

THE PASSIVE HOUSE, A NEW TYPE OF ECOLOGICAL HABITAT

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Abstract

A passive house is a habitat which does not provide noxious during the heating time and manages in an intelligent way the energetical consumptions. This house is provided with an integrated waste management and waste-water treatment and it contains external envelopment very well thermally isolated, windows with frame of laminated wood with three layers of glass and an integrated ventilation system. The integrated ventilation system eliminates the polluted air from the building and it passes through a heat exchanger to recover a part of the thermal energy, transferring that energy to the fresh air that comes from outside the mansion. A passive house can be built anywhere since the concept is simple but, at the same time, intelligent. There is a trend of rapid development of the passive houses in all European countries because their governments offer serious rewards to those who build smart on energetic considerations but, especially for the fact that these houses are particularly healthy and environmentally friendly.

The European Union has prepared several Directives, including "The Energy Performance Directive" in which, each Member State must join. These Directives provide obligations for a better thermally isolated of old and new buildings and the trend of the builders is to adopt new technologies to build the passive house.

The Romanian government has to comply with the European legislation trend and, so, it grants subsidies for those who use renewable energy systems in their building.

Keywords: passive house, intelligent system for waste management

1. Introduction

In the context of a sustainable development of the human society, it is imperiously necessary to find new types of eco-passive buildings for peoples and for the great diversity of human activities.

The sustainable development strategies have to enforce the respect for environment, which may harmonize the globalization and localization processes, frequently categorized as contradictory ones. The respect for environment contributes to the diversity of the local environment, encouraging the creation and innovation processes, to the adaptation process to increasingly complex restrictions coming from the global environment, to the diffusion of the universal values in a local environment, and vice versa, to promote local values by globalizing forces [1].

A passive house is a human habitat without conventional heating system (heating with methane gas, electrical energy or wood) that does not eliminate noxious in the atmosphere.

A standardized passive house has an external envelope, very well thermally isolated. The windows are made from laminated wood. In fact, a lot of layers of wood is laminated together and the result is a very thermally resistant material. For heating this type of house, an integrated ventilation system is designed, which eliminates the vitiated air from the building and passes it through a heat exchanger. This heat exchanger retrieves a part of the thermal power by transferring it to the incoming fresh air outside of home. This type of houses is built now in Germany, Austria, Switzerland and Sweden.

There is a trend toward a rapid development of passive houses in all European countries, due to the fact that these homes are particularly healthy and eco-friendly.

The European Union has developed several directives, among them "The energy performance Directive" that each Member State should adhere.

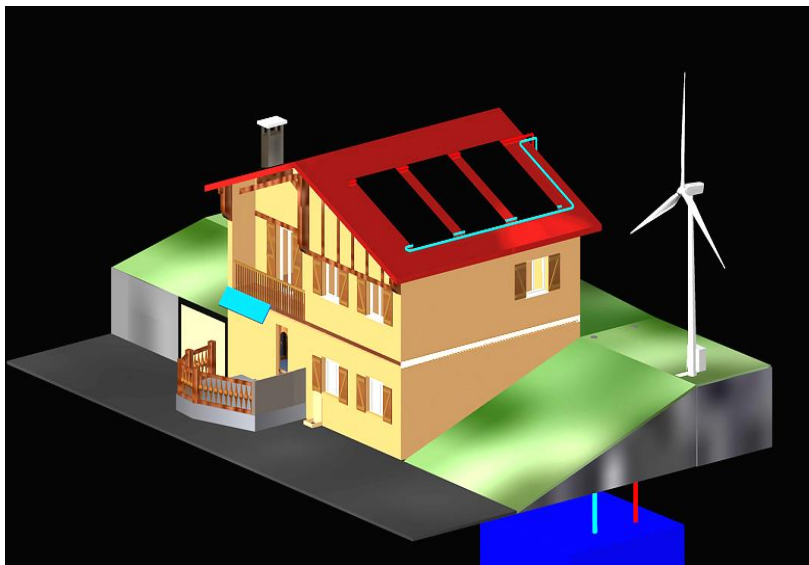


Fig.1. Modular house, on wood rezistance structure

These directives provide obligations for a better thermal isolation of buildings, old and new, with the help of environment-friendly technologies and construction of passive houses instead of classic building. The Government of Romania [2] has to comply with the European trend and legislation, so that it grants subsidies for renewable energies. For heating and cooling processes, this houses uses renewable sources, such as solar cells, photovoltaic cells, wind system.

