Passive House Projects in Norway – an Overview

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1 Introduction

During the last 2-3 years, the interest in low energy and passive houses has increased significantly in Norway. More than 15 passive house projects incorporating more than 1000 apartments are currently in the planning phase, but only a few has so far been completed. This paper includes a description of the projects that have been completed and some of the projects that have come furthest in the planning. The projects are located in different climatic zones, ranging from the relatively mild coastal climate of Bergen to the cold inland climate of Lillehammer. The locations span from 58 to 70 degrees Northern latitude. The work is partly carried out within the framework of the European project "Promotion of European Passive Houses" (PEP), financed by the Energy Intelligent Europe programme (www.passivhouses.org).

1.1 Overview of current passive house projects in Norway

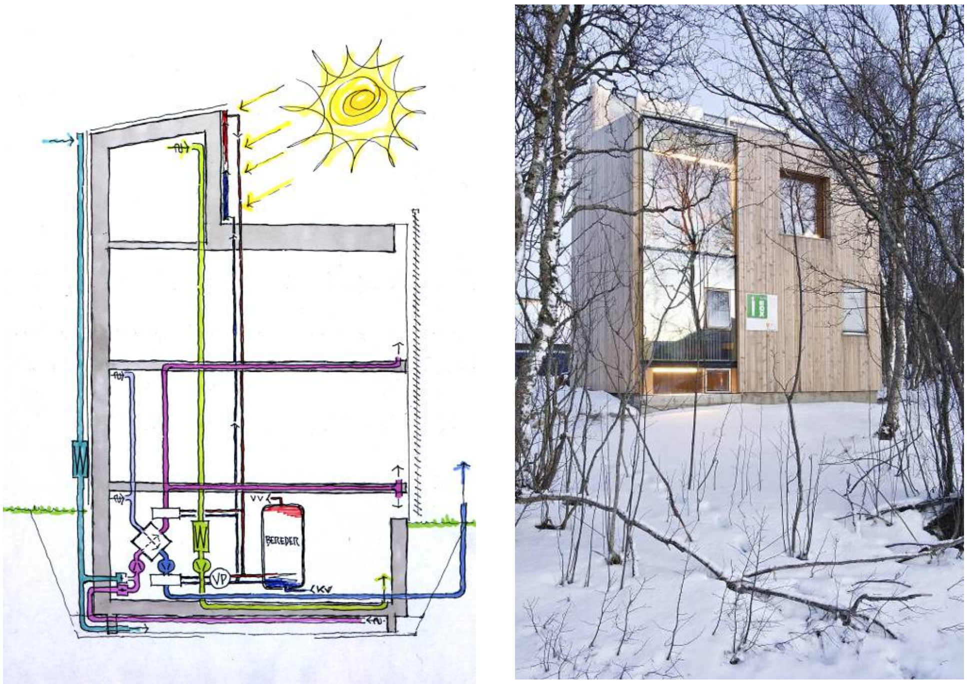
The table below shows an overview of current passive house projects in Norway. In the following, the projects are described in more detail.

Building type	Location	Client /Developer	Architect	Energy Engineering	Status
Single family dwelling	Tromsøya, Tromsø	Passivhus Norge AS	Steinsvik Architects	Steinsvik Architects	Completed Dec 2005
7 dwellings in a row house	Storelva, Tromsø	Maurstad-gruppen	Steinsvik Architects	Steinsvik Architects	To be completed April 2007
Single family dwelling	Sørumsand, Akershus	H. Ringstad	Dipl. Ing. Stephan Blohm and Arch. Toril R. Grønvold	Dipl. Ing. Stephan Blohm, and SINTEF	Construction starts April 2007
1 single family dwelling in a row house	Venstøp, Skien	Hansen & Lauritzen AS	T.A. Danielsen, Aplan Viak	SINTEF and Erichsen & Horgen AS	Completed Fall 2006
28 apartments in multi-storey blocks	Fyllingsdalen, Bergen	ByBo AS	ABO Arkitekter	SINTEF	Construction starts summer 2007

