**EULEB - European high quality Low Energy Buildings**

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**SUMMARY**

The European research project “EULEB – European high quality Low Energy Buildings” intends to provide information about good examples of energy efficient buildings in use, in order to reduce prejudices and lack of knowledge of many key actors of the building market. Therefore, a multilingual CD and website was produced, containing detailed information about 25 buildings from all over Europe including measured data about energy consumptions, construction costs, comfort and user acceptance. 150,000 copies of the CD resulting from this work have been disseminated in the beginning of 2007 through European magazines reaching the target groups of architects and engineers as well as investors and property developers all over Europe. Furthermore, all information is available on the website www.EULEB.info

The project was performed by a European consortium of five Universities and a European umbrella organisation and it was partly funded by the “Intelligent Energy Europe” programme.

**INTRODUCTION**

The energy consumption in Europe is rising from year to year. The replacement of limited fossil fuels by renewable energies is proceeding slowly. As a result, the reduction of CO2-Emissions is proceeding slowly, too.

The building sector plays an important role in the total energy consumption. In order to tap this potential for energy savings and reduction of CO2-emissions the energy-efficiency of buildings has to be improved as soon as possible.

One important measure to achieve these goals is the legislation for new and existing buildings. With the European “Energy Performance of Buildings Directive” (EPBD), which has to be turned into national laws by the European member states, an important step into this direction has been done.

But unfortunately energy efficient buildings are sometimes facing prejudices and image problems resulting from bad examples from the past. Many people mistrust the real energy efficiency in use, the quality of architecture, the user comfort and the cost effectiveness. Other people just have concerns about energy efficient buildings as a result of lack of information.

These prejudices and the lack of information can be reduced and eliminated by providing information and detailed data of existing good examples to key actors of the building market. With a collection of 25 European high quality low energy buildings and detailed information about their architecture, their building concept, their measured energy performance and their
building costs, EULEB helps to improve the image of energy efficient buildings and supports the implementation of the EPBD.

PROJECT TEAM

The EULEB project team consists of five European Universities of which the University of Dortmund coordinated the project and one international association. The Universities are represented by different institutes, which are working in the field of energy efficiency of buildings. They have formed a successful research and teaching network in which several projects already have been performed. The excellent knowledge of the team’s national building stock allowed a detailed identification of buildings from the five largest European countries.

The sixth partner was REHVA, the Federation of European heating and air-conditioning associations. REHVA is a 43 year old umbrella organisation, representing 30 member associations of European experts for building services. Thus, REHVA has direct contact to about 110,000 key actors of the European building market. They supported the project with the expert knowledge and their network which was used for disseminating the results.

Table 1. List of Project partners involved

| University of Dortmund, Lehrstuhl für Klimagerechte Architektur |
| London Metropolitan University, LEARN |
| Università degli Studi di Firenze, ABITA |
| Université de La Rochelle, LEPTAP |
| Universitat Politècnica de Catalunya, AiE |
| Federation of European heating and air-conditioning associations (REHVA) |

SELECTION OF BUILDINGS

A total of 50 public buildings have been identified, predominantly from the countries where the University Partners are situated. To cover the large variety of climatic conditions in Europe, buildings from the very far north (Scandinavia) as well as from the very south of Europe, (Mediterranean countries), were included. Out of the identified buildings, there had to be a selection of five buildings per University Partner for further examination.

For the selection of buildings a simple evaluation system was designed. In this first step, each building was evaluated concerning its qualification to the project. Seven categories (such as quality of architecture, energy consumption, availability of monitored data etc.) with different weightings were used in this subjective evaluation methodology. Low ratings in some of the criteria had to lead to a direct exclusion of a project (for example lack of monitored data).

After having evaluated the 50 identified buildings, a ranking of the buildings identified by each partner could be established, showing which buildings fulfilled the overall criteria best. This process led to the selection of 25 buildings from all over Europe.

SELECTED INFORMATION

The EULEB project should address to different target groups, namely architects, engineers, investors and property developers. All these groups have a very different knowledge background as well as different interests in terms of building information. As EULEB could never satisfy 100% of the different interests in all details, the challenge was to provide a basic set of
general building information. A number of details should address the different target groups and raise the user’s interest to search for more information.

Besides the different building use, the locations of the buildings from all over Europe result in a large variety of differences of the buildings’ boundary conditions, especially in terms of climate. Therefore a visualisation of the buildings locations with reference to the climatic zones of KOEPPEN was used to introduce the user to the influence of locations on the building design and building energy consumption.

