Nordic Analysis of Climate Friendly Buildings

Summary Report




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Main authors
Inger Andresen, SINTEF Building and Infrastructure, Norway
Kirsten Engelund Thomsen, SBi, Denmark
Åsa Wahlstrøm, CIT Energy Management, Sweden

Foreword

This report presents the findings of the work conducted within the project "Nordic Analysis of Climate Friendly Buildings". The project was initiated in March 2010 by a steering group representing the Nordic Council of Ministers. The steering group was composed of the following members:

- Anne Sofie Bender, Nordic Council of Ministers
- Marie Louise Hansen, Erhvervs- og Byggestyrelsen, Denmark
- Marie Kring, Erhvervs- og Byggestyrelsen, Denmark
- Lennart Andersen, Energistyrelsen, Denmark
- Michael Rantil, Energimyndigheten, Sweden
- Björn Marteinsson, Innovation Center Iceland
- Lisbeth Landfald, Statens Bygningstekniske Etat, Norway
- Pekka Kalliomäki, Miljöministeriet, Finland
- Jørn Bang Andersen, Eili Vigestad Berge, Nordic Innovation Centre
- Janus Køster, Departement for Boliger, Greenland
- Ewald Kjølbro, Den offentlige bygningsmyndighed, Faroe Islands

The work has been conducted by a project consortium composed of Statens Byggeforskningsinstitutt, SBi, Denmark, CIT Energy Management, Sweden and SINTEF Building and Infrastructure, Norway. The consortium has received input to the work from the steering group, and from VTT in Finland. Also, the group has received valuable input from 45 representatives of the Nordic building industry that have been interviewed.

Apart from the members for the steering group, the following persons have contributed to the report:

- Inger Andresen (project leader), Mark Murphy, Igor Sartori and Peter Schild , SINTEF Building and Infrastructure, Norway
- Kirsten Engelund Thomsen (project leader Denmark), Niels Christian Bergsøe, Jørgen Rose and Harpa Birgisdottir, SBi, Denmark
- Åsa Wahlstrøm (project leader Sweden), Lennart Jagemar and Daniel Olsson, CiT Energy Management, Sweden
- Jyri Nieminen, VTT, Finland

The work has been financed by the Nordic council of Ministers. The project consortium would like to express gratitude to all the contributors to the work.

Content

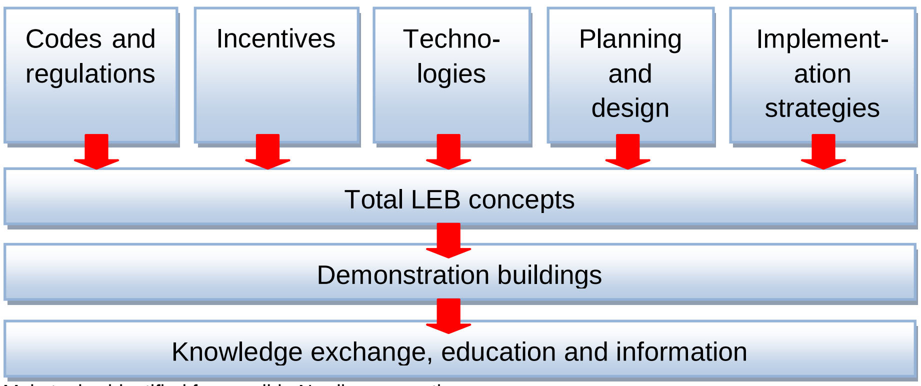
Summary

This report summarizes the findings of the work conducted within the project "Nordic Analysis of Climate Friendly Buildings", financed by the Nordic Council of Ministers. The main goal of the project was to establish a knowledge and decision base for a Nordic innovation program that will promote the development and demonstration of low energy and climate friendly buildings. The innovation program should support a development that brings the Nordic countries to an international forefront with respect to business strongholds and market penetration of low energy and climate friendly buildings.

> *Low energy and climate friendly buildings* are not unanimously defined. In this project the term will encompass buildings with an energy performance at least 25% lower than current national building regulations, and includes passive houses and zero energy/emission standards. In the following text, such buildings will be denoted ***LEB*** *(Low Energy Buildings).*

The analysis shows that the Nordic countries have a significant amount of activities directed towards LEBs, but we can not claim to be world leaders within the field. In order to bring the Nordic countries to an international forefront with respect to LEB market penetration and LEB business, significant efforts are needed.

The analysis also showed that the Nordic countries have many similarities with respect to LEB business and development; however there are different strengths and experiences that would be beneficial to transfer across borders. The analysis has identified 8 main fields of possible cooperation, shown in the diagram below.



Main topics identified for possible Nordic cooperation.

Chapter 1 Introduction

Several studies show that significant efforts in energy efficiency improvements are needed in order to reduce the global greenhouse gas (GHG) emissions. For example, the IEA World Energy Outlook clearly illustrates that more than half of the needed GHG emissions reductions stem from energy efficiency measures, see Figure 1.

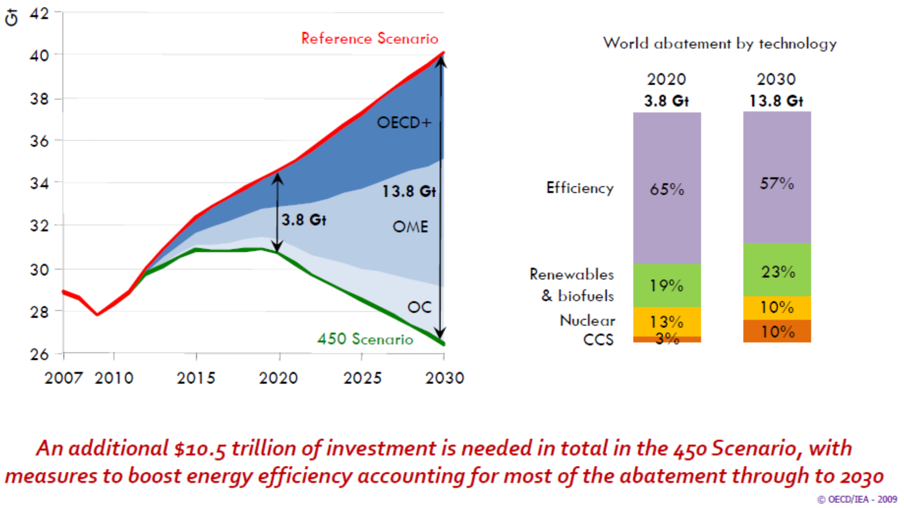


Figure 1. World abatement of energy-related CO_2 emissions in the 450 ppm scenario to stabilize climate change. From IEA World Energy Outlook 2009.

In Europe, buildings are responsible for as much as 40% of the energy use and 36% of the CO_2 emissions.

The EU Directive on Energy Performance of Buildings (EPBD) states that energy performance of buildings is a key to achieve the EU Climate & Energy objectives, namely the reduction of 20% of the greenhouse gas emissions and a 20% energy savings by 2020.

Moreover, the McKinsey report on GHG cost abatements[1] showed with great clarity that improving the energy performance of buildings is among the most cost-effective ways of fighting climate change.

Thus, there is a tremendous potential for energy savings, CO_2-mitigation, and value creation by developing the market for low energy and climate friendly buildings. A recent study by EuroACE[2] suggests that the European energy and CO_2-emission savings may be as much as 568 PJ and 36 Mt CO_2 per year if all new buildings are constructed as low energy buildings from 2012.