Outward, the eco-house is well insulated because it uses windows with three sheets of glass, with sun protection, ensuring a healthy environment for life, without thermal differences in the same room.

Passive house can manage the consumption of electrical energy necessary for domestic use. In the sometime, it is important to use a performing system cleaning the waste water by using a natural system. For the solid waste, it may select the recovery materials and the organic waste can be transformed in compost. An efficient system to produce electrical energy is composed by photovoltaic panels, windy system (with propeller) and, maybe, a Stirling system.

For heating in winter season or cooling in summer season, caloric pumps, horizontally or vertically, in combination with a radian panels, may be used [3].

At the passive house, the systems are used for preheating the fresh air outward. This air is filtered and being brought in the building via the piping buried in the ground.

The passive house represents a new way of approach the construction of houses on wood resistance skeleton. It is a modern house, which was carried out on the wood structure and the walls are made of prefabricated modular materials. This house can be built in the variant:

a). efficient heat shield (Sterol, benzyl, pentane, bromide) with a heat coefficient for the walls of $0.16 \text{ W/m}^2\text{K}$;

b). A combination of materials (60 % recycled paper, 10 % bore salt, 30% clay) for the walls, that ensure a heat coefficient of $0.10 \text{ W/m}^2\text{K}$.

The house can be built in the limits of initial budget and extension in time, according to needs and taken into account financial opportunities. On the first stage of the design, the possibilities of future enlargement shall be taken into account and elements will be provided, allowing for 'connecting' the house parties, in a short period of time (1-2 weeks), with a minimum of clutter.

2. Theoretical Elements about Heating System of the Passive Houses

A passive house needs only a very good thermal isolation and an efficient system of ventilation with inter-cooler. Thermal insulation of the house envelop assumes a rational use of certain materials that prevent heat transmission from the inside to outside in winter and from the exterior toward the interior in summer season. In a rest position, air is not a good heat conductor, so, it is basically a relatively good insulating material. However, in larger areas, as cavities in the walls, the heat can be lost by convection and radiation [4]. The role of insulation is to divide the air volume into compartments, small enough for preventing the formation of convection currents and the air could remain in a rest position. Insulating material reduces radiation from one surface to the other of the air compartment.

Specific thermal resistance of a homogeneous layer of the construction element shall be determined by the relationship [6]:

$$R = \frac{d}{\lambda} \left[m^2 \cdot K / W \right] \quad (1)$$

where d is the layer thickness necessary for calculating, in m, λ – the thermal conductivity for the type of material used in calculation.

For each insulating layer heat flow can be written with relationship:

$$q = \frac{\Delta T_i}{R_i} \quad (2)$$

Where: R_i is the thermal resistance of “ i -th” layer.

Equivalent thermal resistance of one inhomogeneous construction element with several layers perpendicular to direction of the flow heat shield is:

$$R_{\perp} = \frac{\Delta T}{q} \quad (3)$$

or using relationship (2.2), it can be written:

$$R_{\perp} = \frac{\Delta T_1 + \Delta T_2 + \dots + \Delta T_n}{q} = R_1 + R_2 + \dots + R_n \quad (4)$$

The layers of material having few gaps of air introduce a thermal resistance, R_a . Equivalent thermal resistance R_{\perp} of one non-homogeneous construction element is:

$$R_{\perp} = \frac{\delta_1}{\lambda_1} + \frac{\delta_2}{\lambda_2} + \dots + \frac{\delta_n}{\lambda_n} + R_a \quad (5)$$

In the case of non-homogeneous construction element composed of “ n ” parallel areas with the thermal flow, it can be written:

$$Q = Q_1 + Q_2 + \dots + Q_n \quad (6)$$

$$\Delta T = \Delta T_1 = \Delta T_2 = \dots = \Delta T_n \quad (7)$$

where Q is total thermal flow transmitted through the non-homogeneous construction element, Q_1, Q_2, \dots, Q_n are the thermal flows transmitted through each homogeneous construction element; $\Delta T_1, \Delta T_2, \dots, \Delta T_n, \Delta T$ – the temperature variation on each construction element area and, respectively, on the whole component.

