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WHAT IS A PASSIVE HOUSE?

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Abstract

The present study aims to highlight the energy efficiency of the type of constructions named as "Passive Houses", comparing the energy efficiency of a house built in a conventional way with a house built according to the regulations imposed by the Passive House Institute, having as a reference a classic passive house and a premium passive house.
In the first part, the article presents generalities about what a passive house is and how it is built, what criteria should be followed and how such a project is certified, at the same time it is presented how a residential building is built, in a conventional manner, according to the legislation in force.
In the second part of the article, different systems and components that make up a passive house are shown, how they manage to increase the energy efficiency of a house compared to a conventionally built house, at the same time managing to reduce the carbon footprint and reducing the monthly bills for energy.
In the last part of the article, using graphs and tables, it is shown how the energy efficiency of a house is directly influenced by the chosen systems and their quality, how by respecting the criteria imposed by the Passive House Institute one can obtain a total or only partial improvement in the life quality of the living space, energy independence and at the same time a significant reduction in monthly energy payments.

Key words*: carbon footprint, energy efficiency, passive house.*

INTRODUCTION

Nowadays, a frequently debated topic is related to the high consumption of energy that affects biodiversity and accelerates the effects of climate change in an alarming way, as well as the energy crisis with a significant impact on the way to construct a building, or a house.
In the 20th century, different engineers, designers and researchers approached different ideas aimed at reducing the costs for heating and cooling a home and making it more energy efficient, some projects also address issues related to the environment or reducing the carbon footprint taking into account the type of materials, their origin and their implementation.
The thermal efficiency of single-family homes built before 1989 (and many years after) is extremely low. The walls of the houses were generally made with GVP brick (with vertical voids) up to 37.5 cm thick and rarely with BCA at the same time the walls were uninsulated. The slabs of the houses, above ground, from the 0.00 level, and from the last level, under the bridge, were uninsulated.
At that time, in Romania, polystyrene was not used, as it was still a material that was not known to everyone, just like mineral or basalt wool, cellulosic insulation, etc. The joinery was made of solid wood, with two sashes, each with a 4 mm sheet of glass, fixed with putty. Thermal bridges and the lack of tightness of the houses were present almost everywhere, so the energy efficiency of the houses was poor.
New design regulations have appeared (for example: regulation no. 305/2011 of the European Parliament and the Council of Europe), through which member states have introduced provisions, requirements, regarding the safety of buildings and other constructions, health, durability, energy efficiency, environmental protection, economic aspects and other aspects of public interest importance.
The term "Passive House" has been debated for more than 20 years, but it is not clear to everyone what this term includes, on the contrary, the terms "Passive House", "ECO House", "Green

House" are often confused, "Energy efficient house", "nZEB House".

Figure 1. A modern passive house

- What do nZEB and NZEB mean? - these do not represent certifications, they are described at the national level as "near Zero Energy Building" and "Net Zero Energy Buildings", they produce the energy necessary to carry out activities at the local level from non-conventional sources.
- Eco, sustainable and green? - These are vague terms, everyone confuses a passive house with an Eco or Green one, thus the BREAM, LEED and LBC certifications were born.
- Energy independence - It represents the fact that the house will produce the necessary energy by itself, throughout the year. Not all passive houses have energy independence, because this also requires having an energy storage system, not being connected to the public grid.

"Passive houses" are defined as buildings that have an extremely low thermal energy demand; therefore they do not need active heating. Thus, the temperature of the house can be maintained "passively", only by using the existing internal heat sources and the solar energy entering through the windows, as well as by minimal heating of the incoming fresh air.

A passive house receives certification as a passive house when the energy requirement is less than 15 kWh/m2/year, for an energy efficient house it is necessary that the energy requirement does not exceed 45-50 kWh/m2/year, and a nZEB house has an energy consumption of less than 112 kWh/m2/year.

Myths related to building a passive house:

• Passive houses cannot be built from any material; false because only energy efficiency matters. There are many materials recommended but not mandatory.

• A passive house has no windows; not only do they have windows but their placement and size significantly alter the efficiency of such a project.

• Certification can only be done for newly built houses; false, already built houses can also be certified, again, only the energy efficiency of the building is taken into account.

• There are many passive houses; a house is only truly passive if it is Passive House certified.

• The air is closed; if the air is closed it means that something is wrong in the house.

• You cannot open the windows; false, you can open the windows if you want, but it's not necessary.

• Only houses can be certified; false, certification can also be done for offices, schools, indoor swimming pools, etc.

• Passive houses are unesthetic; passive houses can have various shapes, often the simplest shapes are used to have an increased efficiency when it comes to the thermosystem and comfort in the home.

MATERIALS AND METHODS

The purpose of such a project combines comfort and at the same time brings a significant ratio when it comes to saving money, a passive house being much more energy efficient when it comes to heating, even up to 75% compared to a newly built house, at the same time, the electrical energy needed for living can even be up to 100% obtained from non-conventional sources.

Thermal insulation, sealing and controlled ventilation of the rooms add increased comfort to living, in some countries with a much more suitable climate for such a project, the houses no longer need a heating system, some projects abandoning the installation for heat, concentrating more much on the position in front of the sun, thermosystem and ventilation of the rooms. All this is possible only by following a well-defined set of principles.

The basic principles of Passive Houses are:

- Choosing a continuous thermosystem, reducing the thermal bridges between the materials used.

- High degree of air tightness, it has the role of not allowing the transfer of air between the interior and the exterior in an uncontrolled way.
- Choosing a ventilation system that aims to recover heat (HVAC),
- Choosing a quality window system.
- Choosing the exposure of the house so that you benefit from as much heat as possible from the sun.

