Demonstrating cost-effective low energy solutions in Denmark – Results from the Class 1 EU CONCERTO project

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ABSTRACT: The EU Concerto project commenced in 2007 and involves 5 Member States: Denmark, Estonia, France, Italy and Romania. In Denmark approximately 400 dwellings will be designed and constructed as "low-energy class 1" houses according to requirements set by the Municipality of Egedal. This means that the energy consumption is 50% below the existing energy regulations. Sixty-five dwellings have been constructed with a yearly heating demand of 15 kWh/m². The Concerto community also includes a kindergarten (completed) and a senior citizens centre. The Class 1 project uses these stronger energy requirements to drive the technological development of different components covering 3 areas: Eco-buildings, Renewable Energy Supply and Intelligent Building Energy Management System (BEMS). The technologies cover: windows, slab and foundation insulation systems, biomass gasification, local district heating distribution networks, ventilation heat recovery combined with heat pumps and BEMS. This paper describes the status of the project preliminary results and developments.

1 PROJECT OBJECTIVES

1.1 *Introduction*

The intention of the project Class 1 is to use the strengthening of the energy requirements to boost and drive the technological developments and to prove the economic and environmental benefits of ultra-low energy buildings (50% below the new requirements in the Danish Building Regulations) integrated with a renewable energy supply based on biomass and solar heating. The Class 1 project focuses on the optimisation of sustainable energy systems in local communities through an innovative integration of Renewable Energy technologies with ultralow-energy buildings.

The project also puts special focus on the Indoor Environmental Quality (IEQ) to make sure that the energy savings are met without reducing the IEQ standards set out in the design specification phase. The IEQ focus is one of the areas in which the Class 1 project involves partners from other EU member states (MS) who are experts in lighting and thermal comfort issues. Also trans-national cooperation is introduced for the socio-economic research part of the project, which deals with the user point of view (priorities, etc.) in the participating MS.

The Class 1 project demonstrates improvements within 6 individual technologies (windows, slab and foundation insulation systems, biomass gasification, local district heating distribution networks, ventilation heat recovery combined with heat pumps and BEMS) and an innovative integration of these technologies (with solar heating) which leads to improved cost effectiveness.

1.2 *Objectives*

There are 5 scientific, technical and "political" objectives of the Class 1 project:

1.2.1 *Optimise the integration of low-energy building technologies with supply (renewable and conventional) and distribution (heating and electricity) technologies.*

The heating season is reduced considerably when houses are designed for ultralow-energy use. The supply from a solar heating plant with seasonal storage is very difficult to achieve for a whole settlement in a cost-efficient way when some of these single-family houses are geographically “spread” over a larger area. *The original idea of the Class 1 project was to combine district heating from a biomass CHP plant and a central solar heating plant for the new dense, low-rise housing projects with heat-pump heating of the single-family houses, but currently the demonstration project is been changed to cover also some existing municipal buildings and to have them covered by the biomass CHP and the solar plants*. The objectives are to:

- Illustrate that a local distribution network can still be a viable option even when supplying ultralow-energy houses.
- Integrate and use the solar heating system storage tank(s) as buffer tanks for the CHP-produced heating.
- Demonstrate how this integrated supply system can be monitored and controlled by an advanced, yet easy to use, BEMS.

1.2.2 *Advance selected technologies within the 3 areas: low-energy building, renewable energy supply and distribution*

Six technologies that are crucial for the overall goals of achieving ultralow energy houses with a high proportion of renewable energy supply integrated in the supply system have been selected for further development in the project. The 6 technologies are:

- Windows.
- Foundation and floor slab insulation.
- A biomass plant CHP plant
- Low-loss cost-efficient piping system for local district heating distribution systems.
- Integrated heat-recovery and heat-pump system.
- Advanced user-oriented BEMS

1.2.3 *Improve the design, checking and verification procedures.*

Stipulating and checking special energy requirements to a certain neighbourhood is not an easy task. In many MS, the implementation of the Directive on Energy Performance in Buildings (EPBD) introduces new, stringent requirements to the energy performance of buildings or at least new requirements for showing how to comply with the existing requirements. To handle these new provisions in practice requires a certain set of procedures. Based on lessons learned, it is the objective of the Class 1 project to develop procedures that are both useful when a local authority decides to introduce tougher energy requirements (as is the case with Stenloese community) as well as for the general handling of the practical implications of the local implementation of the EPBD.

1.2.4 *Integrate the European eco-label in the building projects (houses and components)*

This objective addresses specifically the environmental considerations which concern the selection of products for the project and reducing the environmental impact of these products by incorporating the EU eco-label in the project.

In this objective, the EU eco-label will be incorporated in the various stages of the project from design and planning to construction and management.

