PASSIVE HOUSE CONCEPT IN EUROPEAN UNION

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The buildings represent one of the great energy consumer – 40% of final energy consumption and 32% of the total GHG emissions generated. Also, reducing of energy consumption and the use of renewable energy sources in the building sector constitutes an important part of the measures needed to reduce the EU's energy dependency and GHG emissions. For this purpose, member states should take several measures to increase the number of very high energy efficient buildings - net zero energy buildings - the buildings which have the annually primary energy consumption equal or less than the energy production from RES on site. The new recast of Energy Performance of Buildings directive will include as target that all buildings built after 2018 in EU countries will have to produce as much energy as they consume on site. In same time, new EPBD will establish the major renovations of existing buildings to meet the minimum energy efficiency requirements. The knowing and implementing of Passive House concept in Romania will add to respect legal obligation as EU member state about the increase the number of very high energy efficient buildings and the reducing of final energy consumption.

Keywords: passive house, energy performance of buildings directive, net zero energy buildings

1. Introduction

Energy is an essential element for the operation of the economy of any country. The period in which Europe benefits from safe cheap energy resources is, however, over, and all the EU members face the challenges raised by climate changes, by the ever heavier dependence on energy imports, as well as on the ever higher energy prices.

The energy sector that includes the domestic and tertiary consumption generates 80% of the greenhouse gas emissions (GHG) in the EU, representing the main cause of climate changes, and, to a large extent, that of atmospheric pollution. The EU commits itself to finding solutions of mitigating climate changes, especially by reducing the global amount of greenhouse gas emissions, both in the Union and worldwide, down to a level likely to limit the global heating to values only a little higher than those in the pre-industrial era. It is considered that, if the current energy and transport policies go on, the CO_2 emissions level will grow until 2030 by 5% in the EU and by 55% on the planet. Clearly, it is necessary to conduct sustained actions, correlated worldwide in order to overcome the crisis.

The EU documents show that in houses and tertiary sector buildings about 40% of the total energy is consumed and mention its upward trend by using the ventilation installations – air conditioning, especially in the south of the EU, which leads to a higher consumption.

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Energy efficiency is the first element of European energy policy affecting citizens. A higher energy efficiency might bring a decisive contribution to attaining sustainability, competitiveness and operating reliability.

On the 19th of October 2006, the European Union Commission adopted the action Plan regarding energy efficiency, comprising measures by which the EU might make visible progress towards fulfilling its main objective, namely reducing its global primary power consumption by 20% until 2020. That means consumption in 2020 by 13% less end energy than now, a saving of 100 billion euros and diminishing the emissions by about 780 million tons CO_2 each year. To that end it will be necessary to make considerable efforts both for supplementary investments in new technologies, much more energy efficient, but also changes in attitude and behavior among all citizens.

The key measures established in the document "An Energy Policy for Europe", proposed by the EU Commission in January 2007, include the "quick growth of energy efficiency of EU buildings and taking initiatives so that the low consumption houses should become the standard of the new buildings".

The European Parliament Report from the 8th of January 2008 (2007/2106(INI)) regarding the "Action Plan regarding energy efficiency: achieving the potential" (COM(2006)0545) specifies a series of requirements regarding energy performance of buildings.

2. Passive house concept in EU

The first concerns of the architects and engineers for reducing the energy consumption in buildings appeared after the first oil shock in 1973. This led to a rediscovery to the principles of interior control of the building through the form of the buildings, their orientation, the arrangement of openings, thermal performance of the materials, by using „passive" technologies. A strictly „passive" concept does not involve any mechanical intervention, but this solution, in general, is not the best one, because the integration of mechanical and electric devices is imposed even for the proper function of the passive elements. The *passive Architecture* is a generic term, used to define an approach that has as objective to reduce primary energy consumption for heating, lighting and cooling of buildings. In 1991 Wolfgang Feist and Bo Adamson applied the concept „passive architecture" to the construction of one house in Darmstadt.