32 apartments in 2 story row houses	Smestadmoen, Lillehammer	LOBB housing cooperative	Asplan Viak and Kai S. Hekne	SINTEF	Construction starts spring 2007
210 apartments in multi-storey blocks	Lerkendal, Trondheim	Skanska Bolig	Selberg Arkitektkontor AS and Madsø&Sveen	SINTEF	Construction starts fall 2007

Overview of current passive house projects in Norway

1.1.1 Single family house at Tromsøya, and 7 dwellings at Storelva, Tromsø, latitude 69.6°N

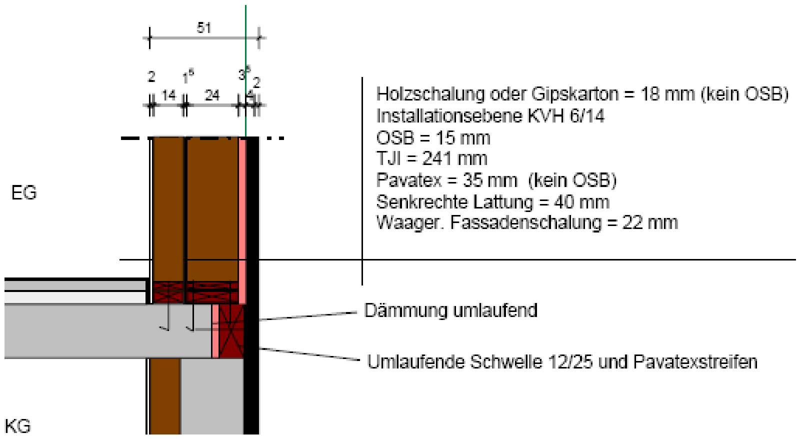


Left: Schematic drawing of the technical system of the I-Box concept (illustration by Odd K. Steinsvik). Right: Picture of the completed dwelling at Tromsøya (photo by Ravn Steinsvik).

Both these projects are designed according to the I-Box© concept from Steinsvik Architects (www.passivhus.no). The single family dwelling at Tromsøya was completed in December 2005, and was the first passive house project to be completed in Norway. The 7 dwellings at Storelva are due to be completed in March/April 2007. Tromsø has a relatively cold coastal climate, with a yearly mean ambient temperature of 3.0°C and design winter temperature of -17.5°. The dwellings are constructed in massive wood elements (from KLH Massivholz, Austria). The exterior walls have 25-30 cm of mineral wool, the roof has 36 cm of insulation, and the floor has 15 cm. The ventilation system is coupled to an earth to air tube collector buried beneath the basement and a compact heat pump unit with heat recovery (Vitotres 343 from Viessmann). The dwellings have no conventional heating systems; the entire space heating load is covered by the ventilation system. A solar collector system produces most of the warm water during the spring and summer seasons.

The total end energy use is estimated to less than 50 kWh/m^2/yr for all dwelling units. The heating energy load for all dwellings is estimated to be below 5 kWh/m^2/yr. The developer has estimated the total construction cost of the project to about 10% above typical construction cost. The indoor temperatures in the dwelling at Tromsøya have been measured during the warmest summer days, and are reported to be in the range of 22-23°C. The windows are equipped with an exterior automatic shading system. The energy use for the Tromsøya house has not been measured yet, but the all the dwellings are to be monitored. Special challenges reported were lack of knowledge and skills among HVAC and electrical engineers, so the architects were to deal with the technical matters on their own. Also, the special construction method related to the massive wood elements, were new to the Norwegian construction practitioners. However, the thermal bridge challenges related to the massive wood elements were found to be relatively easy to solve.

1.1.2 Single family house (NorOne) at Sørumsand, Akershus, latitude 59.9°N



Left: Drawing of the south facade (illustration by Architect Toril R. Grønvold). Right: Detail of exterior wall meeting ground floor slab (Illustration by Dipl. Ing. Stephan Blohm).

