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Certified passive building in Poland

Szymon Firląg, Warsaw University of Technology, Institute of Heating and Ventilation, National Energy Conservation Agency,
E-Mail: sfirlag@nape.pl

dr Ludwika Juchniewicz-Lipińska, Lipińscy Domy Architectural Design Studio
E-Mail: ludwika@lipinscy.pl

1 Introduction

Increase of energy prices and need of natural environmental protection has caused growth of interest in passive houses also in Poland. Although, it is difficult to show buildings, that are strictly corresponding to the passive standard. Very often low energy and experimental houses are called in this way. However it is forgotten that construction standards elaborated for Germany are adequate for those climate conditions. Whereas a house that was built as a passive in Freiburg won't be passive if we will move it to Suwałki (Polish pole of cold).

Thanks to cooperation between architectural design studio Lipińscy Domy, Institute of Heating and Ventilation and NAPE a construction design "Lipińscy Dom Pasywny 1" was created, who's basic goal was adaptation of being in force standards to the local climate conditions of Wroclaw. On a basis of the design a small passive house was built and is now being certified according to PHI procedures. The house was added to the international base of Built Passive House Projects as a first from Central and East European countries. It also took part in international Passive House Day.

2 Location and climate conditions

The climate conditions of Wrocław are similar to standard German conditions. The heating degree hours during heating period is 84 kKh/a, global radiation on East 211 kWh/(m²a), South 423 kWh/(m²a), West 211 kWh/(m²a), North 92 kWh/(m²a) and on Horizontal plane 318 kWh/(m²a).

The design studio decided to build the passive house in beautiful area of new single family housing estate in Solec near Wrocław. The orientation of the house is slightly different from the projected. The garden elevation, with large windows area, is oriented on the South-West not on the South. This difference has been taken into account during the energy calculation, which have confirmed that also for this orientation the house will achieve passive standard.

3 Architectural design

The architecture of a passive house refers to an archetype of a detached house. A simple compact shape projected on a rectangular plan and covered with a pitched roof integrates perfectly with the Polish urban landscape. The proportions of the roof and the walls were designed to be similar as in a traditional house. The only element enriching the mass of the house is a triangular lucarne on the façade with a window lightening the bathroom. We decided to add to the building mass a garage being a necessary standard for Polish investors. The window shapes were designed according to the energy standards.

The maximisation of the efficiency of the sun's gains was reached thanks to an appropriate location of windows in the house façade. Big windows on the southern façade of the house not only guarantee heat gains from the sun but also givea modern touch to the house architecture emphasised by a solar energy collector on the roof surface. The size of the windows on the remaining walls was selected in order to guarantee conformity with the Polish outdoor lighting standards and minimise heat losses. The northern façade was designed not as a "closed" on purpose; a "closed" façade could spoil the appearance of the architecture and make it less attractive. A compact character of the building has been confirmed by the shape coefficient of 0.75, and the garage of an independent structure placed on the western wall plays the role of a heat buffer.

The house function was solved by means of the partially traditional approach, yet with certain innovation. It is the effect of glazed surfaces constituting the walls of the dinning room and the lounge. The house is designed for a four-person family or alternatively for an extended family. You will find a place for house works – a hobby room. The lounge with a mezzanine constitutes the space for daily activities. The big glazed southern façade makes the interior optically larger. The house is very spacious, despite its relatively little area. The kitchen, which is connected with a dining room, includes also a room for a compact heating tower. The room is large enough to fit a washing machine and a handy larder. The openwork steps will take you to the attic divided into two rooms for children with a terrace over the garage, a spacious bedroom with a dressing room for parents, and a bathroom well equipped and full of light. And the mezzanine perfectly unites the interior.

4 Construction

4.1 Slab on ground

At the beginning of construction work the fundaments and ferroconcrete plate of the slab was made. The passive house doses not have basement what simplified construction of the building. The slab was isolated with 30 cm of waterproof polystyrene (thermal conductivity 0,035 W/(mK)), with overall U-value of 0,11 W/(m²K) was achieved.

4.2 External walls

After realization of the slab, external walls were mounted. It took only three days due to use of prefabricated keramzit concrete elements. Except fast montage the technology have several advantages which are especially important in passive housing. First the prefabricated walls from keramzit concrete have high thermal-storage capacity. The second advantage is thickness of load-bearing structure that has only 15 cm. It is very important for the total thickness of the wall isolated with 30 cm of isolation. Use of thin load-bearing structure has allowed avoiding of so called "bunker effect", which can occur in passive houses. The prefabricated walls from keramzit concrete were isolated with 30 cm of Neopor (thermal conductivity 0,031 W/(mK)) and achieved the overall U-value of 0,10 W/(m²K).

