now the indoor air temperature meets the requirements. However, the analysis of volume flow, air velocity and relative humidity shows that current values are lower than those of specifications. Insufficient speed of the indoor volume flow determines lack of oxygen. As a result, indoor hygiene conditions are bad, people feel worse and their productivity decreases. It was possible to compare the data on energy consumption before the renovation and during the renovation. In summer of 2004, the windows of the main building were replaced. In autumn of 2005, the roof and walls of the semi-basement were insulated. In 2003, the heating energy consumption was 920,000 kWh, and in 2005 already 532,000 kWh, i.e. it decreased by 42 %. In 2006, the heating energy consumption made up 547,000 kWh. Compared to 2003, the heating energy consumption decreased by 41 %. In 2005, electricity consumption decreased by about 16 % compared to 2003, and compared to 2004 by 26 %. The level of pollution was measured in the environment of VGTU in 2006-2007: noise pollution (dB), CO pollution (ppm), particular mates pollution (particle pollution) (mg/m³) . A forecast of pollution (noise pollution, dB; CO pollution, ppm) in the environment of VGTU for the year 2010 is provided.

First hand experiences

During the VGTU renovation aiming at energy savings measures, modifications occurred. Because of financial shortages the third renovation component, i.e. ventilation and in consequence the ventilation system, was not foreseen to be refurbished. However, in the process of renovation the three main components – building envelope, heating and ventilation - must be kept in balance. As € 42,605.61 was saved by replacement of the windows, it was therefore decided to use that money for the renovation of the ventilation system.

