

Passive House in Polish Conditions

The completion of an innovative Lipińscy – the Passive House 1 project is an exceptional investment. A demonstration house was built in Smolec near Wrocław (Lower Silesian province) according to an author's project by Lipinscy Domy Design Office with the support of the specialists from the Institute of Passive Houses by the National Energy Conservation Agency (NAPE) The project's fundamental assumption was the adaptation of the effective guidelines for passive house construction developed in Germany to the local climate conditions of Wrocław's vicinity.

Economic Situation

We can distinguish two main trends in the passive construction of detached houses in Europe: the housing development for an individual client interested in the living comfort, low prices of maintenance with low costs of completion is the first trend, whereas the experimental construction with the use of the most elaborate materials and technologies allowing for the construction of zero-energy or almost energy-producing houses is the second trend. We became interested in the possibility of building houses in Poland, which would have a very good climate, low utility costs, and would be marked by the optimised cost of the completion in reference to the planned savings. We focused on a development of the passive house project according to the exact assumptions specified by the author of the passivity concept Dr Wolfgang Feist and simultaneously being possible to perform in Polish conditions for the lowest price possible.

Currently we have a similar situation in Poland as in Germany about 7-10 years ago. First of all people become ecologically aware, especially when prices for energy are growing. An additional factor inclining us to the contemplation of this aspect are public debates concerning the energy safety of the country, the need of the diversification of oil and gas supplies, or the use of renewable sources of energy. A promotion of the energy-saving construction in Poland fits well in the context of the generally discussed aspects of energy. A multitude of potential investors interested in the individual energy-saving construction is growing fast. Only watchful producers of construction technologies are starting to sense the coming upturn of the construction industry. The energy-saving woodwork for doors and windows, latest heating devices, heating pumps, or efficient recovery devices are starting to be available on the market. The real demand is still low, due to high prices of these technologically advanced products.

Using our knowledge of the energy-saving and passive construction gained for some years, we decided to make an attempt to develop and then construct a passive house in the Polish conditions. It is to be a research and educational object and play a promotion role.

Apart from problems of the structural and technological nature, we faced the need to solve two opposing assumptions. On the one hand, we had to design a house originating from the Polish construction tradition and on the other hand, we had to minimise construction costs, which meant the development of the appropriate construction technology and the application of simple yet effective installation solutions. We wanted our house of the Lipińscy – the Passive House 1 project to deserve a title of a technologically simple and reasonable building.

Architectural Project

The architecture of a passive house offered by us 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.



Drawing 1. Visualisation of the southern and northern façade (drawing by Lipiński Domy)

The maximisation of the efficiency of the sun's heat 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 efficiency provided by rays of sunlight but also give a 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 full wall on purpose; a full façade could spoil the appearance of the architecture and make it less attractive.

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 dining 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 device substituting a traditional heating medium. 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.



Drawing 2. Projection of the ground floor and the attic

The design and the structure guarantee the maximum limitation of heat losses and the greatest efficiency of the sun's heat at the same time. 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 project gained the power certificate issued by the Institute of Passive Buildings by the National Energy Conservation Agency according to which the calculated requirement for heat amounts to 13.7 kWh/m²year, with an assumption of an ideal building location in relation to four directions.

Technology of Polish Passive House

Design and concept works concerning the choice of materials and technologies necessary to complete a passive house took us half a year. We performed a market analysis concerning the availability and quality of materials. We found a technologically innovative solution allowing us for building a passive house according to the PHI's (Passive House Institute) guidelines in Poland on the basis of products available on the Polish market. We decided to apply simple solutions generally accepted in Poland, which would be of good quality and for a reasonable price. The construction of external dividing structures was subordinated to the maximum limitation of heat losses resulting from the penetration.

Standard construction guidelines for passive houses suggest that the value of the U heat penetration coefficient of external walls, floors, ceilings, and the roof should not exceed

0.15 W/m²K. During the design process we realised that the house will meet the passivity standard in the climate conditions characteristic for the vicinity of Wrocław if the average U coefficient of the external dividing structures reaches 0.1 W/m²K.

In order to reach such a low coefficient, we had to apply the insulation layers 30-44 cm thick and very good insulation materials.

The house is built on the strip foundation being traditional in Poland and which support the foundation walls reaching the ground level. We carefully planned the thermal insulation of the fundaments and the floor slab resting upon fundament walls. Nevertheless, even perfectly insulated external dividing structures cannot guarantee the passivity standard if thermal bridges are not excluded from the house structure. Thermal bridges appearing in arcades or in the places where an insulation layer breaks or as a result of unevenness of the dividing structure should be totally excluded from passive buildings. It is extremely important to provide an unbroken insulation layer in the external dividing structures and in their junctions. We managed to meet this requirement almost everywhere in the completed project. The fundament walls were the only place where we did not manage to have the insulation layer unbroken. Stahlton Concern operating in Poland since few months helped us to reduce a vertical thermal bridge which was cooling the house walls. We used Isomur base insulation hollow bricks of Jordahl & Pfeifer Company.

