ECOBUILDINGS: TOWARDS AN ENERGY-EFFICIENT EUROPEAN BUILDING STOCK BEYOND NATIONAL REQUIREMENTS

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Summary

The building sector is at present responsible for more than 40 % of the EU energy consumption. The EU 6FP Ecobuildings concept is expected to be the meeting point of short-term development and demonstration in order to support legislative and regulatory measures for energy efficiency and enhanced use of renewable energy solutions within the building sector, which go beyond the Directive on the Energy Performance of Buildings. The projects aim at a new approach for the design, construction and operation of new and/or refurbished buildings, which is based on the best combination of the double approach: to reduce substantially and, if possible, to avoid the demand for heating, cooling and lighting and to supply the necessary heating, cooling and lighting in the most efficient way and based as much as possible on renewable energy sources and polygeneration.

The results of the four Ecobuildings projects BRITA in PuBs, SARA, DEMOHOUSE and ECO-CULTURE are presented in this paper and shall be discussed during the conference presentation. The main focus is on the BRITA in PuBs project with 8 demonstration buildings and additional project results such as retrofit design guidelines, an electronic database on retrofitting knowledge, a quality control toolbox and many more.

Figure 1 The Berlaymont Building in Brussels; head office of the European Commission. The building was energy retrofitted beyond national requirements – an Ecobuilding.

1. Introduction

Ecobuildings (European Commission, 2004) is an energy demonstration initiative of the European Commission (DG TREN) within the sixth Framework Programme. The definition of the Ecobuildings concept according to the Commission is given in the first paragraph of the abstract. The Ecobuildings projects focus mainly on demonstration but do include also minor parts on research and technical development and on training and dissemination.

Since Ecobuildings deal in comparison with Concerto, another EU Commission initiative, (European Commission, 2005) with single buildings, the concept can be applied at any building and in any country.

Concerto aims to demonstrate the high potential for energy efficiency and high share of renewables which can be achieved through a fully integrated approach in high performing communities. In order to achieve this aim, the Concerto projects will apply highly efficient energy saving measures, to significantly increase the percentage of renewable energy supplies and integrate the self supply of renewable energies and polygeneration into ecobuildings. That means that Concerto might be translated to a combination of Ecobuildings with a common and energy efficient supply system. The concept is therefore mainly applied to new settlements.

Ecobuildings as buildings with an energy performance better than required by the national implementation of the Energy Performance of Buildings Directive (EPBD), include different types of energy efficient buildings such as zero heating energy houses, zero energy houses, passive houses, 3-litre houses, ultra-low energy houses, etc. All those names describe different levels of energy consumption, partly with integrated renewables and partly with defined types of technologies. For example a passive house in the original German definition uses the mechanical ventilation system for space heating as well. Therefore it can abandon an additional hot water heating system, however it relates on a hot air heating system, mostly combined with a heat pump. The 3-litre-house concept on the other hand can be realised with many energy-efficient technologies, yet the primary energy demand for heating, ventilation and domestic hot water (plus cooling if necessary) is limited to the equivalence of 3 litre of heating oil per m² floor area. Figure 2 illustrates the relations between the different terms for energy efficient buildings.

Figure 2 Illustration of the some of the many terms used in the area of energy efficient buildings.

What makes Ecobuildings as concept especially interesting is that it can be applied to all type of buildings: new buildings, existing buildings, single buildings or combined in Concerto projects. Various energy saving technologies at the building envelope and the installation systems can be used and combined with renewable energies. Particularly the application at existing buildings is of importance. Today the heating energy consumption of buildings in Germany is shaped by the existing building stock. 95 % of the heating energy is used for buildings that were erected before 1982, see Figure 3. Other EU Member States have similar figures. Therefore new buildings even with a very low energy demand can influence the total consumption only marginally. The focus has to be on the challenge to reduce the energy consumption of existing buildings.

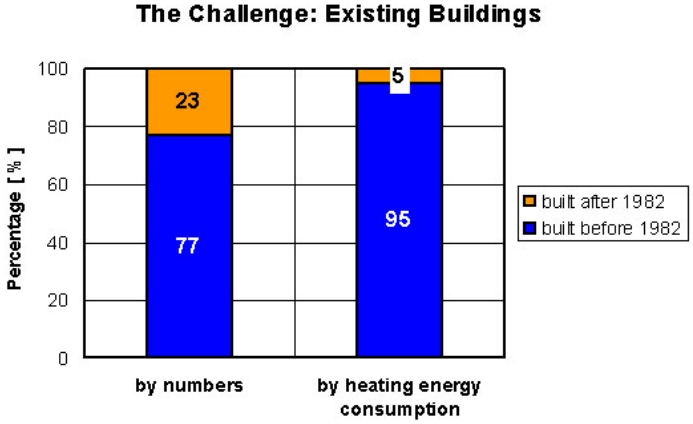

Figure 3 Heating energy consumption in Germany by buildings of different age groups.

