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Summary

In the Nordic Innovation Centre Project, SuccessFamilies, the main objective is to change the business environment in order to speed up the implementation of sustainable renovation of single-family houses – proposing new service concepts that will combine both the technical solutions, financing services as well as other promoting issues to overcome the behavioural, organizational, legal and social barriers that exist in sustainable renovation. A starting point for such a change has been to get an overview of the existing sustainable renovation concepts, i.e. full-service concepts and technical concepts. The paper describes a few Nordic examples of full-service models for renovation of single-family houses which entered the market recently and the provisional success of these concepts. The existing Nordic single-family house renovation market is dominated by a craftsman based approach with individual solutions, traditional warehouses ”do-it-yourself-shops” and some actors marketing single products. To speed up the implementation of sustainable renovation of single-family houses there is a great need for full-service packages. Existing technical renovation concepts, typically focusing on application of only a few of the available technical solutions, have not been successful in realizing large scale energy efficiency gains.

Keywords: Single-family houses, Sustainable renovation, Full-service concepts, Technical concepts

1. Introduction

In a Nordic Innovation Centre Project (2009-2012) named Successful Sustainable Renovation Business for Single-family Houses or in short SuccessFamilies (NICe project number 08191 SR), the main objective is to change the business environment in order to speed up the implementation of sustainable renovation of single-family houses – proposing new service concepts that will combine both the technical solutions, financing services as well as other promoting issues to overcome the behavioural, organizational, legal and social barriers that exist in sustainable renovation. A starting point for such a change has been to get an overview of the existing sustainable renovation concepts, i.e. full-service concepts and technical concepts.

Buildings vary in age, size, architecture, technical standards, and location. In addition to these, availability of skilled work force, financing mechanism, and above all the awareness, interest and demographic characteristics of the occupant influence the form and degree of renovation of buildings. Hence, a standard renovation concept may not be applicable to all types of typical buildings. Each renovation project with different framework conditions may need to be evaluated separately. The concepts are described with this constraint in mind.

The results presented may be useful for everyone involved in sustainable renovation of residential buildings, especially single-family houses.

2. Definition of sustainable renovation concepts

2.1 Sustainable renovation concept

The term “sustainable” includes many environmental, social and economic indicators. In the mentioned project, sustainable renovation is defined with emphasis on primary energy use, but without disregarding the other indicators. A wider definition is for example used by Botta [1]. For a building, primary energy use is the energy used to produce the energy delivered to the building. It is calculated from the delivered energy and exported amounts of energy carriers, using conversion factors. Primary energy includes non-renewable energy and renewable energy. If both are taken into account it can be called total primary energy [2]. A sustainable renovation concept is defined as:

”*A concept that results in cost-effective renovation of a house with substantially better energy performance, coupled to a mainly renewable energy supply system, and improved indoor environment. The level of total primary energy use should be preferably equal to a new house built according to standard building code requirements or better*”

This definition is considering that there might be limited possibilities for introducing energy efficient renovation measures in some buildings, e.g. those worthy of preservation.

To ensure that renovated houses can compete on energy performance with new houses when they are sold, house owners may want to consider the government's plans for introduction of low energy standards for new houses as minimum requirements.

2.1.1 Governmental regulations

In the current Danish Building Regulations [3] two low energy classes are in force as optional possibilities: low energy class 2 and low energy class 1. The two classes are defined as having a calculated energy performance that is respectively 25 and 50 per cent better than the minimum energy performance for new buildings. In 2010 it is planned that low energy class 2 will be the new energy performance limit in the Building Regulations (expected to be issued at the end of June 2010 and in force at end December 2010) and in 2015 it is assumed that low energy class 1 will be the minimum requirement. It is the government's target that by 2020, all new buildings use 75 % less energy than new buildings constructed according to the current Building Regulations. Similar initiatives and plans are ongoing in Sweden and Norway with the purpose of establishing a definition and a development towards low energy buildings [4]. Also in Finland, governmental guidance towards better energy-efficiency in buildings is strong. However, the main initiatives have been different than in other Nordic countries. The strongest efforts have dealt with continuous tightening of building codes of thermal insulations of buildings [5]. In general, the current recast of the EPBD (Directive 2002/91/EC on energy performance of buildings) is an opportunity for the European Commission to introduce a request to member states to define very low-energy buildings at national level, to draw up a national strategy towards this level of energy performance, and to put focus on upgrading energy performance of the existing building stock.