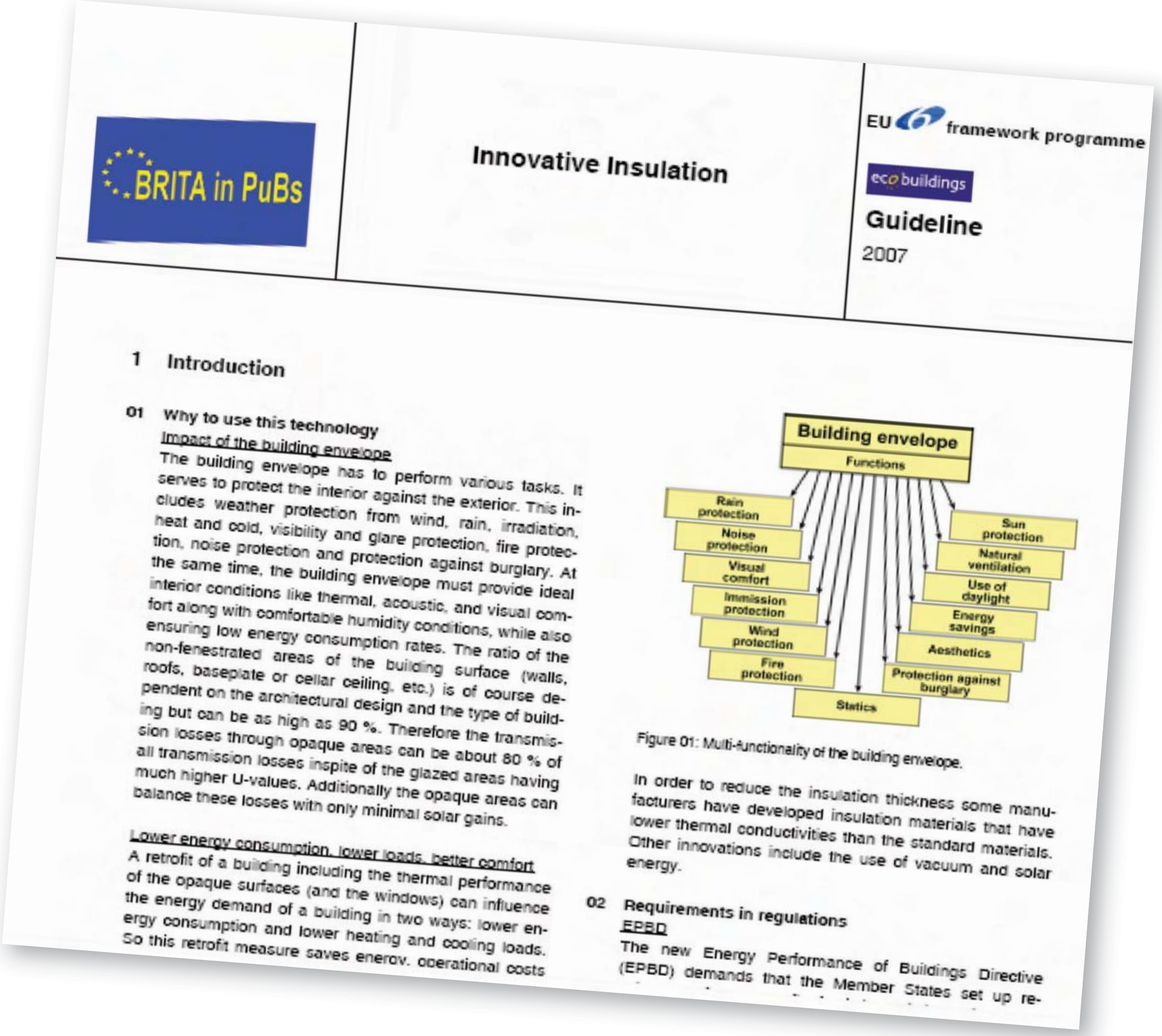
The Tools

Retrofit Design Guidelines

The partners of BRITA in PuBs have written 14 retrofit design guidelines with about 4-8 pages each, focusing on specific technologies like innovative insulation, advanced windows, passive solar heating, reduction of overheating, hybrid ventilation, improved daylighting, solar thermal systems, solar heating and cooling, photovoltaic integration and heat pumps or on more general items. The latter deal with the interdisciplinary design approach, energy simulation tools, life cycle assessment and long-term monitoring. The guidelines contain information on why to use the technology, requirements in regulations, current practice, different innovative solutions with their advantages and disadvantages, energy savings and costs, as well as information on maintenance and best practice examples. They are available for download at the project website.

Available Retrofit Design Guidelines:

01 Interdisciplinary approach to sustainable buildings
02 Energy simulation tools for buildings
03 Life cycle assessment
04 Innovative insulation
05 Advanced energy efficient windows
06 Passive solar heating
07 Reduction of overheating
08 Hybrid ventilation
09 Improved daylighting
10 Solar thermal collectors
11 Absorption cooling
12 PV-integration
13 Heat pumps
14 Long-term monitoring


BRITA in PuBs

Innovative Insulation

EU framework programme
eco buildings
Guideline
2007

1 Introduction

01 Why to use this technology
Impact of the building envelope
The building envelope has to perform various tasks. It serves to protect the interior against the exterior. This includes weather protection from wind, rain, irradiation, heat and cold, visibility and glare protection, fire protection, noise protection and protection against burglary. At the same time, the building envelope must provide ideal interior conditions like thermal, acoustic, and visual comfort along with comfortable humidity conditions, while also ensuring low energy consumption rates. The ratio of the non-fenestrated areas of the building surface (walls, roofs, baseplate or cellar ceiling, etc.) is of course dependent on the architectural design and the type of building but can be as high as 90 %. Therefore the transmission losses through opaque areas can be about 80 % of all transmission losses inspite of the glazed areas having much higher U-values. Additionally the opaque areas can balance these losses with only minimal solar gains.

Lower energy consumption, lower loads, better comfort
A retrofit of a building including the thermal performance of the opaque surfaces (and the windows) can influence the energy demand of a building in two ways: lower energy consumption and lower heating and cooling loads. So this retrofit measure saves energy, operational costs

Figure 01: Multi-functionality of the building envelope.

In order to reduce the insulation thickness some manufacturers have developed insulation materials that have lower thermal conductivities than the standard materials. Other innovations include the use of vacuum and solar energy.

02 Requirements in regulations
EPBD
The new Energy Performance of Buildings Directive (EPBD) demands that the Member States set up re-

