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ENERGY EFFICIENT BUILDINGS – LEGISLATION AND DESIGN

Abstract: *The problem of energy stability in the last few decades has become the most important problem of the world economy and social system. Increasing energy consumption and use of fossil fuels have led to increased environmental pollution due to greenhouse gases emissions. All of this has resulted in global warming and climate changes. EU with their system regulatives obliges its members to continually increase energy efficiency, bringing a number of directives to achieve greater energy efficiency and reduce the existing ecological imbalance on Earth. From many sources, it can be concluded that building sector has the energy consumption about 20 - 40% of total energy consumption and* CO_2 *emission about 36 %. Therefore, it should strive to improvement building energy efficiency, which includes a continuous application of a wide range of activities with the ultimate goal of reducing the consumption of all types of energy with better or equal conditions in the building. One possible solution is the concept of zero- net energy building (ZNEB). These solutions result in reduced greenhouse gases emissions and thus contribution to the protection of the environment and reduce global warming, and therefore a better quality of life.*

Keywords: *energy efficiency; directive; ZNEB; global warming*

1. INTRODUCTION

In the modern world today, the significant part of the total energy consumption is related to the building, so research and development of methods for improving energy efficiency in buildings are very important. Regarding the building sector, from many sources, it can be concluded that the consumption of energy in buildings at the global level is 20 - 40% of total energy consumption, while in Serbia it is at the level of 35 % [1]. It should be taken into account that this consumption is related to the exploitation conditions of buildings, where the largest consumer is heating system (also cooling system), installation for the heating of domestic hot water, household appliances etc. By sectors: final energy consumption is mostly consumed in the household sector 35%, industry 27%, traffic 25%, while other sectors accounted 13% (Fig. 1).

Serbia is among the countries that has the lowest level of energy efficiency in Europe and is located at the bottom of the list among the countries which uses energy rationally. In the structures of total energy consumption of Serbian building, about 60% of the energy consumption is related to the space heating, and the rest to the ventilation, lighting and electrical appliances. This information is fully illustrated by the fact that in Serbia there are 300-400 000 houses which has no thermal insulation - energy inefficient homes, with an annual energy consumption of 220 kWh/m^2, while the European average energy consumption is 60 kWh/m^2. This situation might be considerably improved by using methods of energy-efficient building design, the appropriate choice of materials in the newly designed building and using all of the principles that enable high-quality energy rehabilitation of existing non-insulated structures.

Also, the world's reserves of oil, gas and coal are lower, and problems of global warming, greenhouse gases and air pollution are increasing. Because of that, research and development of renewable energy resources and use have significant impact on the environment [2].

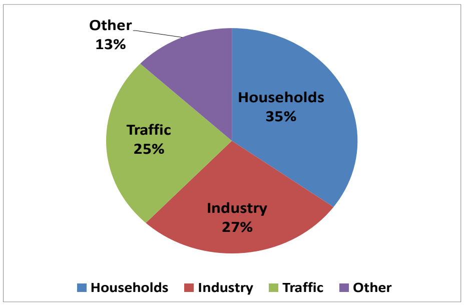

Figure 1 – *Total finaly energy consumption in Serbia 2010.*

Energy efficiency in buildings means the efficient use of energy with the use of optimal measures aimed at reducing energy consumption with financial saving of the end-user, comfortable and quality living in the building, reducing maintenance costs and extending the lifetime of the building, contribution to environmental protection and reducing greenhouse gas emissions and global climate change.

Concept of improving the building energy efficiency involves a continuous and wide range of activities with the final task to reduce the consumption of all kinds of energy, with the same or better conditions in the building.

EU with system regulatives obliges its members to continually increase energy efficiency, bringing a number of directives to achieve greater energy efficiency and reduce the existing ecological imbalance on the Earth.

In the recent years, many of scientists defined different concepts of low-energy buildings. Radical approach for the mitigation of the energy demand is the concept of the zero-net energy building (ZNEB) and positive-net energy building (PNEB) [3], which will be discussed in this paper.

2. LEGISLATION

The legal conditions define all measures and actions aimed at increasing energy efficiency. The European Union has adopted a series of directives on which they are based the regulations adopted by the Republic of Serbia.