2.2 Full-service concept

A full-service concept can be defined as a documented series of actions that can be repeated and that produces individual renovated buildings aiming at fulfilling the defined requirements optimally. The term full-service renovation concept indicates that all relevant steps necessary for the renovation of the building are included - from planning, over demolition to cleaning and maintenance afterwards. Typically, the requirements are defined by the homeowner and building code, e.g. requirements to heat loss (U-values), energy performance (energy consumption), indoor environment (indoor air quality, thermal comfort and daylight) and architectural quality. Some full-service concepts described in this paper may not include technical measures that qualify them to be “sustainable” according to the definition but they are included due to the lack of concepts in the participating countries.

2.3 Technical renovation concept

A technical renovation concept is defined as a package of solutions targeted to a certain category of house (type and age). The package of technical solutions carried out during an overall or step wise planned renovation is a good combination of the full range of technical solutions, especially in order to reach a low energy level.

3. Full-service renovation concepts

Full service renovation concepts aimed at single-family homeowners exist in the Nordic countries but they are not well established. Currently, the renovation market is dominated by a craftsman based approach with individual solutions, traditional warehouses ”do-it-yourself-shops” and some actors marketing single products. Information on full-service concepts in the Nordic countries has been collected on the market situation as it was in autumn 2009. The most interesting concepts (one for each country) are presented and discussed below.

3.1 Denmark - Clean Tech

This concept was introduced May 1st 2009. The facilitator is Dong Energy A/S, one of Northern Europe’s leading energy groups, who runs a business based on procuring, producing, distributing, trading and selling oil, gas, and electricity, and related products in Northern Europe. Dong Energy collaborates with a window manufacturer (Pro Tec Vinduer A/S), an insulation manufacturer (Rockwool A/S), a heat pump supplier (Danfoss A/S), a solar heating manufacturer (Sonnenkraft) and a financing company (Dan-Aktiv A/S). In addition to that they offer to carry out a building thermography. The targeted market segment is the renovation of oil-fired old detached single-family houses with easy-to-carry-out measures/investments with a short pay-back time. Dong’s interest in the market for energy renovation is to earn money and keeping up a good image and loyal costumers but is also related to a commitment to document energy savings (see below).

The concept idea is to offer customers a one contact service (Dong Energy). The homeowner visits the concept homepage and tries out the calculator “Test your house” and gets an idea of relevant renovation measures and the energy saving potential or calls Dong Energy directly. Then the home owner can contact Dong Energy for telephone advice on the most interesting solutions or Dong Energy contacts the costumer based on the typed in information. Dong Energy contacts relevant installers, who make a visit to the house to determine the optimal solutions. A quote on the total renovation is send to the customer together with a flexible loan offer of DKK 15,000 – 150,000 (EUR 2,000 – 20,000). Dong Energy will offer to handle a possible application for national renovation subsidy and to take care of any other necessary paperwork and allowances. After an acceptance of the quote and possibly a loan, the renovation work is carried out by the same installer that inspected the house. Dong Energy offers a five-year guarantee.

According to Dong Energy, the concept has a potential for energy savings of up to 50 % for each house. For an average old house, this corresponds roughly to the energy standard of a new house built to meet the minimum requirements of the Danish building code. At the moment they are concentrating on two concepts: EnergyMinus and EnergyPlus. The first aims at saving energy with new windows and easy-to-carry-out insulation measures such as cavity wall insulation. The latter is providing house owners with more efficient energy supply such as heat pumps (ground heat or air to water). The heat pumps are especially relevant in the around 100,000 houses in Denmark that have oil-fired burners older than 10 years.

