ULTRA-LOW ENERGY BUILDINGS

MARCEL IANCĂU, GHEORGHE IONESCU
University of Oradea,
Faculty of Architecture and Constructions,
1, Universităţii street, Oradea
marcel.iancau@gmail.com, gheionescu@gmail.com

Abstract: Currently, energy-saving construction is stimulated not only by all-too-frequent increases in the cost of household energy to intolerably expensive levels, but also by the recognized need for independence from the major energy systems, due both to the increasing uncertainty of energy supplies and to the increasingly environmentally-conscious attitude of the population. People can no longer accept the fact that their daily needs in terms of energy should be met only by ever-increasing consumption of the Earth's finite resources, when 40-60% of this is lost or wasted, increasing the environmental burden at the same time. What is needed, therefore, is to determine how to satisfy the demands for comfort of people in the 21st century in such a way that, at the same time, the amount of energy needed could be seriously reduced. To date, the best answer to have emerged has been architectural - in the form of ultra-low energy buildings such as passive houses, zero-energy buildings and energy retrofitting.

Key words: Passive house, planning and building, energy retrofitting, public buildings, energy buildings

1. INTRODUCTION

Currently, energy-saving construction is stimulated not only by all-too-frequent increases in the cost of household energy to intolerably expensive levels, but also by the recognized need for independence from the major energy systems, due both to the increasing uncertainty of energy supplies and to the increasingly environmentally-conscious attitude of the population. People can no longer accept the fact that their daily needs in terms of energy should be met only by ever-increasing consumption of the Earth's finite resources, when 40-60% of this energy (perhaps, if we examine the issue more rigorously, 80-90%) is lost or wasted, increasing the environmental burden at the same time.

What is needed, therefore, is to determine how to satisfy the demands for comfort of people in the 21st century in such a way that, at the same time, the amount of energy needed could be seriously reduced. To date, the best answer to have emerged has been architectural - in the form of the passive house system. This architectural concept, originating in Germany, is barely twenty years old, and in this country is still at little more than the experimental stage.

Although the design of Passive Houses may appear quite different, the principle remains the same. The principle behind a Passive House is based on the concept by Amory Loving do reducing investment through energy efficient design. By dramatically increasing the energy efficiency of a building, the HVAC system can be radically simplified upon reaching a certain level of efficiency. [1];[8]

2. PASSIVE HOUSE: COMFORT THROUGH EFFICIENCY

The Passive House is the world's leading standard in energy efficient construction: Energy saved on heating is 80% compared to conventional standards of new buildings. The energy requirement for heating is lower than 10 to 20 kWh/(m²a) (depending on climate), adding up to a low cost of 10 to 25 € per month. Therefore high energy prices are no longer a threat to Passive House occupants.

Exceptionally efficient components and a state of the art ventilation system, achieve these huge savings without compromising comfort, but rather increasing it.

The Passive House concept is a comprehensive approach to cost-efficient, high quality, healthy and sustainable construction. The concept is easy to understand:

A passive house (PH) is a building in which the heat requirement is so low that a separate heating system is not necessary and there is no loss of comfort; in Germany, this is the case if the annual heat requirement is below 15 kWh/(m²a).

The decisive idea to develop cost efficient passive houses was, that to dispense with a heating system the heat requirement need not be zero: If the maximum heat load is less than 10 W/m², then the extremely low required heat load can be provided without additional effort via the supply air. The characteristic figures of Passive houses are: very good thermal insulation (U-values < 0.15 W/(m²K)), avoidance of thermal bridges, high air tightness (n50-values < 0.6 h^{-1}), super-glassing (U-values < 0.8 W/(m²K) with solar transmittance factor g > 50 %) and ventilation systems with highly efficient heat recovery.

For the solar utilization the 'concept' can be described with following examples: the potential of the south side is used differently according to the single solar strategies. For instance the same south orientated

 I.S.S.N. 2067 – 5534 © 2010 JSE

surfaces, which gain the winter sun in a passive way, are available for the electricity generation in summer. As the PV-elements would only provide very few electricity in winter, but in summer have the greatest production potential, they are oriented to the summer sun. The PV elements are not directly one upon the other, but displaced to the north to avoid mutual shading at forenoon or afternoon. The solar windows are largely arranged vertical – orientated to the low winter sun – because they shall deliver only the warmth of the winter sun. The fanlight windows in the south and the windows bring the light from the highest points of the building in the interior and make the best use of the daylight. In summer this fanlights deliver only diffuse sunlight, because they are lying in the North respectively are shaded completely.

To build Passive Houses, highly efficient windows have to be used. The type of glazing and frames will depend on climate, however. In the Central European climate there are three essentials: Triple glazing with two low-e-coatings (or another combination of panes giving a comparable low heat loss),"Warm Edge" – spacers and Super-insulated frames.