The most important European documents related to energy efficiency are:

- Directive 2002/91/EC (EPBD – directive about building energy performance);
- Directive 2010/31/EU (Energy Labelling Directive)
- EU Action plan for Energy Efficiency

2.1 Directive 2002/91/EC (EPBD)

The EPBD (2002/91/EC - Directive on the energy performance of buildings) is the main legislative instrument at EU level for achieving energy performance in buildings [4]. It is estabilished in 2002 and required from all EU member states:

1. improving regulations concerning to the construction of buildings;

2. introducing the certification of buildings related to energy consumption and

3. introducing the regular inspection of boilers and cooling systems.

The Directive came into force on 4 January 2003 and had to be implemented by the EU Member States at the latest on 4 January 2006. It was inspired by the Kyoto Protocol which commits the EU to reduce CO_2 by 8% by 2010, to 5.2% below 1990 levels.

2.2 Directive 2010/31/EU (EPBD II)

On May 2010, a recast of the Energy Performance of Buildings Directive (EPBD II) was adopted by the European Parliament and the Council of the European Union in order to strengthen the energy performance require–ments and to clarify and streamline some of the provisions from the 2002 Directive it replaces [5]. The main goal of EPBD II is to promote building energy efficiency, taking into account outdoor climatic and local conditions as well as indoor climate requirements and cost-effectiveness, for all EU member states. Stricter frames are implied following activities:

1. General framework for a methodology for calculating energy performance of buildings and parts of buildings;

2. Minimum energy efficiency requirements for new buildings and new parts of buildings;

3. Application of the minimum energy efficiency requirements in existing buildings, parts of buildings, parts of buildings under reconstruction, parts of building envelope, the

technical parts of the building for installing, replacing or upgrading;
4. National plans for increasing the number of "nearly zero net-energy" buildings;
5. Energy certification of buildings and parts of buildings;
6. Regular inspection of boilers and air conditioners;
7. Independent control system certification.

2.3 EU Action plan

EU leaders in 2007 pledged to make a highly energy efficient Europe with low carbon emission, which resulted in adoption of 2020 Climate & Energy Package in 2009 [6]. EU Action plan or 2020 Climate & Energy Package is a set of binding legislation to ensure the EU meets its climate and energy targets for the year 2020. The package sets three key targets, according to Directive 2009/28/EC and the "Triple 20" procedure:

- 20% reducing in greenhouse gas emissions
- 20% reducing in energy consumption
- to incorporate 20% renewable energy in total energy consumption,

all of them compared to 1990 levels.
Now EU sets new targets for 2030 (Fig. 2).

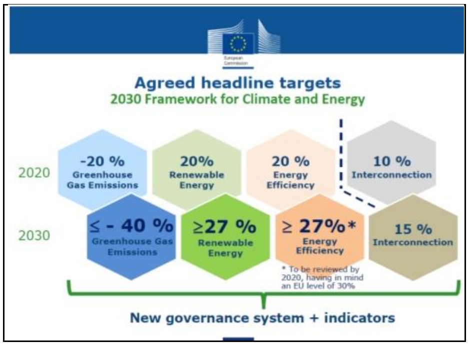

Figure 2 – *2020 and 2030 Framework for Climate and Energy*

2.4 Legislation in Serbia

Republic of Serbia estabilished a series of documents related to the improving building energy efficiency:

- Energy Law (2004) (2012)
- Law on Planning and Construction (2011)
- Rulebook on building energy efficiency (2011)
- Rulebook on the conditions, content and manner of issuing certificates of energy performance of buildings (2012)
- Rulebook on technical inspection of the facility and the issuance of the occupancy permit
- Rulebook on the conditions, program and manner of taking the professional examination in the field of spatial and urban planning, preparation of technical documentation and construction (2012)
- Standards

With these documents, Serbia pledged to make more energy efficient society.