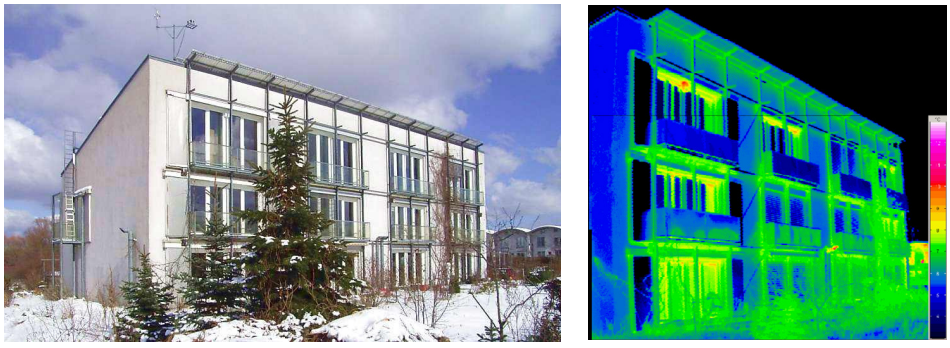

Fig.1. First Passive house.Source: PassivHaus Institut Darmstadt, Germany

That proved to be very efficient, both from the point of view of the power consumption, and that of the comfort achieved in the interior. The experience was resumed four years later in another building based on the same concepts. Starting from the results obtained, W. Feist defined in 1995 the concept of "Passive House" ("Passivhaus"), approaching three essential aspects:

1. the drastic limitation of power consumptions for heating and air conditioning;
2. attaining higher quality requirements (thermal comfort);
3. defining a series of privileged passive systems.

Starting from these principles over 10,000 passive houses were built in Germany, Austria, Switzerland, Belgium and other Central European countries.

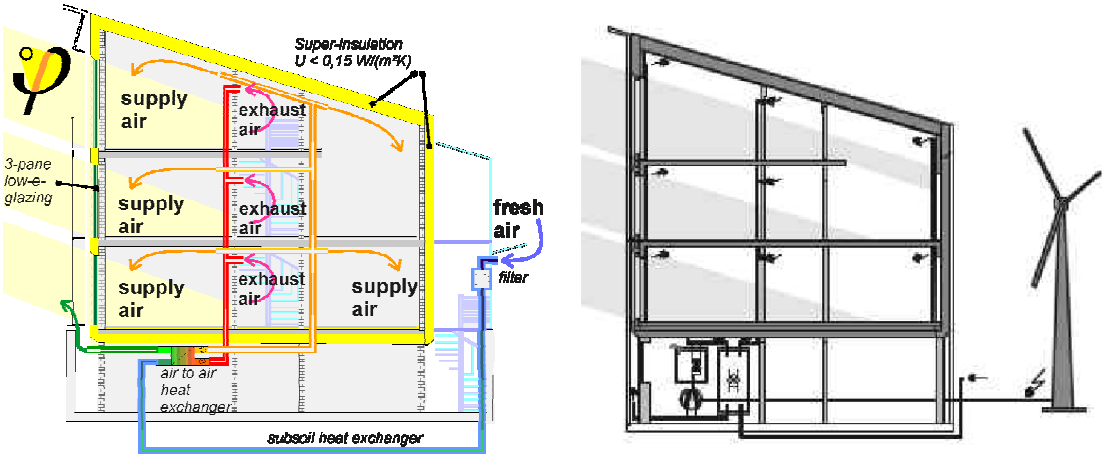

Fig.2. The concept of a passive house. *Source: PassivHaus Institut Darmstadt, Germany*

Passive House is a building which should ensure interior comfort both in winter, and in summer period, with low energy consumption. The main quality criteria for passive house were defined by the Institute Passivhaus from Darmstadt (Dr. Wolfgang Feist), as follows:

