The first apartment house renovation with Passive House components in Norway

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1 Background

A typical building renovation in Norway, as in most other countries, only deals with very modest energy measures. This can result in lost opportunities for decades. Myhrerenga is the first apartment house renovation in Norway which uses Passive House components to reduce energy consumption and environmental impact dramatically.

Myhrerenga housing cooperative is situated 15 km north-east of Oslo in Skedsmokorset and consists of 7 similar blocks, erected in 1968-1970, three storeys high with 24 apartments in each block. There are only two types of apartments, six one-bedroom flats with 54 m² living space and 18 two-bedroom flats with 68 m² floor area per block, in total 168 dwelling units. A façade in need for renovation, together with complaints about draft, cold floors and poor air quality initiated the renovation process in 2006. Since the buildings were in need of a major renovation anyway, the Norwegian State Housing Bank in cooperation with SINTEF suggested an ambitious "Passive House renovation", which is assumed to reduce the overall demand of delivered energy from about 275 – 300 to 80 kWh/m² per year, and to cut the net space heating demand by 80 – 90 percent to about 25 kWh/m² per year.

Figure 1. Myhrerenga: seven similar blocks with west-facing and east-facing main façades.

Myhrerenga is a demonstration project within the IEA Task 37 Advanced Housing Renovation with Solar and Conservation, the connected Norwegian project EKSBO and a new research project on upgrading of post war apartment blocks. After a two year long process, where both a conventional façade renovation and a renovation with Passive House components was considered, the cooperative decided to go for the ambitious renovation in February 2009. After a detailed design phase and a long contracting process, the construction work has started in February 2010.

2 Myhrerenga before renovation

The construction system consists of load-bearing concrete elements, with filled-in wooden construction in the long facades. The gable walls consist of poorly insulated concrete sandwich elements. The roof is a wooden insulated construction above the concrete slab. The walls and the roof are insulated with 10 cm mineral wool (gables only 8 cm or less), while the floor against the unheated basement is insulated with 5 cm EPS (Expanded Polystyrene). The two-pane wooden windows are from the eighties, but nevertheless in need of replacement.

Figure 2. The façade is worn out, and the windows are in need for replacement. Photos: Romerikes Blad

The buildings are reported to be quite leaky, but no air leakage test has been undertaken yet. There are many thermal bridges around wall and floor joints. All apartments have their own balcony, many of them with moisture damages under the slab. The balcony slabs are not cantilevering, but rest on brackets connected with the load-bearing cross wall elements. This makes it possible to replace the balconies by a new construction with their own support and only point wise penetration of the insulation layer, according to the requests of many residents, which want to get larger balconies.

The apartments are connected to an exhaust ventilation system and central heating with radiators in each room, supplied by a boiler house with oil- and electric boilers.

3 The renovation concept

The renovation concept is based on the Passive House principles, with:

- Super insulated building construction (where possible)
- A building envelope with minimized thermal bridges and air leakage
- Triple glazed Passive House windows
- A high efficiency balanced ventilation system with heat recovery

- A simplified heating system

In addition the boiler house will be renovated, and the boilers will be replaced by a combined heat pump and solar system.

3.1 Renovated construction

The measures to reduce the transmission loss are:

- Blown in insulation in the existing roof construction (350 – 500 mm)
- Adding a 200 mm continuous insulation layer to the existing wooden construction (see figure 3) and to the gable elements
- Adding a 100 mm insulation layer to the cellar ceiling, to “thermally decouple” the unheated cellar from the first floor
- All windows and doors are replaced with Passive House windows and doors

U-values before and after renovation are given in table 1.

Construction	U-value before renovation W/m^{2}K (calculated)	U-values after renovation W/m^{2}K (calculated)
External walls main façade	0.40	0.12
External walls gable	~ 0.45	0.15
Roof	0.35	0.11
Floor construction*	0.58	0.23
Windows and balcony doors	2.8	0.80
Entry doors	2.7	1.20

* U-value included the thermal resistance of the unheated cellar.