Other benefits of pursuing low energy buildings include improved energy security and value creation. Although it is difficult to quantify the potential of

[1] Enkvist, P-A. et.al (2007), "A cost curve for greenhouse gas reduction. A global study of the size and cost of measures to reduce greenhouse gas emissions yields important insights for businesses and policy markers.", The McKinsey Quaterly 2007, Number 1, Stockholm.

[2] Jensen et al (2009): "Towards very low energy buildings. Energy saving and CO_2 emission reduction by changing European building regulations to very low energy standards", SBI 2009:03, Danish Building Research Institute, Aalborg University.

value creation within the building industry, the following examples serve to illustrate the potential of “greening” the building industry:

In Norway, a recent study suggests that an ambitious market penetration of low energy buildings will create an increased business potential of 80 billion from 2010 to 2020[3]. This corresponds to about 20,000 new jobs in the building sector.

In Finland the government's energy and climate strategy includes yearly support to renewable energy of 340 million by 2020. It is estimated that the support enables more than 20 000 direct or indirect (subcontracting and manufacturing) new jobs. The present turnover of the climate and environment business is roughly 15 - 20 billion €, of which exports cover 10 billion €. The export of energy technologies was 5 billion € in 2009.

In Denmark, the value of exported energy technologies comprised 58 mill DKK in 2009, or 11% of the total value of all Danish exports.

In Sweden, the turnover for energy and environmental technique is constantly increasing and was 135 billion SEK in 2008[4]. Of this, 37 billion SEK were exports, with Germany and China as the largest export countries. The sector has nearly 6600 companies with 42 000 employees. Wind power and solar energy have the highest turnover increase with about 60% compared to year 2007, and turnovers of 8 billion SEK and 4.5 billion SEK, respectively.

Moreover, reports from both Sweden and Denmark show that the export of technologies within the energy and environmental sector are less affected by the financial recession than other sectors.

This report summarizes the findings of the work conducted within the project “Nordic Analysis of Climate Friendly Buildings”, financed by the Nordic Council of Ministers. The main goal of the project was to establish a knowledge and decision base for a Nordic innovation program that will promote the development and demonstration of low energy and climate friendly buildings. The innovation program should support a development that brings the Nordic countries to an international forefront with respect to business strongholds and market penetration of low energy and climate friendly buildings.

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The work summarized in this report includes the following main activities:

- Overview of codes and regulations for LEB in the Nordic countries.
- Overview of incentives with regards to LEB and a comparison to leading European countries.
- Estimation of the market share of LEB in the Nordic countries compared to lead European countries.

[3] Dokka et al (2009): “Energieffektivisering i bygninger – mye miljø for pengene”, Prosjektrapport 40, SINTEF Byggforsk, Norway.

[4] www.swentec.se

- Overview of LEB technologies, solutions, and R&D activities in the Nordic countries, identifying main focus areas, challenges and future trends.
- Overview of market possibilities of LEB including identification of business strongholds, barriers to the development and implementation of LEB, and the benefits of a Nordic innovation program.

A detailed description of the findings is enclosed in the Appendix.

Chapter 2 Overview of Codes and Regulations

Due to the Energy Performance of Buildings Directive (EPBD 2002/91/EC) all Member States of the European Union have implemented energy performance requirements for new buildings, or will do so in due time. The definitions and levels of the energy performance requirements are set on a national level.

In order to evaluate the market possibilities for products, services and processes for low energy buildings in the Nordic countries, a comparison is made on how national regulations manage energy performance issues and what differences there are between the Nordic countries. National future plans for higher requirements of the building regulations are also described in brief. The chapter will also elucidate the different advantages and strengths associated with the national regulations to show how the exchange of experience between the countries could be beneficial.

Comparison with other European countries

The Energy Performance of Buildings Directive (EPBD) allows for definitions and levels of the energy performance requirements to be set on a national level. This means that the requirements not only are different between the member states, but also that it is very difficult to compare the performance level between the member states since they are based on different definitions, ref. table 1 and other comparisons shown in the Appendix. Furthermore, the large differences in climate conditions between European countries make the comparison even more difficult. For example, the insulation level of a house in Finland may be much higher than for a house in Italy. Still the energy consumption of the Finnish house may be higher than the Italian house, due to the more severe Finnish climate.

Table 1. Definitions for total or primary energy demand including weighting factors

	Total (primary) energy demand [kWh/m²]
Denmark	The total primary energy demand of the building for supplied energy for heating, ventilation, cooling, domestic hot water and, where appropriate, lighting. The limit is expressed as follows: Dwellings: (70+2200/A) kWh/m² per annum, Other buildings: (95+2200/A) kWh/m² per annum, where A is the heated floor area in m² Weighting factor for heat in the primary energy calculation is 1.0 and for electricity 2.5.
Finland	No requirement in BC2010, primary energy in BC2012. (Contains requirements on specific technical performance (U-values and air tightness).)
Iceland	No requirements (Contains requirements on specific technical performance (U-values and air tightness).)
Norway	Total energy demand: Separate requirements for 13 different building categories, calculated with Oslo climate and standardized use. Examples: One family house: 125 kWh/m² per annum + 1600/m² heated floor area, Apartment building: 120 kWh/m² per annum As a general rule 40% of heat demand has to be supplied by other sources than grid electricity or fossil fuels, but exemptions are possible.
Sweden	Delivered energy excluding household appliances (kWh/m² per annum). Dwellings: Southern Sweden. 110; Central Sweden 130; Northern Sweden 150 Premises: Southern Sweden. 100; Central Sweden 120; Northern Sweden 140 All buildings heated with electricity: Southern Sweden. 55; Central Sweden 75; Northern Sweden 95 Solar thermal or photovoltaic systems placed on the building site are not included in the energy performance requirements.

Within the European project ASIEPI (www.asiepi.eu), a method has been developed aimed to compare the energy performance requirement levels between Member States. To be able to compare energy performance among different climates, the energy use of all locations is plotted against the climate severity index of the locations. In short, the severity index is a sophisticated version of the degree days, taking into account the summer as well as the winter severity. The figure below shows comparisons based on the developed model for semi-detached houses.

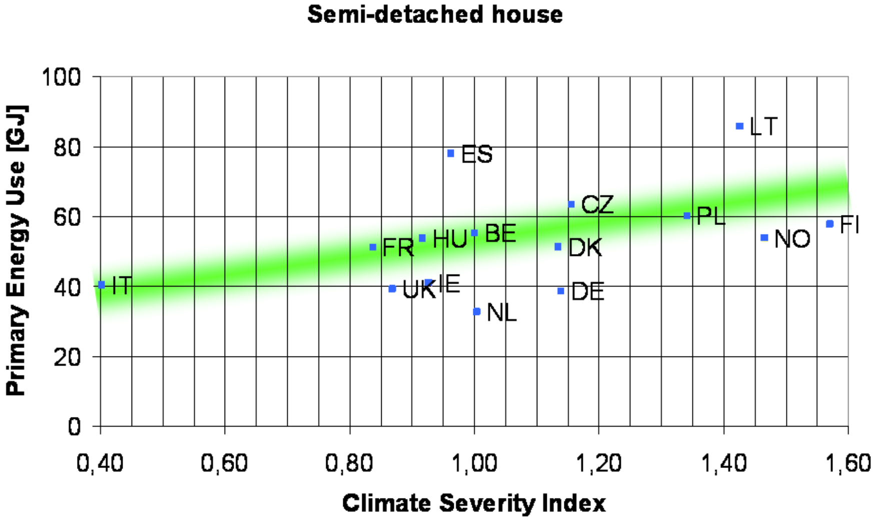


Figure 2. The graph shows total primary energy use for the semi-detached houses used in the comparison method, plotted against the climate severity indexes (www.asiepi.eu).

