COST-EFFECTIVE LOW-ENERGY SOLUTIONS - A DEMONSTRATION PROJECT IN DENMARK - RESULTS FROM THE CLASS 1 EU CONCERTO PROJECT

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Abstract

The EU Concerto project Class1 commenced in 2007 and involves 5 countries: Denmark, Estonia, France, Italy and Romania. In Denmark 442 dwellings will be designed and constructed as low-energy housing units. The Concerto community also includes a kindergarten and an elderly center. The 4 other countries take part as associated municipalities – the direct target groups for the experiences learnt from Denmark.

The Class 1 project uses the demonstration projects to boost the technological development of 6 different key components, covering 3 areas: *Eco-buildings, Renewable Energy Supply and Intelligent Energy Management System.* Furthermore, the benefits of ultra-low energy buildings integrated with renewable energy in the form of biomass-CHP and solar heating energy supply will be demonstrated reaching a further reduced CO_2-emission level.

The paper presents the status and results of the project after 20 months of operation.

1. INTRODUCTION TO THE CLASS1 PROJECT

The municipality of Egedal has decided to strengthen the energy requirements for a new settlement to be erected in the municipality. During the years 2007-2011 a total of 442 dwellings will be designed and constructed with a heating demand corresponding to the new Danish low-energy standard referred to as "low-energy class 1" in a new settlement called Stenloese Syd. This means that the energy consumption will be 50 % below the new energy regulations. 65 dwellings were to be designed and constructed with a yearly heating demand of 15 kWh/m². Furthermore the Concerto community will include a kindergarten and an activity centre for elderly people.

The Class 1 project will use this strengthening of the energy requirements to boost the development of 6 selected key technologies/building components: slab and foundation insulation, window frames, mechanical ventilation with heat-recovery combined with heat-pumps, biomass-CHP, heat distribution for local district heating and user-friendly building energy management systems. Furthermore the economic and environmental benefits of ultra-low energy buildings integrated with biomass-CHP and solar heating based renewable energy supply is to be shown. The demonstration project is supported by specific design guidelines developed within the project, covering Indoor Environmental Quality and energy savings as well as requirements for monitoring and evaluation. The project also covers activities dealing with town planning and regulatory means and has eco-labelling as a cross cutting activity to increase the general awareness of ecological issues. The training activities defined in the project are targeted towards the technical personnel of the local authorities, the builders and the users in the associated municipalities. Finally, the dissemination activities will primarily focus on the associated observer municipalities in Estonia, France, Italy and Romania supported by the organisations around them. Secondly, the dissemination will be directed towards existing networks of cities and municipalities and thirdly towards the public in general.