Most of the certified passive houses in Europe are in Germany, Germany being the cornerstone of passive houses. The first passive house in the world was also built here, in 1988 in Kranichstein – Darmstadt Germany, and since then it has been operating at the same designed parameters.

Figure 2. The first passive house built in Germany

In Romania, the "Passive House" standard is quite difficult to achieve, the cost of putting it into operation being significantly higher than for a conventional house. However, there are completed projects, and some are ongoing.

The first passive house construction in Romania was in the Burlusi - Arges locality (Figure 3. a), but the first certified passive house is EvoHouse"with 4 apartments, from a 45 m2 studio to a 110 m2 2-room apartment (Figure 3. b).

Figure 3. Examples of passive houses in Romania

Another example is Casa Buhnici, from Corbeanca, Ilfov (Figure 3. c).

RESULTS AND DISCUSSIONS

The goal of a passive house is: comfort and a significant ratio for saving money, energy efficiency even up to 75% compared to a newly built classic house for heating, and the electricity needed for living can even be up to 100% from non-conventional sources.

The thermal insulation, sealing and controlled ventilation of the rooms add increased comfort to living conditions, in some countries with a much more suitable climate for such a project, the houses no longer need a heating system, some projects abandoning the installation for heat, focusing more on the position with respect to the sun, the thermic system and the ventilation of the rooms.

Figure 4. Ventilation system with heat recovery (Photo source: INCD URBAN-INCERC)

The criteria for designing a passive house are:
- The heat requirement for heating must be a maximum of 15kWh/m2/year or the thermal load for heating of a maximum of 10W/m2
- Annual space cooling requirement maximum 15 kWh/m2/year
- Annual primary energy consumption of a maximum of 60 kWh/m2
- The air tightness must be high, n50 <= 0.6 hourly shifts
- Frequency of the overheating period of maximum 10%

Classification and certification of passive houses:
- Classic Passive House (this type of house is the classic one)
- Passive House Plus (this type of house produces the energy it needs through non-conventional sources)
- Premium Passive House (this type of house produces more energy than it consumes, so what is produced in addition enters the network, the owner becoming a prosumer).

Figure 5. Heating pump water-soil

Figure 6. Ventilation system with heat recovery directly into the wall

Figure 7. Different types of solar panels (Photo source: INCD URBAN-INCERC)

Benefits of a passive house:

- The uniformity of temperatures is a great advantage when it comes to the comfort felt in the home, as there are no direct cold currents, it results in a much healthier and more welcoming environment, at the same time, throughout the life of the building, mold or moisture will not form behind the thermosystem or inside the home.
- Together with the reduction of electricity and energy for heating the rooms, our bills decrease, in the best case even close to 0.
- The building will withstand legislative changes and at the same time market changes, such a project is more difficult to devalue, all these will contribute to increased comfort, to a much healthier environment and at the same time, the project itself, contributes to the reduction of pollution and indirectly contributes to the reduction of the carbon footprint.

Disadvantages of a passive house:

- Such a project means an additional cost and at the same time a much more competent and specialized workforce, such a project does not take into account the water supply side, the carbon footprint of the materials, nor how they affect the environment.
- The documentation to authorize and certify such a project is much thicker and more difficult to do, at the same time,

and resistant to mechanical shocks of the outer and inner surfaces of the walls is less than in conventional buildings.

The energy balance is a laborious procedure that allows obtaining a real picture, at a given moment, of how the flows of energy carriers enter, are distributed, transformed and consumed inside the balance outline, highlighting the conversion efficiency of energy, size and type of losses for each of the analyzed points. The energy regime of each individual receiver, on each distribution board, up to the general electrical supply board is evaluated.

The energy balance is also a practical way of expressing the principle of energy conservation and highlights the equality between the energies entering and leaving the analyzed circuit for a certain period of time. The energies out of the balance sheet consist of the energies in any form usefully used and the energy losses.

Conventionally, it is considered useful energy, the energy used for: electrical and mechanical drives, steam generators, thermal processes, transport, electrical network elements, welding, lighting, etc.

The energy losses related to the technological process are considered the following: the sensible heat contained in the combustion gases, the heat lost by radiation and convection, the electrical energy lost by the Joule effect, the Corona effect, as well as the electromagnetic and mechanical losses of the engines, etc.

According to Romanian regulations, the energy balance is carried out with the help of a proprietary calculation program, but there is the possibility of using PHPP (Passivhaus Projektierung Paket), designed according to the European standard ISO 13790, which can be used successfully not only in the case of passive houses.

CONCLUSIONS

At the moment, the main effort regarding the implementation of renewable energy sources is focused on improving the technologies, to lower their costs.

It is especially desired to increase the performance of the equipment and reduce the energy consumed in operation, but also the judicious choice of processes, depending on the geographical conditions and the habits of future users.

The passive house is a certification standard based on measurements made on a building by an accredited institution.

The passive house requires compliance with 5 criteria, these being insulation, sealing, avoiding thermal bridges as much as possible, a ventilation system with heat recovery, the window system and the exposure of the building.

Passive House represents a certification that only considers energy efficiency.

More and more people want a life as comfortable as possible, free of expenses and worries, the projects related to energy efficiency, more precisely passive house projects have made everyone think, all those who want to build in 2023 a house also consider this possibility.

However, such a project requires more extensive documentation and a specialist to handle all the necessary.

Even if not all projects are certified as passive houses, there is still the possibility that the projects only meet some criteria, thus reducing monthly expenses.

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