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Analysis criteria for zero energy buildings (zeb)

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Abstract

This paper presents the new trends in the global "green" architecture, which is related to the performance of low-energy buildings and their classification. Emphasized the great importance of this method of construction with respect to environmental protection and has been shown several examples of architectural performed worldwide. Their efficiency is confirmed in residential buildings, as well as large public and commercial buildings. The aim of this study was to analyze the experiences in their applications, their promotion and that wider application.

Keywords: architecture, energy efficiency, renewable energy classifications

Introduction

According to the study, which was done by the World Business Council for Sustainable Development (WBCSD - World Business Council for Sustainable Development), the building waste a large part of the 40% of the total world consumption of energy and raw materials, and consequently, the carbon dioxide and other gases that cause the greenhouse effect. These data suggest that the greatest potential for achieving energy savings just in buildings.

The increase in environmental awareness, increase energy prices and knowing the limitations of fossil fuels and the need for greater reduction in emissions of greenhouse gases in the atmosphere, resulted in an increase in the construction of energy efficient buildings in the world. Commercial and residential buildings use almost 40% of primary energy and 70% of electricity (EIA data). The energy used in the building sector continues to increase and is expected to increase by another 50% by 2025.

Looking at history, people have thought about how to build a house that is energy efficient: thermal comfort - winter warmer and cooler in summer. This problem has been studied Socrates, so this research is known as the "Socratic house" where there is an evident influence of the Sun on the shape, layout and construction of the house. In Serbia, the concept of building stems from the architecture of Lepenski Vir, which originated in the Neolithic period - long before Socrates. Houses at Lepenski Vir, which opens to the south, very similar to the Socratic house. Such houses can become a role model for modern solutions of low-energy houses which incorporate new technologies and materials, as they provide comfort with minimum energy consumption for heating and air conditioning. The definition of low-energy buildings (LEB) and Zero energy building buildings (ZEB) is still uneven in the world, and thus slow standardization and their wider application. ZEB definitions are needed for those who explore the local or state government, funds that should be financially encouraged, designers - the designers and their assessors (Energy Performance of Buildings Directive [EPBD], 2010).

Types of energy efficient building

Subject Zero Energy Building (ZEB) gained more importance in recent years, becoming part of the EU-US policies on energy efficiency in buildings. The amended EU Directive on the Energy Performance of Buildings (EPBD) stated that by the end of 2020, all new buildings must be "nearly zero energy buildings" (EPBD, 2010). For the Building Technologies Program US Department of Energy (DOE), the strategic goal is to achieve "zero energy consumption in homes by 2020 for commercial buildings to achieve zero energy consumption by 2025" (U.S. Department of Energy [DOE], 2008).

Energy-efficient buildings can be performed in principle in two completely different ways:

- in the form of closed facilities, which by its structure, shape and technical solutions (heating, lighting and air conditioning) does not use the energy of the environment, but are limited to the reduction of consumer energy total isolation inside the building of the environmental impacts,
- in the form of open facilities, which reduce power consumption maximum use of ambient energy.

Between these two extreme approaches an optimum construction of the energy, and there are "intermediate solution", which are combined with the advantages of the above methods. This group includes the self-heating of the house - solar pit. The essence of this concept in architecture is that using physical and natural laws (heating, cooling, air circulation and heat insulation) for the house itself acts as a heat regulator. The total energy used in a building can be provided by passive systems (building - architectural solutions) and active systems. Unlike active systems, passive with no special system devices - installations, but the whole structure works as a solar energy collector: all functions of the active system and they take the parts and elements of the building. The use of passive solar energy systems requires an appropriate degree of protection for all structural elements exposed to heat loss to the outside area. In this manner was collected, and the accumulated heat within the space is being saved. The house, which affects the solar energy can use it almost every day, even on cloudy days. (Sartori, et al., 2010).

Important details that can be applied to passive solar systems are orientation relative to the Sun, isolation building, lighting, grooving, temperature zoning, the principle of the double layer, thrombus wall etc.. Active solar systems are based on mechanical installations, which converts solar radiation:

• directly into electrical energy - photovoltaic (PV) cells, or

• thermal - solar collectors.