Although the Poles are extremely attached to the brick technology, especially to ceramic solutions, we decided to build our house in the prefabricated technology, due to a prepared offer of the “finished passive house”. The technology of prefabricated walls from gravelite-concrete seemed to be a good compromise. The producer’s additional colouring in a brick colour highlights the fact that it is the ceramic material. And this is important in a country where its inhabitants are antagonised by the large panel building. The asset of the prefabricated technology in the passive construction is a great accumulation capacity of the gravelite-concrete prefabricated elements. The level of the sun’s heat efficiency in a passive house does not always equal its current requirement for heat and this can result in overheating of the building. In order to avoid this phenomenon, the exceeding levels of heat should be stored to be released later when the temperature in the house decreases. The direct accumulation in the solid house structure constitutes the simplest way of the heat storage. Its appropriate usage beneficially impacts the utility comfort of a passive building and its energy balance.

We used the unique silver-grey Platinum Plus Termo Organiki polystyrene foam for the house insulation. This product is the warmest polystyrene foam available on the Polish market. The boards are enriched with a graphite composition improving their insulation properties. This polystyrene foam is produced on the basis of the innovative raw material of BASF Company. Its thermal conduction coefficient is record-breaking and equals $\lambda \leq 0.031$ W/mK.

At the moment of the construction preparation no Polish producer manufactured windows for passive houses. We used Clima Design door and window woodwork of REHAU Company.



Drawing 3. Placement of Isomur base insulation hollow bricks



Drawing 4. Installation of the gravelite-concrete prefabricated elements



Drawing 5. External dividing structures insulation



Drawing 6. Window installation



Drawing 7. Tight connection of external walls with the window woodwork – vapour-proof plastic wrap before gluing



Drawing 9. Pressure test

The house is equipped with the mechanical ventilation including the heat recovery function. In order to improve the efficiency of the ventilation devices, we installed a ground exchanger. We chose Awadukt Thermo REHAU installation tested in passive and energy-saving houses. Vitotres 343 of Viessmann Company is a heating unit. This compact device is equipped with an integrated exhaust and blow-in air handling unit with a countercurrent heat exchanger. It is marked by the heat recovery capacity of 80 %. The efficiency of the built-in air handling unit is maximum 230m³/h, however an optimal air current is about 150 m³/h. And this value was assumed as a calculating value in the ventilation system project. On the one hand, the air current allows for meeting the hygiene standards but on the other hand, it does not lead to an excessive decrease of air humidity inside the house.



Drawing 10. Completing – frontal image



Drawing 11. Completing – image from the garden side

Performance

We decided to build the house in a beautiful area of newly constructed detached houses in Smolec near Wrocław (Lower Silesian province). The plot, on which the house is built, is optimal (700 m²). The garden provides a possibility for a good arrangement. Because the house is to play a demonstrative role, we chose a corner plot with a convenient access road. And this location makes the house exposed to sunlight, for no other buildings shade it from the southern side.

The building orientation differs slightly from the project assumptions. The garden façade of a big glazed surface is directed towards the South-West and not towards the South. This difference was taken into consideration in the energy calculations which confirmed that the passivity standard will be met also in this orientation.

We started the construction works in July 2006 with placing the ground heat exchanger. The pipes were arranged below the freezing line 1.5-2.0 m deep. The ground heat exchanger is to guarantee that during the winter the temperature of the air penetrating the building will not fall below zero degrees. However, during hot summers the air going through the ground heat exchanger will be cooled to pleasant temperatures.

In August 2006 a trained team performed ground works, and constructed fundamentals, a slab of reinforced concrete, and floors. A well designed and fixed insulation of divisions touching the ground is a very important aspect. The house has no basement which simplified its structure. The slab of reinforced concrete was insulated with a 30 cm layer of the waterproof polystyrene foam having very good insulation parameters (the thermal conduction coefficient $\lambda = 0.035$ W/mK, and the finishing casing around the building was added). It allowed the floor touching the ground to reach the coefficient of $U = 0.11$ W/m²K.

Three days after the construction of the slab of reinforced concrete the walls were installed. The prefabricated technology of Praefa gravelite-concrete facilitated the fast construction of the external walls. It is a particularly advantageous solution in the case of a house constructed in the “finished passive house” system. We developed a project in the brick technology of Silka calcium-silicate brick for individual clients. In both cases we obtained the external partitioning of the penetration coefficient of $U_o = 0.10$ W/m²K by means of the additional polystyrene foam insulation.