2. The 4 Ecobuildings Projects of the 6th Framework Programme

2.1 Similarities and Cooperation

The 4 Ecobuildings 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 diverse. However besides a general information exchange (mainly via the coordinators) the work plan in all projects foresaw a common dissemination task. Main parts of this task are a website portal for all 4 projects (www.ecobuildings.info), common posters, an Ecobuildings newsletter and a high quality brochure including all demonstration projects. Additionally the project BRITA in PuBs has organised two Common Ecobuildings Symposia in Berlin in November 2005 and Stuttgart in April 2008 with presentations from all projects and many interesting discussions (Kratz, Erhorn, 2005 and Goerres et ali, 2008). Figure 4 shows the actual Ecobuildings poster.

Figure 4 Common poster of all 4 Ecobuildings projects.

2.2 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. The pilot project is the actual demonstration project, where the recommendations of the investigations and research are implemented. The reference project is a housing complex that has recently been renovated (or which is in the process of renovation) according to the usual local (national) standards. The pilot projects and reference projects are compared in terms of improvement of:

- energy consumption,
- sustainability in general and
- socio-economic aspects.

The demonstration buildings are new or renovated (partly social) housing complexes:

- old urban building in the centre of Bilbao (Spain)
- social housing complex in Budapest (Hungary)
- a development of residential buildings in Attica (Greece)
- suburb housing projects in Copenhagen (Denmark)
- high-rise multi-dwelling houses in Graz (Austria)
- low-rise multi-dwelling houses in Warsaw (Poland)

Besides the demonstration buildings, the project will produce the following results: A common evaluation protocol and a state-of-the-art-in-renovation report.

2.3 ECO-Culture

The ECO-Culture project addresses demonstration of energy efficient technologies integrated into three high-performing cultural ecobuildings:

- the Danish Royal Theatre, Copenhagen (Denmark)
- the Amsterdam Library, Amsterdam (The Netherlands), see figure 5
- the New Opera House, Oslo (Norway).

Figure 5 Photo of the newly erected Ecobuilding Amsterdam Library.

Focus is on investigations, demonstration and testing of the following technologies which have been selected out of the integrated ECO-concepts as being especially innovative and contributing to further development:

- energy storage ("climate belt" with thermoactive slabs, double aquifer)
- heat pump (sea water, ground water)
- advanced demand controlled hybrid ventilation
- building integrated PV systems
- advanced Building Energy Management Systems (BEMS) and benchmarking
- use of environmental friendly concrete for thermal storage in thermoactive slabs.

2.4 SARA

SARA aims to construct sustainable, cost effective, high energy performance, public-access ecobuildings that are immediately replicable at large scale in many locations. The ecobuildings 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. These aspects, applied across various climatic regions produce large scale social, urban and environmental benefits. The project will therefore contribute to future development of European energy policy and legislation that will accelerate market penetration of innovative sustainable technologies. The project includes the following demonstration buildings:

- office and exhibition hall, Sinabelkirchen (Austria)
- primary School, La Tour de Salvagny, (France)
- community centre (refurbishment), Naples, (Italy)
- health centre, Barcelona (Spain)
- supermarket, Ljubljana (Slovenia)

- student service building, Southampton (UK)
- community centre, (refurbishment) Bukara, (Uzbekistan)

In combination with the demonstration buildings the project works on an instant replicability potential, an integrated BMS and monitoring, shared solutions and interests and technical advice and support.

2.5 BRITA in PuBs

The BRITA in PuBs project (Bringing Retrofit Innovation To Application in Public Buildings) aimed 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 was 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, nursing 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 included socio-economic research such as the identification of real project-planning needs and financing strategies, the development of design guidelines, 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, see Figure 6, an Ecobuildings E-learning module, architectural student courses and a facility managers training based on the results of the demonstration projects.