The most important document is Rulebook on building energy efficiency, which:

- prescribes the conditions that objects, depending on the purpose, must satisfy,
- provides a method of calculating thermal properties of the objects.
- prescribe the obligation of determining the energy requirements for existing buildings.
- determine the conditions, content and manner of issuing the certificate of energy efficiency of buildings

This regulation applies to:

1) the construction of new buildings
2) reconstruction, upgrading, renewal, renovation, repair and rehabilitation of existing buildings energy

The average energy consumption for heating in buildings in Serbia is over 150 kWh/m^2 per year, while in developed European countries it is below 50 kWh/m^2. It is evident that this fact is forcing Serbia to intensify activities to support the standards that apply in the EU or, at least, to significantly closer to them.

3. ENERGY EFFICIENT BUILDINGS

There are five main categories of energy-efficient buildings: Low-energy house; Passive house; Zero Energy House; Autonomous house and Energy plus house [7].

3.1 Low-energy house

There is no global definition for low-energy house. Because national standards vary considerably, 'low energy' developments in one country may not meet 'normal practice' in another. In Germany a "Low Energy House" (Niedrigenergiehaus) has an energy consumption limit of 50 kWh/m² per year for space heating. In Switzerland the term is used in connection with the MINERGIE standard – no more than 42 kWh/m² per year should be used for space heating. Right now, it is generally considered that low-energy house uses around half of energy mentioned in those standards for space heating, typically in the range from 20 - 30 kWh/m² per year.

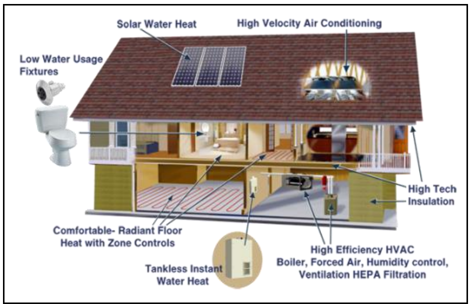

Figure 3 – *Low-energy house*

Low-energy building typically use high levels of insulation, energy efficient windows, low levels of air infiltration and heat recovery ventilation to lower heating and cooling energy (Fig 3). They may also use passive solar building design techniques or active solar technologies.

3.2 Passive house

Definition of passive house is: "A Passive House is a building, for which thermal comfort can be achieved solely by post heating or post cooling of the fresh air mass, which is required to fulfill sufficient indoor air quality conditions – without a need for recirculated air". Some countries have their own standards that define passive house in more strict way. In Germany the term passive house refers to the rigorous, voluntary, Passivhaus standard for energy efficiency in buildings. In Switzerland is in use similar standard – MINERGIE-P. It is estimated that the number of passive houses around the world range from 15,000 to 20,000 and the vast majority have been built in German-speaking countries or Scandinavia.

Figure 4 – *Passive house*

The Passivhaus standard for central Europe requires that the building fulfills the following requirements:

- The building must not use more than 15 kWh/m² per year in heating and cooling energy.
- Total energy consumption (energy for heating, hot water and electricity) must not be more than 42 kWh/m² per year
- Total primary energy (source energy for electricity and etc.) consumption (primary energy for heating, hot water and electricity) must not be more than 120 kWh/m² per year

3.3 Zero Energy House

A house with zero net energy consumption and zero carbon emissions annually is called zero energy house. Zero net energy consumption means that zero energy houses can be autonomous from the energy grid supply, but in practice that means that in some periods power is gained from grid and in other periods power is returned to grid. To achieve this energy must be produces on-site with non polluting renewable energy sources. Zero energy houses are also very interesting from environmental point of view because renewable energy means that greenhouse gas emissions are very low.

3.4 Autonomous house

An autonomous building is a building designed to be operated independently from infrastructural support services such as the electric power grid, municipal water systems, sewage treatment systems, storm drains, communication services, and in some cases public roads. Autonomous building is much more than energy efficient house – energy is only one of resources to gain from the nature.

Figure 5 – *Autonomous house*

3.5 Energy plus house

Energy-plus-house is house that on average over the year produces more energy from renewable energy sources than it imports from external sources. This is achieved using combination of small power generators and low-energy building techniques such as passive solar building design, insulation and careful site selection and placement. Many energy-plus houses are almost indistinguishable from a traditional home, since they simply use the most energy-efficient solutions (appliances, fixtures, etc) throughout the house. In some developed countries power distribution companies have to buy surplus electricity from energy-plus homes, and with that approach house can even earn money for owner.