The energy saving potential is fairly limited as only cavity wall insulation is offered as part of the package. Cavity wall insulation does not ensure a uniform and unbroken insulation layer without thermal bridges like e.g. an external insulation solution. Cavity wall insulation reduces the U-value from about 1.5 to 0.4-0.7 W/m^{2}K, whereas an external insulation of 200 mm mineral wool will reduce the U-value to 0.15 W/m^{2}K. Furthermore, ventilation with heat recovery is not part of the concept. Both external insulation of facades and ventilation with heat recovery have great potential for end-use energy savings and also a better indoor environment.

As part of the agreement with the home owner, Dong Energy has secured the right to report the realized energy savings to the Danish Energy Agency. They are committed to document a certain amount of energy savings each year like any other Danish utility company.

After introduction of the concept there has been encouraging response from the targeted homeowners, but it is too early to conclude if it has been a success. The concept is aimed at energy saving measures with a short pay-back time – one could say measures that anyhow might have been carried out. Improvements to the concept may be to include further-reaching measures like ventilation with heat recovery and internal and external wall insulation.

Link to more information on the concept: http://www.dongenergy.dk/PRIVAT/CLEANTECH/

3.2 Sweden - Sustainable renovation of heating systems

Primary energy use can be reduced significantly by replacing resistance heaters with district heating system. But, there is a general perception in Sweden that it is difficult to convince large number of homeowners with resistance heaters to connect to district heating system, which is necessary to create sufficient heat demand to justify the investment in the district heating network. However, the municipality-owned energy companies in the city of Östersund (2005 - 2006) and Växjö (in 2002) have applied a rather similar marketing campaign to convince a large number of homeowners in their respective cities to connect to the district heating network. The case study in Östersund [6] is discussed below.

The about 700 houses in the Odensala district of Östersund (Central Sweden) were built mostly during the 1970s and were heated with resistance heaters. A survey in June 2005 showed that 84 % of these homeowners did not intend to replace their heating systems over the coming 4 years, even though it was economically and environmentally beneficial to replace resistance heaters with district heating, heat pumps, or pellet boilers, for which a government investment subsidy was available. However, by the end of 2006, a market campaign by the energy company “Jämtkraft” convinced 78 % of the 456 homeowners of all age and income group to sign contracts to connect to its biomass-based district heating network. The campaign was successful because of its package offer and information provision, which addressed factors that were important in homeowners’ choice of heating system. The survey prior to the campaign showed that homeowners gave priority to economic aspects and functional reliability, and preferred to collect information from installers and interpersonal sources.

Jämtkraft’s package offer included de-installation of the existing resistance heaters, installation of water-based heat distribution system and heat exchanger, connection to the district heating network, guaranteed delivery of hot water, heat and electricity during the renovation period, a 2-year guarantee on the installed system, a fixed price for each installed radiator, a fixed cost for extending the district heating network to a house, and a fixed district heat price (which was lower than the prevailing electricity price) for 5 years. Of the total investment cost, 30 % could be obtained as a government investment subsidy and the company facilitated the homeowners to apply for it. Jämtkraft made arrangements with a bank, which was willing to provide 30-year amortizing loans at a low interest rate (about 2.5 % including fees, before tax deduction). The offer also included an option for the homeowners to get a discounted price for connection to Jämtkraft’s fibre optic broadband network through which multiple companies provide internet service. The company hired two installation firms to carry out the in-house installation works.

Jämtkraft initiated its marketing campaign in June 2005 by informing the homeowners through home-delivered leaflets that it was planning to expand the district heating/broadband network to Odensala. The leaflet included a one-day free entry ticket for the households to visit an annual trade fair in Östersund, where Jämtkraft had a stall about district heating. Subsequently, it invited the homeowners to attend information meetings, which were organized at a well-known meeting place close to Odensala (in the evening), the company’s own premise, and at the local Christmas market. The invitation letter included a booklet which contained explanation of the advantages of district heating, how it functions, the installation process, examples of the experience of existing customers, and frequently asked questions. A thank-you note was sent after the meetings. In all

these meetings, representatives of the installation firms and the bank participated to answer homeowners' questions. In December 2005 Jämtkraft sent the package offer to all homeowners. In February 2006, a demonstration vehicle was parked in Odensala to demonstrate the functioning of the district heating system.