The main objective of waste management system is to maximize economic benefits and, at the same time, to ensure the protection of the environment. Granite and marble industry generates a large amount of wastes, mainly in the form of powder, during sawing and polishing processes, which pollute and harm the environment.

For most of the year, these materials maintain constant temperatures in the interior of the house, without the need for other heating system.

In winters with extremely low temperatures (-20°C), there is a need for an active heating element (electrical radiator with oil, etc.), but one of very low power, so, even in conditions of extremely low temperatures, temperature will be comfortable in the house passive.

Typically, the investment used to implement a system of effective classical heating will be used for a better thermal isolation of windows and exterior walls and for a better ventilation of the house interior.

The heating, ventilation and air-conditioning systems are focused on the use of renewable energy sources. First, in order to cut down energy consumption, a heat exchanger placed in the soil will be recommended. In winter, it takes the thermal energy stored in the ground and uses it for preheating of freshly inserted air into the flat, like in Fig. 2.

In summer, the air is taken from the atmosphere and it is inserted into the flat, after a precooling, by passing it through the same heat-exchanger of the assembly.

For a passive house, performant (ecological) materials can be used for thermal isolation (envelope) of the building (see Table 1).

To ensure that a building can be categorized as a passive house by the Passive House Institute [4], a research on the demands of thermal energy necessary for heating is made. The passive house space must necessitate less than $15 \text{ kWh/m}^2/\text{year}$

(this corresponds to a combustion of less than 1.5 l of petrol/m²/year) in order to be a passive house.

Table 1. Data on the materials used for passive houses

Types of material	U/M	CELLULOSE PULP organic/natural	BASALTIC MATERIAL inorganic/synthetic	MINERAL WOOL inorganic/synthetic	POLYSTYRENE organic/synthetic
Components		60 % recycled paper, 10 % bore salt, 30% clay	95 % Diabase, basalt and 5 % liaison material , phenol formaldehyde petroleum	Quartz sand, soda, borax, sodium sulphate phenol formaldehyde, petroleum	Sterol (from petroleum), benzyl, pentane, bromide
Mechanical properties					
Thickness	mm	20 – 400	20 – 200	20 – 240	10 – 400
Density	Kg/m ³	30 – 80	30 – 90	14 – 50	10 – 20
Pool resistance	N/mm ²	-	0.0007 – 0.8	0.005	0.15 – 0.52
breaking strength	N/mm ²	-	0.00012 – 0.0075	0.005 – 0.015	0.09 – 0.22
Thermal properties					
Thermal conductivity	W/(m ² K)	0.097	0.085 – 0.10	0.25 – 0.4	0.15 – 0.24

