COST-EFFECTIVE LOW-ENERGY ADVANCED SUSTAINABLE SO1UTIONS – CLASS 1

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1 Abstract

The Municipality of Egedal has decided to strengthen the energy requirements for a new settlement to be erected in the municipality. In the years 2007-2008 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. 69 dwellings will be designed and constructed as so-called "passive house" buildings 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 and drive the technological development of 6 selected technologies/building components covering the 3 areas: Eco-buildings, Renewable Energy Supply and intelligent energy management system and to prove the economical and environmental benefits of ultra-low energy buildings integrated with biomass- and solar heating based renewable energy supply. 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 about ecological issues. The training activities defined in the project are targetet towards the technical personnel of the local authorities, the builders and the users. Finally, the disseminaton activities will for one thing 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.

2 Project objectives

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

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 ultra low-energy use. The supply from a solar heating plant with seasonal storage in a cost-efficient way is very difficult to achieve for a whole settlement when some of these single-family houses are geographically “spread” over a larger area. The idea of the CLASS 1 project is to integrate a bio-mass CHP plant with heat pump heating of the single-family houses with summer solar heating for domestic hot water. The objectives therefore also are to:

1. Illustrate that a local distribution network can still be a viable option even when supplying ultra low-energy houses.
2. Integrate and use the solar heating system storage tank(s) as buffer tanks for the CHP-produced heating.

3. Finally, to demonstrate how this integrated supply system can be monitored and controlled by an advanced, yet easy to use, Building Energy Management System.

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

Six technologies that are crucial to the overall goals of achieving ultra-low energy houses with a high share of renewable energy supply integrated in the supply system have been selected for further development in the project. The six technologies are:

- Windows.
- Foundation and floor slab insulation.
- A bio-mass 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 Building Energy Management System

3. Improve the design, checking and verification procedures.
Setting and checking special energy requirements to a certain neighbourhood is not an easy task because of the following considerations:

a) The requirements have to be defined and presented in such a way that they appear reasonable. This means that they have to be presented along with suggestions for how to reach the requirements and economical calculations showing the expected benefits (e.g. payback time of the additional costs).
b) A procedure/methodology has to be defined for the builders/owners to show how they comply with the requirements (e.g. what certificates are necessary for components such as windows, heat recovery units, what design calculation is required, etc.).
c) The building applications from the owners/builders have to be dealt with by the local authority, who have to give feed-back to the builder/owner about missing information or not correct assumptions (e.g. wrong window area in the calculations).

In many countries the implementation of the building energy performance directive 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 rules 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.

4. Integrate the European ecolabel in the building projects (houses and components)
This objective addresses specifically the **environmental considerations** which concern the **selection** of products **associated** to the project and reducing the environmental impact of these products by incorporating the EU ecolabel in the project.

The meaning of associated products is defined as any products used in the project other than those products directly related and included by the above objectives.
These include:

- Products used in the building and maintenance of the houses and common buildings such as hard floor coverings, paints and varnishes, lubricants and cleaning products
- Products used by the residents such as appliances, indoor paints, paper products, cleaning products and textile products

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

The EU ecolabel 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 ecolabel.

5. Demonstrate large scale implementation at close to market technical and economical conditions

The implementation of new, tougher requirements is always met with scepticism from the building market professionals. Architects, contractors and producers see things from different perspectives and they are instinctively almost always against new requirements.
The architects: because they feel that the requirements limit their possibilities for creative building design.
The contractors: because they have to introduce new ways of doing things and their obvious claim is that costs rise when they have to do this.
The producers: because they think that this might cause them to loose market shares (for example brick manufacturers).
These stakeholders fight against new tougher requirements and try to convince the politicians that these requirements are absolutely not viable, not cost-efficient, etc. To convince these groups and to pave the way for forthcoming tougher general energy requirements in the building regulations, it is important to demonstrate in a large scale and close to the normal (business as usual) situation that the design and construction of ultra low-energy houses with a high degree of renewable energy supply indeed is a viable option.
In this particular case the additional investments are viable with a pay off (return for investment) in a reasonable amount of years because of EU-support to this demonstration project.
With the present situation the EU-support can be said to make up for a "missing" raise in energy prices of 25% - expressed differently, if energy prices where 25% higher the EU-support will also act as a catalyst to drive the development of the 6 technologies mentioned above to a faster market introduction and reduces the costs which in turn reduce the amount of years before the additional costs of similar projects reach the break-even cost situation (before energy prices have raised 25%).
In conclusion the objective is to pave the way for a faster introduction of the demonstrated ultra low-energy building technologies and the integrated renewable energy supply – in this case the bio-mass CHP plants in combination with solar heating systems.