The EU eco-label will be integrated through contractors and community officials so that the final users of the settlement (the residents) will be ensured a supply of less environmentally damaging products and knowledge to understand the EU eco-label, Paxevanos, and Mørck (2009).

1.2.5 *Demonstrate large-scale implementation close to market technical and economic conditions*

The implementation of new, tougher requirements is always met with scepticism from the building market professionals. Architects, contractors and manufacturers see things from different perspectives and they are instinctively almost always against new requirements.

To convince these groups and to pave the way for forthcoming tougher general energy requirements in the building regulations, it is imperative to demonstrate in a large scale and close-to-normal (business as usual) situation that the design and construction of ultralow-energy houses with a high degree of renewable energy supply is indeed a viable option.

In conclusion the objective is to pave the way for a faster introduction of the demonstrated ultralow-energy building technologies and the integrated renewable energy supply – in this case the biomass CHP plants in combination with solar heating systems.

2 STATUS OF WORK

The municipality of Egedal has advertised the construction sites at the new settlement area Stenloese South 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 constructed a kindergarten in compliance with the above restrictions and a social housing association (KAB - Copenhagen Social Housing association) has completed an ultralow-energy house project – comprising 65 dwellings. Besides, the construction of the senior citizens centre and 30 single-family houses have commenced.

The photos below present an overview of the Stenloese Syd settlement from the air.

Figure 1. Photo of the Stenloese South settlement.

2.1 *The demonstration buildings*

The Class 1 project encompasses 5 different types of building demonstration projects:

- 65 ultralow-energy social housing units – the KAB social housing project;
- A kindergarten;
- A centre for senior citizens;
- About 90 single-family houses;
- 4 dense low-rise building areas;

Of these targets, the first two have been met, the third is almost finished and about 30 single-family houses have been built. The first of the 4 plots for low-rise housing areas have been sold and a project is being developed.

2.1.1 *The KAB social housing project*

The project comprises 65 dwellings in two sizes: 82 and 110 m². The houses are built as row-houses and the construction is prefabricated room-size elements – meaning that each apartment consists of two elements put together at the building site. Thus construction time at the site is very short. The dwellings have been designed for a net heating load of 15 kWh/m²/y. This is well below the Danish low-energy class 1 standard which generally leads to net heating loads of about 25 kWh/m²/y. The first year's measurement shows a heating load of about 20 kWh/m²/y, which is probably due to leakage on the assembling lines. This is being mended in the last months of 2009. The dwellings are primarily heated by the ventilation air from a mechanical ventilation system with heat recovery. One-two radiators have been mounted to ensure that heating can maintain comfort temperatures in very cold winters. The houses are to be supplied with heat from the district heating network fed by the planned biomass CHP plant and a central solar heating system (also part of the Class1 CONCERTO project).

Figure 2. Photo of the KAB-ultralow-energy housing project.

2.1.2 *The kindergarten*

The new kindergarten for the Stenloese South area has been designed for low energy class 1 according to the Danish Building Regulations. The kindergarten has 2 heat pumps in series for space heating and one separate heat pump for hot water heating. Space heating is a floor heating system and it is striking to observe the very low temperatures were needed to heat the kindergarten – even in winter months. A mechanical ventilation system with heat recovery ensures good quality indoor air.

Figure 3. Photo of the kindergarten.

2.1.3 *The centre for senior citizens people*

An activity centre for designed for elderly people of the municipality and allowing them to relax with hobbies and other indoor activities. The centre has been designed for low energy class 1 and a net heating load lower than expected for this class. It is also heated by a heat pump and has mechanical ventilation with heat recovery. The construction principle is steel plates buried about 1 m in the ground and then insulated on both sides, reaching very low U-values with no thermal bridges.

Figure 4. Photo of the centre for senior citizens – under construction.

2.1.4 *Single-family houses*

About 30 single-family houses have been constructed or are under construction. They are all designed for low energy class 1 standard according to the Danish Building Regulations. They have a minimum of 3 m² thermal solar collector and are heated by individual heat pumps.

Figure 5. Photo of two single-family houses.

2.1.5 Intelligent *building* control

All the buildings of the Class 1 project will be monitored and controlled by an advanced BESM. The system will be targeted at users enabling them to monitor and control their own comfort and energy consumption. The system will be internet-based to reduce costs and enable residents to use their own computers for direct access to all data related to their own home and to comparative data from the other households. This will e.g. enable them to compare their own energy use with the average of all similar households. The users will have a number of different options, e.g. to set up a vacation period, where temperatures can be kept lower. If they return home earlier than expected, they can turn on the heat from an internet café anywhere in the world. The system will also hold a budget for the energy consumption and therefore allow the residents to compare their actual use with the budget.