Table 1. U-values before and after renovation

The façade surfacing will be stripped, and damaged insulation in the existing post-and-beam structure will be replaced. Bolted on the existing studs, a new vapour permeable façade construction will be added, consisting of oriented strand boards (OSB) with sealed joints, 20 cm unbroken mineral wool insulation and a new façade lining. Passive House windows will be placed in the insulation layer, fixed in the boards and studs and air tightened to the OSB by expanding foam caulking. The new balcony studs will be placed respectively on the outside of the façade and between insulation and façade lining. Due to the continuous layer of insulation on the outside of the existing construction, the thermal bridges will be reduced significantly.

Both the vapour permeable façade and the non-ventilated roof solution are not common in Norway. Therefore, these constructions were discussed carefully in workshops. In addition, a test wall was built to quality assure mounting and sealing of windows in this construction. To avoid future moisture problems, the humidity in the wooden roof construction will be measured at some typical places after the renovation.

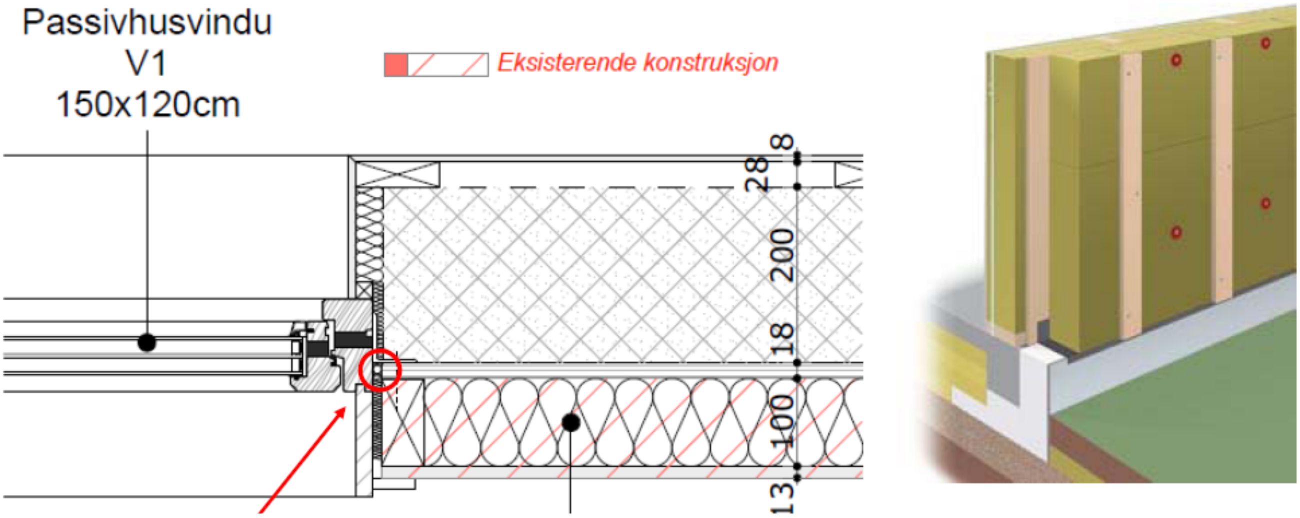

Figure 3. **New façade with 20 cm insulation and vapour permeable OSB on the outside of the existing 10 cm stud wall. Expanding foam caulking between new Passive House window frame and OSB. Illustration: Arkitektskap AS and Rockwool AS.**

3.2 Reducing infiltration losses

A blower door test will be undertaken on representative apartments to test the air leakage (N50 value) before renovation. Since the residents are complaining about draft, it is assumed to be rather high, estimated around 4 – 10 ach at 50 Pa.

The requirement after renovation is 0.6 ach @ 50 Pa (“Passive House” air tightness). The main air tightness layer on the facades will be the OSB board with sealed joints. All air tightness details around windows, at the foundation, the junction between the external wall and the roof, are carefully designed with work description to achieve this high level of air tightness. The air tightness will be measured both when the air tightness layer is in place and when the apartments are finished.