Extract from the design guideline on innovative insulation

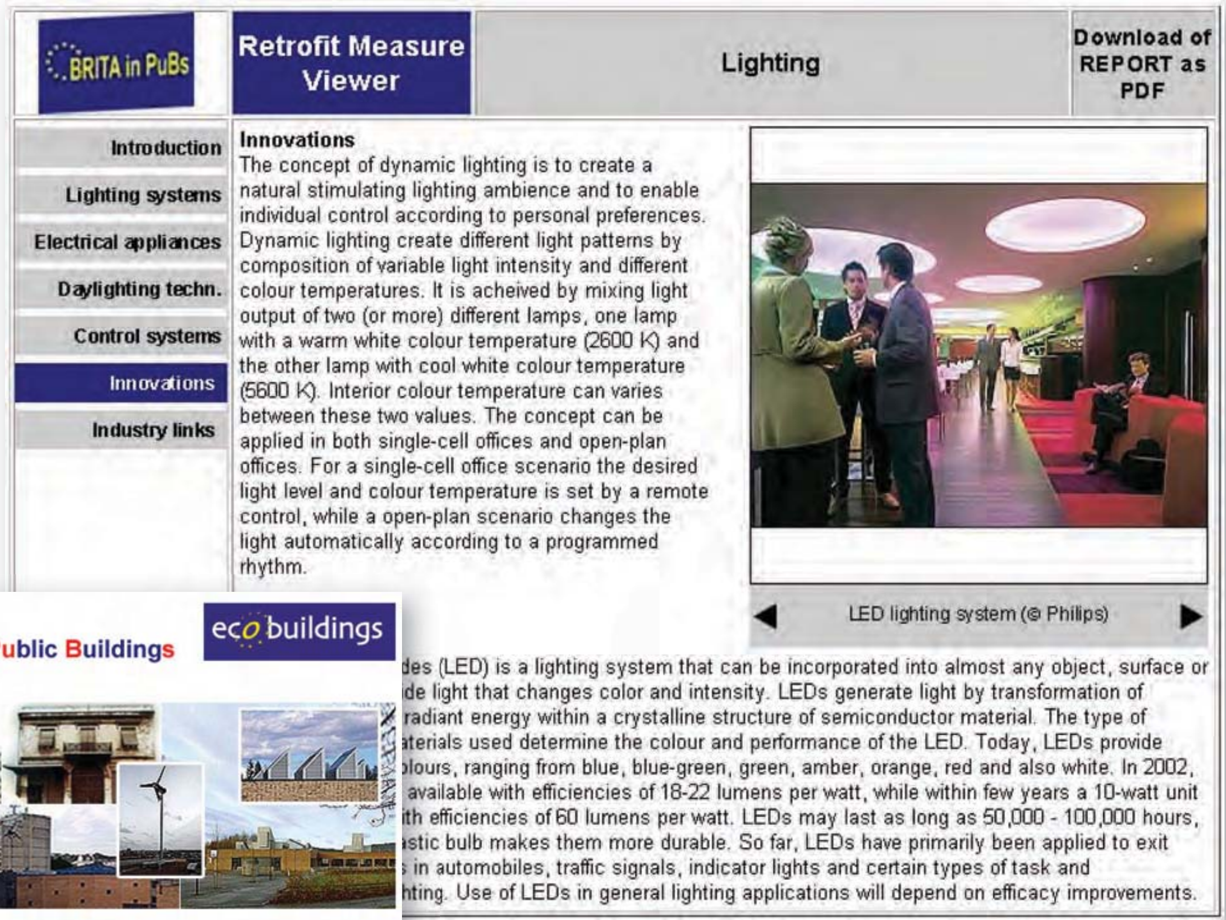
BIT – BRITA in PuBs Information Tool

An internet based electronic database offers many different types of information for decision-makers on public renovation projects. The BRITA in PuBs information tool BIT presents in an clearly structured and simple to use way all demonstration buildings from the project plus additional more than 30 educational case study buildings from a just finished IEA project. In a matrix the buildings are opposed to different retrofit strategies starting with the building envelope, over heating and ventilation systems, solar control and cooling systems, lighting systems to renewables and management methods.

An additional feature of the information tool is the performance rating tool. Here the user can visually compare the electricity, heating and water consumption of a specific building with the national average for in total 19 different building types.

The retrofit technologies and the case studies are described in detail in so-called viewers. For both, the case studies and the retrofit measures, more detailed information is offered as pdf-downloads including the final reports from the demonstration buildings and the retrofit design guidelines.

The BIT Tool can be used on the BRITA in PuBs website www.brita-in-pubs.eu



Retrofit Measure Viewer within the BIT Tool.

Title page of the BRITA in PuBs information tool BIT.

