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FOREWORD

Intensive technological development, improved standard of living and population growth on Earth demand an increasing consumption of all forms of energy and, on the other hand, cause negative effects on the environment. Having this in mind, the United Nations have defined the sustainable economic development in the Millennium Development Goals, and the presidents of seven most developed countries, so called G7 Group, signed the declaration in Brussels, in which, inter alia, they emphasised the following goals:

- *reduction of greenhouse gas (GHG) emissions,*
- *improvement of energy efficiency, and*
- *promotion of the use of clean and sustainable energy technologies and continuation of investment in innovations.*

Particularly negative effects on the environment come from the electricity generation plants, taking into account that they are fuelled by fossil fuels. Therefore, the increased use of renewable electrical power sources is expected in the following period, both globally and in this country.

The main goal of the 5th international conference on renewable electrical power sources is to analyse the comparative advantages and disadvantages of modern solutions in the field of renewable electrical power sources used globally and in this country, and to provide a constructive platform for the exchange of competent opinions and ideas related to the development and use of these sources.

This international conference is for the fifth time organised by the Society for Renewable Electrical Power Sources, which has been a part of SMEITS (Serbian Union of Mechanical and Electrical Engineers and Technicians) since 2010.

Belgrade, October 2017

PREDGOVOR

Intenzivan tehnološki razvoj, rast životnog standarda i porast broja ljudi na Zemlji, zahtevaju sve veću potrošnju svih vidova energije, dok se na drugoj strani kao posledica, javljaju negativni efekti po životnu sredinu. Imajući ovo u vidu, UN su definisale održiv ekonomski razvoj u Milenijumskim ciljevima a predsednici sedam najrazvijenih država, takozvane Grupe G7, potpisali su deklaraciju u Briselu u kojoj su, između ostalih, istakli i sledeće ciljeve:

- *smanjenje emisije gasova staklene bašte,*
- *unapređenje energetske efikasnosti, i*
- *promovisanje primene čistih i održivih energetskih tehnologija i nastavak ulaganja u istraživanja i inovacije.*

Posebno negativan uticaj na životnu sredinu imaju postrojenja za proizvodnju električne energije imajući u vidu da kao pogonsko gorivo uglavnom koriste fosilna goriva. Zbog toga se u svetu, kao i kod nas, u narednom periodu očekuje povećanje primene obnovljivih izvora električne energije.

Osnovni cilj 5. Međunarodne konferencije o obnovljivim izvorima električne energije jeste da se analiziraju uporedne prednosti i nedostaci savremenih rešenja u oblasti obnovljivih izvora električne energije koja se primenjuju u svetu i kod nas, i da se obezbedi plodotvorna razmena kompetentnih mišljenja i ideja vezanih za razvoj i primenu ovih izvora.

Ovaj međunarodni skup po peti put organizuje Društvo za obnovljive izvore električne energije koje u okviru Saveza mašinskih i elektrotehničkih inženjera i tehničara Srbije (SMEITS) postoji od 2010. godine.

U Beogradu, oktobra 2017.

SADRŽAJ

3. Aplikacije i usluge • Applications and services

ZGRADE NETO-NULTE POTROŠNJE ENERGIJE SA ASPEKTA KORIŠĆENJA FOTONAPONSKIH PANELA

ZERO-NET ENERGY BUILDINGS FROM ASPECT OF PV USAGE

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There is a growing interest in zero-net energy buildings (ZNEBs) in recent years. From 31 December 2020, all new buildings will be nearly zero-net energy consumption buildings (ZNEBs), according to the recast of the European Directive 2010/31/EU. Photovoltaic (PV) has many potentialities in a ZNEB scenario, thanks to its features. The perspective of use of PV enlarges from the architectural scale to a wider scale, including the space close to the building or even to the urban and landscape scale. The authors of this paper consider new possibilities and perspectives for the use of PV in ZNEBs, and also opportunities for investigating the relationship between PV and ZNEBs. One of possibilities is Landscape Integrated Photovoltaics (LIPV) as the next area for the PV investigation from the design point of view. It is obvious, by looking at the ZNEB as an artificial landscape that the traditional forms for buildings and cities will completely change in future.