3.3 New ventilation system

The existing ventilation system is a centralised exhaust fan system, where each exhaust fan serves 6 apartments. After renovation a centralised balanced ventilation system will be used, where the air handling unit (AHU) will be placed on the roof above each stair case. Each AHU will serve 6 apartments. Existing shafts and the old rubbish chute will be used as far as possible. The heat recovery efficiency of the AHU will be 82 – 83 %, and the specific fan power (SFP) will be 1.5 kW/(m^3/s), fulfilling the Passive House requirements.

3.4 Energy supply systems

Since the heat loss is radically reduced, there is no need for all the existing radiators.

Except the bath room, most of the old radiators will be plugged, but the radiator in the living room will be replaced by a new one, designed to heat the whole apartment.

The existing central energy system will be renovated, and the oil- and electric boilers will be replaced with air-to-water heat pumps. Three heat pumps, 25 kW each, will run in cascade. A solar collector system, consisting of 44 vacuum solar collectors placed on the roof nearest to the boiler house, will complement the heat pump system in the summer, so most of the heat pumps can be turned off in the warmest summer months. The heat pump- and solar system will cover most of the space heating and DHW demand, but one of the electric boilers will be kept to take the peak load the coldest periods.

4 Calculated energy use

The amount of bought energy is measured (2004 and 2007). Simulations regarding energy demand have been made using the new constructions. In the goal for the demonstration buildings, the solar collectors are designed to cover 50 % of the domestic hot water heating. The energy demand of the demonstration project is shown in table 2.

Energy Demand [kWh/m²a]	Before renovation (measured)*	After renovation** (simulated)	
		Net energy demand	Delivered energy
Space Heating	195 – 220	25	15
DHW	30	30	15
Fans and pumps	10	10	10
Electricity use (lighting and appliances)	40	40	40
Sum	275 – 300	105	80

* Varying from year to year.
** To be measured after renovation.

Table 2. Energy demand calculated as delivered energy to the building, before and after renovation.

The assumed result indicates a reduction of the net space heating demand by 80 – 90 percent and a reduction of the overall demand of delivered energy by 70 – 75 %. This has to be verified by measurements after renovation.

5 Costs and profitability

The overall construction cost is estimated to 70 millions NOK, plus 4.5 millions for design and construction supervision. This includes new drainage and larger balconies. In total, these 74.5 million NOK are equal to 6 840 NOK per square meter, or about 850 Euros/m², including vat. The overall investment cost for the Passive House renovation is 20.7 millions higher than for a conventional façade renovation. This is equivalent to 1 900 NOK or 235 Euros per square meter. Taking into account allowances of 6.4 millions, granted by the Norwegian energy agency Enova, the additional cost will be reduced to 1 310 NOK or 160 Euros per square meter.

The extra cost of the energy measures is calculated to be covered by the reduction in energy costs, even without subsidies. In fact, included the grants, the total monthly cost for both the capital costs and the energy costs will be ten percent lower than with a conventional façade renovation. The overall monthly cost is calculated to 3 190 NOK for a one-bedroom apartment and 3 990 NOK for a two-bedroom apartment. This is 300 – 400 NOK lower than with a conventional renovation, equivalent to 40 – 50 Euros per apartment. In addition the indoor climate in the apartments will be substantially improved with regard to both air quality and thermal comfort. The value of the apartments is expected to increase.

6 Preliminary conclusions

The result so far is that cost effective renovation with Passive House components is possible even in Norwegian average climate. At the same time, both the decision making process (due to the fact that most dwellings in Norway are owner-occupied) and the design/optimization process (the construction industry is not "familiar" with new technical solutions) can be more difficult than in Central-European countries like Germany and Austria.

Figure 4. Myhrerenga before and after renovation. Illustration: Arkitektskap AS.

7 References

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