![Figure 1. Locations and climatic zones of selected buildings and example of climatic data in EULEB](image)

Each building presentation starts with some general information about the exact building name, location address, relevant persons involved in the design and construction, information about the buildings’ areas and volumes etc. These information are accompanied by images (external and internal views) and plans (site maps, floor plans, elevations and sections) visualising the architecture of the building. To visualise the appearance and the atmosphere of the buildings, short professional video clips provide extra impressions beyond the static images and plans.

The climatic conditions are described in more detail by statistical diagrams and some figures, like the ASHRAE classification [1] which relates the climate to the energy consumption of buildings. The next sections give general descriptions of the building construction including the thermal quality of the building envelope and the general energy concept and technical systems.

Special features of the building concept, which are significant for the energy efficiency of the building, are described and visualised in more detail. These features have been grouped to the categories Insulation, Solar control, Lighting, Heating, Cooling, Ventilation, Materials, Renewable energies, Co-Generation and Rainwater use.

The energy performance of the buildings is evaluated with measured energy consumption. Where available, the consumption is separated by fuel type (electricity, gas, oil etc.) and load type (heating, cooling, ventilation, lighting etc.). This allows giving a detailed overview on the building’s energy performance and calculating the respective partly and total primary energy consumptions. All values are related to the building’s usable floor area and compared with national average and standard values where available.
The real building costs have been documented in relation to the usable floor area of the building. Where available, the total costs are divided by cost categories and national average costs for a similar building have been used for comparison.

![Figure 2. Example of Energy performance and construction costs in EULEB](image)

The visual comfort has been measured by luminance pictures, which have been taken and processed for all buildings in the curse of the EULEB-project. They give an impression of the luminance and possible glare effects in a typical room of the building.

In order to evaluate the quality of the buildings, user acceptance studies have been performed in all 25 buildings. Using a simple questionnaire with 12 questions concerning temperatures, air quality, lighting, comfort, user influence, architecture etc. allowed creating a detailed evaluation and an overall user acceptance.

![Figure 3. Example Visual comfort expressed by luminance pictures and results of post occupancy studies in EULEB](image)

Based on the building data described above, the “Benchmarking” section provides a comparison of the building costs, the energy performance and the user acceptance of all 25 buildings. These characteristics depend on many variables such as building use, climatic conditions etc. which have to be taken into account. Thus, in EULEB the buildings have been grouped ac-
According to building type and climatic zone. Although this of course does not take into account all relevant parameters (user influences, etc.) a rough comparison could be established.

With this compilation of building data, the general and specific interests in terms of design, technical details, energy performance and costs of the target groups Architects, Engineers and Property Developers have been addressed as much as possible.

**COMPARISON OF BUILDINGS**

The comparison of different buildings generally is a very sensitive process as many different boundary conditions like the use of a building, the climatic background etc. Still then, other factors like the occupants’ behaviour will have influences on the results and are very difficult to separate.

In the EULEB project, the 25 buildings have been compared in the section “Benchmarking” in the three main categories “Economy”, “Energy” and “Quality”. The buildings have been grouped by building type and by climatic zone. The climatic zones have been defined according to the ASHRAE-classification system [1]. This method takes into account the heating and cooling degree days of a certain location and thus takes into account a building’s energy demand resulting from climatic conditions.

The Economy-Benchmarking shows a significant variance of the total building costs, within one building type and on climatic zone. But discounting some extreme values, general statements can be found: The total building costs for office buildings constitute generally about 1400 and 2100 €/(m² usable floor area). For the educational buildings this value generally reaches between 1000 and 1500 €/(m² usable floor area).

![Figure 4. Comparison of building costs in EULEB](image-url)
Comparing the energy consumptions of the 25 buildings again brought a significant variance even within one building type and climatic zone. But again, a general statement could be, that for example for all three building types, a total primary energy consumption between 100 and 220 kWhPrim/(m² usable floor area) can be achieved.

**Figure 5.** Comparison of energy consumptions in EULEB

**Figure 6.** Comparison of overall user acceptance in EULEB
The overall user acceptance has been compared in the Quality benchmarking diagram. Generally positive results are obvious, independent of the building type and the climatic zone.

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Figure 7. Support by the European Commission

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REFERENCES