Wood Framework Passive house in eight stories Portvakten, Växjö

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Abstract

In the block Portvakten Söder in Växjö two extremely energy efficient eight-storey houses with wooden framework and passive house technology have been built. The 64 flats were ready to move into in summer and autumn 2009. The project is the result of a long collaboration that began in the summer 2005 between the building proprietor Hyresbostäder (a municipal housing company) and the Energy Agency for Southeast Sweden. NCC, Växjö participated as general contractor. Martinssons in Bygdsiljum was the constructor and supplier of the extremely well insulated and airtight framework. IV Produkt Växjö was the constructor and supplier of the energy efficient air handling units with an extremely high heat recovery, which were new on the market. The goal with the project was to erect high-rise buildings with a solid wood frame and to integrate passive house technology in order to reduce the use of final energy to 45 kWh/m2,a. At the time of planning the national building code, Boverkets Byggregler, had a restriction of maximum final energy at 110 kWh/m2,a. After three years operation we can conclude that the aim for very low use of final energy has been met.

Keywords: solid wood construction, passive house, heat recovery, zero-carbon house, waste water heat recovery

Introduction

In Växjö two passive houses with solid wood framework were built in the block Portvakten Söder, altogether 64 flats in two eight-storey houses. The municipal housing company Hyresbostäder together with the Energy Agency for Southeast Sweden developed this concept, built on experiences from passive houses in among others Lindås and Värnamo, during 2005 and 2006, within the governmental KLIMP project "Energy efficient Växjö". The project was also a part of the SESAC project part of the FP6- EU programme CONCERTO. SESAC was led by Växjö municipality with the Energy Agency for Southeast Sweden as technical coordinator. The houses were ready to move into in the summer and autumn 2009.

Figure 1 Block Portvakten Söder, Växjö. Eight-storey passive houses with wooden framework.

Management

A basic and decisive factor when a passive house project of this size is carried out is to realise that everything starts with an initiated and experienced landlord who, based on high landlord competence, can drive through the fresh ideas needed. This experience came into Portvakten Söder directly from the construction of the block Oxtorget in Värnamo.

An increased level of commitment, an inclination for development, and a continuous focus on low energy use is also needed all through the building process and from all actors taking part.

Landlords's competence and planning

The project started in 2005 when Hyresbostäder contacted the Energy Agency for Southeast Sweden, where fresh experience from the construction of the block Oxtorget in Värnamo was available. A six month long period of training for Hyresbostäders staff in groups followed, when experiences from Landskrona and Värnamo were considered as well as experiences from German passive house projects. The work led to a concept with suggestions for technical solutions of framework, climate shell and installations. Stefan Olsson continued to work as the landlord's energy expert through the project, with the responsibility to keep all partners focused on the energy issues.

Figure 2. Development phase. Creative development discussion with representatives for landlords, general contractor, subcontractors and researchers.

Purchasing and development phase

With the technical concept elaborated within the landlord's organisation as described above a purchasing of a general contractor started. A number of bidders where selected in a pre-qualification phase where the candidates described their experiences and thoughts about the building of these passive houses.

After that pre-qualification phase a negotiation purchasing followed, where also a requirement level with the highest acceptable cost for the landlord was mentioned. Every bidder met the landlord at least once to present their set-up. Finally NCC, Växjö was considered the appropriate contractor and an intention declaration to go into development phase was signed. Pre-qualification and negotiation purchasing took 3–4 months all in all. When the development phase started a new directive to build a wooden framework came to Hyresbostäder from its owner VKAB. This meant that much had to be worked through again and the supplier of wooden framework, Martinssons, entered the development work.

The aim with the development phase is that the landlord and his experts (in this case the Energy Agency for Southeast Sweden) together with the selected general contractor (in this case NCC, Växjö) with its subcontractors together work through the technical concept to include also the subcontractor's experiences. In this case expert knowledge was available from researchers at Lund University, SP (Technical Research Institute of Sweden) and IVL (Swedish Environmental research Institute) within the Vinnova project "The future wooden house" (Vinnova is the Swedish Governmental Agency for Innovation Systems).

All the important sub areas as building construction, moisture, the building's air tightness, ventilation, control systems and heat recovery were worked through and revised. Initial climate and energy calculations were also made. Furthermore a method was developed for testing the air tightness of the structural components of the outer walls at the factory.