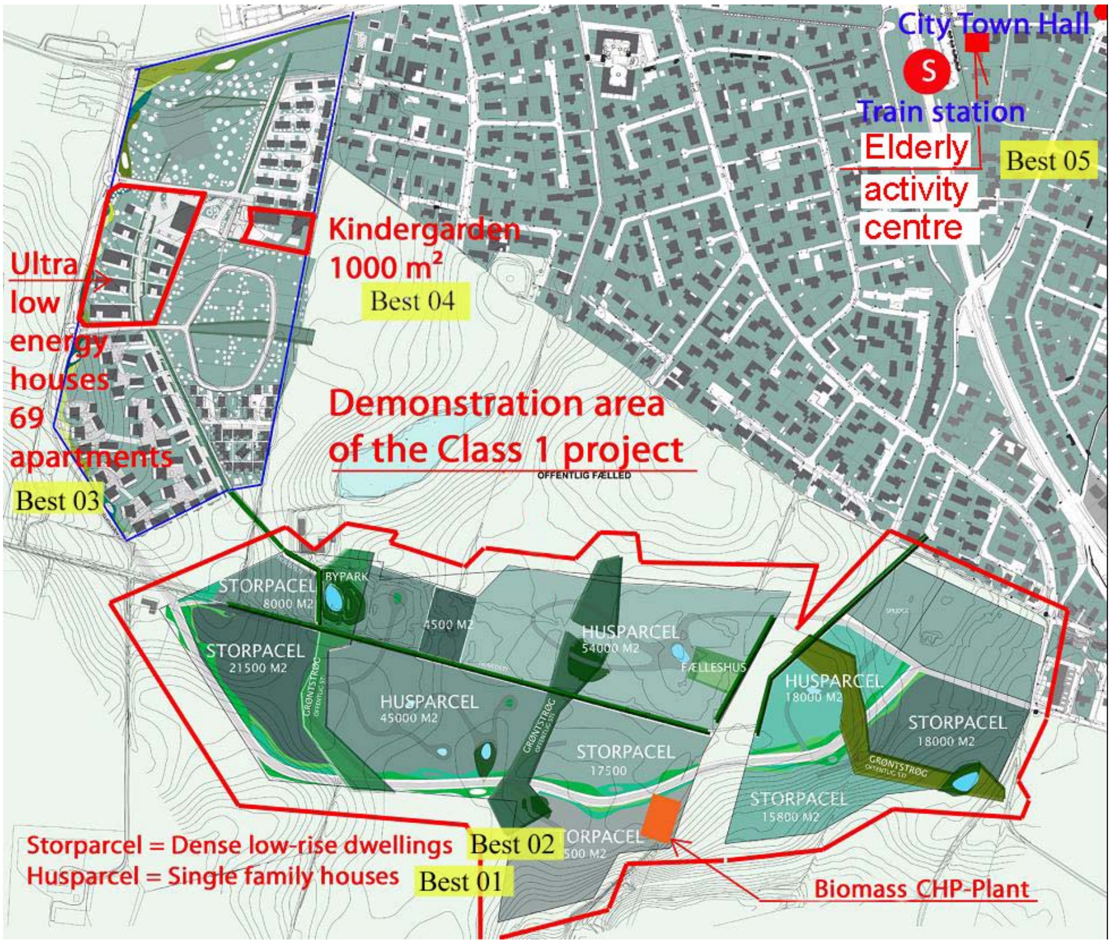

Figure 1. Overview of the Stenloese Syd settlement. "Best 0x" refers to the demonstration project identification number in the EU contract.

Energy classes

The Danish Building Regulation (BR) defines a building's energy consumption in relation to a so-called energy frame. For dwellings the energy frame includes heating, hot water and electricity used for pumps and ventilators, which are part of the heating and ventilation system and for institution and offices also electricity for lighting is included. If the calculation shows a cooling need this will be added as well, even if there is no cooling system installed. In the energy frame may be included production of heat and electricity with solar energy - solar thermal and solar cells. The calculation of the energy frame of a building is conducted according to "SBI-Guidelines 213" from the Danish Building research institute. The calculation takes into account the sun, personal production of heat and the buildings heat accumulative properties. Calculation is done using the tool Be06 (or other tools with the same kernel). It is a method based on monthly energy balances using monthly averaged weather data.

A dwelling which meets the energy requirements must be shown by the Be06 calculations to meet the building requirements expressed in the following formula:

Energy frame = 70+2200/A in kWh/m²/year, where A is the heated floor area.

Within the Danish Building Regulation two low energy classes have been defined. The definitions refer to the energy frame definition. The two classes are called low energy class 2 and low energy class 1, respectively. Where low energy class 1 refers to the strongest requirements.

Low energy class 2
A dwelling can be classified as a low energy class 2 house if the needed energy for heating, ventilation, "cooling" and hot water use (as defined in the energy frame) does not exceed 50+1600/A in kWh/m²/year, where A is the heated floor area.

Low energy class 1
A dwelling can be classified as a low energy class 1 house if the needed energy for heating, ventilation, "cooling" and hot water use (as defined in the energy frame) does not exceed 35+1100/A in kWh/m²/year, where A is the heated floor area.