2.1.6 *Evaluation of user preferences*

One part of the demonstration activities deals with the evaluation of the user preferences to improve targeting of future buyers/builders of low-energy houses. During the first 12 months of the project the methodology was determined and the initial interviews carried out, Quitzau, Munthe-Kaas, Hoffmann and Elle (2009).

The project in Stenloese South has been groundbreaking for Danish low-energy building projects. Though hampered by the financial crisis, the project has shown that it is possible for a municipality to promote low-energy building on market terms. The project is important as a showcase for low energy buildings in various ways. Firstly, it is an example of proactive municipal involvement in environmental issues, secondly it is an example of how low-energy dwellings do not have to compromise when it comes to comfort and thirdly it has given important experiences with user preferences and the role of the building industry. Finally, it has contributed to develop the competences of building industry.

The project is to be viewed as a success as it has documented it possible to promote low-energy dwellings for ordinary people on market terms. The newcomers, clients as well as tenants, seem to be perfectly ordinary inhabitants in those types of dwellings. Their main motivations for moving to the area, was the price and location and the possibility to live in a newly built home. It is also worth to mentioning that a great deal of the newcomers has moved primarily because they were obliged to, for example by a divorce, or because of dissatisfaction with their former dwelling. It is evident that environmental standards by themselves will hardly work as a motivating factor for the main part of clients or tenants outside the greenest segment. Even though it is generally viewed as a positive asset of a dwelling, the low-energy aspect does not seem to have been the main priority for any significant part of the population of Stenloese South. From other research on moving habits and dwelling preferences, we see that moving mainly has to do with changes in the life of the individual or family, which makes the current dwelling inadequate. The choice of a new dwelling is also dependent on several factors, such as economy, location and transportation, before people consider the environmental profile.

However, though not the main driver, it is worth mentioning that a big majority of the respondents in this survey seems to like the idea of municipal environmental involvement. Generally, low-energy dwellings and environmentally sound projects are viewed as positive.

Legislative measures seem to be an effective way to ensure a more environmentally sound building industry as the client/industry relation seems to create deadlocks where neither part is willing to take the initiative to innovate voluntarily when it does not seem economically profitable. As new opportunities emerge - it is now possible to include environmental demands in local planning - it is much easier for municipalities to stipulate low energy requirements through legislation, though it still requires quite a lot of work to manage the developmental processes as neither clients nor industry have much experience with low-energy requirements.

Information about the consequences of building and living in low-energy dwellings might be a central issue. Construction budgets of 5 to 10 years might help visualize the benefits of energy efficient housing. Also, specific guidance in the choices of technology might be a good idea, as long as the building industry does not have sufficient experience to give competent advice. In the case of single-family houses it might be a good idea to involve the clients in the new residential area in the early stages of the process, as collective solutions might mean even less energy consumption than in individual low-energy dwellings. This kind of project might also mean that the impact on society through “ambassadors” might increase, as the clients (or tenants for that sake) have more ownership of the project. This is of course conditional on the process and the dwellings running smoothly.

On one hand, it is problematic that the newcomers to Stenloese South did not choose the area because of the environmental profile, as it makes it difficult to sell new building projects with energy efficiency as an argument. On the other hand it seems that the newcomers to Stenloese South are perfectly ordinary people and the project thus documents that it is possible to work with low-energy building projects on market terms.

2.2 *The development of products*

During the first 12 months period the development work for the windows - Haulrik and Mørck (2008) and the heat recovery heat pump system - Svendsen and Mørck (2008) have been completed and a considerable part of the development work for the district heating network innovation and the bio-mass CHP-plant have been undertaken.

2.3 *Participant list*

The main part of the project is carried out in Denmark and the 4 associated MS receive the results and lessons learned and convey and implement them in their national municipalities. The table below lists the participants of the Class 1 project.

Table 1. Participant list.

Entity	Country
Municipality of Egedal	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

3 CONCLUSIONS

In the coming months (the project runs for 60 months) the next demonstration buildings are to be 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. A guideline activity was to review existing design guidelines in the participating MS. The aim of this investigation was to evaluate the cross applicability of existing guidelines in participating MS and how they fit with national implementations of the Directive on Energy Performance of Buildings. The first step was to do a survey on the existence and the contents of national or local guidelines in the participating MS: Denmark, Estonia, France, Italy and Romania, (Castellazzi, Citterio, Mørck, Thomsen, Kase, Charlot-Valdieu, and Balica, (2009).

The conclusions are that in general the Danish guidelines have been evaluated to have a good applicability in all the other MS. 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 a low summer cooling demand, but in France (not in the metropolitan area), solar cooling should have a good potential and is being developed.

The items that had a 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 water 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 their respective MS, Castellazzi et al., (2009). In general there seems to be a lack of up-to-date design guidelines for dwellings of different categories. With present low-energy requirements and wishes for sustainable buildings the guidelines developed 10 or more years back are outdated.

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*

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