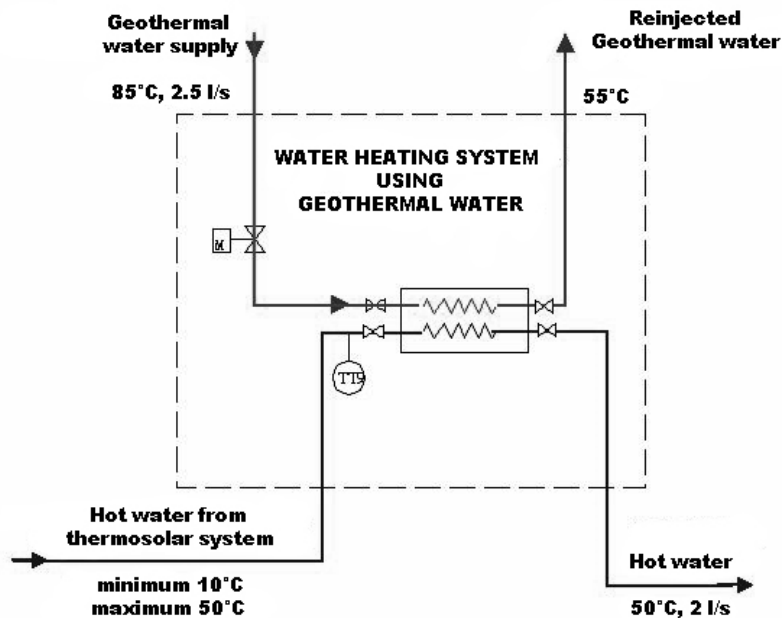


Fig.2. Water heating system that use geothermal water [6]

Thus, the energy demand for heating the house liabilities is about ten times smaller than in the case of a conventional house. Secondly, there should be provision

for using solar energy for heating water bins. The fluid is heated in solar receptors, located on the building roof and then it is directed to a storage reservoir. If possibilities roof, the geothermal energy may be used. The scheme is shown in Fig. 3???. Hot water can be obtained at 50°C for consumption. This system can be combined with a thermo-solar system after reintroducing geothermal water at about 55°C. The supply of geothermal water is made at about 85°C. Soil temperature at a depth of 2 meters varies between 7°C and 10°C, even in the cold season.

For heating the air inside of passive house, an air exchanger could be used. Fresh air (which in winter can have, for example, a temperature of -10°C) is first drawn from the outside, filtered and then introduced into the underground heat exchanger. As a result, after the air exits from the “air exchanger”, it may have a temperature of about 7°C.

In the collector heat (using the counter-current system), over 80% of vicious air, which comes out of the building, transferring his temperature to the fresh air flow that entering from outside. In this way fresh air is heated to approximately 18°C.

3. Original Integrated System for Passive House, Heating and Cooling

A heater system (Fig. 4), consists of a doubled burned with a heat exchanger supplied with hot water. First component comes into action only when there is available hot water. After exit from fresh air heater has desired temperature, usually at approximately 40 °C. Air is then circulated through the pipes that pass through the inside insulated chambers up to nozzles of relief.

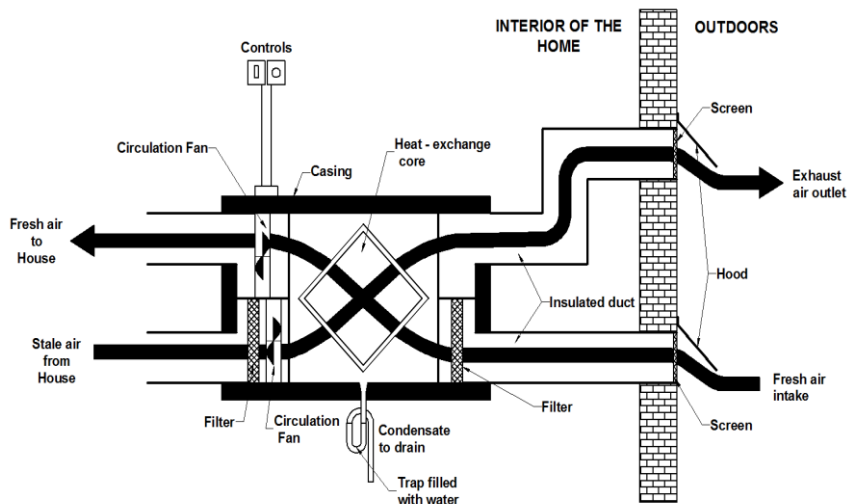


Fig. 3. Heating and ventilation integrated system for a passive house

Due to transfer of heat by conducted transients and radiation on this path the air penetrates the rooms at a temperature between 18 and 20°C. The vitiated air is extracted from the kitchen and the bathroom and constitutes in collector, in fact, a heat source for the fresh air.

Collector of the output of vitiated air at temperature of about 7°C, and it is cooled to about 1°C in a small heat pump. The energy recovered here is sent to the storage reservoir of the thermal power.