Passive house
The so-called "Passive house" - concept has achieved widespread use in several countries in Europe. The term passive refers to the overall idea that the houses do not need a conventional heating system. The complete definition and much more about passive houses can be found at http://www.passivhus.dk/. The key technical requirements are:

- Net space heating demand: Below 15 kWh per year per m² net area
- Total primary energy: Below 120 kWh per year per m² net area
- Infiltration: Air change rate below 0.60 h^{-1} by pressure test with 50 Pa.

2. WORK PERFORMED AND ACHIEVEMENTS UNTIL AUGUST 2009

The municipality of Egedal has advertised the construction sites at the new settlement area Stenloese Syd for sale with special energy requirements for all buildings to be built according to the Danish low-energy standard class 1 or better. Furthermore the usage of solar energy for hot water preparation and heat pumps for heating in the single family houses is required.

During the first year of the project the municipality itself has constructed a kindergarten in compliance with the above restrictions and a social housing association (KAB - Copenhagen Social Housing association) has completed an ultra low-energy house project – comprising 65 dwellings. Besides, the constructions of the elderly centre and the 13 single family houses have commenced.

The photos below present an overview of the Stenloese Syd settlement from the air and two of the building projects during construction – the KAB social housing project and a single family house.

Figure 2. Photo of the Stenloese Syd settlement

 

Figure 3. Two of the building projects during construction

Evaluation of user preferences

One part of the demonstration activities deals with the evaluation of the user preferences to improve target future buyers/builders of low-energy houses. During the first 12 months of the project the methodology was determined and the initial interviews been carried out. The analyses and documentation is currently underway, a draft report has been produced and the final report will be available in the fall of 2009.

Legislative analysis

Also, proactive attempts, in order to promote low-energy settlements in the participating countries of the Class 1 projects, have been identified and documented to understand legislative and planning means in the process of promoting sustainable community projects more specifically. A draft report has been produced and discussed among the participants. The final report will be available in the fall of 2009.

Key product technological developments

Two industrial partners have made considerable progress in developing new and/or improved products more suitable to low-energy building project. They are: (1) the window manufacturer PRO TEC, who has developed a special low energy window towards a more competitive and flexible product – PRO TEC 7 and (2) Genvex, which has carried out the development of the HVPC ventilation unit with heat recovery and integrated heat pump for low energy houses – including new fans, an improved counter current heat exchanger and lesser pressure drops in the unit.

PRO TEC developments

PRO TEC has advanced the low-energy window PRO TEC 7. The Class 1 engagement has contributed to reducing production costs by 30 % by process changes and machinery investments. Compared to for example German passive house windows the product is vastly more cost-effective. However PRO TEC 7 is still about 10 % more expensive than traditional aluminium clad timber windows and now a very cost-effective solution. During the development process it is now possible to supply inward opening doors and tilt/turn windows and more is coming in the near future, (Haulrik and Mørck, 2008).

Genvex developments

GENVEX has advanced a mechanical ventilation system with heat recovery and integrated heat pump for house heating. HVPC is the further development of our product series VPC. The new product series will be developed in 3 sizes in order for us to be able to cover dwellings from 50 m^2 to 300 m^2. The products are designed for use in highly insulated dense dwellings in Europe and they must be able to observe the regulations of the different countries, among others be approved according to regulations and requirements of Minergie P+, Passive House and Low Energy Class 1, (Svendsen and Mørck, 2008).

HVPC will have the following improvements:

- New fans with lower energy consumption
- Counter current heat exchanger
- Less drop of pressure in the unit
- Full automatic control with lower energy consumption
- Adjustable compressor with frequency control
- Bypass
- Exploitation of solar energy at low temperatures.

