A net Zero Energy Building in Finland

Buildings and the whole built environment are in a key role when societies are mitigating climate change and adapting to its consequences. The building sector can significantly reduce energy use by incorporating energy-efficient strategies into the design, construction, and operation of buildings. In addition building sector can further reduce dependence on fossil fuel derived energy by increasing use of on-site and off-site renewable energy sources.



MIIMU AIRAKSINEN
VTT, Finland
Miimu.Airaksinen@vtt.fi

JARI SHEMEIKKA
VTT, Finland

JUSSI JOKINEN
Isover Saint Gobain

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A net zero energy building refers to a building where the amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building in a year. A net zero energy building bases on a very low-energy building concept to minimise the energy demand. The low energy demand defines the design of the building integrated renewable energy production systems.

A zero energy house in Finnish climate

The building was designed based on architecture competition organised by Saint-Gobain ISOVER in co-operation with Finnish Association of Architects SAFA, Rakennuslehti Building and construction magazine, VTT Finnish Technical Reseach Centre and WWF World Wide Fund for Nature. The competition was big and all together 81 proposals were achieved. The selection of the winning proposal was hard due to many very good solutions. The winning proposal was named as BLOK and it was designed by architects Tiina Antinoja ja Olli Metso from Muuan Studio (http://www.muuan.fi/).

Figure 1. The architecture of the building.

The building was built on a housing exhibition located in southern Finland (latitude 60). Due to the schedule of the housing exhibition area, the process had rather tight schedule and good co-operation was needed between various design teams from the project. The core of the design of the building was to develop an attractive home which is suitable for typical family living preferences.

The cornerstone in design was to first minimise the energy demand for heating, cooling and electricity use, and then to cover the energy use by building integrated energy production at the yearly balance level. The main heating source was ground source heat pump but also solar heat can serve a share of heating use. In addition the building was equipped with a fire place capable to store some heat in its massive structures. The space heating was distributed with a floor heating maximising the use of solar heat (low exergy system).

The ground source heat pump efficiency SPF (seasonal) was 3.5 for space heating and 2.5 for domestic hot water heating. The solar thermal collector system was faced towards south with an angle of 15–30 degree from horizontal and the collector surfaces area was 6 m².

The surface area of the photovoltaic system was 80 m². Also the PV system was installed in the southern façade of the roof at the same angle as the solar thermal collectors. The PV system consists of 72 CIS-type thin film modules. The system is has 3 inverters each rated for 3 kW power.

The structures were designed for high thermal resistance, corresponding very low energy building structures in Finnish climate. The U-values of the structures are shown in **Table 1**. The window solar heat transmission factor (g-value) was 0.49 except for the west façade 0.34. The air tightness of the envelope at 50 Pa was 0.4 m^3/m^2h (measured value).

Table 1. U-values of the structures.

Structure	U-value (W/m²K)
Exterior wall	0.09
Roof	0.06
Base floor	0.09
Window	0.75
Door	0.6–0.75

Calculated energy consumption

In the design phase calculations it was assumed that the building is occupied by four persons and that their domestic water use is 120 dm^3/person, day. It was also assumed that 40% of the domestic water use is hot water, thus 48 dm^3/person, day. The ventilation was calculated according to the Finnish building code (0.5 ach) corresponding a 72 dm^3/s fresh air flow. The efficiency of the heat recovery unit in the ventilation system was designed for 80% and the set point temperature for heat exchange surface freezing was –10°C, corresponding the yearly heat recovery efficiency rate of 76% for the ventilation system. The surface temperature for the floor heating with clinker surfaces was assumed to be 26°C for comfort reasons, other spaces were controlled by the room temperature. Lighting is assumed to be LED and all household equipment is assumed to have the best energy label classification A++.