Low-energy building

Low-energy means low power consumption to provide heating, cooling and domestic hot water in one facility. That means building more energy efficient homes and use free renewable energy to additionally reduction of energy bill, which is 4 to 5 times less money for much better comfort. Low-energy is always related to the amount of primary energy necessary to provide comfortable life tenants of a building. To be low-energy, the amount of energy must be below certain limits, which vary from country to country. Frequently, low-energy refers to the energy required for heating or energy required for heating and hot water. Sometimes, it is the energy for heating, cooling, hot water, ventilation and lighting. Depending on which consumption is calculated, the energy threshold is different.

Primary energy

Energy consumed in a building should be measured in the form of primary energy. For example, when coal or natural gas used for heating, then the primary energy from fossil fuels is directly converted into heat.

Primary energy is the energy before transformation. Primary energy mainly comes from fossil fuels (oil, natural gas, coal and uranium), or downloaded from renewable energy sources (hydro, wind, solar, geothermal)..

Electricity

In any building, usually a combination of primary and electricity to provide all the energy needs. Electricity is a secondary energy, which is produced using primary energy, mostly coal, hydro and nuclear power plants. Due to the losses that occur during the production and transport of electricity, all primary energy used is converted to usable electricity. To calculate how much primary energy consumed in a building, it is necessary to convert the electric energy to primary energy. Losses that occur during the production of electricity are taken account of the conversion factor. This factor is used when converting kilowatt-hour of electricity in kilowatt-hours of primary energy. It varies from 2 to 3 depending on the country. This means that the consumption of 1 kWh of electricity in the building, is responsible for 2 to 3 kWh of primary energy in the energy balance.

Renewable energy

Renewable energy is energy that can not be exhausted because the source of energy is not affected by its use or the source is naturally replenished. The largest use of renewable energy in the world is hydroelectricity. For buildings, renewable energy is most commonly used by geothermal, solar, wind and biomass.

Renewable energy can be very effectively used for heating or cooling buildings, for the production of hot water or electricity. Using renewable energy is calculated in the use of primary energy, but that energy can not be taken into account in the same way as the use of primary energy from fossil fuels. In fact, the local use of renewable energy is generally free of charge, does not contribute to global warming and protect from the rising price of energy.

Financial Incentives

In order to encourage more large-scale use of low-energy buildings using renewable energy sources, some countries have introduced various financial incentives. Program EcoEnergy renovation (EcoEnergy Retrofit), which was conducted by the Canadian government in the period from 2007 to 2012, he achieved great success and could serve as a model for achieving energy efficiency in a way that meets the basic principles of sustainable development, so-called. "Triple bottom line": social, environmental and economic feasibility. This program has enabled Canadians to reduce renovation costs necessary to achieve energy efficiency, and therefore their energy bills and at the same time protecting the environment. EcoEnergy renovation program has been very successful investment for the promotion of energy efficiency in a time of economic crisis, and effectively implemented in 250,000 households.

In Austria there are subsidies that are applied to realized greater energy efficiency (EE) in the house of the requirements that are required by the building regulations that include extra insulation, improved windows or installation of renewable energy sources and efficient EE devices. In some Austrian provinces, this has led to the fact that almost all buildings in the construction of EE beyond the standard requirements.

In Bulgaria Project for residential energy efficiency (Credit Line - REECL) helps develop credit mechanisms to encourage residential EE improvements. Individuals can benefit from the incentive grant of up to 30 per cent of the amount, which they took from the banks implemented EE measures (up to € 2,000) (REECL, 2013).

Bulgaria offers tax exemptions for owners of "highly energy-efficient buildings," if you have the necessary certificates. (Tax exemption for a period of up to 10 years). In the UK, all new zero-carbon buildings to the value of £ 500,000 are exempt from tax offenses, and decreased VAT - contributions. In France, the applied tax incentives for energy efficient power facilities, as well as subsidies to the border of 16,000 € (from 2005) at home. In Sweden, households can benefit from the 30 per cent tax relief when converting direct electric heating systems with a mass or heat pump (since 2006). Croatia has made energy program of reconstruction of family houses from 2014 to 2020 introducing government subsidies of 40-80% for investments in energy improvements of buildings. The reconstruction of the approximately 2,000 buildings a year while achieving energy savings of 15.2 GWh and reducing emissions of 14,000 tonnes of CO_2 per year.