EU Ecolabel

The aim of this activity is to integrate the EU Ecolabel through Ecolabel information dissemination to associated stakeholders, through use of Ecolabel products by building contractors and end users and by attracting enterprises to the Ecolabel scheme. The project has shown that it is very important to be thorough in the research and in particular to identify the decision makers as early as possible (before they take decisions on product use). A main barrier in integrating the EU Ecolabel is the lack of certified products available nationally. This is discouraging for building contractors who are not that willing to change to foreign suppliers because of unknown factors such as reliability, price and logistics. Ecolabel ignorance is also a main barrier and initiatives to overcome this must be prioritised so that the benefits of using Ecolabel products are made clear. Redefining targets and procedures are necessary to ensure the best possible results. One of the important issues that has emerged in this project is the necessity for "Ecolabel competence - training workshops" for the participants. It is important that municipality key personnel (purchasers, planners and other staff involved) are well informed and aware of the possibilities and benefits regarding the Ecolabel and Green product procurement. Future work will focus on "dense low rise dwellings" as this is a very promising area for introducing Ecolabel products and for training of key actors, (Paxevanos and Mørck, 2009).

Special guidelines for stenloese syd

Four special guidelines will be developed in the Class1 project covering the following subjects:

- Specific design guidelines for Stenloese Syd
- Review of existing guidelines presented as a grid of applicability for each country checking how they fit with national implementation of EBPD
- Effective monitoring in dwellings and (Building Energy Management System) BEMS integration
- Effective plants monitoring and BEMS integration

The two first of these activities have been completed and is presented shortly below.

3. SPECIFIC DESIGN GUIDELINES FOR STENLOESE SYD

A set of guidelines for designing low-energy houses and a suitable heating system is presented in a report (Citterio et al., 2008). The definition of low energy houses is bound to be dependent on the country and climate which it concerns. These guidelines have been developed for the Danish conditions and it should be noted that appropriate measures have to be taken if they are transferred to other countries. Generally, a low energy house is a house that uses considerably less energy to maintain comfort conditions than a house built according to the standard that is current practice at the location in question.

The guideline report is divided in chapters concerning the thermal envelope planning and design phase, the air tightness, the indoor environmental quality, the thermal comfort, the daylighting and visual comfort and finally the user influence on the energy performance.

Shown below are some examples of good thermal envelope technology solutions, but the guidelines also show examples of unnecessary insulation.

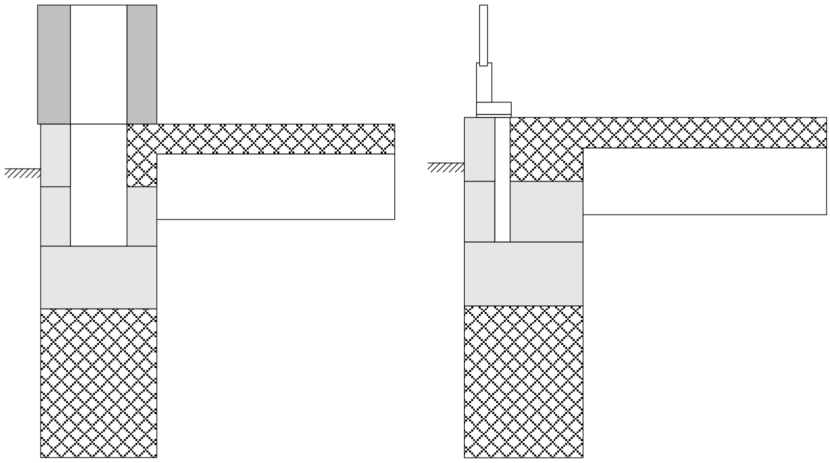

Figure 4. Sections of a joint between the outer wall/foundation/slab-on-ground respectively door/foundation/slab-on-ground

The insulation in the outer wall continues into the foundation. Both solutions are in terms of thermal technology good as the thermal bridges are reduced heavily because of the big insulation in the foundation. The contractors have paid much attention to minimizing the thermal bridges in the foundations.