3.3 Norway - Jadarhus Rehab

The company Jadarhus Rehab AS was established late summer 2007 by Jadarhus AS (132 mill NOK in 2008), which designs and builds new single-family houses and smaller apartment buildings. The group sees potential in the retrofitting market, and decided therefore to found a separate company to develop this market. In 2008 Jadarhus Rehab AS achieved a turnover of nearly 32 mill NOK (EUR 3.85 mill) and a net result of nearly 3 mill NOK which is a very good achievement for a new company. Their partners are: IHT (Architects), Nordic Dørfabrikk AS, Skarpnes (tiles), Velux, Optimera, HTH Kitchen, and some others.

Jadarhus is located in Stavanger and its market is the south west region of Norway. Their target group is people who instead of buying new land to build their own house, have concluded they want to buy an old house which they can renovate. They assist the customer throughout the full process, and energy efficiency is only one part of the package. Here are some arguments from their brochure:

- We would like to contribute to realise the potential in every existing house.
- We take into account the right architectural choices in respect to the environment of the house as well as the original style and form of the house.
- We put emphasis on choosing the most economical and environmental friendly solutions.
- We increase the value of your house through good architecture and solid handcraft.
- We take the responsibility from A to Z.
- We create opportunities in a market with lack of available building sites and high prices.
- We cooperate with the best suppliers in the building industry.

Jadarhus Rehab starts the process with a meeting with the client, in which they study the potential of the house. Based on this, they plan a building process which is similar to the process for a new house.

Their technical solutions are tailor-made to the customer's wishes. Regarding energy efficiency initiatives, they describe these examples: Easy actions such as additional insulation in cold attics, new windows with lower u-values and reduced draft and air leakages around the window, change of outside panels and build in new windproof layer, as well as checking the passages between the foundation wall and the tier of beams, outer wall and roof, additional tightening of windproof materials and jointing around critical parts. Advanced measures such as additional layer of insulation, either on the inside or outside of the wall, building walls between warm and unheated rooms, attics to be outfitted may be additional insulated either on the inside or the outer part of the roof. The energy savings potential depends on actions.

Jadarhus Rehab has strong focus on market value, architecture and comfort. They are one serious actor which takes care of the whole process. However, they can improve on tools to demonstrate the customers how the house will be like after the renovation, ventilation system, financing package, monitoring system and a better marketing approach.

Link to more information on the concept:
http://jadarhus.no/images/stories/downloads/rehabilitering.pdf.

3.4 Finland - ENRA

ENRA is an abbreviation of "Energiatehokkaan remontoinnin ja asumisen ohjelma", The program for energy efficient renovation and living. ENRA started in January 2009 as a pilot program in the Pakila area in Helsinki. This is an area with typical single-family houses from 1940-50's (mainly so called "Veteran houses") and from 1960-70's. The experiences are very limited as the concept was

only launched recently and no renovations have yet been finished. Now the concept is also being launched to other areas, by recruiting and educating more ENRA experts.

The concept was developed by a group of companies, led by a renovation company (Rustholli Oy). The other participants are a window and door manufacturer (Domus Group Oy), a ventilation system manufacturer/supplier (Enervent Oy), an insulation manufacturer (SPU Systems Oy), an energy certificate supplier (Raksystems Anticimex Oy) and a heat pump supplier (Thermia Partners Oy). VTT-Technical Research Centre of Finland has supported the concept development