4.3 Roof

Gable roof of the passive house has traditional wooden construction. The only difference consists in use of triple isolation system. Its first element is polystyrene roof panels with average thickness of 14 cm. The second isolation layer is grey polystyrene which fills areas between rafters. The polystyrene is 20 cm thick and has thermal conductivity of 0,033 W/(mK). The last 10 cm thick isolation layer, consist of plates from Neopor fixed under the rafters. Implementation of triple isolation system enables to achieve U-value of 0,08 W/(m²K). It is especially important because heat losses through the roof forms significant share in energy balance of the house.

4.4 Windows

The windows have plastic frames (Clima Design profile) with five chambers and additional liners of isolation material. The U_f-value of 120 mm width frame is only 0,71 W/(m²K). The U_g-value of used triple-glazing is 0,6 W/(m²K). Achievement of such high thermal parameters was possible due to low-emission coating and argon gas space between glasses. The consequence of using triple-glazing is decrease of the total solar energy transmittance to 0,52. But by using a high-tech frames and glazing the average U-value of all windows is only 0,72 W/(m²K). The front door is made of plastic and has U-value of 0,8 W/(m²K).

4.5 Thermal bridges

The problem of thermal bridges has been taken into account since the first planning solutions. The isolation is assured on the whole envelope of the house, among others through thermal separation of the building and the garage. Independent load-bearing structure of the garage, made it possible to continuously isolate from each other the two part of the building. In certain points the envelope is interrupted by elements (connection of fundament walls and slab on ground) that, thanks to their thermal properties, are nonetheless able to limit the risk of thermal bridges to minimum.

Figure 1: Actual view of south façade of the passive house in Wrocław

Figure 2: Actual view of north façade of the passive house in Wrocław

5 Heating, ventilation and DHW system

The passive house is equipped with compact heating tower Vitotres 343. It is responsible for heating, ventilation und preparation of DHW. The heart of the tower is small heat pump which uses the exhaust and external air as energy source. The max heating load of the pump is 1,5 kW and is enough for heating of ventilation air and DHW. The tower has integrated ventilation system with heat recovery ratio of average 80 %. Efficiency of the ventilation system was increased thanks to use of air-to-earth heat exchanger. It enables preheating of the ventilation air during winter and cooling of the air in summer. The exchanger was buried on depth of 1,5 - 2,0 m, built in Tichelmann system and consists of 100 m of ∅ 200 plastic pipes. The consequence of using the exchanger is also higher efficiency of air/water heat pump. Average air flow rate of ventilation system is 135 m³/h. This amount of air enables distribution of the heat and does not lead to decrease of air humidity in the house. The DHW is heated in 250 cylinder with help of heat pump and vacuum tube collector.

6 Energy performance

Implementation of complex solution in regard to architecture and construction of the passive house has allowed to significant reduction of energy demand of the building. It was confirmed by calculations done with the PHPP program. The estimated energy performance of the house is as follows:

- Yearly space heating demand is 15 kWh/(m²a). The same house built according to Polish regulations uses 123 kWh/(m²a), i.e. eight times more.
- The peak heating load is 11,2 W/m² and is slightly above passive standard. However the heating load is six times lower than a load of a standard house. The total heating load is 1,52 kW and can be fully covered by compact heating pump. The assumed average air flow rate is 135 m³/h and enables distribution of the heat in the house.
- The demand for heating of domestic hot water is 14 kWh/(m²a) and is two times lower than in standard house. It is however almost identical as space heating demand. Reduction of heat demand was possible because half of the energy is supplied by solar collectors.
- The passive house has also very low primary energy demand of 105 kWh/(m²a). This amount of energy is enough for space heating, preparation of DHW, lighting, cooking and work of electrical devices. The house built according to current standards use about four times more primary energy.

7 Construction cost

Estimated construction cost of the passive house is about 38 % higher than cost of house built according to Polish regulations. The significant difference in cost (higher than in

Germany), results from the fact of poor availability of passive construction components on Polish market. Many of them, e.g. windows, are not yet produced in Poland, what makes them very expensive. However, we can expect that together with development of low energy and passive housing, their prices will become lower.

House type	Standard	Low energy	Passive
Living area, m²	130,4	130,4	130,4
Space heating demand, kWh/m²a	123,0	44,7	13,7
Construction cost, EUR	78 401	89 955	108 448
Cost per living area, EUR/m²	601	684	832
Additional cost, %	-	**15**	**38**
Demand for heating of DHW, kWh/a	3 721	1 861	1 861
Heating and DHW system	Gas boiler	Gas condensing boiler, solar collector	Compact heating tower, solar collector
Yearly heating and DHW cost, EUR/a	980	341	194
Cost reduction, EUR	-	639	786
SPBT, years	-	**18**	**38**

Table 1: Comparison of construction cost of the house in three different standards

8 Conclusion

Passive building standard can be successfully adapted to colder climate conditions. The only problem is higher difference in construction costs between passive and standard buildings than in West European countries. Therefore the passive standard should be promoted not only among investors and contractors but also among polish producers of building components. Only domestic production of e.g. isolated window frames can make building a passive home in Poland more cost-efficient.