After a four months development phase a turnkey contract was signed and planning in detail began.

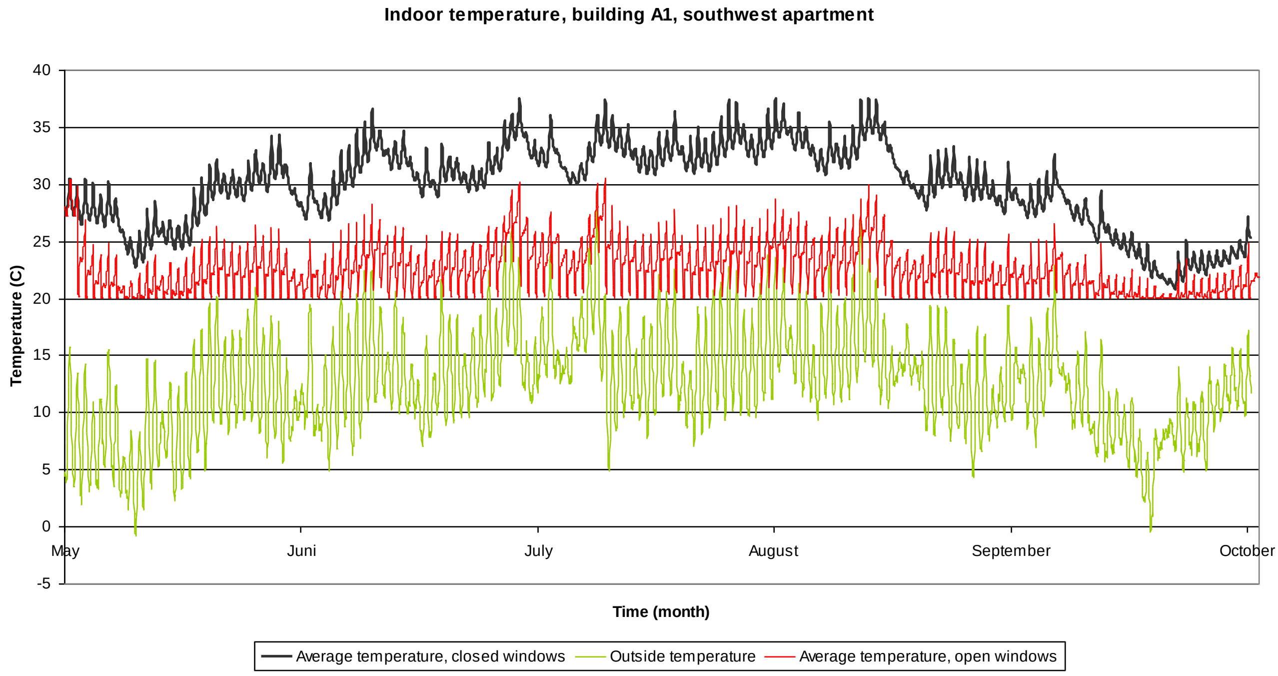

Figure 3 Indoor temperature. Results from calculations (IVL) showing that airing is necessary to have an indoor temperature that is not too high. With airing in the evening the indoor temperature will exceed 25°C only for a short time.

Implementation

At the same time as the planning in detail was made, the ground work started, the ground-plate and first storey were casted and production of structural components was planned/started up at the factory (Martinssons). Air leakage tests were performed at the factory on all outer wall structural components. When the first wooden elements were assembled at the building site (end of October 2008) the assembly fitters had one day of training.

Decisive for the final quality was that all workers involved understood how important their work was to complete the planned construction. During the training all the previous work with planning and projecting and how the air leakage test of the final construction should be done at the site was described (Blower-door testing). All assembly of the wooden structural elements took place under a tent which covered the building site and protected against weather.

Initial air leakage tests were performed at the first wooden storey as soon as it was practically possible, after about a week. After some complements acceptable air tightness was achieved and a working method had been developed. Due to practical difficulties to perform air leakage tests at every floor level separately a final Blower-door testing of the house was performed when all storeys and the loft floor were assembled (February 2009).

Figure 4. Weather protection. All assembly work takes place under protection against weather.

The first house was ready to move into 1 July 2009 and the second house 1 October 2009, all according to the time plan. An important part of putting the houses into operation was to transfer the necessary information to Hyresbostäder's staff responsible for operation, and to provide the coming tenants with relevant information. All flats were equipped with individual metering of electricity, hot water and cold water.