Note that the figures in the graph should be handled with extreme care and can otherwise be misleading due to the fact that the energy performance calculations in some countries are based on energy needs and in other countries on total energy uses, etc. The figure indicates, however, that although the Nordic countries are on the "better" side of the green line, we cannot claim to be the European leaders in energy performance requirements.

Recast of the Energy Performance of Buildings Directive

The accepted recast of the Energy Performance of Buildings Directive (EPBD 2002/91/EC) published in June 2010, will have major influences on the national building codes. The directive sets requirements that the Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set. Requirements may differentiate between new and existing buildings. The Member States shall ensure that by 31 December 2020, all new buildings are nearly zero energy buildings, and after 31 December 2018, public authorities that occupy and own a new building shall ensure that the building is a nearly zero energy building. The Member states shall have intermediate targets for improving the energy performance of new buildings for 2015.

Furthermore the directive requires that Member States shall take the necessary measures to ensure that when buildings undergo major renovation the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements.

The directive implies that the building regulations for both new construction and renovation may get higher requirements within the next years. This means that products, services and processes for low energy buildings for the construction and building sector must be adapted to the new requirements.

The building market

The construction of dwellings seems to be increasing. In Sweden, 24 500 constructions of dwelling units are planned in 2011, an increase of 50% compared to 2009. In Finland, it is estimated that 27 500 dwelling units will be realized in 2010, which is an increase of 44% compared to 2009.

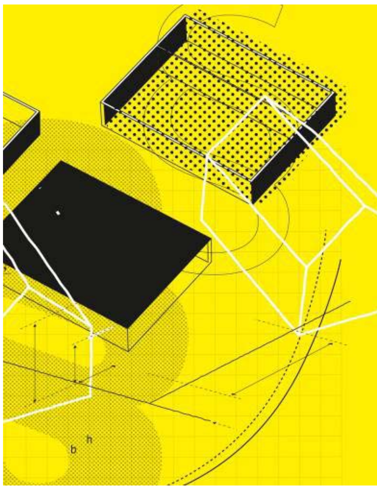
The growing markets with new requirements are an excellent opportunity for the building industry to develop new products, services and processes for low energy buildings.

To develop new innovations requires a stable and large market. Possibilities of a larger market within the Nordic countries would be beneficial. When established in the market, it will be easier to further develop the products, services and processes for export to other European countries.

Prospects for a common Nordic market

It is not easy to compare the building code requirements in kWh per square meter since all countries have slightly different definitions of included energy, heated area and boundary conditions. This can be seen within the tables in the Appendix. Even though the building codes differ, they have a lot of similarities and there are good prospects for inventions of products, services and processes for low energy buildings on a common Nordic market.

Different advantages with the Nordic building codes



Danish regulations have the advantage that they include two definitions of low energy buildings within the building code. This gives a pronounced way of new construction for the building proprietors that want to go a step ahead. The other advantage with the Danish regulations is that they have early on announced when, and how much, the requirements will be strengthened in the future. The announcement of expected future requirements has been very positively received by the industry as it allows them to prepare for and plan towards this development and thereby cooperate with the officials to achieve the overall target, instead of being presented to new requirements only a year in advance. This also means that the building market has expanded with the introduction of products and materials that comply with the new requirements for low energy buildings.

Norwegian regulations have the advantage that they include all energy use within the building, i.e. energy use for lights and equipment is included. This implies that efficiency measures on lights and appliances are also encouraged. However, this is only possible for lighting energy use, since the values to be used for calculating the appliance energy use are standardized.

Swedish regulations have the advantage that they require verification of energy performance with measurements within two years of operation. This means that quality assurance during the building process will be very important.

Finnish regulations have the advantage to set requirements of heat load and Swedish regulations have requirements of maximum installed heating power in electrical heated buildings. This is an important regulation that may reduce the need of electrical power from the electrical system in the future.

Cooperation needs for upgrading and implementation of codes

The above examples of advantages and differences between Nordic building regulations show that the Nordic countries have different knowledge and experiences that would be useful to share between them. A Nordic collaboration is therefore likely to be very beneficial.

The recast of the EPBD implies that all new buildings must be ”nearly zero energy buildings” in the end of 2020. The national building codes will be affected extensively in the future by the requirements within the recast of EPBD. Furthermore, there is still an urgent need to plan for the needed upgrading of the existing building stock. Building regulations are in its infancy for renovation in all Nordic countries.

Cooperation between the Nordic countries will facilitate the implementation of these new requirements. Thereby the development and introduction of products, services and processes for low energy buildings would be strengthened, which in turn will strengthen both the Nordic internal market as well as the export market.

Chapter 3 Overview of Incentives

Besides codes and regulations, several incentives may be used with the purpose to get the construction and building sector to voluntarily speed up the implementation of low energy buildings. Incentives address a specific target group to voluntarily focus on, take actions or perform measures with a specific purpose.

The chapter gives a brief overview of environmental and energy assessment methods for buildings. The overview also includes financial deals that support energy efficient buildings. The purpose is to illustrate possibilities for experience exchange that would be beneficial between the countries.

Environmental and energy assessment methods world wide

There are innumerable amounts of assessment methods on “the market”; international, national and local methods. A rather large share of these methods focuses mainly on environmental issues, were energy is just one of many things to pay regard to. But there are also energy assessment methods that have totally focused on energy.

Examples of international environmental assessment methods are BREAAM (UK), SBTool (Canada), CASBEE (Japan), green star (Australia), LEED (USA) and DGBN (Germany). A brief description of these is given in the Appendix. Some of the methods are very well known internationally while some are less known. Although the prefix *international* in some cases may be arguable, the intention here is to describe well established assessment methods and methods that can or could (based on presumptions) be used internationally.

Examples of well established energy assessment methods are the Passivhaus standard (Germany) and the Minergie standard (Switzerland). Minergie is an example of a successful voluntary incentive. The Minergie concept has lead to dramatically changed performance requirements in the Swiss building code and that more than 15 000 certified buildings have been built or planned with very good energy performance. Meanwhile, a great number of buildings in Switzerland have been built with much better energy performance than required according to national building codes, as a non certified spin off effect of Minergie.

Environmental assessment methods used in Nordic countries

In Finland, an environmental classification system called Promise have been developed for comparison of building performance and for managing environmental life cycle issues in building projects. The system covers environmental loadings, use of natural resources, health of occupants, and environmental risks. However, the system has not been widely used so far.

In Norway, a tool for calculating the greenhouse gas emissions of a building has been introduced (klimgassregnskap.no). The tool has so far been used in a few projects, and will be used in all the pilot building projects of the program FutureBuilt (futurebuilt.no).

Miljöklassad Byggnad is a Swedish environmental assessment method that has been developed and tested during the last years. The classification covers energy, the indoor environment, and chemical substances in the building. It is now ready to be used and a few buildings have been certified.