The calculated delivered energy was 8 200 kWh yearly corresponding 53 kWh/-living-m^2. Roughly 60% of the energy is used for heating and ventilation. The ventilation includes the electric energy used for fans. The heating and cooling energy consumption corresponds to 20 kWh/m^2 yearly which corresponds 39 kWh/m^2 yearly energy demand for heating and cooling. The cooling system was integrated to the ventilation system to cool the supply air. The cooling demand was covered by the bore hole energy during the summer period.

The calculated electricity production from the installed PV system is 8 200 kWh yearly, **Figure 3**. Evidently the major share of the production comes during summer months. This leads obviously to a high imbalance at yearly bases. During summer months the excess electricity is sold to the grid operator.

The solar thermal production was estimated by using Finnish National Solar calculation method (Aurinkoopas 2012), and the calculated production was 1 900 kWh corresponding 335 kWh/m^2 of collector surface. The produced solar heat covers roughly 45% of the yearly domestic hot water consumption.

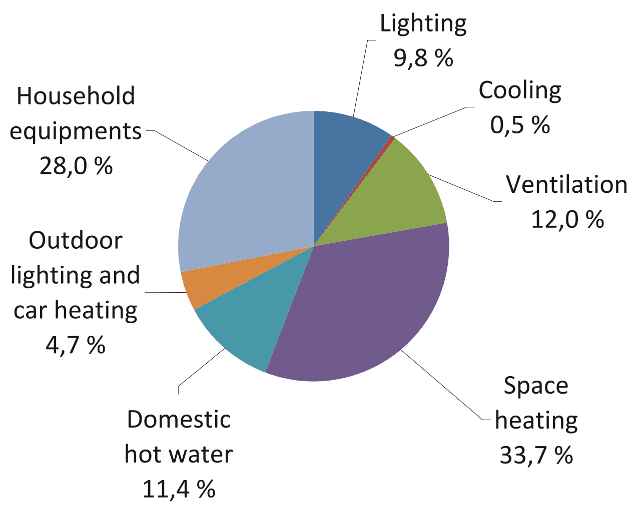

Figure 2. The electric energy consumption of the building.

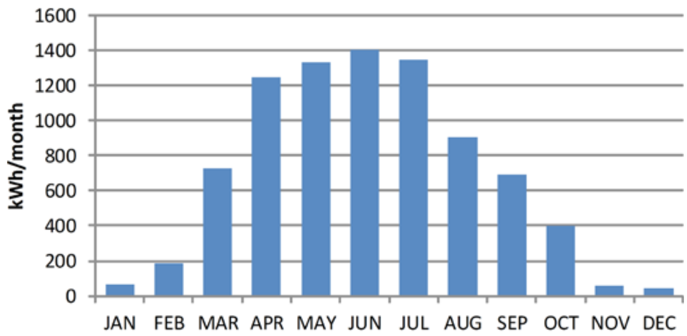

Figure 3. Calculated solar electricity production. The calculation is based on Soleras. (http://www.soleras.fi/)

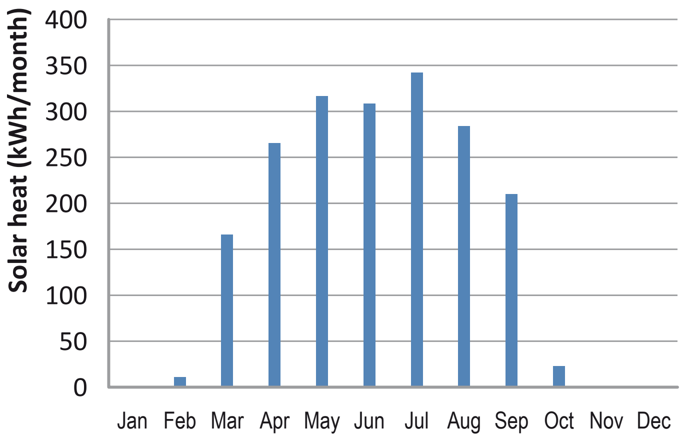

Figure 4. Calculated solar heat production.

The building performance is monitored at detail level. The first preliminary results are showing a promising results and further analyse is carried out currently to see the holistic picture about the building performance in real use. ■