The other source of heat for this tank is made up of the system to capture the solar energy. If neither of these two sources is not able to supply energy needed, the tank has to have a electric heater or using other sources conventional of energy.

Another limit imposed on a passive houses refers to overall energy consumption conventional obtained, directly or indirectly, on fossil fuels (which includes energy for heating the home, formulation hot water, lighting, commissioning of the equipment electrical, etc.) which does not exceed 120 kWh/m²/year.

4. Renewable Energy for Passive House

Another source of renewable energy be taken into account is that of the soil, it can serve and the air preheat freshly what is entered into the flat. About modern solar cells discusses also Dr. Giso Hahn into the scientific contribution: “*New Materials for Photovoltaic Energy Conversion. Solar Cells from Ribbon Silicon*” and confirms the use of crystalline silicon as basic material of modern solar cells, with a tendency towards less expensive *polycrystalline* wafers.

Ribbon silicon makes use of a different preparation technology to avoid this material loss, and so yields considerable cost savings. In terms of efficiency, solar cells made from ribbon silicon wafers are already nearly competitive with conventional cells and can be integrated into existing production lines for solar cells on a crystalline silicon basis [9]. (Wengenmay & Bürke, 2008).

In the event of a draft a dwelling proves that these two energy limits are not exceeded, German law granted important economic facilities of owner. Consumption of heat measured of the first passive houses constructed like prototype in our laboratory, was less of 15 kWh/m²/year.



Fig.4. Energetic solutions-photovoltaic panels mounted on the roof of passive house [5]

Nikolaus Meyer presents the structure and function of CIS thin-film solar cells (Copper Indium disulphide – CIS, a thin-1 µm semiconductor film as absorber into a glass substrate) considered as day-solar modules into the scientific contribution: “*CIS Thin-film Solar Cells. Photovoltaic Cells on Glass*”. The fabrication of these CIS photovoltaic cells (Fig. 4), demands a complex process technology, consumes a

large quantity of materials and has been developing as an alternative to cell technology by Hahn- Meitner Institute (HMI) from Berlin [9]. The Sulfur Cell Solartechnik GmbH enterprise, founded on the basis of the HMI technology, is now setting up for pilot plant production. The costs of electrical energy produced with CIS modules are estimated to be about 50 % cheaper by comparing with the costs to obtain conventionally electrical energy [9].

A safe way to supplement the electricity necessary to the household equipment functioning is to use photovoltaic panels mounted on the roof of the passive house, as shown in Fig. 5.

Thermal load to a normal building is of the order of 10 kW to 100 m² habitable surface, which means approximately 100 W/m². Standard insulated heating systems are the same in more than 80% of cases; they shall consist of heaters with water or oil, pipes and radiators.

It is necessary to use solar panels for heating the water, especially in the summer season when the thermal load of the building is less than 10 W/m². This is the idea which is at an essential basis of the "passive houses" to which heat losses are reduced so much that it is no longer required a separate heating system.