BRITA in PuBs

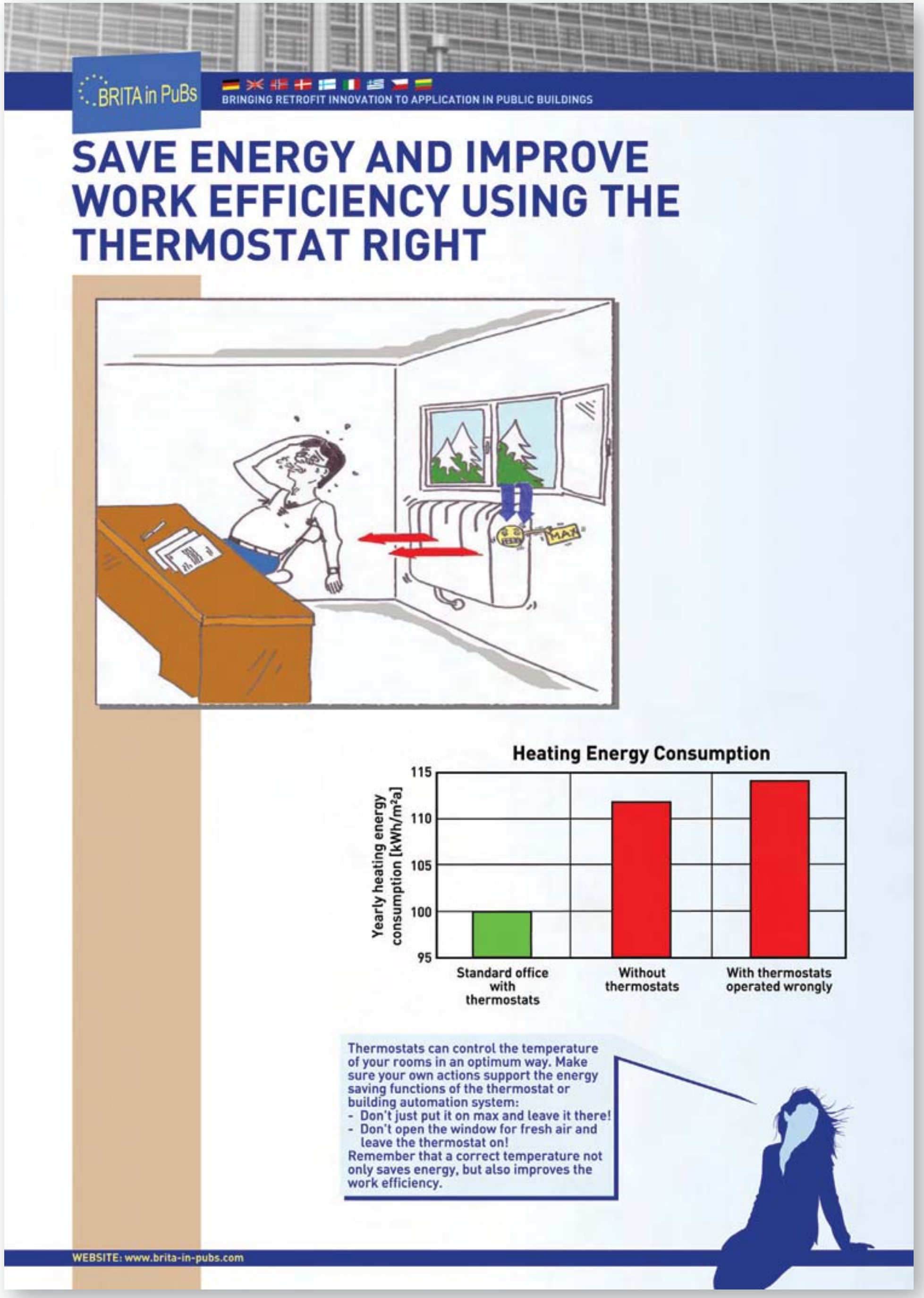
BISH – Blackboard Information Sheets

Many reservations against energy conservation and renewable energies result from lack of knowledge and ignorance on this subject in the different social, age and professional groups. The user behaviour has a strong influence on the energy performance of buildings, it can increase or decrease the energy consumption for heating, cooling, ventilation 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 different target groups (occupants like pupils and teachers or office workers/care-takers and maintenance personnel/administration) simple blackboard information sheets has been developed specifically, which informs on positive and negative influence possibilities to the energy consumption and indoor comfort of buildings. Besides showing the energy consumption and cost differences it will give advice on how to improve the comfort level with no- and low-cost measures.