Energy technical concept

In all essentials the contents in the technical concept that was elaborated in the first training and planning phase remains. The load-bearing building framework consists of wooden material according to Martinssons' concept. To achieve the high air tightness required (in this case the requirement was 0.2 l/sm2 at 50 Pa) a plastic foil was applied in an appropriate protected way in the construction. Insulation consists of mineral wool and rock wool. Minerit boards were selected as facing. The demand for heat power at design outdoor temperature -20^{o}C is 10 W/m2.

The windows consist of a three-glass construction (U-value 1.0 W/m2K) with solar protection glazing (slightly tinted). Airing can take place since the windows are able to open.

Ventilation is made by a central FTX unit with energy efficient fans and double cross-flow heat exchangers with a degree of heat recovery (efficiency) of 85%. Hyresbostäder has a recognized standard to use central ventilation units since many years, but unfortunately there was no unit with that degree of heat recovery required available on the market when the project started. The landlord insisted on his requirements and challenged a number of suppliers, and finally a solution appeared which managed to fulfil the requirements.

The existing biofuel based district heating in Växjö is used for hot water production and supply of the backup heat needed in the flats when the internal production of waste heat from household appliances, people and activities is too low to meet the demand (for example at extreme cold of long duration, during holidays when the flat is not used or when the flat is inhabited by a low number of persons with a low "household activity"). The backup heat is supplied via the supply air and controlled via a room thermostat.

The flats are equipped with household appliances with Energy class A+ or A++ and with energy efficient light fittings and light sources.

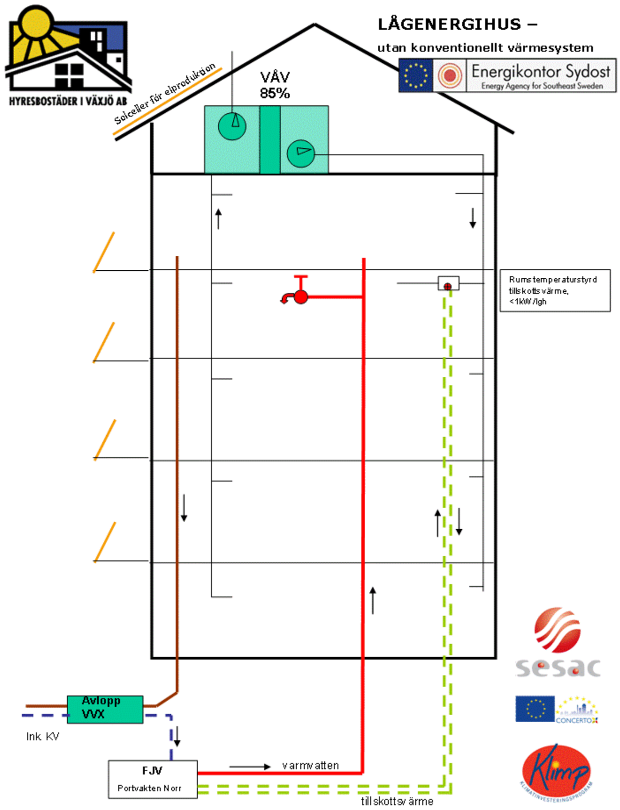

Figure 5. Passive house installations. Draft of installation system.

A wastewater heat exchanger was mounted on the waste pipe common for the two houses. Waste heat from the waste water is transferred to preheat the cold water coming in for hot water production. The waste water heat exchanger of Swedish design consists of two concentric tubes, with the wastewater passing in the inner tube and the cold water in the outer one. Calculated savings are approximately 5 kWh/m2 heated area,year.

Solar cells for electricity production were planned to be mounted on the sloping roofs turned southwards but due to the economic crisis in 2008 this was not realized.

In order to affect the tenants "energy" behaviour a display was installed in each apartment were it is indicated actual use of electricity and hot/cold water and corresponding costs. The tenants can also on the internet follow their use of energy in comparison to a "Växjö average" user. Initial monitoring in the SESAC-project showed substantial savings – up to 25-30%.

Investment costs

The investment costs for this first multi-storey house with wooden framework and passive house technology were in the order of 10–15% higher than in a conventional building with concrete framework. The absolute figure for total production cost was appr. 21 900 kr/m2 BOA incl tax (2009).