These components harmonize in a way that the total heat loss of such a window is only half as high as compared to a conventional new window. But direct and indirect solar gains are collected through the glazing, too. Therefore, it has been demonstrated that by using these highly efficient windows, the result will be a positive energy balance even in the Central European winter period, as long as the orientation is suitable and the shading not excessive.

The thermal loss coefficients, Uw, of such Passive House windows are lower than 0.8 W/(m²K) according to the new European standard (EN 10077). One consequence of such a low heat loss is that the interior surface temperature of such a window, even in cold European winter nights, will exceed 17 °C. These results in excellent thermal comfort even near the window: There will be neither trouble with "cold radiation" from the window nor an unpleasant lake of cold air at the floor.

The 17 °C condition for minimum internal surface temperatures of windows in a Passive House is the defining requirement for Passive House windows in any given climate

Through the chosen alignment (architecture) of the PV elements and the south glazing the building concept uses the changing stand of winter and summer sun without having to move itself or it's elements: the winter sun reaches into the building and the direct summer sun is entirely absorbed by the PV elements.

The Passive House vision defines highly ambitious long term goals for the future building stock.

Passive Houses can be new-build or renovation. They can be homes, offices or public buildings. Passive House proposes a target framework for how to design and renovate such buildings that contribute positively to human health and well-being by focusing on the indoor and outdoor environment and the use of renewable energy.

ENERGY- Contributes positively to the energy balance of the building

A Passive House is energy efficient and all energy needed is supplied by renewable energy sources integrated in the building or from the nearby collective energy system and electricity grid.

INDOOR CLIMATE - Creates a healthier and more comfortable life for the occupants

A Passive House creates healthier and more comfortable indoor conditions for the occupants and the building ensures generous supply of daylight and fresh air. Materials used have a positive impact on comfort and indoor climate.

ENVIRONMENT - Has a positive impact on the environment

A Passive House interacts positively with the environment by means of an optimised relationship with the local context, focused use of resources, and on its overall environmental impact throughout its life cycle. [1];[3]

3. USING ENERGY BALANCES TO MEET ENERGY EFFICIENCY

All energy is conserved - no energy gets lost. However, energy can escape out of the region, where the energy service is utilized. This is, what we call an "energy loss", although the energy only moved to another place and may have changed its form.

Already this introduction shows, that energy balances only make sense within a well defined region with a well defined boundary. The boundary of the region is called the envelope.

In the case of heating or air conditioning the region of interest is the "heated or conditioned space". More precise: It is the volume in the building, which is conditioned to comfortable thermal conditions. In most cases it is convenient, to include "passively heated" parts, as long as the balance envelope will be simplified. Generally the envelope should be chosen by pragmatic considerations: For a building it is convenient, to choose the envelope at the external surface of the insulated external building shell (Fig. 1).

The task for heating or air conditioning now is just to keep the temperature inside of the envelope constant

If we have a look at a heat flow going inside out through the envelope, it may be hot air moving out through a window. Such a "heat loss" would reduce the "Inner Energy" inside the volume; and that would cause the temperature drop inside of the building. Just that should be avoided in order to keep the conditions comfortable. Therefore the energy flow to the outside has to be compensated: Another heat flow has to be created, going outside in, to keep the level of the temperature.

That is in important insight: The need for heating is always only a reaction on heat losses. Because of the law of energy conservation a building will stay well conditioned - as long as there are no heat losses. It is a pit, that the physical mechanisms by which hotter systems transfer heat to a cooler environment are quite numerous and efficient. If we do not "isolate" the hotter system (by insulation), in general a lot of heat will get lost by heat conduction, convective heat transfer and radiation. "Heating" always is the substitution of energy losses -

therefore "heating" can be reduced to an arbitrary low amount by effectively avoiding losses.

There is some luck when looking at the heating task: There are some free "heat gains", too: For example the solar radiation through the window panes (so called passive solar energy) and the energy of the electricity supply, which is converted to "internal heat sources" in the building. This adds to the heat radiated from persons inside the building. This energy is as well transferred through the envelope into the house - at any time, when the persons enter the building or nourishments are delivered.

Under the simplified conditions given here, it is simple to give the energy balance of the building: The sum of the heat losses equals the sum of the heat gains. .(Fig. 2)

It is quite simple to calculate the heat losses (depending on the insulation). The internal heat sources and the passive solar energy can be estimated as well. Therefore, on the basis of an energy balance the heating energy required can be calculated.

There is only one minor problem: The amount of the solar gains which can not be utilized has to be determined. But even for this there are well validated simplified formula given e.g. in the European norm EN 832. For practice, these methods have been integrated to the "Passive house design package".[2];[3];[4].