The following 8 BISHes have been produced in English and in different national versions:

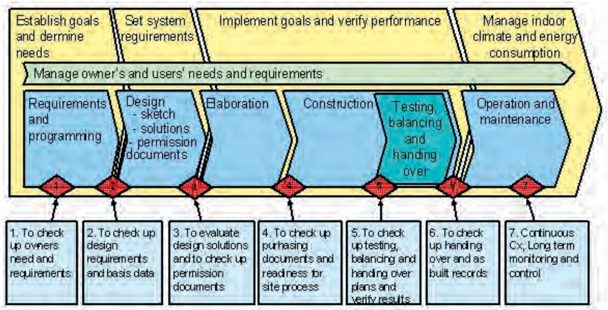
1. Save cooling energy with night ventilation
2. Save electricity through the intelligent use of daylight
3. Save cooling energy with shading
4. Save energy and improve work efficiency using the thermostat right
5. Report defects to the maintenance personnel
6. Monitoring and targeting is basis for successful energy retrofitting
7. Instrumentation and control and
8. Keep windows closed when air-conditioning is on



Example of a blackboard information sheet for training energy efficient user behaviour.

Quality Control Tool Box

A quality/performance control toolbox - a concept from design to post construction life long management, using BEMS/REMS - type procedures and using prevailing methods. The toolbox has been developed in an electronic/internet based form and is structured according to the three major building project stages, which will be linked. The figure below shows how the requirements and goals will be checked between each stages of the project. Each diamond, "salmiac" contains a list of tasks and operations – checklists.



The tool-box includes

- Risk-management and preliminary energy/life-cycle costs calculations for the design and planning stage commissioning
- Quality control procedure for implementation stage including the analysis of the realization phase of the demonstration buildings and in the stage of use
- Development of electronic display information panels and the involvement and acceptance of the users (a user and service manual model)
- A web-based energy and facility management monitoring system, which has feedback to the planning stage and can be used in benchmarking
- Energy audit model for ascertaining the performance of the building

E-Learning and Student Courses

An intelligent computer learning system is developed and installed at the VGTU and will assist the user/reader in selecting the most relevant text from the electric textbook to study for a specific subject. This part of the module based on an automated analysis of key words included in the different chapters of the BRITA in PuBs reports.

The texts in the electronic textbook will consist of pdf-files of the design guidelines and demonstration project reports. For each text a set of related questions and answers is developed for the intelligent testing system. The questions and answers has been developed by the guideline and demonstration project authors.

The e-learning module includes:

- Intelligent computer learning system
- An electronic textbook with results from BRITA in PuBs,
- Intelligent testing system

Optionally are three more elements:

- Videos
- Audios
- Discussion forum

Based on the results of the BRITA in PuBs and the other Eco-Building projects course material in the format of Power Point Presentations (PPP) in English is developed. A training part will also be developed, aimed at applying the lecture themes to practical case studies. Some project partners offering the course at least once in his/her institution, and for making concrete efforts to embed the course in the curriculum, for example as an elective course for graduate or undergraduate students where most applicable and/or as part of professional training packages.

The course methodology includes an integrated approach :

Part 1 - Lectures

A: Lectures as basis for Q&A and discussions
Themes:
- Lessons learned from the BRITA in PuBs and the other Eco-Buildings projects
- Interdisciplinary approach to sustainable built environments
- Energy efficiency and energy supply from renewables
- Energy simulation tools
- Life-cycle cost analysis tools

Part 2 - Learning to solve similar challenges through training

B: Selection of existing buildings that students can visit as case study
C: Collection of existing information on each building
D: Analysis of use patterns in the building
E: Auditing conducted in selected parts of building (daylight, humidity, temperature measurements)
F: Interviews of users on thermal and comfort issues
G: Scenario of environmental retrofitting intervention
H: Development of the best-integrated design solution for each building
I: Final design and construction of components

The courses are held at the schools of architecture in Athens, Milano, Stavanger and Trondheim.

Analysis and Reports

The project has performed socio-economic research such as an overview report on financial strategies in the different participating countries for the improvement of the energy quality in the existing building stock. A detailed analysis of barriers for the energy efficient retrofit of public buildings was also made. Both reports are available on the website together with a communication guide for energy renovations in different languages, 8 reports on the concept development of the demonstration buildings, the proceedings of the first Eco-Buildings Symposium and the Eco-Buildings Discussion Document: What are Eco-Buildings and why are they needed in the Seventh Framework Programme (FP7)?