Figure 6 – *Energy plus house*

4. ZERO NET-ENERGY BUILDINGS

Within the built environment the term ‘net energy’ is often used to describe a balance between energy used by the building and its occupants and systems and energy produced by its renewable energy systems. Employing this meaning, various definitions of ‘net-zero energy building’ are widely used. Historical definitions of zero energy are based mainly on annual energy use for the building’s operation (heating, cooling, ventilation, lighting, etc.) [8]. The term ‘net-zero energy’ is frequently used to present the annual energy balance of a grid connected building but it does not consider the energy inputs to deliver the building and its components (Fig. 7). As such it is not directly associated with the use of the term ‘net energy’ as related to life cycle energy accounting and as defined in ecological economics and in the renewable energy field.

The Zero Energy Building (ZEB) is a complex concept with number of already existing approaches that spotlight different aspects of ZEB [9]. Furthermore, the energy balance calculation of a building equipped with on-site and/or off-site renewable energy generation systems and/or interacting with the utility grid and striving to fulfil ‘zero’ goal is not an easy task.

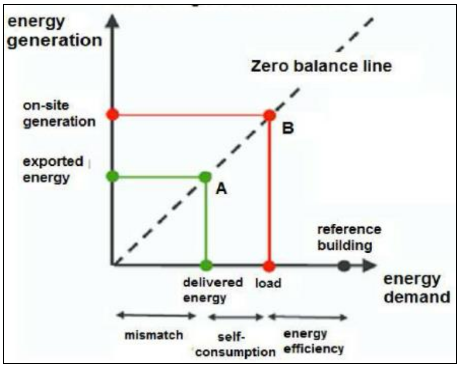

Figure 7 – *Types of balance and grid interaction in a Zero Net-Energy Building*

In zero net-primary energy building, the amount of consumed energy and saled energy as surplus to the electricity grid, is multiplied by a conversion coefficient of final to primary energy, which allows flexibility in terms of energy use for heating. In recent years the concepts of zero net-energy building consumption have been improved, so in energy analyzes embodied energy is taken into account (for solar systems, thermal insulations…).

According to the definition given by Kapsalaki, zero net-energy building (ZNEB) produces all energy it consumes during year, and the yearly electrical energy supplied to the electricity grid balances that received from the electricity grid [3].

The Positive net-energy building (PNEB) produces more energy than it consumes during year, and the yearly electrical energy supplied to the electricity grid is higher than that received from the electricity grid [3].

The Negative net-energy building (NNEB) produce annually less energy than it needs, ie. surplus electricity being sold to the electric grid is less than the electricity purchased from the grid (annually) [3].

The concept of ZNEB is based on the urgent need to reduce carbon emissions and to reduce the energy consumption by increasing energy efficiency. Due to the existence of awareness of environmental protection, as well as the enacted legislation to promote the construction of houses with zero net-energy consumption, nowadays it has already built a number of houses of this type in the world.

For zero net-energy building design, it must takes into account the following: building orientation and climate zone, location of the building, insulation degree at the building envelope, optimized high-performance glazing, optimized use of daylighting, low density ambient lighting (electronically controlled), control according to calendar unit, control of plug and processes, super efficient HVAC systems, greater use of heat pumps and using renewable energy sources.

Integrating and simulation of joint use of various technologies in the development of the buildings with zero net-energy consumption is done from the point of maximum exergy and energy efficiency, minimizing emissions of carbon dioxide and other harmful substances, and maximizing economic effects.

5. CONCLUSION

Energy efficiency is important and in future it will be even more important. To achieve energy efficiency we will have to adapt to new energy sources and new ways to save energy. Energy efficient house is only one part of that. Building regulations and standards are evolving towards ‘zero energy’. The European Parliament recently approved a recast of the Energy Performance of Buildings Directive proposing that all new buildings in the EU be at least ‘net-zero energy’ by 2020. Net-zero energy buildings (NZEBs) are expected to play an important role in fighting climate change and reducing the energy use of the built environment.

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