The Nordic Swan includes a labelling system for residential buildings, but this has not been widely used in any of the Nordic countries.

The British BREEAM system and the American LEED system are slowly gaining ground in the Nordic countries, but there are several difficulties to adopt them to national conditions. At the moment several projects are ongoing within the different countries in order to interpret the LEED and BREEAM rules for the different national requirements.

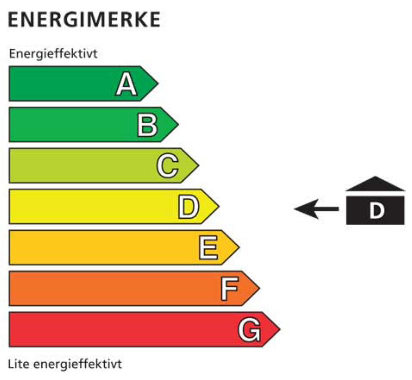
Energy assessment methods used in Nordic countries

To a minor extent the German Passivhaus certification has been used directly within the Nordic countries. However, there are some difficulties with using the German Passivhaus directly. These difficulties are primarily that the climate conditions within the Nordic countries are different, considering temperatures, wind and solar conditions. The more severe climate conditions in the north will make the requirements set for the German climate very difficult to reach. There are also several differences considering commonly used definitions on for example dimensioning outdoor temperature and air leakages and also on requirements on for example ventilation rates. Furthermore, the template values for internal heat from persons and domestic appliances are not directly suitable for Nordic building users.

Sweden, Norway and Finland have therefore made their national interpretations for a requirement specification of Passive houses. These energy assessment methods have now started to be implemented with certification schemes.

Also the EU assessment method GreenBuilding is gaining ground in Sweden, but the energy requirements are rather weak compare to the other voluntary energy assessment methods.

Energy labelling systems (EPBD)



The Energy Performance of Buildings Directive (EPBD 2002/91/EC) implies that the Nordic countries should have implemented energy labelling systems. Here all buildings, from very energy efficient to buildings that waste energy, are supposed to get energy labels.

Denmark implemented an energy labelling system for all buildings already in 1997. Iceland has decided not to implement an Energy Labelling system due to their favourable energy supply. In Sweden, the system of energy labelling was implemented from October 1st 2006 for multifamily houses and public premises and from January 1st 2009 for all buildings. In Finland the system was introduced from January 1st 2008, and in Norway from July 1st 2010. Potentially, the energy labelling system may also provide a knowledge base for energy performance measurements and innovations within the building energy sector. However, this requires efforts both from the authorities and from the building industries.

Financial incentives

Financial incentives are generally scarce within the Nordic countries, except for Norway that has had an increased implementation of LEB with instruments from the Norwegian State Housing Bank (NSHB) and Enova. The NSHB has for several years promoted environmental quality in buildings with advantageous loans, grants, and information. Almost half of all new homes financed with the NSHB's basic loan had a special environmental quality.

Cooperation needs for common Nordic incentives

Generally speaking, the Nordic countries have been fairly slow to implement voluntary incentives such as energy and/or environmental assessment methods. An earlier and stronger focus on such incentives would most likely have led to a faster market growth for LEBs, as can be seen in for example Germany, Switzerland, and Austria.

Since the Nordic countries have difficulties to directly adopt the successful international assessment methods, it would be advantageous to create a Nordic common voluntary energy and environmental assessment system. It should be possible to define LEB while regarding the differences between the building regulations within the Nordic countries. The construction and building sector would definitely benefit from a more harmonized incentive market situation.

Chapter 4 Market Share

This chapter gives a brief overview of the classification of LEB in the Nordic countries together with an overview of the market share of LEB. Overviews of the market share of LEB in selected European countries are also included.

Comparing market shares of LEB in the Nordic countries to lead European countries, the following conclusions may be drawn:

Although the statistics and verification documentation are insufficient, it seems as if Denmark, Finland, and Norway barely equal European lead countries like Germany and Austria with respect to the deployment of LEB. In Sweden, the market share of LEB seems to be significantly lower. When it comes to very low energy buildings like passive houses and zero energy houses, the Nordic countries are well behind the European lead countries. Taking the colder Northern climate into account together with the obvious possibilities of collaboration, the Nordic countries ought to be leading countries. The study shows that the Nordic countries would have to improve significantly in order to obtain the position of being leaders in this field.

In general, one may conclude that both statistics of LEB and verification of actual LEB performance in the Nordic countries are poor. Also, official definitions of LEB have not been available within the Nordic countries[5], but are now being established.

Denmark

In Denmark the term low energy building has been well-known since the mid seventies. The current Danish Building Regulations, BR08, define two low energy performance levels termed Low Energy Class 2 and Low Energy Class 1. Furthermore, together with the implementation in Denmark of the Energy Performance Building Directive (EPBD) in 2006 the existing energy certification scheme was adjusted and the accompanying database containing the energy certificates issued was updated.

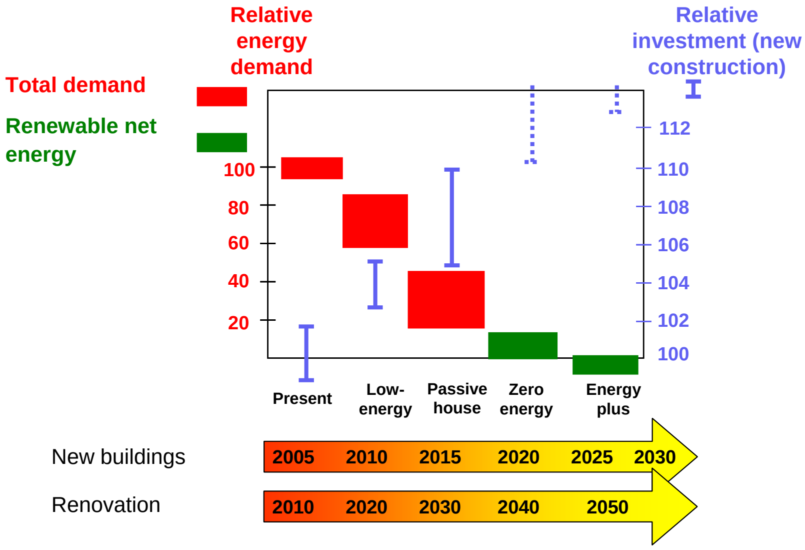
Figure 3. Relative distribution of houses completed in LEB class 1 and 2 in Denmark from 2007-2009. The figure is based on combining data from the Energy Certificate Database and Statistics Denmark.

[5] except in Denmark, where there have been a clear definition of LEB within the building code for several years

Based on the definitions and on combining the Energy Certificates Database and data from Statistics Denmark, the market share of LEB in Denmark is estimated to be about 10 % for single family houses and 5-10 % for each of the categories apartment blocks, offices and educational buildings. Figure 3 shows how the market share of houses in low energy classes 1 and 2 has increased from 2007 to 2009.

Finland

In Finland, a low-energy building was first defined in the early 1990's. Private builders built hundreds of low-energy houses, however, although the interest in low-energy buildings increased, the development was quite slow. Now, the basic requirements of the National Building Code 2010 guide the construction towards low energy buildings. The investment in energy-efficiency is in the range of 2 - 5 % compared to a standard house of 2010. The Finnish passive or very low-energy house definition has spurred a rapid development and construction of passive house concepts. There are specialized companies that build only passive or very low-energy houses. The City of Helsinki, e.g., has ordered that when the building site is located on land owned by the city, all buildings must fulfil at least the requirements of energy label class A.