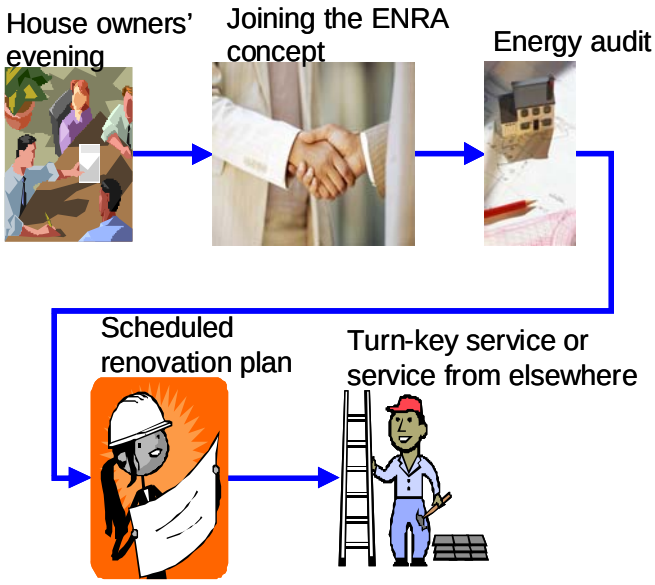

Fig. 1. The ENRA concept

In fig.1, the ENRA philosophy which is discussed more in detail in the following text, is shown. Potential clients are invited to participate in a house owners' evening. The effects of climate change and the role of buildings in it are explained to the audience. Then the actions taken by the global community, European Commission and governments are presented. The possibilities of the house owner to contribute are described with an outline of the different renovation actions that help combat the climate change. Other benefits from energy renovation improvement of thermal comfort and air quality are also discussed. The participants in the house owners' evening are then offered the possibility to join the ENRA program. They will fill in a contact information sheet, if they want Rustholli's ENRA expert to take contact with them.

In a short notice, an ENRA expert will contact the customer to set up a date for an energy audit. In the energy audit, the house will get an energy certificate, an estimation of the most suitable energy efficiency improvement actions, and a cost estimation.

After the energy audit, the ENRA expert will visit the customer, to find out the individual renovation needs of the family in question. All renovation needs are mapped and their priority order is noted. They might include renovation that has nothing to do with energy, but a lot to do with the living comfort. A time schedule is set up according to the needs, financing possibilities and other circumstances of the family. After this, the customer is free to choose other service providers, or buy the turn-key service from the ENRA-group. With the turn-key service, the customer also gets a list of pre-chosen alternatives from the material and device producers in the ENRA-group. The ENRA expert will also look for other suppliers, if the customer wants something that is not covered by the ENRA-group, e.g. solar heating systems.

Rustholli Oy uses only A-labelled windows for the ENRA-houses. Insulation products are based on polyurethane which has an about 30 % lower thermal conductivity than for example mineral wool (widely used in Denmark) and is therefore especially suited for typical Finnish internal insulation

solutions. In general many wooden Finnish houses have got a brick or other heavy rain shield and many of these houses can be improved visually by using a thermally more effective external insulation solution with less thermal bridges and a new rain shield.

The pre-chosen ventilation system has heat recovery based on the rotating wheel (annual heat recovery rate up to 73 %) in order to cope with the very low winter temperatures. The system can be used for heating, heat recovery and cooling. Heat pumps are offered as a fairly cost and energy efficient energy supply solution (many houses are electric heated) after a renovation that has reduced the energy demand significantly.

Link to more information on the concept: http://www.rustholli.fi.

4. Technical renovation concepts

Technical renovation concepts or packages of technical solutions for single-family houses, capable of reducing the final energy use to a very low level in combination with renovation, serve as the base premise for implementation of sustainable renovation of single-family houses. Technical renovation concepts with the potential to result in great energy savings are described. Focus is on technical solutions relevant for renovation of typical single-family houses in the Nordic countries.

4.1 Sustainable energy solution

The sustainable energy solutions for reducing the primary energy demand of buildings to a very low level and to meet the energy demand with use of the mainly renewable energy supply technologies includes an optimal balance between energy savings and renewable energy supply technologies. Examples of renewable sources are solar, wind, hydropower, wave, waste, biomass etc. A suitable approach is to search for a long-term optimal balance between energy savings and supply of renewable energy. Then it will be obvious to investigate the optimal transformation of the existing building stock and its energy system for the entire building stock. The best solutions could be implemented in all new buildings and settlements, and by gradually implementing energy renovations, i.e. combined general renovations and extensive energy savings in existing buildings when a renovation need is identified.