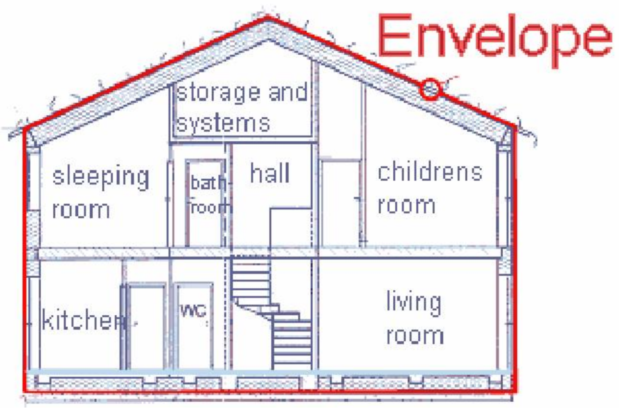

Fig.1 It is convenient, to choose the envelope for energy balance of a building at the external surface of the insulation

4. RETROFITTING OLD BUILDINGS WITH PASSIVE HOUSE COMPONENTS

The modernization of the existing building stock is the most important task in the future for the building sector. Presently all of those involved emphasize this, from housing policymakers to builders and building industry.

The energy savings potential of using passive house components is very high.

When renovating using only passive house components, heating energy consumption decreases to one tenth of its original value.

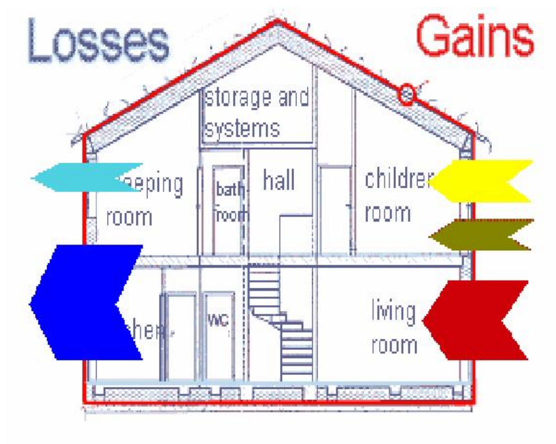

Fig.2 Heat losses (transmission and ventilation losses) exit the building through the envelope. Heat gains enter the building through the same envelope. Using the law of energy conservation , the sum of the gains equals the sum of the losses as long as the Inner Energy does not change.

If it is only possible to add insulation to the interior, but passive house components are used, it is still possible to reach a 75% reduction in energy conservation. This shows that the best market available Passive House components are viable solutions well into the future.

The conditions for work and living are also drastically improved. Retrofitting is not limited just to energy aspects. The use of bio insulation materials can also replace the common use of non-renewable solutions. This kind of refurbishment is integral because the planners introduce broader ecology aspects and future impact of the building to environment.

Retrofitting of energy in-efficient buildings, to passive or adequate low energy buildings significantly reduces energy use and ensure more quality of living conditions. General revitalization of the buildings is often connected with the functional refurbishment and with the architectural planning – but always the necessary steps are bigger construction and building physics changes on the thermal envelope of the building and implementation of the new technology for heating and air conditioning. The result of significant investment in the building is increasing of the usage efficiency and also their market price. The passive standard in renovation for the building (in a way that their users are not disturbed) are acceptable also for public buildings, for example schools, kindergartens, homes for elderly people, medical institutions.

Instructions for retrofitting are based to integral renovation procedures, which are in line to modern principles, with usage of renewable ecological, natural materials. These materials are not wasting our living environment and living surfaces with substances which are harmful for human health. For residents and users this kind of construction allows healthier and efficient living conditions, more comfort because of warm thermal envelope of the building, lower energy costs because of optimal heath insulation and recuperation, and off course – fresh air due to controlled air conditioning. [3]

5. ENERGY EFFICIENCY REDUCES ENERGY LOSSES - THE ENERGY DEMAND APPROACHES ZERO

Energy efficiency does not require a compromise in occupant comfort - not at all. Using higher efficiency makes it possible to increase comfort while reducing energy consumption. The passive house is a paradigm for this approach in the building sector. And the same principles can be utilized in other sectors as well: A car using just 1 liter gasoline per 100 km reduces consumption by 75 % (without loss in rider comfort), an LCD-monitor saves some 70 % of the electricity demand of CRT-monitors and compact fluorescent bulbs save 75 to 80% of the electric power needed by incandescent bulbs.

Energy efficiency: Energy consumption is reduced by more innovative and intelligent products and by intelligent process integration. In most cases this needs some additional investment, but these are cost-effective as a rule. The products needed could be produced near the customer. This gives rise to employment and innovation.

The Passive House is a perfect example for what can be done with really energy efficient concepts: The energy consumption of Passive Houses is just some 10% compared to the average of the building stock, but the comfort in the buildings is even better.