Source: Construction sector's energy efficiency strategy. VTT 2008

Figure 4. Estimated market penetration of passive and very low energy buildings in Finland.

There are no official statistics on the amount of low energy or passive buildings available, but based on information from various industries, the market share of these buildings is estimated to be between 10 and 20% of all new housing. The market share is growing steadily.

Norway

In Norway, the interest in low energy and passive houses is quite large and several hundred projects are in the planning phase. Several hundred low energy buildings have been built, but only a few passive houses.

Currently, low energy and passive house levels are officially defined for dwellings only (NS 3700:2010), but work is underway for establishing a standard for other types of buildings. However, the energy labeling system includes requirements for calculated delivered energy for 13 different building categories. There is no national register of low energy and passive buildings. Estimations of the market share of LEB are therefore associated with substantial uncertainty. Nevertheless, the market share of new LEB is estimated to be about 10 % for residential buildings – both single family houses and apartment blocks – about 8 % for office buildings and less than 1 % for other types of buildings including educational buildings. However, there is virtually no information about the actual (measured) energy consumption of the alleged low energy buildings.

Sweden

In Sweden, market introduction of low energy houses and passive houses has been very slow. A few good examples including passive houses were realised around 2000 and 2001, but it was not until 2004 LEB were realized at a larger scale.

There have not been clear definitions or certification schemes for neither passive houses nor low energy houses in Sweden. A Swedish standard with definitions will be ready by mid 2010 and a certification scheme for passive houses is just launched. Therefore, it is difficult to exactly define the buildings between them. Furthermore, there is currently no national register of low energy and passive buildings. It is estimated that LEB in Sweden account for less than 1 % in all building categories. However, taking into account planned buildings within this year and next years, the market share will increase, particularly for very low energy buildings like passive houses.

Iceland

In Iceland there are no limitations for the total primary energy demand and therefore no registration of low energy buildings in Iceland exists.

Europe

Across Europe low energy buildings are known under several different names. Furthermore, what energy use is included in the definition varies from country to country and in addition the definitions for passive houses and equivalent concepts are very heterogeneous. According to the Commission's Info-Note on "Low Energy Buildings" of Sep. 2009, more than 12,000 low energy houses have been built in Europe, mostly located in Germany, Austria and Scandinavia. Exact figures are difficult to obtain due to the fact that in most countries there are no national register of low energy buildings.

The statistics regarding passive houses is more developed. It is estimated that in Germany there are about 8,000 passive house dwellings (May 08) equalling a market share of about 1 %. There are indications, however, that to some extent not all of the houses actually built according to the passive house standard are certified and hence registered as passive houses.

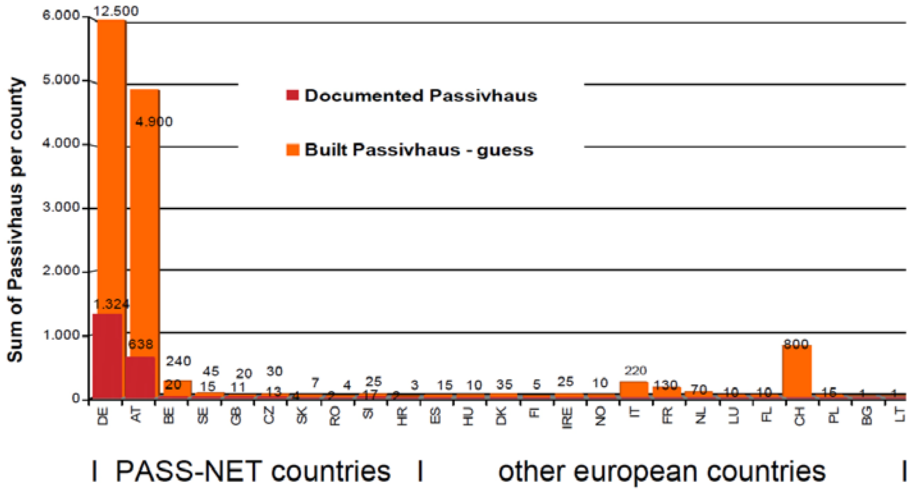


Figure 5. Documented and built – guess – passive houses in Europe. Source: International Passivhaus Database, Establishment of a Co-operation Network of Passive House Promoters (PASS-NET), 1. Period of documentation 2007 – 2009, http://www.pass-net.net/index.htm.

Chapter 5 Overview of LEB technologies, solutions, and R&D activities

This chapter presents an overview of LEB technologies, solutions, and R&D activities, including main topics, examples of pilot building projects, and future needs and trends. The analysis clearly indicates that there are a lot of similarities between the Nordic countries and only a few differences. Below is a summary of the findings.

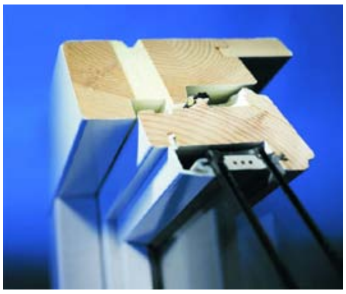
LEB development focus areas and business strongholds

The following focus areas and business strongholds with respect to LEB technologies and solutions have been identified:

Construction details for air tight and highly insulated building envelopes

This has been a focus area in all the Nordic countries, and has lead to the development of new insulation and air tightness products, as well as new construction methods and increased use of verification procedures (blower door tests and thermography). Major market players include Nordic product manufactures, consultants, construction companies and R&D institutes.

Passive house windows and doors



The first Nordic passive house window was produced by a Finnish company in 1994 (with total U-value 0.7 W/m^{2}K). Later, several Nordic passive house windows have been introduced to the market with total U-value down to 0.6 W/m^{2}K. Still, there is a need for further development, in particular of high insulating doors and improvement of the products with respect to thermal insulation, air-tightness, solar and light transmittance, and environmental loadings.

Balanced mechanical ventilation systems with heat recovery

Ventilation systems with high efficiency air-to-air heat recovery units for LEB houses have been developed by several Nordic companies. In Norway, rotary heat exchangers are the most commonly used in LEB projects, while in Sweden, counter flow systems are more wide spread. In the passive house concept from Germany and Austria, space heating with ventilation air is prevalent. Such systems have been introduced with success in Swedish, Danish and Finnish LEB projects. In Norway, however¸ ventilation space heating has been met with scepticism, due to uncertainties about indoor climate. This shows a need for transfer of experiences between the Nordic countries.

Energy efficient tap water devices

In Sweden, several demonstration projects have shown that installation of new energy-efficient taps and shower mixers can substantially reduce the use of water and energy for heating the tap water. Development of energy-efficient tap water devices has been ongoing for a decade in Sweden. The development is focusing on reducing water consumption while still keeping the end users requirements of comfort.

Heat pumps
Spurred by building regulations and financial incentives, heat pumps have gained a significant market share in all the Nordic countries (except Iceland). This includes all types of heat pumps including air-to-air, air-to-water, and ground/water source systems, ranging from small residential units to large multi building installations. Several Nordic manufacturers exist. Ground source heat pump systems are gaining interest, due to higher reliability and requirements to cover a higher fraction of the heating and cooling loads. Further development and optimization of the systems are needed in order to reduce costs and increase reliability.