The technologies offered by us are welcomed on the Polish market. They are marked by the good quality and the low price. These technologies prove to be perfect for the construction of passive houses. The prefabricated technology's advantage is its relatively thin supporting structure of 15 cm. It is particularly important for the general thickness of a wall insulated by a 30 cm insulation layer. The use of a thin supporting wall allowed to avoid the “bunker effect” possible to occur in passive buildings.

The roof truss was built in the traditional manner. Works of thermal insulation, woodwork and insulation installation lasted for four months. A layer of the special self-supporting polystyrene foam (20 cm) enriched with graphite and having the thermal conduction coefficient $\lambda = 0.033$ W/mK was inserted between rafters. Polystyrene foam boards (10 cm) were fixed under the rafters and polystyrene foam panels (15 cm), extruded to be inserted under roofing tiles and without additional laths, were placed over the rafters on the layer of the OSB boards. The total thickness of the roof insulation is 45 cm. As a result of the application of the three-layer insulation system the heat penetration coefficient reached $U = 0.08$ W/m²K, which is especially important, for heat losses through the roof can have a significant influence on the energy balance of the building.

The windows were constructed from Clima Design sections of REHAU Company and have the heat penetration rate of $U = 0.7$ W/m²K. The system obtained the certificate of

Darmstadt Institute of Passive Houses being selected for the construction of passive buildings. A unique structure of the sections guarantees perfect thermal parameters and also the required tightness. It is especially important in the case of the front door. We used REHAU front door of the coefficient of $U=0.8 \text{ W/m}^2\text{K}$. The door meets all the requirements of passive buildings in reference to the thermal insulation and tightness against the air penetration. The window panes also have very good parameters. A set of Insoglas and Guardian insulated glass was used, whose heat penetration coefficient is $U=0.6 \text{ W/m}^2\text{K}$. Such good thermal parameters were possible as a result of the application of the low-emission coatings and filling space between the panes with argon. The g rate of the total permeability of sunlight equals 0.52. The application of such a modern woodwork allowed for the average U coefficient for all the windows of $0.72 \text{ W/m}^2\text{K}$.

We used special bands of Soudal Company for the building insulation. At the moment the house is in the finishing stage. We are preparing to install Vitotress 343 integrated device for passive houses of Viessmann Company and place the recovery system.

For the tightness is a very important factor in construction of a passive house, we had to plan appropriate solutions already at the design stage. The effectiveness of all solutions applied in the passive house, whose target was to limit the uncontrolled infiltration of the external air, was tested by means of the pressure test. We obtained a very good result of $n_{50} = 0.3 \text{ l/h}$.

As a result of the application of complete solutions in reference to the house architecture and the structure, the building heat requirement was significantly limited. The tests completed by means of the PHPP programme and performed of the Institute of Passive Buildings by National Energy Conservation Agency (NAPE) confirmed the above mentioned issue. The heat requirement in the standard heating season for the house constructed in Smolec nearby Wroclaw is $15 \text{ Kwh/m}^2\text{a}$. Such a house constructed in accordance with the valid Polish standards will need $123 \text{ kwh/m}^2\text{a}$, hence over eight times more.



Drawing 8. Open Days of Passive Houses: November 2006

The construction of the passive house in Smolec attracted a lot of attention. Many investors from the country visited us during the Open Days of Passive Houses organised by PHI throughout Europe last year. We are planning the opening the house as a demonstration model of a passive house for the spring 2007. We will invite all who are interested in the passive and energy-saving construction. Various tests will be performed in the house for two years.

To summarize, it is important to present the completion costs in Polish conditions and refer them to the costs of the standard construction.

The cost of a completed passive house as a turnkey project: PLN 379 thousand (about EUR 97 thousand)

The cost of 1 square meter of the finished passive house as a turnkey project: PLN 2.4 thousand (about EUR 630).

The cost of 1 square meter of the standard individual construction: PLN 1.8 thousand (about EUR 460)

At the moment the cost of passive house construction is about 37 % higher (about EUR 154 more for 1 square meter), whereas the estimated time of the investment return is 20-30 years. It is important to emphasise that the cost of the standard individual construction is about 3.5 times lower than in conditions of the West, and specialist products intended for the passive construction have the same prices on the Polish and the Western markets.

We are witnessing a constant increase of the house building costs in Poland (about 5% in 2006) and the production of some products such as windows or efficient recovery units has already started on our market. The products will be available for prices lower than for equivalent Western products.

We can carefully suggest that within few years the passive houses in Poland will be profitable, especially when energy costs are gradually growing.

Ludwika Juchniewicz-Lipińska PhD, Eng. of Architecture

Miłosz Lipiński PhD, Eng. of Architecture

Lipinscy Domy Design Office

ul. Belgijska 69, 54-404 Wrocław

tel. +48601590018

email: ludwika@lipinscy.pl