The design, orientation and materials of a Passive House are optimized to use as little energy as possible and to utilize renewable energy sources, thus making it CO_2 neutral. All energy is produced from renewable energy sources, either integrated into the building or taken from the nearby collective energy system and electricity grid.

Low energy consumption is reached through a holistic approach where orientation and design of the building ensures maximum use of the power of the sun. The use of high-performance products, intelligent control systems, dynamic façade and window solutions with optimised shading and screening will create a building that can be controlled according to the rhythm of the year and day.

The initial cost of a Passive House can be higher than the cost of a conventional building because low energy consumption is attained by more energy efficient solutions and constructions (walls, roof, floors, windows, heating and ventilation system), and utilisation of green technologies (solar panels, solar cells, heat pumps, etc.). However, these added costs are offset by savings in primary energy, and by production of renewable energy. It is therefore important to calculate the total costs and savings during the design phase (construction costs) and the operation phase (running costs). [2];[4].

6. ZERO-ENERGY BUILDING (ZEB)

In concept, a net ZEB is a building with greatly reduced energy needs through efficiency gains such that the balance of the energy needs can be supplied by renewable technologies.

At the heart of the ZEB concept is the idea that buildings can meet all their energy requirements from low-cost, locally available, nonpolluting, renewable sources. At the strictest level, a ZEB generates enough renewable energy on site to equal or exceed its annual energy use.

A ZEB typically uses traditional energy sources such as the electric and natural gas utilities when on-site generation does not meet the loads. When the on-site generation is greater than the building's loads, excess electricity is exported to the utility grid. By using the grid to account for the energy balance, excess production can offset later energy use. Achieving a ZEB without the grid would be very difficult, as the current generation of storage technologies is limited. Despite the electric energy independence of off-grid buildings, they usually rely on outside energy sources such as propane (and other fuels) for cooking, space heating, water heating, and backup generators. Off-grid buildings cannot feed their excess energy production back onto the grid to offset other energy uses. As a result, the energy production from renewable resources must be oversized. In many cases (especially during the summer), excess generated energy cannot be used.

Various supply-side renewable energy technologies are available for ZEBs. Typical examples of technologies available today include PV solar hot water, wind, hydroelectric, and biofuels. All these renewable sources are favorable over conventional energy sources such as coal and natural gas;

A building that buys all its energy from a wind farm or other central location has little incentive to reduce building loads, which is why we refer to this as an off-site ZEB. Efficiency measures or energy conversion devices such as day lighting or combined heat and power devices cannot be considered on-site production in the ZEB context. Fuel cells and micro turbines do not generate energy; rather they typically transform purchased fossil fuels into heat and electricity. Passive solar heating and day lighting are demand-side technologies and are considered efficiency measures. Energy efficiency is usually available for the life of the building; however, efficiency measures must have good persistence and should be "checked" to make sure they continue to save energy. It is almost always easier to save energy than to produce energy. [5];[6];[7];[9]

7. CONCLUSION

Passive house becomes a topic of great interest for architects, other experts, investors and builders. The use of renewable energy sources enabled the accomplishment by far the biggest energy savings in the construction industry, ensuring optimal conditions for healthy living without harmful gas emissions.

Energy efficiency in buildings at the low-energy and "passive house" standard levels is presently the basic prerequisite for considering and formulating long term strategies, which with the task of meeting energy needs and system maintenance respond to requests of environmental protection and improvements in the context of sustainable development.

REFERENCES

[1] Feist W.: ***Step by Step Towards Passive Houses,*** 11th International Conference on Passive Houses, Bregenz, Austria, 13-15 April 2007

[2] Feist W.: ***Energy Efficiency Reduces Energy Losses,*** 11th International Conference on Passive Houses, Bregenz, Austria, 13-15 april 2007

[3] Miščević Ljubomir: ***Design and construction of Passive Houses in Croatia,*** Alps-Adria Conference on Passive Houses, Pecs, Hungary, 4-6 September 2009

[4] Mr.Sc. Praznik Miha, Mr.Sc. Kovič Silvija: ***Passive House planning in Slovenia,*** Alps-Adria Conference on Passive Houses, Pecs, Hungary, 4-6 September 2009

[5] Toricelli P., Pless S., Deru M.: ***Zero energy buildings: A critical look at the definition,*** ACEE Summer study Pacific Grove, California, USA, 14-18 august 2007

[6] http://www.buildup.eu/category/free-tags/zero-energy-buildings

[7] http://www.asiepi.eu/information-papers.html

[8] http://www.passiv.de/

[9] http://www.europarl.europa.eu/sides/getDoc.do?language=RO&type=IM-PRESS&reference=20090330IPR52892

I.S.S.N. 2067 – 5534 © 2010 JSE