The ambition of this project is to be the first dwelling in Norway which is self-sustained with energy over the year. It will also be the first Norwegian project certified by the Passivhaus Institute in Darmstadt. The 3 storey dwelling has a total floor area of 345 m^2. Sørumsand is located close to Oslo, with a yearly mean ambient temperature of 6.2°C and a winter design temperature of -20°C. Global horizontal solar radiation is 970 kWh/m^2/yr. The U-values of the envelope construction are as follows: floor 0.09 W/(m^{2}K), wall 0.11 W/(m^{2}K), roof 0.09 W/(m^{2}K), windows 0.76 W/(m^{2}K). The ventilation system has high-efficient heat recovery and air is preheated via a ground coupled heat exchanger. There will be a water based floor heating system in bathrooms and hallways. LED lighting and A-labelled household appliances as well as a building management system will be installed to reduce the electricity use to a minimum. The house will also be equipped with a roof mounted, grid coupled PV panel of about 5 kWp and vacuum tube solar collectors that produces 2350 kWh/yr for DHW. Auxiliary heating is electrical. The total heating energy and power use is estimated to 14.9 kWh/m^2/yr and 9.9 W/m^2, respectively. Total end energy use is estimated to 62 kWh/m^2/yr. The developer has estimated the total construction cost of the project to about 10% above typical construction cost. Special challenges so far have been difficulties related to finding a suitable, biomass-fired central heating system with low (3-5 kW) output.

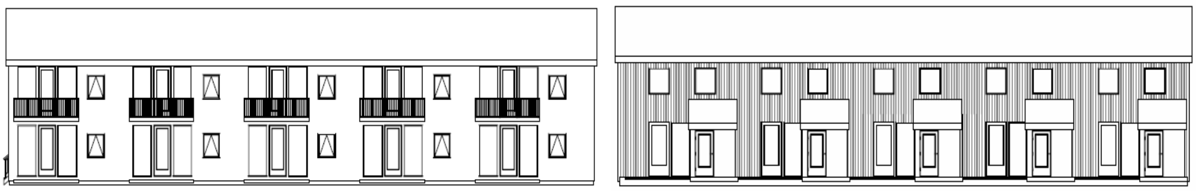
1.1.3 Single family house at Venstøp, Skien, latitude 59.3 °N

This passive house is part of a 7 house development including 2 low energy houses. The houses were completed in Fall 2006, and monitoring has started. The small town of Skien has a climate typical of the east coast, with a mean annual temperature of 5.6°C and a winter design temperature of -20°C. Global horizontal solar radiation is 930 kWh/m^2/yr. The construction of the passive house includes exterior walls and floors with 30 cm of insulation, and 45 cm in the roof. Windows are triple glazed with a U-value of 0.8 W/m^{2}K. Infiltration rate has been designed to 0.04 ACH using 2 air-tight layers and careful detailing. The house is equipped with a mechanical ventilation system with 80% heat recovery. The heating system includes water based floor heating in bathrooms. A novel air-to-water heat pump system with an average COP of 3.2 (kW-Smart, www.abk.as) provides space and DHW heating. Assuming energy-efficient lights and appliances, the heating energy load was estimated to 22 kWh/m^2/yr and the total end energy use was estimated to 64 kWh/m^2/yr. Thus, the heating load does not meet the passive house requirement; however the total end energy use is comparable to a passive house. The construction cost of the passive house was 8-10% higher than the standard houses. Special challenges reported were some extra time spent on fine tuning of the ventilation system during commissioning, and some dew gathering on the exterior surface of the windows during wet and cold mornings and afternoons.