3 The demonstration area/project

The Class1 demonstration project will be carried out in a new settlement area Stenloese Syd of the Municipality of Egedal. This new area is located to the South of the town of Stenloese. For the first phase of the inhabitation of this new settlement the municipality of Egedal (then: Stenloese Municipality) decided to impose certain requirements to the buyers of land:

-No PVC allowed
-No pressure impregnated wood allowed
-Rainwater has to be utilised
-The energy demand for space heating should not exceed 30-34 kWh/m²/year (depending on building type - row houses or single family houses). In spite of these requirements all the land area was sold quickly out.

The location of Stenloese is shown on the map of Denmark to the right.

The **second phase** of the development of Stenloese Syd has been selected to be the demonstration site for the Class 1 project. For this phase the Municipality of Egedal has

decided to continue the good experiences from phase 1 and has made an official decision in the Town Council to further strengthen the energy requirements for all the buildings to be erected there. In this second phase In the years 2007-2008 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". This requirement means that the energy consumption will be 50% below the new energy regulations introduced with the implementation of the EPBD (Energy Performance of Buildings Directive) in Denmark in 2006 (which are app. 25 % lower than the previous regulations). Another 69 dwellings will be designed and constructed as so-called "passive house" buildings 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 buildings will be supplied with energy from an integrated bio-mass CHP plant, electrical heat-pumps and solar heating systems.

Calculations of the economy of reaching the low-energy class 1 level show that with the current energy prices this is not yet cost-effective, which the requirements for phase 1 were. Therefore there is a need for financial support to the builders and developers to reach reasonable pay back times. The demonstration support from the CONCERTO programme is therefore a prerequisite to make this happen.

The exact location of the Class 1 project area appears from the map on fig.2.