Examples of unnecessary insulation

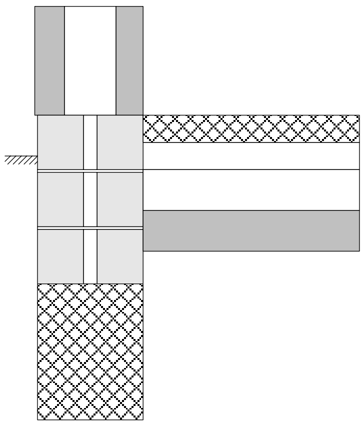

Figure 5. Section of a joint between the outer wall/foundation/slab-on-ground with three insulated light-weight concrete blocks in the foundation

Detailed analyses of different foundation have shown that it has no meaning to use an insulated third course and this can be replaced by a cheaper massive block.

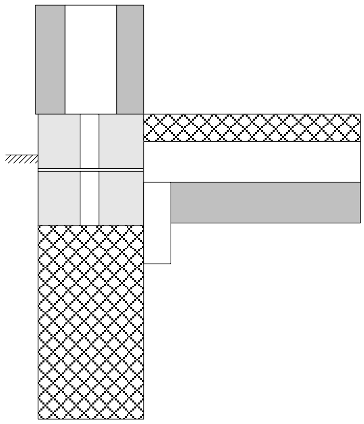

Figure 6. Section of a joint between the outer wall/foundation/slab-on-ground with vertical insulation inside of the foundation

Detailed analyses have shown that on well insulated foundations the inside vertical insulation has a very small influence on the linear loss coefficient.

Airtightness

There is a direct connection between the airtightness of a building and the energy consumption. Furthermore the airtightness has a big effect on the indoor climate. There should be a certain ventilation rate in a building, but it is crucial to be able to control, where the air enters and where it exits. When the air leaks through openings e.g. at windows and assemblies, it can create a draught, which lowers the indoor air comfort level. At the same time moisture begins to form in the construction when cold and warm air meet. Condensation in the construction constitutes a risk of mould growth and results in poor indoor climate.

Experience shows that leaks are often found at installations, assemblies and transitions between outer walls, floors, roofs, windows and doors. Problems often occur when there is a change of construction material or change from one building part to another. If the building has to be airtight, it is necessary incorporate airtightness right from the start of the project. A well organized design of the location of the vapour barrier and the principle for its unbroken continuity should be decided at the planning stage and should be clearly and unambiguously stated in the design material.

The advantages of building airtight can be summarized as follows:

- Energy saving
- Prevention of moisture damage
- Improved indoor climate (no draught/draught along the floor)
- Improved air quality (control of ventilation etc.)
- Improved sound insulation as direct airborne sound is discontinued.

The rules for airtightness in the Danish Building Regulations

New buildings should be airtight. Under normal conditions the demand for air change per hour for dwellings is 0.5 h^{-1} corresponding to 0.33 l/s m^2 with a room height of 2.4 m. In normal buildings, the demand for air change through openings in the thermal envelope should not exceed 1.5 l/s m^2 heated floor area at a pressure test of 50 Pa (average excess pressure and depression of the building). This corresponds to an infiltration rate of 0.13 l/s m^2 at normal pressure.
The local authorities can demand that a Blower-Door test should be made before issuing a permit to use the building. In a conventional building, it is permitted that approximately 1/3 of the air change takes place through infiltration.

Indoor environmental quality

A range of guides are available that deal with noise, lighting, ventilation etc. These books are very specific about construction methods. SBI Direction 196: The Indoor Climate Guide gives an overview and precise guidelines for planning buildings with respect to the indoor climate on a holistic basis. It is therefore a tool for consulting architects and engineers in their daily work and may also be useful for construction firms, clients and authorities as well as parties in the building process. The guide has 34 chapters, which can be read independently of each other.

The chapters are grouped in seven parts as follows:

- Indoor climate
- Requirements and guidance
- Planning, design, construction and operation
- Design tools
- Impact of the outdoor environment
- Functional requirements for thermal envelope and layout
- Construction elements and components.