Partnering organisation and integrated energy design
Several of the LEB demonstration projects in Sweden have successfully tested a new way of organisation, called partnering. Partnering is a cooperation contract model where the client, construction companies, architects, consultants, and other key actors are solving the assignment together and share the responsibility for achieving the energy and environmental goals. A related concept of cooperation is integrated energy design (IED). In these processes, new computer based tools like advanced energy/environmental tools and BIM play an important role. Both partnering and IED have been introduced in the other Nordic countries, but have so far not been wide spread used. Finland seems to be the most advanced on the use of BIM.

Total LEB concepts
The development of total concepts for low energy buildings include taking into account the whole range of challenges related to the realization of successful LEBs; planning and design strategies, integrated energy technologies, building layout, envelope design, and construction, operation and maintenance issues for different types of buildings in different climates and local settings. Financing and life cycle costing, as well as implementation strategies are also parts of the concept development. These issues have been part of the activities related to pilot building project in all the Nordic countries. However, Sweden has worked most extensively and structured with this issue, and have also developed a “total concept for renovation” to LEB standard (BELOK).

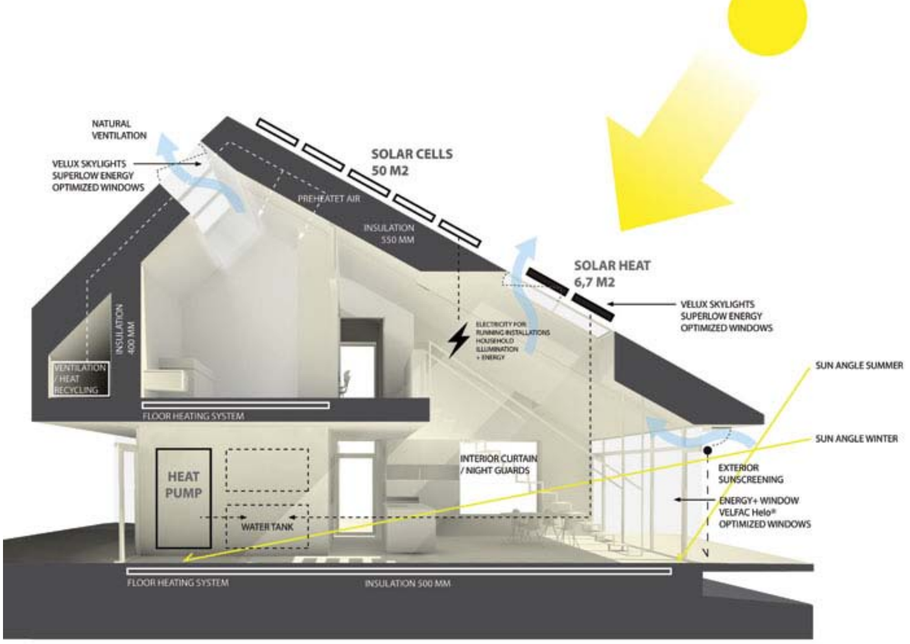


Figure 6. The energy concept of the Danish “House for Life” – an “active house” from Velfac, www.velfac.dk.

Pilot building projects

Several pilot LEB projects have been carried out in the Nordic countries. The projects provide highly valuable testing grounds for new technologies, solutions and strategies. Also, a very important role of the pilot projects is to serve as "success stories" and frontrunners for others to follow and learn from. However, the number of pilot projects is still limited, and only a few of the projects have been thoroughly measured and evaluated with respect to energy performance and user satisfaction. Thus, there is a large need for a coordinated effort to learn from Nordic pilot building projects.

Vargbroskolan, Storfors
Example of a low energy building project that has been thoroughly monitored with respect to energy performance.

All the different energy uses has been monitored and reported, including space heating, hot water, ventilation fans, pumps, lighting, and appliances. Also the energy production of the PV system has been monitored.

The total energy use is less than one third of the requirement of the Swedish building code.

From the analysis it is clear that the Nordic countries have had more or less the same focus and development concerning low/zero energy buildings during the last years. This focus has resulted in the launch of strategic national research and implementation programmes or innovation centres, e.g. Zero Emission Buildings (ZEB.aau.dk) in Denmark, Zero Emission Buildings (ZEB.no) in Norway and LÅGAN[6] in Sweden. The research programmes typically encompasses the national research institutions, universities and governmental institutions along with a broad representation from the building industry (including architectural and engineering companies, developers, construction companies and producers of materials). In conclusion, this testifies towards a strong and unified collaboration of government, researchers and building industry within the Nordic countries towards low/zero energy buildings in the future.

Future R&D needs

The Nordic countries agree on several R&D topics that need to be addressed in order to achieve the future goals concerning low/zero energy buildings:

- Highly insulated building envelope constructions with further reduction of thermal bridges.
- Energy efficient ventilation systems, with high-efficiency heat recovery, and hybrid ventilation systems utilizing thermal storage.
- Integration of combined heat and power systems in the building.
- Energy efficient lighting with focus on developing dynamic façade solutions where daylighting and shading systems are combined.
- Heat pump systems and biomass systems optimised for low loads combined with heat storage systems and other forms of renewable energy sources.

[6] http://www.energimyndigheten.se/sv/Foretag/Energieffektivisering-i-foretag/Lokaler-och-flerbostadshus/Bygga-och-renovera/Samordning-av-energieffektivisering-i-byggnader/Program-for-byggnader-med-mycket-lag-energianvandning-LAGAN/

- Passive house windows and balcony doors with reduced transmission heat loss and increased solar gains.
- Increased focus on the users, and developments concerning utility interactive systems, user friendly and efficient energy management systems and research into user cultures and attitudes towards low/zero energy buildings.
- Complete heat recovery systems for renovation of apartment blocks. Including solutions for air tightening of the building envelope, innovative solutions for installation of the duct system and construction of fan rooms. This includes both solutions with heat exchangers between supply and exhaust air, as well as solutions with exhaust heat pumps.
- District heating net techniques for areas with LEB.
- Combination of different systems such as heat pumps or bio fuels systems with solar energy systems (PV and thermal) for increasing the share of renewable energy.
- Development of photovoltaic systems and small wind turbine systems. This includes technique for connecting, measuring and contracting of connection to the grid.
- Development of energy efficient building products and services system with low environmental impact in a life cycle perspective.
- Development of complete concepts for construction and renovation of LEB including near zero energy houses concepts.

Overall, a strong Nordic research collaboration concerning the development of new and innovative solutions for future low/zero energy buildings is obvious. Although the Nordic countries may face some individual problems, it is evident that the majority of challenges are common Nordic problems. This indicates a huge potential for reaping mutual benefits from sharing and exchanging knowledge concerning research and experimental projects with focus on energy savings in both new and existing buildings.

Chapter 6 Analysis of Market Possibilities and Needs for an Innovation Program

The purpose of this activity is to give an overview of the market possibilities of low energy buildings, both in each Nordic country as well as market possibilities for export mainly inside the EU. The analysis is based on interviews with key persons from selected companies and institutions. The interview questions were mainly framed to highlight business strongholds, barriers and general ideas on how to improve the LEB concept and business. Key persons were interviewed in Denmark, Iceland, Norway, and Sweden, altogether 45 interviews. The key persons represent 11 categories related to the building industry, more exactly:

- Architects
- Consultants
- Construction
- Developers
- Financing institutions
- Building managers
- Knowledge institutes
- Insulation materials, nano-materials, air tightness products
- Windows, glazing
- Solar collector systems
- Photovoltaics
- Heat pumps
- Biomass/gas systems
- Ventilation systems
- Heating and heat recovery systems (wastewater, earth HX)

The answers to the questions differ depending on background of the key persons. A detailed description of the interviews is given in the Appendix. Some general answers are accounted for below.