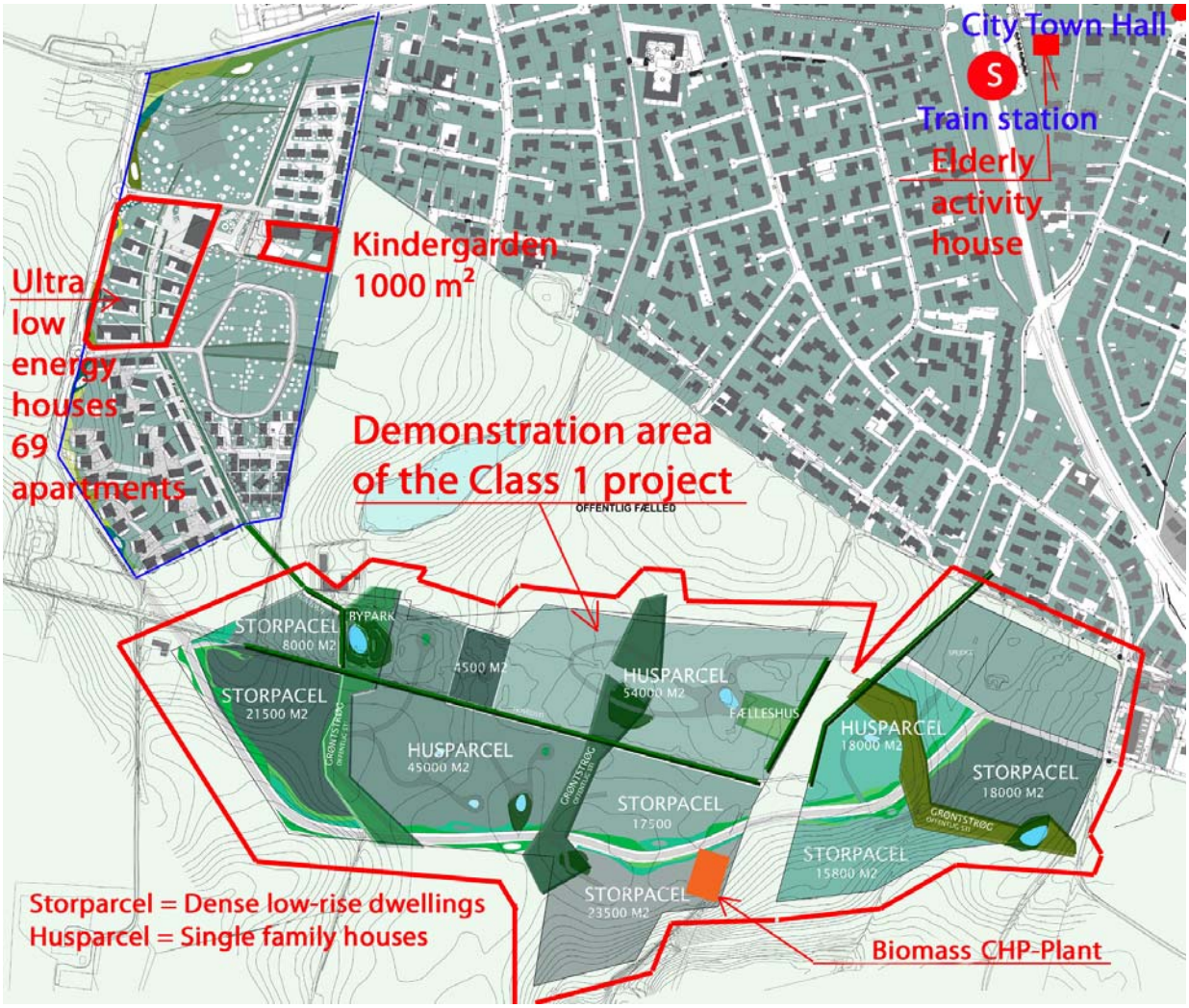

Fig. 2 Map of Stenloese showing the demonstration site - 2nd phase of Stenloese Syd

4 Advancement of selected technologies

The underlying idea behind the objectives of the Class 1 project is to focus on the solutions, technologies and methodologies used to accomplish the goals of the demonstration projects. This is not to say that the successful completion of the demonstration project is not important as a showcase and proof of that ultra low-energy houses can be built and how it is done.

The present situation for most building component manufacturers is that they are busy serving the market with present solutions and generally do not develop their products to adhere to or surpass future energy requirements until it is necessary. The possibility of providing a product to 511 dwellings and EU plus financial development support in the Class1 project, however, affords a significant incentive to motivate the manufacturers in developing a 'next generation product. The development process will be aiming at cost-efficient components suitable for ultra low-energy housing projects.

I. Windows: Glazing with low U-values are readily available on the market today. However, windows that combine low-U-values frames, wall integration possibilities with low or no thermal bridges and architecturally pleasing design at a reasonable cost are hard to find. Often building designers choose less efficient (with higher thermal losses) windows because of their appearance and price. The objective is therefore to develop competitive windows for the market which meet the requirements of low U-values, are cost-efficient and at the same time meet the "requirements of the eye".

II. Foundation and floor slab insulation: The thermal bridges along the foundation and the losses towards the ground are becoming of greater importance as the general insulation level of the buildings increase. Floor heating systems are often used in low energy houses - for good reasons with respect to comfort and low temperature needs from the supply system (reduce losses in the distribution system and is preferable in combination with heat pumps and solar heating). The efficiency of floor slab insulation and foundation becomes even more important when floor-heating systems are used. Despite that, not enough emphasis is put on to these parts of the building fabric, which in many cases in the past has lead to excessive losses and thus the goals of low-energy building projects were not met. The objective is therefore to develop simple cost-efficient and well-documented solutions that are easy to integrate in the building design for the building designers – applicable for different wall construction types (for example: light wooden walls or heavy back walls and light coverings, etc.)