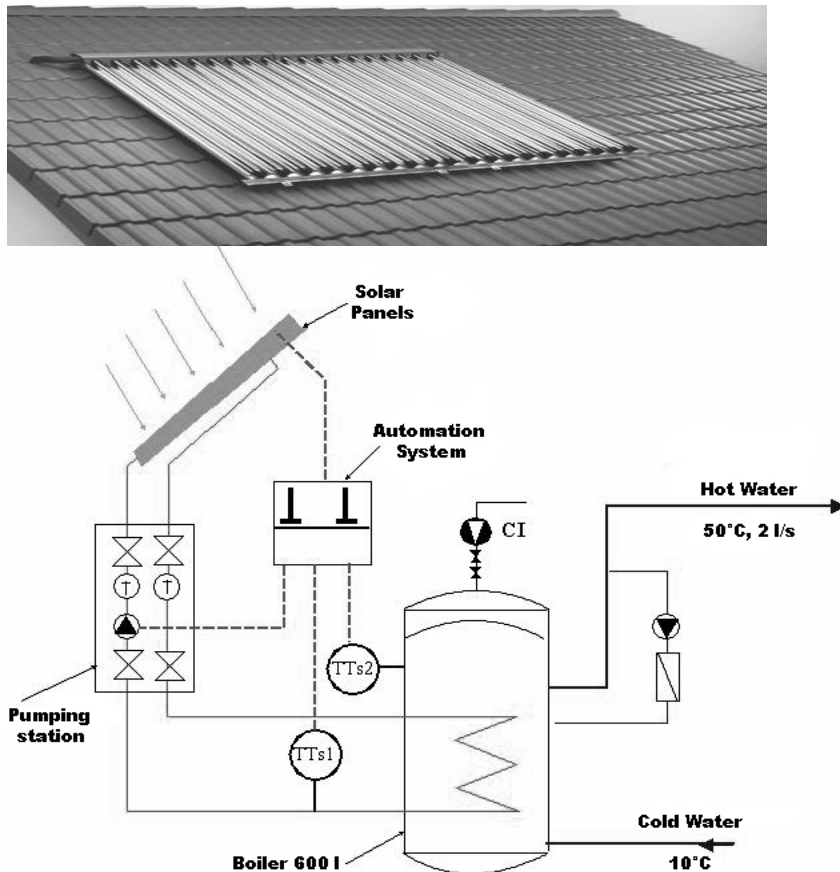


Fig. 5. System with solar panels for water heating [9]

Depletion of reserves of conventional fuels, the effects of pollution due to their use and the progress in using renewable energies are a permanent incentive to the creation of new energy technologies.

The system that used solar panels needs an installation like in the figure no.6, which is composing by automation system, pumping station, boiler, pipes, thermocouples and other fittings).

Domestic hot water preparation is the greatest consumer of energy in a passive house (about 80% of the total requirement of heat). Because this operation requires only ensure that average temperatures, can be easily accomplished through the use of renewable energy such as solar energy.

On the research made we observe that the limits of 120 kWh/m²/year included new consumers energy industry (such as, for example, the air conditioning systems used in the course of season hot). This types of consumers can be usually find in a passive house, although it can be integrated solar solutions for cooling in addition to general compliance of the building.

A passive house standard exterior envelope contains a very well insulated (usually at least 10cm of expanded polystyrene high-density of 30kg/m³), windows from laminated wood with three layers of glass and a ventilation system integrated which eliminate vitiated air from the inside. It passes through a heat exchanger which recovers a part of the thermal power by transferring it to fresh air coming from the outside into the house.

5. The Use of Wind System

For a passive house, in addition, we can use a wind system to produce electrical energy (Fig. 6).

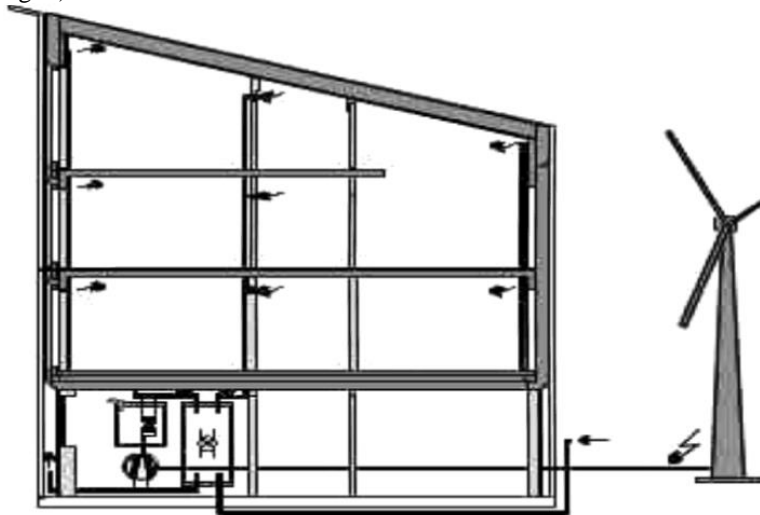


Fig. 6. The wind system (with propeller) used for electrical energy production [6]

The research that we made used scenarios, that integrating both ecological and social principles to improve landscape multifunctional in a suburban area, with a special focus on the role of woody patches. We evaluated how improving some

functions of woody patches (suitability for forest species, mitigation for road impact and recreation) can help creating a multifunctional landscape. We combined the scenario visualization through GIS (we adopt the study at our specifically condition in Galati area) the maximization of functions based on ecological principles, and the use of fuzzy logic. The scenarios obtained show that improving existing woods can help to maximize multiple functions.