LEB experiences

Most of the respondents are frequently involved in LEB projects. Some of the respondents claim that almost all their building projects are LEB, even though only a few of them can be defined as passive houses or other buildings with very good energy performance. The definition of LEB is generally a bit vague.

The reason for their involvement in LEB projects differ. Several of the respondents mention that they expect higher requirements with respect to LEB from both authorities and the general public. Some municipalities require LEB as a part of their local environmental policies while some customers are just simply interested in LEB. Individual engagement and conviction among the interviewed are probably also reasons why LEB projects are carried out.

R&D experiences

Several of the respondents have been involved in R&D projects related to LEB, generally projects that somehow involve optimization of energy performance of buildings, etc.

The projects often involve several national and international partners, ranging from suppliers and producers of products, through architects, developers and consultants, to R&D institutes and universities.

Other examples of R&D experiences where think-tanks, development of internal guidelines on how to build LEB and experience feedback routines from LEB projects.

Barriers for development of LEB market

The main barriers seem to be financing and lack of knowledge and competence. The answers indicate that the first barrier quite often seems to be a result of the second barrier since the knowledge and use of life cycle cost analysis (LCC) is very limited within the real estate branch. The aspects mentioned with respect to financial barriers differ depending on country, but lack of long term perspective seems to be a main problem. Many of the interviewed persons claim that this limited perspective is valid for all categories; from financial institutes to proprietors. Several respondents mention that there is a need for stable and predictable financial incentives.

Other barriers often mentioned where:

- Limited amount of information from “success stories”. The LEB concept is not marketed enough.
- Structural barriers, e.g. the difficulties in introducing new technologies and solutions to replace well established products, services and infrastructure.
- Reduced accessible floor area (thick walls reduce the area).
- Fear of reduced thermal comfort (mostly when it comes to passive houses).
- Different local environmental policies regarding LEB
- Lack of “crisis consciousness”, i.e. lack of serious commitment to sustainable development.
- The Nordic energy supply system is perceived to be “clean”, which reduces the interest in energy efficiency measures.

Figure 7. More well documented demonstration projects like the Finnish IEA5 house build in Pietarsaari, is needed, www.vtt.fi.

What a Nordic innovation program should focus on

The interview answers gave no unanimous conclusion with respect to what topics a Nordic innovation program should focus on. Nevertheless, several of the respondents mentioned the following topics:

Knowledge exchange

Most of the interviewed claimed that exchange of knowledge among the Nordic countries would be useful. This could be done in several ways, e.g. through a common knowledge platform or through information campaigns targeted at different stakeholders. Knowledge platforms should include participants from industry (producers, consultants, developers, construction companies, etc.), as well as authorities, universities and R&D institutes. The target group of information campaigns may be financial institutes, building owner societies and tenant organizations. Information campaigns should contain knowledge from shining examples (thoroughly investigated).

Education and training

With regard to one of the main barriers above (lack of competence), some of the interviewed wanted producers of building services systems in general and building workers/craftsman in particular to undergo education and training programs leading to certificates, preferably certificates on a Nordic level. A Nordic certification system would most likely raise the status of these categories which may attract young people to the branch. Moreover, it would make a good example for the rest of Europe to follow. Bygga Bo Dialogen in Sweden is a good example of national training courses, free of charge, in sustainable building and maintenance (even though it does not contain certification), see: www.byggabodialogen.se

Evaluation of LEBs in use

This includes structured monitoring and verification of energy performance, indoor environment and user satisfaction. Such reliable information from one or more Nordic countries would be very beneficial for introducing the products in other Nordic countries or similar markets abroad.

Increasing the cost-effectiveness of LEBs

Development of components, products and concepts that are more cost-effective and robust with respect to user behavior.

Common principles for codes, standards, certification and incentives

More Nordic cooperation on developing common principles and requirements for codes, standards, documentation/certification, and incentives. This would make it easier for the Nordic companies to adapt and market their products and services in all Nordic countries.

Efficient solutions for renovation of LEBs

There is a great need to develop effective solutions and incentives for energy-efficient renovation of existing buildings.

Other focus areas mentioned were:

- Methods and tools for integrated energy design, strategic energy planning, and life cycle costing

- Design support and guidelines
- Pilot building projects – reference projects
- The development of verification and documentation procedures
- Analysis of the development of the Nordic and European energy market
- List of arguments (based on statistics from validated LEB's) for discussion with financial institutes
- A guideline with illustrative examples on how to build LEB (refurbishment included), not just a list of defined requirements.
- Permission for LEB to be built outside the development site (as a compensation equivalent to the thicker walls)
- National incentive models. Example: less expensive site price for LEB
- Possibility for building owners to sell electricity (this is possible in Germany)
- Building codes designed to encourage LEB's
- Common local environmental policies regarding LEB.
- Financed (or partly financed) pilot projects for development of technical systems

Advantages of a Nordic innovation program

All of the respondents considered a Nordic innovation program to be useful. Generally, they thought a common program could <u>increase the Nordic LEB business strongholds, and lead to higher market penetration for Nordic LEB products and services</u> both within the Nordic region and toward increased exports.

Several mentioned that cultural and climatic conditions are quite similar among the Nordic Countries, which facilitates cooperation across borders. However, some differences where brought up, e.g. related to the property structure, but these were not considered a main obstacle.

The benefit of information and knowledge exchange among Nordic countries was also mentioned by several, e.g. the benefit of learning from each other. It would also reduce double work and double research within the Nordic countries

A couple of the respondents mentioned that the Nordic perspective with respect to "clean" production, high quality design, democracy and the valuation of common goods should be an advantage with respect to taking the world leadership in green innovations.

One of the respondents answered elegantly: *"There is an obvious beauty in combining the Swedish engineering science, the Danish pleasure of life and pragmatism, and the Norwegian fighting spirit".*

Consequences of not having a Nordic innovation program

Most of the respondents answered that the Nordic market and businesses would <u>develop slower and fall behind</u>. It would lead to less good performance, slower development, less Nordic cooperation and the Nordic countries would lose the opportunity to be in the frontline.

Other, more specific consequences mentioned were:

- Inefficient use of the R&D capacity
- Inefficient use of resources

- Higher failure rates
- More different solutions with lower market shares
- More expensive solutions
- Small actors that cannot bring major changes alone

Necessary conditions for increased development and market for LEB products and services

Many answers here are similar as for - *What a Nordic innovation program should focus on* (see above). However, a lot of the answers here focus on financial support. But the opinion differs a lot depending on country, which makes the answers hard to summarize. One can basically say that the absolute majority of the respondents in all countries asked for financial subsidies, all countries except Sweden where literally none of the respondents wanted direct subsidy.

Those <u>in favor of financial subsidies</u> answered:

- Need for public financial support in the innovation phase, to reduce risk.
- Support should be related to % improvement relative to current regulations
- Economic support for planning and market introduction (of buildings and products)
- Economic support for pilot buildings, especially integrated energy design
- The economic support mechanisms must be predictable and non-bureaucratic

As mentioned, the Swedish respondents said they did not want financial subsidies, but if there were they would use it.