Keywords: *Photovoltaics, zero-net-energy buildings*

Postoji sve veće interesovanje za dostizanjem koncepta zgrada neto-nulte potrošnje energije (ZNEBs) u poslednjih nekoliko godina. Od 31. decembra 2020. godine, sve nove zgrade će biti približno neto-nulte potršnje energije (ZNEBs), u skladu sa Evropskom Direktivom 2010/31/EU. Zahvaljujući karakteristikama fotonaponskih panela (PV), njihovo korišćenje ima mnogo potencijala u dostizanju ZNEB koncepta. Perspektiva upotrebe PV povećava se od arhitektonskog na širi opseg, uključujući i prostor u neposrednoj blizini zgrade, sve do urbanistički uređenih predela i prirodnih predela. Autori ovog rada razmatraju nove mogućnosti i perspektive za upotrebu PV u ZNEBs, kao i mogućnosti za ispitivanje odnosa između PV i ZNEBs. Jedna od mogućnosti su Integrisani fotonaponski paneli u pejzažnim predelima (PIPV) kao sledeća oblast istraživanja PV sa projektantske strane. Očigledno je, posmatrajući ZNEB kao veštački prirodni predeo, da će se tradicionalne zgrade i gradovi u potpunosti izmeniti u budućnosti.

Ključne reči: *Fotonaponski paneli, zgrade neto-nulte potrošnje energije*

1 Introduction

Photovoltaic energy conversion is widely considered as one of the most promising renewable energy technologies which has the potential to contribute significantly to a sustainable energy supply and which may help to mitigate greenhouse gas emissions [1].

PV systems are still an expensive option for producing electricity compared to other energy sources, but many countries support this technology. Over the last five years, the global PV industry has grown more than 40% each year [2]. A radical approach for the mitigation of the energy demand is the concept of the ZNEB [3].

By definition, Zero-Net Energy Building (ZNEB) produces all energy it consumes during year, and yearly electrical energy supplied to the electricity grid balances the amount received from the electricity grid. The topic of zero energy buildings (ZNEBs) has received increasing attention in recent years, until becoming part of the energy policy in several countries. In the recast of the EU Directive on Energy Performance of Buildings (EPBD) it is specified that by the end of 2020 all new buildings shall be “nearly zero energy buildings” [4].

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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 [5]. 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 rooftops of buildings. It can be easily integrated anywhere into the building envelope.

The perspective of use of PV grows from the architectural scale to a wider scale, including the space close to the building or even to the urban and landscape scale [6].

This paper is organized in the following way. In Section 2 the basic concept of ZNEBs is presented. In Section 3 and Section 4 use of PV in ZNEBs and conclusions are discussed and presented.

2 Zero-net energy buildings

Net energy concept have been applied in many fields since 1970s, including renewable energy. Technique used as the net energy analysis compares energy delivered to society provided by technology with the total energy used to produce it in an adequate form. Usage of net energy in buildings refers to optimization of energy consumption in buildings and amount of energy produced in its renewable systems, thus making balance between these two [7].

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 [5, 7].

The ZNEB designed with PV panels installed on the roof [2] is shown at Fig. 1. Electricity generated by the PV array is limited with the size of PV array.