Monitored results

Calculations during the planning phase showed that final energy for heating incl. ventilation, domestic hot and building common electricity should be appr. 45 kWh/m2,a (compared to the actual building code restriction of 110 kWh/m2,a). Monitored results show even somewhat lower final energy use as figure 6 below.

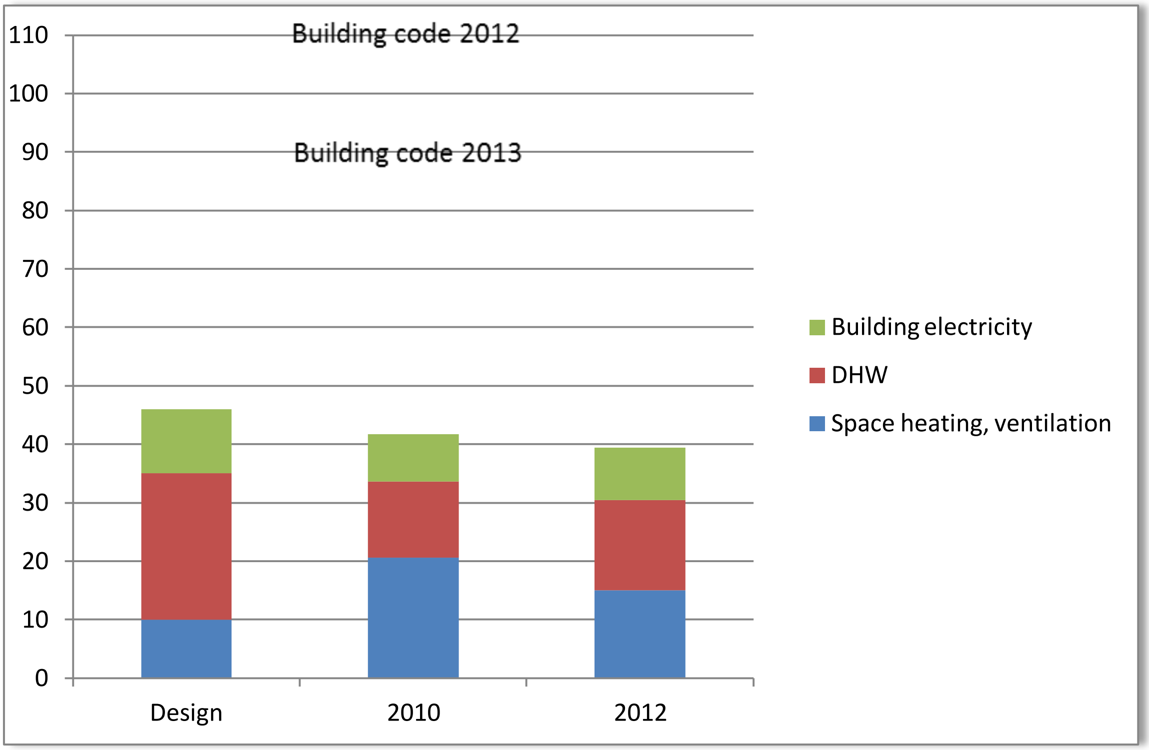

Figure 6 Design goal and monitored results – kWh/m2 (Atemp), a. Building code restrictions are indicated for comparision.

The outcome of 2010 is adjusted to actual heating degree days and the fact that only 50% of the dwellings were used due to lack of tenants the first year of operation. More interesting is the outcome of the year 2012 which was a “normal” year according to local weather conditions and the fact that 100% of the dwellings were rented.

We can conclude that in total the outcome is even lower than expected (<40 kwh/m2,a). It is also clear that space heating, incl ventilation, has reached a higher level than expected and the opposite goes for domestic hot water and building electricity. It has not yet, in detail, been investigated why the outcome looks like this. Possible explanations for the space heating outcome are lower efficiency in the waste water heat recovery than expected which can be stated from monitoring results and that the anti-freezing protection in the ventilation heat recovery system has not work in an optimized way. During the spring of 2013 further work with evaluating the monitored results will take place and these can hopefully be presented during the PHN13.

Furthermore preliminary monitored use of electricity for household appliances indicates appr. 25 kWh/m2,a. This is to be compared to the estimated level at planning which was 40 kWh/m2,a.

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