Electricity is high quality energy (high exergy) and should only be used where absolutely necessary [7] or should be used with high primary energy use efficiency. Heating of buildings could be based on the use of thermal energy from possible sources, e.g. solar, waste incineration, low temperature heat in combination with heat pumps, and biomass. An energy efficient supply system is when heat is cogenerated with electricity in a district heating plant and supplied to end-user in areas with sufficient heat demand. Such a system also allows for central heat storage facilities that can smooth out the differences in production and consumption of heat. Houses outside a district heating system need other types of heating systems, e.g. ground-source heat pumps or pellet boilers.

Buildings account for about 40 % of the total final energy use in the Nordic countries (and EU). Residential buildings are responsible for 70 % of the energy use in buildings in the Nordic countries of which roughly 75 % is used in single-family houses. This category of buildings is thereby responsible for half of the final energy use in buildings. Most of the energy used in buildings is for heating of rooms and domestic hot water. Electricity is used in large quantities for building services such as circulation pumps, lighting, air conditioning and ventilation, as well as for the electrical equipment used in homes, shops and offices.

A sustainable energy system could combine renewable energy with high energy efficiency. This is highly relevant to buildings, where the potential for energy savings is large, and renewable energy technologies for both heating and electricity are available.

4.2 Energy renovation of buildings

The carrying out of holistic and low energy renovations of buildings result in relatively large

investments. Therefore it is important that there is a need for a thorough renovation not only based on energy savings. The crucial point is to link the extensive energy savings to the normal renovation measures, in that way reducing the price of implementing the savings. The need for a thorough renovation may typically be due to:

- Physical degradation of main components such as roof, facade and windows.
- Bad thermal indoor comfort, e.g. due to bad insulation, draft from windows or over-heating problems in summertime.
- Health problems, e.g. due to problems with fungi again due to badly insulated walls and bad ventilation or allergic people who have problems with pollen, which infiltrate into the house.
- Wish for an improved overall architecture and use of the house, including rebuilding and extensions.

One of the needs or a combination of the needs mentioned above can as a result create the need for carrying out a thorough renovation of a building, typically comprising renovation of the roof, the facades, changing the windows and establishing a ventilation system. If this is the case, then there is a potential for carrying out a thorough renovation.

The technical energy renovation measures that can be applied in existing buildings on a component level can be described within five categories of measures: Building envelope, building services systems, building supply systems, appliances and continuous commissioning. The continuous commissioning (or “Cx”) means clear definition, capturing and documentation of end user requirements and their compliance assessment and verification in all the phases from design through realisation to the operation and use [8]. In the operations phase, it includes for example implementation of metering and control, optimization of system operation and control schedules and user guidelines.

4.3 Sustainable low energy renovation concepts

Technical renovation concepts have typically main focus on application of only a few of the available overall technical solutions. Overall renovation of single-family houses or a step wise planned renovation should be carried out based on design solutions with good combinations of the full range of technical solutions in order to reach a low energy level.

4.3.1 Design strategy

The technical design strategy can be described based on the Trias Energetica concept, which has been developed for the design of low energy buildings in Norway [9]:

- Reduce the energy demand by avoiding unnecessary use and by implementing energy saving measures
- Use sustainable sources of energy instead of fossil fuels
- Use energy as efficiently as possible

The concept indicates that the most sustainable energy is saved energy. The main benefit of the concept/method is that it stresses the importance of reducing the energy demand before adding systems for energy supply. This promotes robust solutions with the lowest possible environmental load.

4.3.2 Technical principles

To reach a low primary energy level, different technical solutions such as renovation of roof, facade, changing windows, installation of energy efficient heating systems, and establishing a ventilation system etc., need to be combined. The technical principles are:

- **Reduced transmission heat losses** by high standard of insulation of building envelope constructions using preferable integrated system solutions. Thermal bridges should be reduced to a very low level. Total insulation thicknesses for wall, roof and floor after renovation should

by around 20 to 40 cm, resulting in U-values of around 0.10 – 0.15 W/m²K, while windows should be triple-glazed and have positive net energy gains.