- ✓ Compact form and good insulation – *All elements of the opaque building envelope should be well insulated so that the overall heat transfer coefficient does not exceed* 0.15 *W/ (m²K).*
- ✓ South orientation and shading elements – *The use of passive solar equipments is very important to passive house*
- ✓ Energy efficient carpentry and glass – *Windows (glass and frame) must be characterized by overall heat transfer coefficient not exceeding 0.80 W/ (m²K), with solar radiation absorption coefficients around 50%.*
- ✓ Air tightness envelope – *The air exchange through leaks must be less than 0.6 times the house volume*
- ✓ Passive preheating fresh air - *Preheating fresh air may be introduced to the interior through underground channels which change the heat with the ground and preheat the fresh air at temperature over 5 °C, even in the cold days of winter;*

- ✓ Efficient recovery of evacuated heat air with an heat air-air exchanger – *The most part of sensible heat from the evacuated air is transferred to fresh air introduced into the building (the recovery rate over 80%)*
- ✓ Preparation of domestic hot water using renewable energy sources – *Domestic hot water is prepared with solar panels or heat pumps;*
- ✓ Energy efficient appliances and electronics – *refrigerators, freezers, machines, lamps, washing machines, etc., with low power consumption*
- ✓ The annual consumption for heat should not exceed 15 kWh/m^2 year;
- ✓ The total consumption of primary energy for all consumers from home (heating, hot water, ventilation, pumps, lamps, cooking and appliances) should not exceed the value 120 kWh/m^2 year;
- ✓ The interior temperature will not fall below 20^o C in winter, and in summer will be maintained under 26^o C;

Based on these limitations, any additional consumption of energy may be covered with renewable energy sources.

All this means that the entire energy consumption of a passive house is less than a quarter of the energy consumed by a new building that meets national rules, and less than electric energy and domestic hot water preparation in a new average building in Europe.

Table 1 synthesizes the basic characteristics differentiating a passive house from other houses, even from those with power consumptions usually considered low:

Table 1

Basic characteristics differentiating a passive house from other houses

Compact form and good insulation	All the opaque construction elements of the envelope should be well thermo-insulate, so that the global heat transfer coefficient **U** should not exceed 0.15 W/(m²K).
South orientation and shadowing elements	Using passive solar equipment is extremely important for passive houses
Power efficient joinery and windows	The windows (glasses and frames) should be characterized by a global heat transfer coefficient U at the most equal to 0.80 W/(m²K), having about 50% solar radiation absorption coefficients.
Air proof envelope	The air exchange from failure to seal off has to be lower than **0.6** times the volume of the house per hour.
Passive preheating of fresh air	The fresh air can be brought to the interior by underground channels that exchange the heat with the soil and preheat the fresh air at a temperature of over 5 °C, even in the cold winter days.
The efficient recovery of the heat from the air exhausted by an air–air heat exchanger	Most sensitive heat from the exhausted air is transferred to the fresh air allowed into the building (over **80%** recovery rate)
The domestic hot water preparation from renewables	Domestic hot water is prepared by means of solar panels or heat pumps.
Energy efficient household and cooking appliances	Refrigerators, freezers, cooking stoves, lamps, washing machines, etc with a low power consumption.

The two key elements that have to be taken into consideration at choosing the site and architectural solution for a passive house are the orientation of the main façade against the sun and the compactness of the building. As far as possible, the main façade will be oriented to the south and will not be shadowed, so that the solar power should contribute to a large extent to the heat balance of the building in winter.

A compact solution, in which the ratio between the outer surface and the size of the building is minimum, leads to the reduction of heat losses and reduces also the cost of the envelope of the building.

The maximum reduction of the heat losses is carried out both by the reduction of heat losses by conduction, and by sealing of the building against air, in parallel with carrying out an efficient ventilation system.

The improvement of the heat insulation does not reduce only the heat losses, but also leads to providing a higher temperature of the walls (in winter close to the temperature of the inner air), which betters the interior thermal comfort and reduces the condensate risk in walls.