III. A bio-mass gasification plant with CHP – production: Bio-mass in the form of wood chips or wood residue product is available in quite large quantities in many European countries and has therefore already gained some interest to be used as a renewable energy source. However, simply burning the (often wet) wood chips is not as easy as it sounds, and as a result several initiatives have been launched to try to gasify the wood chips and then use the gas for either gas furnaces or a CHP engine. The Danish company BioSynergi has patented a new gasification process and erected a first pilot plant at a district heating plant (in a town called Graested). The objective is to develop this plant into a 2nd generation complete gasification CHP plant with a large market potential.

IV. Low-loss cost-efficient piping system for local district heating distribution systems. When heating energy demand gets lower than a certain threshold the traditional district heating system solutions can not longer be used to serve the buildings in a viable way for two reasons: 1. The losses in the distribution get too high in relation to the demand that is covered, 2. The expenses in installing the distribution system are too high in relation to the load covered, which means that the fixed heating energy price will have to be unreasonable high to pay for the installation over the payment

period. In parenthesis it can be mentioned that even for a natural gas distribution system – the low energy loads generate the same economical problem to get the installation paid. On this background the objective is to develop the distribution pipes and connection system - for a dense, low-rise housing area - to become technically and economically viable – also for ultra low-energy dwellings.

V. Integrated heat-recovery and heat-pump system.
When the heating energy demand for individually heated homes is reduced to the ultra low-energy level which will be the case for the Class 1 buildings a traditional hydronic heating system is no longer a viable solution. As explained above the distribution system's installation costs and losses especially for sparsely located single family houses. The installation costs of a traditional hydronic system to be heated form a gas or oil burner, which will be high relative to the load to cover must also be considered and added to the cost. Electricity and a heat recovery system for ventilation air are installed anyway in an ultra low-energy building. It is therefore an almost obvious solution to combine heating by heat pump(s) with the heat-recovery system and use the mechanical ventilation system to distribute the heat. These systems do exist, but it is the objective of the Class 1 project to develop this solution further towards a truly cost-efficient solution.

VI. Advanced user-oriented Building Energy Management System
It has been experienced a number of times that the user influence on the energy performance of buildings (low-energy or standard) has a significant impact. For identical houses this can lead to a factor 3 in differing performance. In the Class 1 project, special effort will be devoted to user training to minimise this impact. This training will be based on on-line information from a BEMS system presented to the users in a clear and intuitively understandable way. The BEMS system is also needed for the optimum control of the integrated Renewable Energy supply system mentioned above. Thus the objective of this development is to produce an affordable individual housing unit that can serve the purpose of user-training by showing the users the results of their use of the house and comparing this to the ideal and/or average performance. This unit will be integrated in an overall BEMS system that controls and monitors the supply for the whole neighbourhood.

5 Further Research and dissemination activities

A number of activities have been identified to support the demonstration project, to assure its success and to maximise the benefits from the project:

- Development of comprehensive, yet easy to use design guidelines, and design checklists covering not only the low-energy requirements but also the Indoor Environment Quality (IEQ), dealing with daylighting and thermal comfort
- Development of methodologies/protocols for the verification of proposed building projects to reach the goals. This also includes practical and economical methodologies for self-checking that the desired goals will be reached with the proposed design – and for checking the buildings during the construction process (a continuous commissioning process).
- Socio-economic analysis focusing on the preferences of the users.
- Legal framework analysis reviewing the planning and regulatory means in the participating countries.
- Analysis of the integration of Renewable Energy supply in the form of bio-mass gasification based CHP, heat pumps and solar heating and the distribution networks for the low-energy housing settlements of Stenloese Syd.
- A cross-cutting Eco-labelling activity that will include product selection as well as training and information activities.

- Monitoring of the energy consumptions of the new settlements and the energy flows and losses in the distribution network.
- Develop user training material – both in relation to best use of their houses for optimum comfort and lowest energy consumption and - as a separate activity - about the choice of ecolabel products.
- Dissemination of the acquired experience on the municipal level (setting requirements and controlling that they are fulfilled) to the local politicians
- Dissemination of the technical experiences to building professionals. Part of this dissemination will be the marketing carried out by the building component manufacturers.