The scenario improving recreation is the most suitable to increase biodiversity, and it can also help to mitigate road impact. The scenario approach can help decision-makers during the planning process, because it is user-friendly [7]. In conclusion, passive house is defined by two basic elements: an envelop that is a very well thermal isolation for the building and the missing of classic heating system.

A passive house needs only 10-15 kWh/m² per year, or the equivalent of a maximum of 1.5 m³ of natural gas or 1.5 liters of fuel oil per 1 m² for the heating surface per year. The second element of a passive house is the heating system that is replaced by a simple ventilation system, but smart, whose costs do not raise much above costs of a heating classic system.

So, we get loss much less power when we ventilated house (less than warm air to the outside) and more comfort in the interior (less cold air entering into your home).

6. Conclusions

Passive houses are reflected in construction of houses, villas, boarding houses, holiday homes, modern residential neighborhoods, offices, shops, warehouses. Can be build in areas of earthquakes, floods and hurricanes frequent with (0-10 %) above a price of construction for conventional houses.

There's some additional costs (thermal isolation in addition, frames at the window, and triple window, the ventilation system particular seal and the implementation of the tire perfect dwelling), which in fact are compensated for the savings obtained by eliminating heating system. Invoice cost of energy will be of 5 to 10 times less than in a conventional house.

Another advantage undeniable of building a passive house is the quality of materials, there is no condensation and undesirable molds and, factors that extend the life of the building with a tens of years compared with a conventional home.

Speed of construction of the house is very high, so that your investment is dampened much faster than in a classical building, and the quantity of labor is reduced significantly.

It shall be reduced with 10-20% the workmanship of house execution, both to the structure, as well as the finishes that are much easier to be performed, as compared with construction of conventional type.

Another important advantage is the high speed of construction of the house. That is between 3-5 months (foundation, walls, and a layer of plaster on the outside, windows and exterior door, magnificent residence, section of metal roof).

For construction is not necessary heavy machinery and equipment of buildings. A model for the management of environment risks was created, based on a hierarchical of the risks and a set of suggestions for improvement and prevention, which would ensure a sustainable development of emerging territorial structures [8]. These types of ecopassive habitats can be built in the areas, where a lot of industrial plant was disused.

A passive house is a dwelling which does not eliminate noxious gases and which do not require an auxiliary heating system (on gas or electric current).

Thermal energy is supplied by a ventilation system that picks up the air from the outside of the house and then this air is constitutes in collector, in fact, a heat source for the air fresh condensed that ensures the thermal comfort of the dwelling.

Passive houses are completely enrtgetical independent because uses alternative energy systems, renewable energy sources (solar panels, photovoltaic panels, wind energy, heating pomp system, radiant panels).

This type of house offers habitable conditions very comfortable and healthy, both in winter and summer.

Those that suffer of various allergies (current, dust, asthma, etc.) may keep the windows closed in spring or autumn, without any problems, because the house is permanently supplied with fresh filtered air.

The system provides resistance to moisture and rotting. Waters from flooding does not penetrate the walls and the construction material used does not absorb more than 3% moisture. Outer walls are 50% more resistant to weathering than the walls of brick classics.

Inside of house, the condensation is eliminated because the dew point is moved 100% outside the building. The system supports any type of interior and exterior finishes.

The passive house offers very good stability to strong winds and earthquakes.

The building costs shall be detected by the reduction with 85% of the costs of heating costs in winter and cooling costs in summer. Due the protected casting of concrete, passive houses can be constructed in cold weather (about -5⁰C).

Longevity and durability of construction is much higher than the conventional systems.

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