- **Minimized ventilation heat losses** by introducing a mechanical ventilation system with heat recovery that will reduce heat losses by about 80 % or more while increasing both thermal comfort and air quality.
- **Minimized infiltration heat losses** (additional air flow due to wind and stack effect). A precondition for ventilation with heat recovery is a high level of air tightness of the building envelope, minimizing losses from warm air leaking through cracks and crevices.
- **Minimized ventilation electricity use.** Electricity use for ventilation must be minimized. Otherwise the primary energy savings may be mostly lost. A low use of electricity can be ensured using so-called EC fans and a well designed duct system.
- **Optimized utilization of internal and passive solar heat gains** by e.g. introducing thermal mass or increased glazing area by new windows with a narrow frame.
- **Minimized water heating demand** by more energy efficient user behaviour, insulation of hot water tank and pipes and solar heating (in Denmark solar heating for DHW can typically supply a family with 60-70 % of their need for hot water). Solar heating is particularly relevant for a house with a heating demand in the summer period allowing for a shut down of the primary energy source (e.g. boiler) and thereby eliminating the idling heat loss.
- **Efficient energy supply** for the remaining space heating and hot water demand by e.g. low energy district heating systems in the cities and small and high efficient heat pumps outside the cities, wood pellet burners or during a transitional period gas/oil boilers etc. Keeping existing heaters in water-based heating systems allows for a lower system temperature and therefore a more efficient production (especially regarding heat pumps) and distribution of the heat demand. Houses without a hydronic system can most of the year comfortably use the ventilation system for space heating.
- **Mainly passive measures for overheating control** like overhangs and shading devices (e.g. awnings). Glazing for solar control also in single-family houses, could be an unconventional but relevant option due to a much shorter heating season in low energy renovated houses and limited solar radiation in winter. Experiences with new low energy houses show that they actually suffer less from overheating than regular houses because the thermal insulation keeps the summer heat out.
- **Intelligent control and continuous commissioning.** Intelligent control and continuous commissioning is relevant in new low energy buildings and also in renovated low energy single-family houses to make sure that the expected energy savings are delivered. The energy use is very sensitive to bad operation of heating and ventilation systems, solar shading devices etc. Therefore, an implementation of metering and intelligent control including optimization of systems operation and control schedules is a precondition for a low energy use. An effort to educate the house owner by providing user guidelines on how to use heating and ventilation systems may have a big impact on energy use and thermal comfort etc.
- **Electrical appliances**. Low energy renovation concepts also include appliances. In countries or regions where cheap electricity is not available, it is often very profitable for homeowners to save electricity by changing into new A-labelled white goods, more efficient lighting and IT equipment etc.

4.3.3 Non-energy aspects / benefits

The non-energy aspects / benefits of low energy renovation concepts are many. Carrying out a comprehensive low energy renovation requires the set-up of a good planning and means a relatively large investment. In order to deal with the large investment costs, it is important that there is a need for a thorough renovation not only based on energy savings. The need for thorough renovation of the house may rise as a result of physical degradation of main building components, bad indoor housing comfort, health problems etc.

External thermal insulation of facades is advisable; resulting in an internal surface temperature close to the indoor air temperature and therefore the construction is protected from internal condensation and lasts longer. Minimisation of thermal bridges and improved air tightness also reduces structural damages. By using new and better performing materials when renovating buildings to a low energy level, the architectural quality of the building can be improved at the

same time. However, building requirements imposed by local authorities and the type of building can often limit the choice of materials to be used.

The thermal comfort both in winter and summer can be expected to be better than in normal houses. The uniform air renewal and no cold draught provides for good indoor air quality. External thermal insulation and good air tightness avoid condensation and thus growth of moulds and fungus. Internal insulation results in lower temperature of building components and increases the risk of moisture problems. Acoustic improvements can be expected due to the insulation and tightening of the building envelope.

