Jasna Radulovic[1)]
Milorad Bojic [1)]
Danijela Nikolic[1)]
Jasmina Skerlic[1)]
Dragan Taranovic[1)]

1) Faculty of Mechanical Engineering, University of Kragujevac, Serbia
{jasna, bojic, danijelan, jskerli, tara}@kg.ac.rs

TOWARDS NET ZERO ENERGY BUILDINGS: POSSIBILITIES FOR PHOTOVOLTAIC USE

Abstract: *There is a growing interest in zero net energy buildings (ZNEBs) in recent years. Several countries have adopted or considering establishing ZNEBs as their future building energy targets to help alleviate the problems concerning the depletion of energy resources and the deterioration of the environment. Also according to the recast of the European Directive 2010/31/EU, all new buildings shall be nearly ZNEBs. In the future, design has to consider not only the space we use directly but also the space required to provide for electrical and thermal energies from renewable sources: the surface necessary for placing the energy generation devices. Photovoltaic has many potentialities in a ZNEB scenario, thanks to its features and enormous decrease in green house gas emissions when they operate. The authors of this paper consider possibilities and perspectives for the use of PV in ZNEBs from different aspects.*
Keywords: *Photovoltaic, zero net energy buildings*

1. INTRODUCTION

During the last years the attention given to the zero net energy building concept increased. Several countries have adopted or considering establishing ZNEBs as their future building energy targets to help alleviate the problems concerning the depletion of energy resources and the deterioration of the environment. Among different strategies for decreasing the energy consumption in the building sector, ZNEBs have the promising potential to significantly reduce the energy use and as well to increase the overall share of renewable energy. However, in order not to fall short of expectation, there is a need for commonly agreed ZNEB definition framework and a robust 'zero' calculation methodology. According to the recast of the European Directive 2010/31/EU, all new buildings shall be nearly ZNEBs. In the matter of fact, at the European level, the nearly ZNEBs should be reality in just eight years [1].

Today, the renewable energy systems have a significant impact on the environment, so the development of renewable energy resources and the use of renewable energy are essential. One of the most promising renewable energy technologies is photovoltaic (PV) energy conversion. PV energy conversion represents the direct conversion of sunlight into electricity. Commercial PV materials commonly used for PV systems include solar cells of silicium (Si), cadmium-telluride (CdTe), coper-indium-diselenide (CIS) and solar cells made of other thin layer materials [2].

From renewable energy, the building may usually produce electrical energy by the PV array on its roof. If the building is also connected to the national electricity grid, the building may consume electrical energy either from the PV array or from the electricity grid. The generated electrical energy may feed either the building or the electricity grid. The building supplies the electricity grid with electrical energy when there is the electrical energy surplus in the building. When there is electrical energy shortage in the building, the electricity grid supplies the building with electrical energy [3].

All the ZNEBs use some sort of PV technology. Photovoltaics can be used exactly where the energy is consumed (‘on-site’ energy generation). PV modules are often placed on roof tops of buildings. It can be easily integrated anywhere into the building envelope. Such system is termed building-integrated photovoltaic (BIPV), and it helps to increase the power generated per unit floor area of the building [4].

This paper is organized in the following way. In Section 2 the basic concept of ZNEBs is presented. From an architectural point of view, the way PV is used in the building is described in Section 3. In Section 4 and Section 5 use of PV in ZNEBs and conclusions are discussed and presented.

2. ZNEB CONCEPT

ZNEBs can be used to refer to buildings that are connected to the energy infrastructure. In ZNEBs, there is a balance between energy taken from and supplied to the energy grid over a year. By definition, ZNEB produces all energy it consumes during year. The ‘‘zero-net’’ concept means that yearly the excess electrical energy supplied to the electricity grid balances the amount received from the electricity grid. Positive-net energy building (PNEB) produces more energy than it consumes during year. The ‘‘positive-net’’ concept means that yearly the excess electrical energy supplied to the electricity grid is higher than the amount received from the electricity grid. For better economy, it may be recommended for ZNEB to go toward PNEB [3].

The increasing number of ZNEB research studies implies the growing attention given to ZNEBs. These studies demonstrate the potential of ZNEBs to help alleviate the depletion of energy resources and the deterioration of our environment [4]. A summary of some recent studies [3, 5-7] is shown in Table 1, [4]. In general, ZNEBs involve two design strategies; the first one is to minimize the need for energy use in buildings, through more energy-efficient measures, and the second one to adopte renewable energy and other technologies to meet the minimal energy needs.

Table 1. Summary of recent ZNEBs case studie

Region/country/city	Ref.	Building	Renewable energy and other technologies
Hong Kong	[5]	Residential	PV, BIPV, solar hot water, wind turbines.
Las Vegas	[6]	Residential	PV tiles, solar water heater.
Madrid and Shanghai	[7]	Residential	Solar thermal hybrid HP, PV-powered reversible HP.
Serbia	[3]	Residential	PV with water-to-water HP, GSHP (ground-source heat pumps).