1.1.4 28 apartments at Fyllingsdalen, Bergen, latitude 60.4°N

The 28 passive house apartments are planned as a part of a large low energy dwelling complex "Løvåshagen" with a total of 80 apartments. The construction will start summer 2007. The average size of the apartments is 80 m^2. Bergen has a relatively mild and moist coastal climate, with a yearly mean ambient temperature of 7.8°C and design winter temperature of -10°. Floor slabs are in-situ concrete and exterior walls are wood frame with 35-40 cm of mineral wool. Windows have a U-value of 0.8 W/(m^{2}K) (N-Tech from Nor-Dan). Slab on ground has 35 cm of rigid foam insulation. Thermal bridges are minimized to < 0.02 W/mK. Air tightness is planned to reach the requirement of n_{50}=0.6 ACH. Each apartment has a mechanical ventilation system with 80% heat recovery (rotary wheel, placed in the bathrooms). The apartments have a simplified water based heating system with floor heating in the bathroom and one radiator (800-1000W) in the living room. Each apartment also has its own solar heating system delivering about 19 kWh/m^2/yr. Auxiliary heating energy is supplied by electricity. Heating energy use is estimated to 15 kWh/m^2/yr and the total end energy use is estimated to 70 kWh/m^2/yr. The developer has estimated the total construction cost of the project to about 1000 NOK/m^2, which corresponds to about 5-6% above typical construction cost.

1.1.5 32 apartments at Smestadlunden, Lillehammer, latitude 61.1°N



North facade (left) and south facade (east). Illustration: Asplan Viak.

At the city of Lillehammer, LOBB housing cooperative has planned to build 32 dwellings in 2-storey row houses. The construction will start spring 2007. The average size of the apartments is 90 m^2. Lillehammer has a cold and relatively dry inland climate, with a yearly mean ambient temperature of 3.3°C and design winter temperature of -25°. Floor slabs are in-situ concrete and exterior walls are wood frame with 35-45 cm of mineral wool. Windows have a U-value of 0.8 W/(m^{2}K) (N-Tech from Nor-Dan). Slab on ground has 35 cm of rigid foam insulation and roof has 55 cm of mineral wool. Thermal bridges are minimized to < 0.01 W/mK. Air tightness is planned to satisfy the requirement of n_{50}=0.6 ACH. The ventilation and heating systems are similar to those of the Løvåshagen project described above. Each apartment also has its own solar heating system delivering about 20 kWh/m^2/yr. Heating energy use is estimated to 15 kWh/m^2/yr and the total end energy use is estimated to 70 kWh/m^2/yr. The developer has estimated the total construction cost of the project to about 950 NOK/m^2, which corresponds to about 5-7% above typical construction cost.

1.1.6 210 apartments at Lerkendal, Trondheim, latitude 63 °N

In the city of Trondheim, the construction company Skanska is planning a large passive house project consisting of more than 200 apartments. The construction will start in the fall of 2007. The average size of the apartments is 55 m^2. Trondheim has a yearly mean ambient temperature of 4.9°C and design winter temperature of -19°. The construction is based on steel columns and pre-cast concrete floors, with exterior walls in either foam insulated concrete sandwich elements or wood frame construction. The roof has 50 cm of mineral wool. Windows have a U-value of 0.8 W/(m^2K) (N-Tech from Nor-Dan). Floor towards the parking cellar has 35 cm of insulation. Thermal bridges are minimized to < 0.02 W/mK. Air tightness is planned to meet the requirement of n_{50}=0.6 ACH. The heating and ventilation systems are similar to that of the Løvåshagen project described above. Heating energy use is estimated to 15 kWh/m^2/yr and the total end energy use is estimated to 85 kWh/m^2/yr. All thermal energy is supplied by the district heating system. The developer has the ambition to keep the construction cost equal to their standard construction cost.

1.2 Lessons learned and future prospects

The greatest challenges reported are related to finding appropriate energy systems, i.e. there is a lack of efficient energy supply systems based on renewable energy. Also, there seems to be a lack of high-efficient ventilation aggregates. With respect to designing the construction details, the greatest challenge is connected to exterior walls. There is also a lack of standardized design details with respect to minimizing thermal bridges, thus the design of such details is time-consuming.

Extra investment costs of the passive house projects range from 0 to 10% compared to normal standard. The costs seem to increase proportionally with the size of the project, i.e. the highest costs are for the single family houses and the lowest costs are for the larger apartment buildings.

Estimated total end energy use range from 50 to 85 kWh/m^2/yr. However, these numbers are not confirmed, since none of the houses have yet been monitored. Thus, the greatest challenge related to ensuring the further success of passive houses in Norway is to establish some form of organised performance testing or certification scheme.