Concepts and definitions of energy efficient buildings

Low energy buildings (LEB)

Expressions for low-energy buildings LEB and ZEB are often used for commercial purposes, without a clear understanding of the policy-making and national goals of individual countries, and it may be that some facilities receive status ZEB including some criteria load environment, thanks to the oversized PV - photovoltaic systems but without the use of other energy-saving measures. For these reasons, this definition is not suitable as a basis for legislation and national policy, it is proposed and introduced the definition of Net ZEB - which is comprehensive and takes into account all relevant aspects of energy (EPBD, 2010).

There is no global definition for low-energy buildings, but it is the buildings that have better energy performance than is required in the applicable building regulations (standards for energy efficiency and use of alternative sources of energy) (EPBD, 2010). These buildings usually include exceptional insulation, energy efficient windows, excellent sealing and application of heat exchangers to reduce the energy required for heating and cooling. Also, they can use the techniques of passive solar architecture and design and active solar systems for water heating or electricity generation (PV - photovoltaic).

There are different types of requirements in relation to energy consumption across Europe. For example DK low-energy Class 1 (Denmark) - 35 + 1100 / A kWh / m^2 / year (energy for heating, cooling, ventilation and hot water systems, where A is the surface area of the heated part of the building). Minergie (Switzerland) - 42 kWh /m^2/year (energy for heating, cooling, ventilation and water heating). Effinergie (France) - 50 kWh/m^2/year (energy for heating, cooling, ventilation, water heating and lighting). Passivhaus (Germany) - 120 kWh/m^2/year (energy for heating, cooling, ventilation, water heating, lighting and household appliances). Currently, seven EU member states to define what a building into a low-energy building: Austria, Switzerland, Denmark, UK, Finland, France, Germany and Belgium (the Flemish part of the country) and four other countries were planning this, Luxembourg, Romania , Slovakia and Sweden.

Passive Houses

Definitions for passive houses are more heterogeneous, because here the same term means two completely different types of homes in Central and Northern Europe (Germany, Austria, Sweden, etc.), and in Southern Europe (Spain, Italy, Portugal, Greece).

In Southern Europe the term *Passive house* (eng. Passive house) means that the house is designed in accordance with the concept of passive design (Passive Design), ie. use of passive technologies (large glass area for solar energy transmittance, sun visors to protect against overheating in the summer, etc.).

In Central Europe the term *Passive house* (eng.- Passive House, germ.- Passivehaus) refers to buildings that were built by the same name standard, which was set up at the Institute in Darmstadt, Germany. Passivehaus the building was constructed so that the temperature of indoor air is achieved without active heating system, but the air temperature in HVAC systems. In order to achieve that, other solutions of passive design are used, as well as the latest technological advances: orientation to the south, insulated glass surface (U-value of 0.75 W/(m^2 K), excellent tightness, lack of console and cold bridges ... In order to construct the building Passivehaus, basic prerequisite is enough sunlight on the land, including urban environment - without high-rises, which obscured the sun. However, often do not respect this basic human right - the right of the sun, which indicates the need for urgent and consistent application solar urban planning. This involves making charts thrown shadows of objects on the basis of which should be done solar zone Tickets and solar rents Maps. Privileged location must be collected (Sartori et al., 2010). (Many countries, regions and cities have solar regulation, claiming that the right to use natural resources - solar energy in real property, for example, the City of Boulder, Colorado has a solar thermal ordinance (2006), which guarantees access to sunlight for homeowners and renters in the city. This regulation protects solar access to existing buildings and maintains the potential for renewable energy systems in buildings).

Zero-energy and zero-carbon homes

Basically ZEB concept is the idea that buildings can meet all of its energy. The specificity of zero-carbon (zero-zero) house is, as its additional energy requirements, which alone can produce from its own sources (solar energy, heat pumps, etc.), make up the network, which is entirely from renewable sources ("green loans"). House with zero-energy (or net-zero-energy) consumption, in annual terms, can be energy independent, but in practice this means that at some point in producing more energy than it consumes, and return it to the network, while in some periods have greater needs to be compensated from the network. This occurs primarily for this reason, they are renewable sources of energy in the grounds usually dependent on the time of year. Achieving ZEB no connection to the outside network will be very difficult, because the current generation of technology for energy storage is limited. Scenario, energy storage on site will be required in the near future.

Energy-positive home

Energy-positive, or plus energy (positive energy) houses, they are homes that annually produce more energy from renewable sources than it consumed from external sources (heat pumps, water heating solar panels, photovoltaic - PV).