3. PV IN BUILDINGS

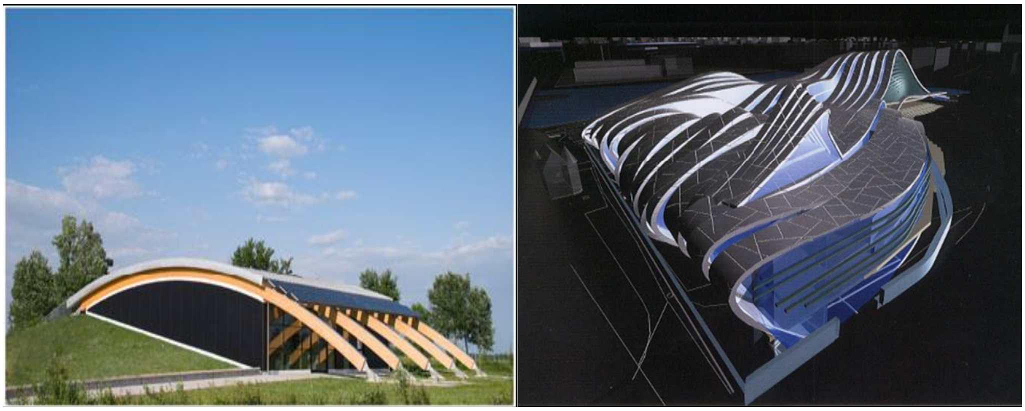
The use of PV in buildings is under investigation since more than two decades, being recognized as a main factor for the exploitation of PV and the reduction of the CO_2 emissions of buildings.

In many buildings, PV has been used in a very successful way from the architectural point of view.

The Polins - multifunctional building (offices, meeting rooms, auditorium), designed by Marco Acerbis and built in Portogruaro (Venice) in 2009 [8-9] is given in this study as example. Facing south, form and materials were studied to maximize solar gains and minimize energy requirements in summer and winter, Fig. 1a. [10].

From the architectural point of view, the PV system forms a natural continuation of the roof, which separates geometrically from a continuous sheet into rows of PV modules. These modules are simple but refined part of the architecture, forming an essential part of the building's design, in particular because sitting along the main south-facing front, at the top of the laminate wood arches. They protect this outward extension of the building, preventing overheating inside in the summer months when the sun reaches its maximum elevation and irradiation, and favour solar capture in the winter months [10].

In perspective, new photovoltaic thin film will be the only technology suitable to satisfy the requirements of the most advanced architectural theories, which is interesting also from a compositive point of view. In the near future the development of new photovoltaic thin film modules will be able to match not only traditional architectures, but also the most innovative tendencies that favour envelopes characterized by free morphologies, Fig. 1b. The development of photovoltaic thin film modules, ensuring a satisfying flexibility of the surface, and the possibility to design appropriate shapes, could be the tool to transform architectural objects into energy generators [11].



a) b)

Figure 1. a) Polins, Portogruaro, Italy, 2010. b) Z. Hadid, Mosque, Strasburg, 2000.

4. PV IN ZNEBs

In a ZNEB scenario, PV can generate energy, 'on site' and 'at site'. The energy generation is considered 'on-site' if the energy generation system is within the boundary of the building, namely the building's footprint. The 'at-site' energy generation implies that the energy generation system is detached from the building, and it is placed within the building 'site's' boundary.

As an example of ‘at-site‘ energy generation PV design, the NREL Research Support Facility, built in Golden, Colorado (USA) in 2011 and designed by the American firms Haselden and RNL’s [12-13] is given in this study. The building has been designed to be a prototype of ZNEB, and in fact, it obtains the ZE balance; but to get such a result, a PV carport has been placed at a certain distance from the building (at building’s site), in the parking area, and the energy generation from this system has been accounted in the building’s energy balance [10].

The carport does not relate in any way to the building’s perception. It is physically ‘at-site’ but not designed together with the building, with the result that building and carport do not interact with each other, a part the energy balance.

It can be concluded that from the design point of view, the ‘at-site’ generation is part of the building’s design only if it is in a formal relation with the building. A PV generator detached from a building has to be designed at the appropriate scale so to consider the building and the detached PV generator as parts of a whole system, that is, ‘the site itself [10].

The example we gave just implies on various possibilities for using PV in ZNEBs. This kind of investigations in future will certainly be a wide field of interest for researchers.

a) b)

Figure 2. The NREL Research Support Facility, Golden, Colorado, US, 2011. a) the building; b) the PV carport.

5. CONCLUSION

In this paper the perspectives and possibilities of PV use in ZNEBs are considered. The consequent influence of the use of PV on the architectural image of the building, and on the way the city itself can look like, is very considerable, opening up a new wide perspective for the relationship between PV and architecture.

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