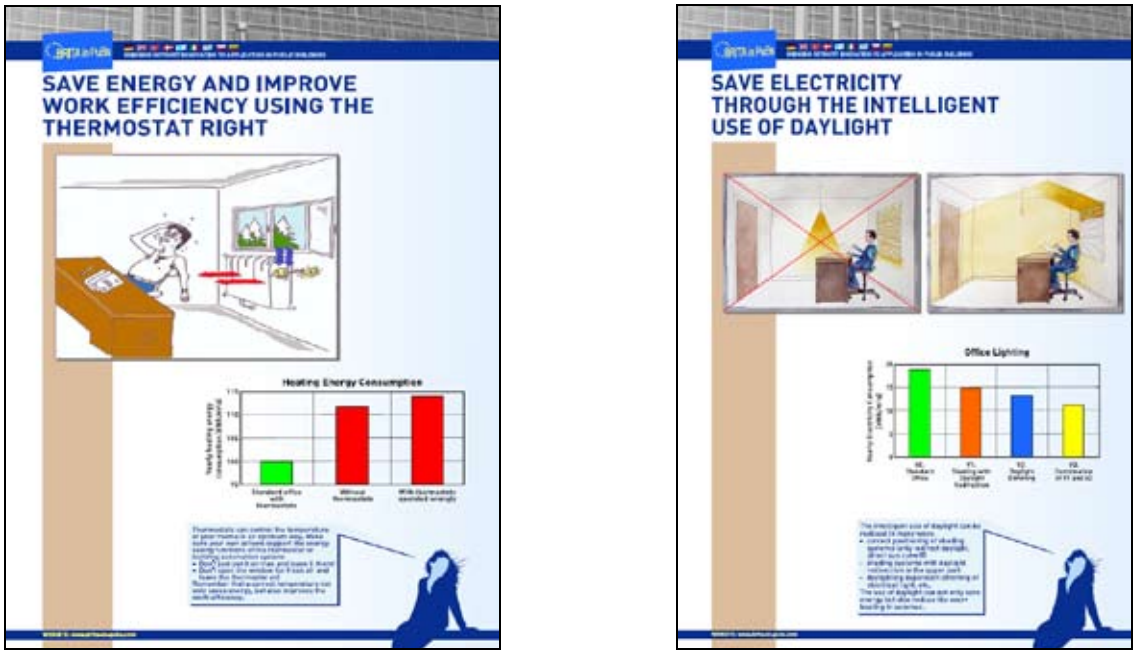

Figure 6 Examples of blackboard information sheets for training energy efficient user behaviour.

The demonstration buildings are listed in the following:

- nursing home Filderhof, Stuttgart (Germany)
- city college Plymouth (UK)
- community centre Borgen (Norway)
- church Hol (Norway)
- cultural centre Proevehallen, Copenhagen (Denmark)
- Evonymos ecological library, Athens (Greece)
- students centre “Brewery”, Brno (Czech Republic)
- main building of the Vilnius Gediminas University (Lithuania)

The project website (www.brita-in-pubs.eu) contains a building diary with updated information on the status of the demonstration projects. Figure 7 presents an overview of the buildings.

Figure 7 The demonstration buildings in the BRITA in PuBs project after the retrofits.

The general aim of the retrofits at the demonstration buildings was 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 was analysed by user comfort questionnaires. All buildings were monitored for at least one year. The diagram below compares the primary energy consumption before and after the retrofit for each building. The reduction factors of the buildings range between 1.2 and 4.1 and the average is 2.2 and therefore meets the goal (Citterio et al, 2008).

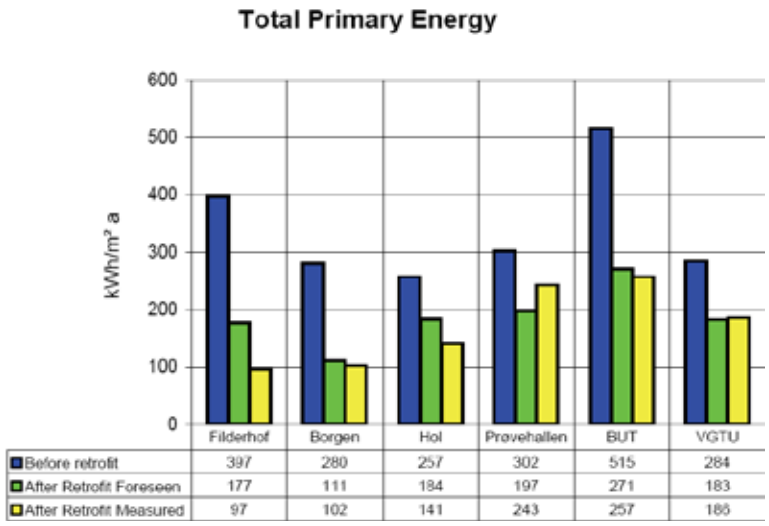

Figure 8 Comparison of the total primary energy consumption before, calculated after and measured after the building retrofits. The results of the Evonymos building are not yet available.