To carry out this insulation the thickness of the wall grows, from 8-10 cm in a usual house, to values that might exceed 30 cm. Not only the thickness of the insulation is important, but also its structure and the removal of heat bridges; to that end the insulating envelope will not have discontinuities and will surround the entire building, including the foundation and ceiling.

Fig.3 Insulation the thickness of the wall. *Source: PassivHaus Institut Darmstadt, Germany*

As regards the windows, it is necessary to use at least a triple glass layer and the space between the glass layers filled with an inert gas (usually argon) ensuring global heat exchange coefficients lower than 0.85 W/ (m^2K). A Low-E film that reflects the infrared radiation should cover the glasses. The windows will be oriented mainly to the south, acceptably to the east and extremely rarely to the west and north. The handling of the window frames, their sealing system and shadowing system are other important elements that will be taken into account when designing and building the house.

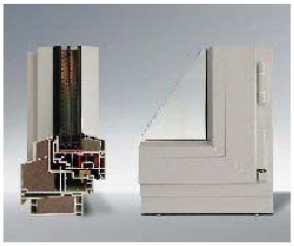

Fig.4. Examples of windows. *Source: PassivHaus Institut Darmstadt, Germany*

As the heat transfer losses through the envelope of the building are very low due to the improved thermal insulation, the heat losses by the infiltration of the air from the outside may prevail and might be the main causes of the heat losses. For that reason, one should pay attention to carrying out the sealing of the building, walls, glassed surfaces, doors, etc. A good sealing of the building ensures both the reduction of heat losses in summer and a reduction of the degradation risk of the building. In the case of the passive houses the air exchange should not exceed $n_{50}<0.6\ h^{-1}$ in the conditions of interior – exterior pressure difference of 50 Pa.

The fresh air supply is ensured by controlled mechanical ventilation (CMV) in a double flow. The mechanical supply and exhaustion make possible the upgrading of the ventilation according to needs, irrespective of the exterior climate conditions. The ventilation will blow fresh air in the living area (living, study, bedrooms) and will absorb from the kitchen area and the bathrooms the used air full of pollutants and humidity. To reduce the heat losses by ventilation, the passive house will necessarily be equipped with a heat recovery system (double flow system). The heat exchanger recovery rate should be ≥80%. To meet the goals of power efficiency, it is compulsory that the power necessary for ventilation should be $<0.4\ Wh/m^3$ of circulating air. The heat efficiency of the ventilation system can be improved by using an air-soil exchanger, used for preheating in winter and for pre-cooling the fresh air in summer; this way the risk of freezing the condensate in the heat recovery exchanger is wholly eliminated.

The general heating is done passively by:

- using the passive solar heat transmitted through the windows or glassed facades;
- the heat from the electrical appliances and from the inhabitants.

As it has a low heating power demand, a passive house should operate without a conventional heating system, but just with a simple system that should take over the consumption peaks that could contain solar panels, heating pumps or a small boiler on biomass in the areas with lower calculating exterior temperatures.

As compared with a conventional house, a passive house has obvious advantages. Considerable heat savings are made, it provides a good heating comfort and an excellent air quality.

Table 2

Comparison between a passive house and a conventional house

Country	Heat necessary for heating		Heat necessary for cooling	
	Standard house	**Passive House**	**Standard house**	**Passive House**
	(kWh/m2 year)	(kWh/m2 year)	(kWh/m2 year)	(kWh/m2 year)
Germany	90	15	0	0
Italy	83	10.5	4.63	3
France	69.6	17.4	N/A	5
Spain	59	8.7	32.1	7.9
Great Britain	59	15	0	0

Thus, the houses currently made in Romania require about 350 kWh/(m^2yr), and according to the most exacting current European standards, the heat demand for a new classical house rises to about 150 kWh/(m^2yr). The reduction of this demand in passive houses down to 15 kWh/(m^2yr) points to the huge energy saving potential that in the case of a house of about 300 m^2 can reach 100,000 kWh/yr. Besides, the power demand of a passive house can be sustained by using renewable energy resources, resulting in a major reduction of greenhouse gas.