As an input for estimations of the economic feasibility of energy saving measures, reliable cost data is needed from the start of the planning. If the renovation of the house has to take place anyway, the most interesting cost data for estimating the economic feasibility is not the overall cost of measures, but the extra cost of the energy saving measures. For most measures and for combinations of measures, the following data is relevant:

- Cost for renovation measure according to national building code
- Cost for recommended low energy renovation measure
- Extra cost of measure compared to measure according to national building code

Besides cost for renovation for the estimations of the economic feasibility the following parameters are relevant:

- Lifetime of insulation measures, windows, heating, ventilation and DHW systems etc.
- Interest rate
- Loan period (calculation time)
- Energy price of electricity, district heating, gas, oil, wood etc.

The economic feasibility of an energy saving measure can be improved by public subsidy. In general the increased energy performance and modernization of the house will improve the value of the house on the market.

5. Discussion

The main objective of the project SuccessFamilies is to change the business environment in order to speed up the implementation of sustainable renovation of single-family houses. Based on the current status of the renovation market, the authors estimate that to speed up the implementation, not only new better renovation concepts need to be developed, but society needs to help out by making better incentives structures, e.g. increased tax on energy and/or subsidy programmes. Combined with an outlook for rising global energy prices, sustainable renovation of single-family houses has the potential to become an important market area in the future. Positive signals towards this development can be seen already now since several new renovation service packages or solutions have come into the market within the last year. Also two Finnish hardware store chains now offer this kind of services.

6. Conclusions

In the Nordic countries, there are few examples of “full-service” renovation concepts with reasonable success. These concepts have just recently entered the market, e.g. the Danish “Clean Tech” and Finnish “ENRA” concept, and their success is yet to be evaluated. The described Swedish full-service example of renovation of heating systems by replacing resistance heaters with a district heating system, shows that a focused and patient marketing campaign with emphasis on economic aspects and functional reliability can sell a package deal to a large share of the target group. The existing technical renovation concepts, focusing typically on application of only a few of the available technical solutions, have not been successful in realizing large scale energy efficiency gains. Renovation of single-family houses might be carried out based on design solutions with good combinations of the possible range of technical solutions in order to reach a low primary energy level. Existing renovation concepts need to be developed to include

sustainable low energy renovation system solutions, full-service packages including financing and continuous commissioning to make sure the expected energy savings are delivered. The focus should be on making it easy, simple and secure for the consumer to invest in a low energy renovation of their house. The non-energy benefits of the energy renovation are worth emphasizing in the marketing. The building sector needs easy to use knowledge and initiatives which ensure that they can offer solutions which fulfil the demand for quality, economy and a simple process.

7. References

[1] BOTTA M. "*Towards Sustainable Renovation – Three Research Projects*", doctoral dissertation, School of Architecture, Royal Institute of Technology, Stockholm 2005.

[2] EN 15603:2008, *"Energy Performance of Buildings – Overall Energy Use and Definition of Energy Rating",* 2008.

[3] "*Building Regulations 2008*", The Danish Ministry of Economic and Business Affairs, Danish Enterprise and Construction Authority, Copenhagen, 2007.

[4] WITTCHEN, K.B., ENGELUND THOMSEN K., "*European national strategies to move towards very low energy or passive buildings*", Danish Building Research Institute, Aalborg University, and EuroACE, 2008.

[5] "*National Building Code of Finland - Thermal insulation in a building - Regulations 2003*", Decree of Ministry of the Environment on thermal insulation in a building, Issued in Helsinki on 30 October 2002.

[6] MAHAPATRA, K and GUSTAVSSON, L. (2009). Influencing Swedish homeowners to adopt district heating system, *Applied Energy*, 86: 144-154

[7] NIELE F., "*Energy – Engine of Evolution*", Shell Global Solutions, 2005.

[8] PIETILÄINEN, J. et al, "*Rakennuksen toimivuuden varmistaminen energiatehokkuuden ja sisäilmaston kannalta*" [Guidebook for life-cycle commissioning of buildings energy efficiency and indoor climate], Espoo 2007, VTT Research Notes 2413, 173 p. + app. 56 p. (in Finnish).

[9] DOKKA T.K., RØDSJØ A., "*Kyoto Pyramiden*", 2005. www.lavenergiboliger.no