A Life Cycle Assessment of the retrofits has also been made within the project. The analysis showed significant energy and environmental convenience of the accomplished retrofits. In particular the energy and environmental payback times that resulted were very low, with values varying from 0.3 to 2 years. This means that in a relatively small time period the global energy and environmental investments are fully repaid by the obtained benefits. The relatively long useful time of the retrofits therefore produces large energy consumption savings and avoidance of emissions of large quantities of pollutants. It is interesting to note that the largest benefits are generally related to the insulation of the buildings: high efficiency windows, mineral wool and glass wool sheets, in fact, insulation allows great energy savings over a long period with a relatively short life-cycle impact. Even renovation of heating plants and lighting systems produces large benefits. In contracts, the use of renewable energy had lower benefits due to the low productivity of the plants with outputs sometimes lower than expected at the design stage.

The demonstration projects have their own national and international dissemination results, for example the community centre in Borgen had Chinese visitors and the wind generators in Plymouth have been presented in tv footages by both, the BBC and the local commercial television (see project website for the videos).

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 (Triantis et al., 2006). A detailed analysis of barriers for the energy efficient retrofit of public buildings was also made (Thunshelle et al., 2006).

The partners of BRITA in PuBs have written 14 retrofit design guidelines (see figure 9) 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.

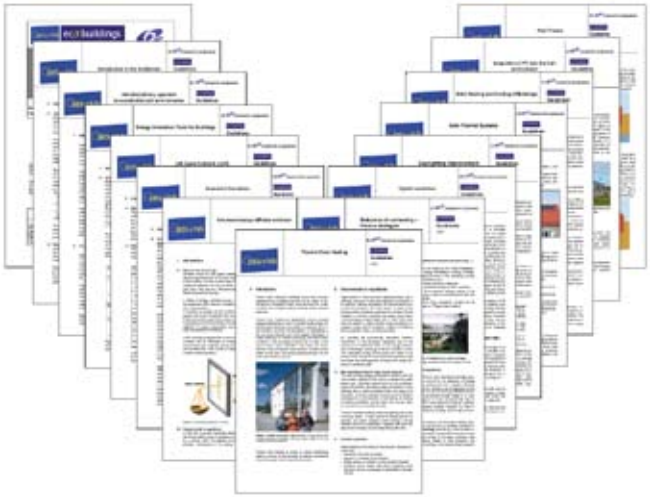

Figure 9 Cover pages of the available retrofit design guidelines (Thunshelle et al., 2008).

An electronic database offers many different types of information for decision-makers of public renovation projects. The BRITA in PuBs information tool BIT (Erhorn-Kluttig et al., 2008) presents in a 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 (Erhorn et al., 2003). 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. Figure 10 presents the title page of the BIT tool. The retrofit technologies and the case studies are described in detail in so-called viewers, see Figure 10. 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.

Figure 10 Title page of the BRITA in PuBs information tool BIT (left) and Retrofit Measure Viewer (here: Lighting Innovations) within the BIT tool.

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.

Another project result is the quality control toolbox. The energy efficiency of buildings should be confirmed in all major stages of a renovation project: planning and design, implementation, use, operating and maintenance. The energy and facility management costs can be optimized by using *BEMS* (Building Energy Management Systems). All major stages of a renovation project are described in the toolbox and put into practice by using new auditing tools e.g. review lists. The review lists are introduced in appendixes.

The demonstration projects and the other project results are documented and illustrated in the BRITA in PuBs brochure. The brochure, with the title page shown in figure 10, can be downloaded from the project website.

Figure 10 Title page of the BRITA in PuBs brochure containing information on the demonstration buidings and all other project results.

3. Conclusions

All four described Ecobuildings projects offer various interesting project results which are now available for use and/or download at the websites. The combination and close link between demonstration projects, socio-economic research and training plus dissemination resulted in a very good transfer of the lessons learned from the demonstration buildings and the combined knowledge of the participating experts to the target audience reaching from public authority decision makers to facility managers, students, building users to the general public. The main conclusion however is that the Ecobuildings concept by the European Commission is a key solution for the major challenge in building energy efficiency: the existing building stock.

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