BRITA in PuBs

eco buildings

Project n°: TREN/04/FP6EN/S07.31038/ 503135

Acronym: BRITA in PuBs

Title: Bringing Retrofit Innovation to Application in Public Buildings– BRITA in PuBs

Instrument: Integrated project
Thematic Priority: 6.1.3.2.1 ECO-BUILDINGS

D7
Financial Strategies for low energy public retrofits in Europe

Revision: **0**

Due date of deliverable:	**31/10/2005**	Actual submission date:	**15/11/2005**
Start date of project:	**1/5/2004**	Duration:	**48 months**

Lead contractor name for this deliverable and organisation:
Euphrosyne Triantis
N.T.U.A., Greece

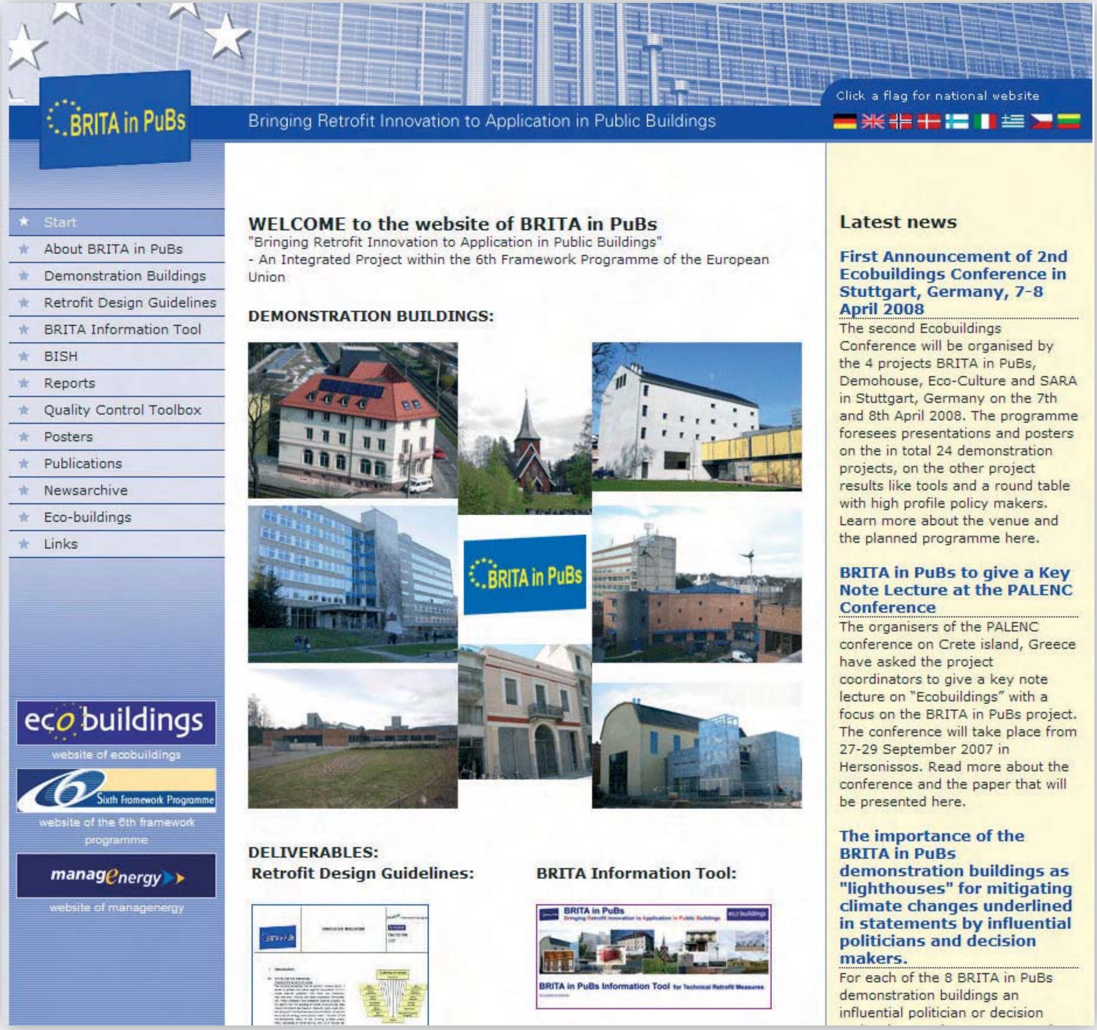
Project coordinator name and organisation:
Hans Erhorn
Fraunhofer Institute of Building Physics