Parallel with the marketing of the technologies, the project dissemination activities will be directed towards European towns and communities. The associated observer communities and municipal organisations will follow the Stenloese Syd project closely through all the phases and will therefore benefit from the lessons learned directly. The dissemination will use the European city networks within the project partner list (SUDEN, Nuovo Circondario Imolese, Association of the Local Development Promoters Vrancea (APDL) external networks like "climate alliance", "greenprices" and Energie-cites.

Expertise in indoor comfort and daylighting is introduced through mayor players in this area who are partners in the project (ENEA and ENTPE) and the experiences from other international cooperation efforts, for example the Commissioning Annex of the IEA ECBCS programme will be followed closely through personal contacts at Cenergia, SBi and ENEA.

The overall idea of the project and (how) the conceptual interactions between its activities are illustrated on figure 3.

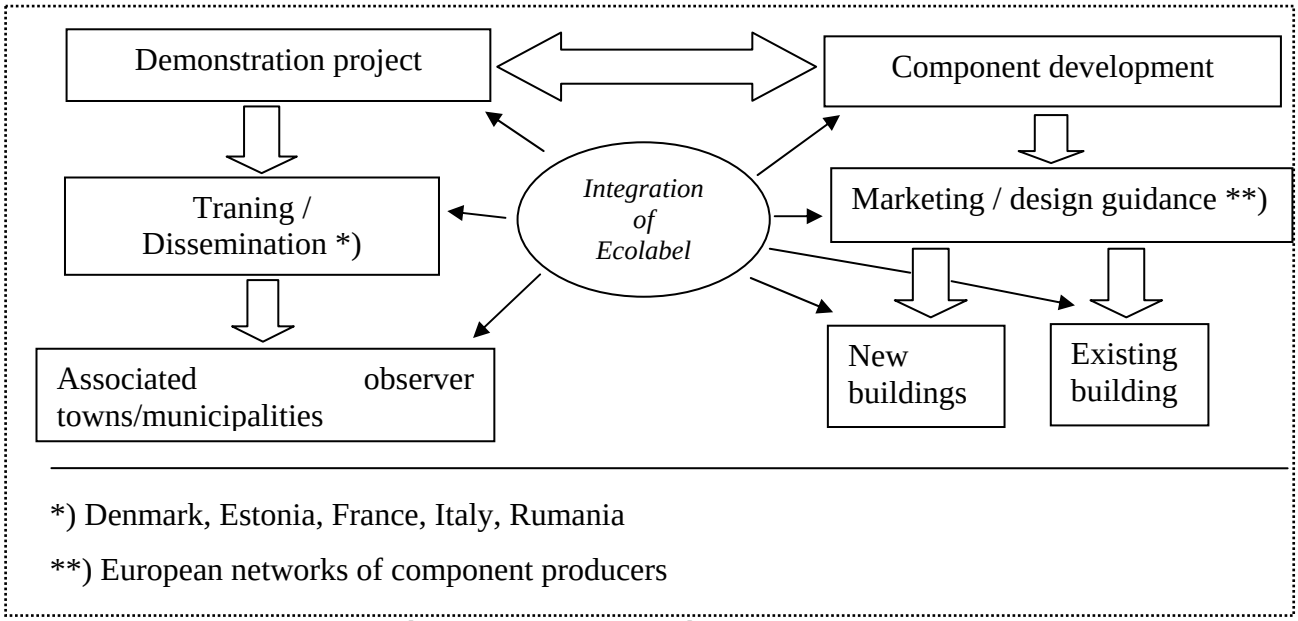

Fig. 3 Class1 project conceptual overview.

6 Participants

Five European countries participate in the project. The main 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. Besides participants from Italy and France are acting as work package leaders. The table below lists the participants of the Class 1 project.

Egedal Municipality	Denmark
Cenergia Energy Consultants	Denmark
Danish Building Research Institute	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
TAC 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
Comune di Bologna	Italy
Sustainable Urban Development European Network	France
Municipality of Begles	France
Association of the Local Development Promoters	Romania
Municipality of Focsani	Romania

7 Status

The contract with the EU has not yet (May 16, 2007) been signed, but the contract is under preparation. The Danish Energy Research Programme (EFP) is supporting the project.

8 References

As soon as the project is up and running more information will be found at the web-address: www.class1.dk.