Anyway, not all of the answers dealt with financial subsidies. Here are some other answers about necessary conditions:

- Development of incentives and regulations
- Feed-in tariffs for distributed renewable energy
- Public institutions must lead the way, drive the development
- Well documented pilot projects should lead the way – show that technology is performing as expected.
- Profound technical knowledge needs to be developed
- Developers/buyers/clients must have competence and give specific and concrete energy requirements
- Nordic information on validated LEB projects. Preferably LEB projects from many different geographical locations.
- National building codes should require some amount of solar heating (as in Portugal, Spain, South Africa, some countries in South America and soon in Italy.
- Make it possible to sell heat surplus (to neighbours) and solar electricity

Most of the respondents expressed interest in collaborating with other Nordic partners, and with other types of businesses and institutions. All types of actors in the value chain of LEB were mentioned, the most frequently mentioned include knowledge and R&D institutions, architects, consultants, material and product suppliers and producers, installers, construction companies, developers, and end users. However, some of the respondents stressed that they should be allowed to choose collaborative partners freely (not to be dictated by the innovation program). Also, many respondents stated that users (end users or businesses) should be actively involved in R&D projects and that they should feel ownership for the innovation.

Chapter 7 Conclusions

The analysis shows that the Nordic countries have a significant amount of activities directed towards LEBs, but we can not claim to be world leaders within the field. In order to bring the Nordic countries in an international forefront within respect to LEB market penetration and LEB business, significant efforts are needed.

With respect to the market share of LEBs, statistics and verification documentation is insufficient. However, it seems that Denmark, Finland and Norway barely equal European lead countries like Germany, Switzerland and Austria. In Sweden, the market share of LEBs is significantly lower, but taking into account planned buildings within this year and the next years, the market share will probably increase significantly. In Iceland, there are virtually no LEBs. When it comes to very low energy buildings like passive houses and zero energy houses, the Nordic countries are well behind the European lead countries.

Moreover, it is disturbing that both statistics of LEB and verification of actual LEB performance in the Nordic countries are poor. Also, official definitions of LEB have not been available within the Nordic countries[7], but are now being established.

A main conclusion from the analysis is that a closer Nordic cooperation within LEB development and implementation would be beneficial for the region as a whole. In general, this may be justified by the simple fact that together the Nordic countries would create a larger common market for LEB products and services, and be stronger in the competition against other countries. A strong Nordic market for products, services and processes for low energy buildings will facilitate the possibilities for the export market.

The analysis also showed that the Nordic countries have many similarities with respect to LEB business and development; however there are different strengths and experiences that would be beneficial to transfer across borders. The analysis has identified 8 main fields that would be strengthened by a Nordic cooperation. These are shown in figure 8 and described below.

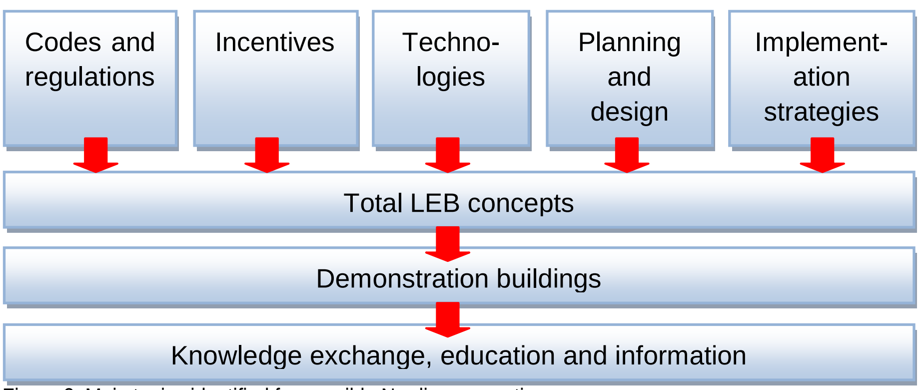


Figure 8. Main topics identified for possible Nordic cooperation.

[7] except in Denmark, where there have been a clear definition of LEB within the building code for several years

Codes and regulations

The recast of the EPBD implies that all new buildings must be ”nearly zero energy buildings” by the end of 2020. Thus, the national building codes will be affected extensively in the future by the requirements within the EPBD. Furthermore, there is an urgent need to plan for the needed upgrading of the existing building stock. Building regulations are in its infancy for renovation in all Nordic countries. Cooperation between the Nordic countries will facilitate the implementation of these new requirements. Thereby the development and introduction of products, services and processes for low energy buildings would be strengthened, which in turn will strengthen both the Nordic internal market as well as the export market.

Incentives

Compared to the “best” countries in Europe, the Nordic countries have been fairly slow to implement voluntary incentives such as energy and/or environmental assessment methods. An earlier and stronger focus on such incentives would most likely have led to a faster market growth for LEBs. It would be advantageous to create Nordic common voluntary energy and/or environmental assessment systems or to commonly adapt one of the international assessment systems.

Development of LEB technologies

The Nordic countries have made significant progress in developing LEB construction details and components like passive house windows, heat recovery units and heat pump technologies. Also building technologies, for example the construction of air tight buildings, are well developed within the Nordic countries. The products and techniques are, however, not mainstream within the Nordic countries. Also, the products need to be further developed and optimized with respect to reduction of cost and improved environmental performance. Heat supply systems need to be developed to suit lower heat demands. Moreover, there is little experience with energy supply systems like CHP (combined heat and power) systems. This development could benefit from involving different Nordic companies and institutions that are experts in the different parts of the value chain of LEBs.

Design and planning strategies

New planning and design strategies like partnering contracts and integrated energy design (IED), need to be developed and implemented into the building practice. There is limited knowledge of such methods in the Nordic countries, but some experiences have been gained in various pilot projects.

Implementation strategies

Considering the relatively similar culture of the Nordic countries, common cooperation projects on marketing strategies could be beneficial. The study of user cultures and user acceptance of LEBs could benefit from a Nordic cooperation. It is important to increase the market size for components and services. With a large Nordic internal market, the technologies and costs will be more competitive, which will prepare the ground for a larger export market.

Development of LEB concepts

Different total concepts for different types of low energy buildings should be developed. The total building concepts include planning, design, construction, technologies, layout, operation, marketing and financing. In particular, it is important to develop LEB concepts and strategies for renovation of existing buildings, like Sweden has started. Several demonstration projects within the Nordic countries show that knowledge about total concepts for LEB is progressing, but needs to be further elaborated in order to become mainstream.

Demonstration buildings

There is a great need for well documented and successful pilot projects to serve as “leading stars” for the development of the LEB market. Also the pilot building projects are very important testing grounds for new technologies, development of competence, and knowledge building. Since the climate and cultural settings in the Nordic countries are quite similar, coordinated efforts within pilot building implementation, evaluation and verification would be very useful.

Knowledge exchange, information and education

Finally, the analysis showed that there is a substantial need for exchange of knowledge and experience among the Nordic countries. Also, cooperation about education and certification programs is beneficial. Such effort should address all the different actors in the value chain of LEBs, and contain information from well documented pilot building projects within the Nordic countries. For example, a common certification program for craftsmen will facilitate a common market for products and services for LEB.

Appendix: Nordic Analysis of Climate Friendly Buildings – Detailed Report