The indoor air quality has a big influence as we spend most of our life indoors, at home and at work. The indoor climate should therefore be of such a character that it not only reduces the risk of discomfort, illness or symptoms, but also ensure pleasant conditions. A good indoor climate affects the concentration and working capacity positively.

In the Danish "The Indoor Climate Guide" the indoor climate is defined as:

- thermal conditions determined by air temperature, radiant temperature, air velocity and humidity in the air
- air quality described by the content of pollution as dust, humidity in the air, gasses and steam and therefore also smell
- static electricity described by the charging the people
- light conditions described by the light intensity, colour, contrasts and reflections
- sound conditions described by volume and frequency
- ion radiation described by radon concentration.

4. REVIEW OF EXISTING GUIDELINES PRESENTED AS A GRID OF APPLICABILITY FOR EACH COUNTRY

The second guideline activity reviewed existing design guidelines in the participating countries. The aim of this investigation was to evaluate the cross applicability of existing guidelines in participating countries and how they fit with national implementations of Energy Building Performance Directive. The first step was to carry out an enquiry about the existence and the contents of national or local Guidelines in participating countries: Denmark, Estonia, France, Italy and Romania.

The conclusions are that in general the Danish guidelines have been evaluated to have a good applicability in all the other countries. The summer conditioning with absorbing cooling systems (from Italian guidelines) have been considered to be not applicable in Denmark and Estonia. This can be explained by the facts that in Estonia and in Denmark there is a low solar radiation and the low summer cooling demand, but in France (not in the metropolitan area), solar cooling should have a good potential and are under experimentation.

The items that had a general consensus from all experts were the following:

- Building envelope and thermal insulation

- High efficiency boilers
- High efficiency air conditioning systems
- Thermostats and radiator valves to prevent overheating
- Cooling demand assessment
- Lighting systems efficiency standards and control systems
- Water accounting and use saving
- Low temperature floor heating systems
- High efficiency heat pumps
- Design process check.

All the guidelines proposed by the Danish, Italian and Romanian experts fit with the national implementation of EPBD in the related country, (Castellazzi et al., 2009).

5. PARTICIPANTS IN PROJECT

The main part of the project is carried out in Denmark and the 4 associated countries are receiving the results and lessons learned and are conveying it to their national situation. The table below lists the participants of the Class 1 project.

Table 1. Participant list

Egedal Municipality	Denmark
Cenergia Energy Consultants	Denmark
Danish Building Research Institute, Aalborg University	Denmark
Dept. of Civil Engineering, Tech. Univ. of DK	Denmark
PRO TEC Windows A/S	Denmark
Dansk Leca A/S	Denmark
BioSynergi Proces ApS	Denmark
Genvex A/S	Denmark
Logstor A/S	Denmark
Electronic Housekeeper A/S	Denmark
IB Aksiaal OÜ	Estonia
Valga Town Government	Estonia
Ente per le Nuove Tecnologie l'Energia e l'Ambiente	Italy
I Istituto Cooperativo per l'Innovazione	Italy
Commune di Bologna	Italy
Sustainable Urban Development European Network	France
Municipality of Begles	France
Association of the Local Development Promoters	Romania
Municipality of Odobeşti	Romania

6. EXPECTED END RESULTS, INTENTIONS FOR USAGE AND IMPACT

During the coming months (the project runs for 60 months) the next demonstration buildings are to completed, the biomass CHP plant combined with a large array of solar collectors is to be implemented and the monitoring initiated. The users will be followed and assisted and the lessons learned will be documented. Also the development of the next 4 key technologies will be completed. The training and dissemination will be carried out. One possible development is that one or more of the associated communities will also begin the implementation of new CONCERTO demonstration projects.

It is expected that the experiences, lessons learned and R&D carried out as part of the Class 1 project will pave the way for the development, design and construction of sustainable, low- or zero- CO_2-emission communities in the future.

The Danish Energy Research Programme is also supporting the project.

Further information about the Class1 project is to be found on the project website: www.class1.dk

7. REFERENCING

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