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

BRITA in PuBs report

The Website

Actual information in 9 languages are available on the project website



www.brita-in-pubs.eu

The Team

Eco-Buildings Fellows

Project Partner and Participants

Fraunhofer Institute of Building Physics Department Heat Technology Nobelstrasse 12, 70569 Stuttgart, Germany
Hans Erhorn, Heike Erhorn-Kluttig, Simon Wössner

City of Stuttgart, Office of Environmental Protection Department of Energy Management Gaisburgstr. 4, 70049 Stuttgart, Germany
Frank Bross, Jürgen Görres, Nina Weiss

IT Power - The Manor House, Chineham Court, Lutyens Close Chineham, Hampshire, RG24 8AG, United Kingdom
Manuel Fuentes, Paul Reed, Sharlene Wilson

Plymouth City College Kings Road, Devonport, Plymouth PL1 5QG, United Kingdom
Gilbert Snook

SINTEF - Building and Infrastructure Alfred-Getz-vei 3, 7465 Trondheim, Norway
Karin Buvik, Anne-Grete Hestness

Danish Building Research Institute (SBi) Department for Energy and Environment Dr. Neergaards Vej 15, 2970 Hoersholm, Denmark
Kirsten Engelund- Thomsen

VTT - PO Box 18021, 90571 Oulu, Finland PO Box 1000, 02044 VTT, Finland
Timo Kauppinen, Jorma Pietilainen

Ente per le Nuove Tecnologie l'Energia e l'Ambiente, ENEA-ENE SIST, Via Anguillarese 301, 00060 S. Maria di Galeria – Roma, Italy
Marco Citterio

Politecnico di Milano, Department of Building & Environmental Sciences & Transport (BEST), Piazza Leonardo da Vinci 32, 20133 Milano, Italy
Frederico Butera, Simone Ferrari

Università degli Studi di Palermo Dept. D.R.E.A.M., Viale delle Scienze, 90128 Palermo, Italy
Fulvio Ardente, Marco Beccali, Maurizio Cellura

National Technical University of Athens (NTUA), 9, Heroon Polytechnious Street 15780 Athens, Greece
Euphrosyne Triantis

EuDiti – Energy & Environmental Design 11, Therianou Str., 11473 Athens, Greece
Eva Athanassakos

Evonymos Ecological Library 9, Asomaton Str. 10553 Athens, Greece
Moissis Kourouzidis

Brno University of Technology Faculty of Mechanical Engineering Technicka 2, 61669 Brno, Czech Republic
Pavel Charvat, Miroslav Jicha

Vilnius Gediminas Technical University, Department of Construction Economics a. Property Management Sauletekio al. 11, 2040 Vilnius, Lithuania
Arturas Kaklauskas, Aiste Mickaityte Saulius Raslanas

Forschungszentrum Jülich Projektträger Jülich, PTJ-ERG Leo Brand-Straße, 52425 Jülich, Germany
Silvia Bach, Markus Kratz

Asker Municipality, Jørgensløkka 60 1372 Asker, Norway
Stein Grimstad, Jan Rolland

Hol kirkelige fellesråd (Hol church council) Nerolsgutu 2, 3575 Hol, Norway
Astri Tingstad

Norwegian Building Research Institute (NBI) SINTEF Building and Infrastructure Forskningsveien 3b, 0314 Oslo, Norway
Kari Thunshelle

Sivilarkitekt Harald N. Røstvik AS/ Sun-Lab, PB 806 Sentrum, 4004 Stavanger, Norway
Harald N. Røstvik

Cenergia Energy Consultants Herlev Hovegade 195 2730 Herlev, Denmark
Karina Juul Larsen, Ove Mørck

Københavns Kommune Uddannelses- og Ungdomsforvaltningen (UUF), Islands Brygge 37, 2300 Copenhagen, Denmark
Eva Holm-Joergensen, Bent Tildestrup

Fraunhofer Institut Bauphysik IBP

LANDES-HAUPTSTADT STUTTGART

it Power

PLYMOUTH CFE

SINTEF

Asker kommune

BYGGFORSK Norwegian Building Research Institute

HARALD N. RØSTVIK AS CIVIL ARCHITECT SPECIALIST SOLAR ENERGY

CENERGIA

Københavns Kommune Uddannelses- og Ungdomsforvaltningen

SBi

VTT

ENEA

POLITECNICO MILANO

EYAITH EUDITI

VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

PtJ Projektträger Jüllich Forschungszentrum Jüllich