This is achieved by combination of the generators of electricity low power and energy efficient solutions such as passive solar design, insulation, choice of plot and orientation of the object, heat pumps, heat exchangers, water heating solar panels, and photovoltaic - PV.

Methods of performance of low-energy house

In the last two decades the world has built many individual residential buildings in accordance with the principles of greater energy efficiency, such as house like a flower, house inside the house, passive solar pit - house, dug atrium houses, houses with buffer areas or houses with manual control (Krnjetin, 2004, 1996, 2005). However, only in the last few years appear larger building complexes that include the entire collective housing blocks and neighborhoods with strong energy rationality. The next section will show examples of several implemented or design solutions.

Hamnhuset, Sweden (BuildwithCaRe demo-project, CARE CarbonReduction)

BuildwithCare program is partially funded by the *Interreg IV B North Sea Programme*, which aims omnipresent energy efficiency in construction (Figure 1). Began in 2008 and includes local and regional authorities, universities and institutions from 10 regions in five states in the North Sea. Hamnhuset is one of the projects of the program and serves as a demonstrative example of a new building for multi-family housing in Sweden. This is the largest housing estate in Sweden, built by the Passivhaus concept with 116 residential units. It was completed in 2008. Technologies - Solar panels cover all the hot water needs during the summer months (about 135,000 kWh/year). Winter for heating uses electricity from green sources. Estimates of consumption for heating and hot water are about 28 kWh / m², and electricity consumption 29 kWh / m² per year. Comparison of costs and savings are obtained: an increase in cost of construction compared to conventional object was 4%. This means that this project cost about 80,000 euros more than the object of the same size and purpose, which was built by Swedish standards. This difference is compensated in the first three years of use of the facility. Additionally, Hamnhuset can reduce CO2 emissions by 75% despite the fact that it takes more material, which is transported from greater distances.

Figure1. Hamnhuset, Sweden (Build with CaRe demo-project, CARE-Carbon Reduction)

Lodenareal Innsbruck, Austria (the largest Passivhaus complex in Austria)

Neu Heimat Tirol, as an investor in the public domain, built as part of the largest Passive House project in Austria - Innsbruck Lodenareal - complex with 33,000m² and 354 building. The project must meet strict Passivhaus standards and be certified by the Passivhaus Institute in Darmstadt. Technologies used: total energy consumption per year and per square meter will monitor the Passivhaus requirement of 15 kWh/m² with a 7kWh/m² per year for heating. Approximately 80% of the energy for heating will be covered by a combination of pellet stoves and boiler, and the remaining 20% with 1,050m² solar panels. Also, the isolation characteristics of the ventilation will be made in accordance with the requirements of the Passive.

Figure 2. Lodenareal Innsbruck, Austria (the largest Passivhaus complex in Austria)

Floating City for Climate Refugees, Vincent Kalb – Belgium

Global climate changes, which occur due to excessive and irrational use of energy in buildings, the warming of the planet will cause melting glaciers and raising sea levels. In an attempt to organize human settlements, which will enable the shift of entire cities such vessels, climate refugees made numerous studies and interesting projects. Figure 3 shows the idea of a floating city (Vincent Kalb - Belgium), which was created inspired by water flowers - water lilies, designed so that in terms of energy to be independent.

Figure 3. Floating Cities for Climate Refugees (Vincent Kalb - Belgium)

Conclusion

Low energy houses and electricity installations are one of the most effective ways to reduce the total environmental burden of humanity on planet Earth. Turning to nature, without disturbing its equilibrium, should be one of the goals of the modern approach to the design and energy-efficient construction. The focus should shift from providing additional energy from renewable sources, reducing the need for energy from conventional, because "it is the greenest energy that is not used."

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Biography

Ph.D. **Slobodan Krnjetin** works as a professor at the Faculty of Technical Sciences in Novi Sad. He teaches Ecology and the constructed space and Construction and Environmental Protection. Specific scientific areas addressed are environmental protection in construction and fire protection. He has written more than 100 papers, published at home and abroad, and participated in the development of more than 30 research projects in the field of protection. In the Federal Institute for Standardization he was president of the Committee for Standards in the field of construction and technical measures to protect against fire and *Commissioner for Standards in the field of environmental management (HP A270).* Within the work of these committees, for 16 years, he was the driver of the Yugoslav standards. He participated in the organization of four international scientific conferences on environmental protection cities and suburbs. He is the founder and president of the Ecological Society of the Faculty of Technical Sciences.