3.Conclusion

Thinking about a solution for the "passive house" should be adapted to the climatic and geographical conditions specific of the site. Above all the details of the insulation of the building, windows and ventilation cannot be the same in no matter in which part of the globe the site might be. The conditions specific of each region that should be taken into account when designing the passive house, mainly are:

- the local building traditions, and
- the specific climatic conditions.

As regards the achievements in various EU countries, it is necessary to carry out an analysis on the architectural constructive solutions and to elaborate a design and execution guide of some types of "passive houses" adapted to the geographical and climatic conditions of Romania. To that end ISPE together with academic partners (Bucharest Polytechnic University, Ion Mincu University of Architecture and Urbanism, Bucharest Technical Construction University, The Scientific Academy in Romania) and other economic agents (Bucharest Institute for Electrotechnical Researches and Design, Baia Mare AGECOM) proposed to carry out the "PASSIVHAUS" project within the National Research, Demonstration and Innovation Plan II, Innovation section. Taking into account the lack of information and experience in Romania, the project proposes the actual realization of a "passive house" that should be an object of study and analysis, but also of promotion on the real estate market of buildings having performance of the "passive house" type. It is taken into account that in Europe we already built over 8000 "passive houses", with power efficiency much higher than the values required by the current standards. It is worth

mentioning that a "passive house" is built with the technology available on the market and with extra costs relatively easy to assimilate on the Romanian real estate market.

Within the program financed by the EC "Intelligent Energy Europe – 2006", ISPE participates as a partner in the project "Establishment of a Cooperation Network of Passive House Promoters – PASS-NET" under the coordination of the Austrian Society for Environment and Technology – ÖGUT. This partnership includes a series of top relevant organization, as follows:

- Interessensgemeinschaft Passivhaus Österreich, Netzwerk für Information, Qualität und Weiterbildung, IG Passivhaus – Austria;
- Passivhauskreis Rosenheim Traunstein e.V, PHK – Germany
- Swedish Environmental Institute Ltd., IVL – Sweden;
- Centrum pasivního domu, CPD-the Czeck Republic;
- Inštitút pre energeticky pasívne domy, iEPD-Slovakia
- Mariborska razvojna agencija (Maribor Development Agency), MRA-EIC – Slovenia;
- Association for Environment Conscious Building, AECB-Great Britain;
- Passiefhuis-Platform vzw Belgium, Passiefhuis-Platform-Belgium

Arhitektonski Fakultet Sveučilišta u Zagrebu, Arhitektonski Fakultet Zagreb – Croatia

This project, begun in 2007, has the purpose of promoting and disseminating the authorized information regarding the technology for building passive houses in Europe, focusing on the new EU member states.

Taking into account the high potential in obtaining energy saving and the reduction of greenhouse gas emissions by implementing the standards renowned for building passive houses, the project PASS-NET will focus on the intense promotion and raising the citizens' awareness by educational and training activities. In a few countries of this partnership there is a high degree of absorption of the standards for building passive houses, as these experiences need to be transmitted also to the other countries. That will strengthen the collaboration and allow the know-how exchange between the participating countries, while boosting new initiatives all over Europe.

This project will gather the EU member states with significant successes in promoting the passive house standards with EU member states with less relevant experience, and will create a framework favourable to the collaboration in order to promote the actions for increasing power efficiency.

REFERENCES

[1]. *CEPHEUS - Cost efficient passive houses as european standards. Project-Number: BU/0127/97 Sponsored by the EUROPEAN COMMISSION, DIRECTORATE-GENERAL XVII, ENERGY;*

[2]. PASS-NET - Establishment of a Co-operation Network of Passive House Promoters. *Project-Number:EIE/07/259/S12.4466712; http://www.pass-net.net/*

[3]. Passivhaus Institut Darmstadt - Das Institut für Forschung und Entwicklung hocheffizienter Energieanwendung. http://www.passiv.de/