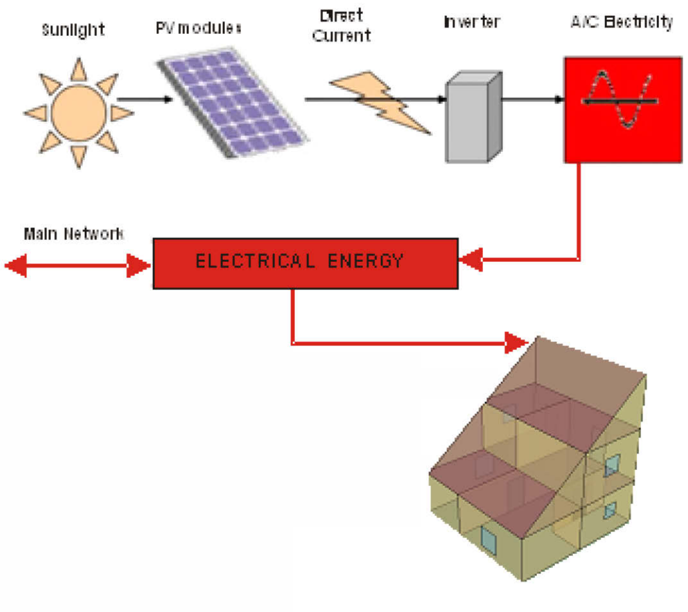

Fig 1 - Zero-Net Energy Building with PV module

When PV system would not directly satisfy the building needs for electrical energy, then the rest of electricity will be used from the electricity grid. When the PV system would satisfy the building needs for electrical energy, then the rest of PV generated electricity will be fed-in the electricity grid [2].

PV modules are placed on buildings' roofs, as well as on other facades of building envelopes in order to increase the number of installed modules. This system is called building integrated PV (BIPV). It helps to enhance electricity generation using solar energy as a supplement or alternative to the electricity grid. Nowadays semi-transparent BIPV modules are often used, permitting entrance of daylight into the interior and still maintaining the function of electricity generation. Another way to increase the energy efficiency of PV is the hybrid photovoltaic thermal system (HPVT). A solar cell has a 9-18% solar-to-electric conversion efficiency, i.e. more than 80% of the solar radiation received is not converted into electricity, but either reflected or dissipated as thermal energy. [7]

3 Examples of PV use on ZNEBs

Two different applications of PV are used in ZNEB scenarios, 'on-site' and 'at-site' [5]. First one implies that the energy generation system is mounted at building envelope, while second one means that the energy generation system is detached from building, moved to building site's boundary.

The NREL Research Support Facility, built in Golden, Colorado (USA) in 2011 and designed by the American firms Haselden and RNL's [8] is given in this study as an example of 'at-site' energy generation PV design. This building has been designed to be a prototype of ZNEB. A PV carport has been placed at a certain distance from the building, in the parking area, and the energy generation from this system has been accounted in the building's energy balance [6]. It is not created together with the building, as it is physically placed 'at-site' of building, not 'on-site'. In this way energy balance is enhanced, because building and PV carport do not interact. When designing at-site system, PVs have to be designed at the appropriate scale to make overall system building-PV as 'the site itself' [6].

Another example of 'at-site landscape PV design' the Solar Strand, designed by the Californian landscape architect Walter Hood, built in 2012 at the Buffalo University (USA) is given. In 2010, the University of Buffalo launched a competition for the design of a 1.1 MW_p PV (5500 PV modules) system to be placed in the campus area for powering the dormitories [6, 9].

The design challenge was transforming a large PV system from a mere technical system into an element of the campus landscape, which could make people more confident with the place they live in. Hood conceived an array of PV modules, whose pattern was designed as if the modules were the elements of a DNA molecule (Fig. 3).

The ground where PV is located obviously has a double function: for the student's enjoinment, as well as for the landscape equipment.

Fig 2 – The NREL Research Support Facility, Golden, Colorado, US, 2011. [8]

The examples we gave just imply some of possibilities for using PV in ZNEBs. This kind of research in future, which take into account the possibility of considering PV as a 'Landscape-integrated PV', will certainly be a wide field of investigation.

Fig 3 - The Solar Strand, Buffalo University Campus, Buffalo (US), 2011. Design: Walter Hood, Hood Design. Pictures by courtesy of the architect ©W. Hood. [9]

4 Conclusion

Today, the use of renewable energy has significant impact on the environment, thus the development of renewable energy systems is essential. As one of the most promising renewable energy technology, photovoltaic energy conversion has been explored in this paper. PV energy conversion represents the direct conversion from sunlight to electricity. In a Zero-net-energy buildings scenario, photovoltaics are also very suitable for generating energy 'at-site'. In this design the energy generation system is detached from the building. This fact enlarges the perspective of use of PV from the architectural scale to a wider scale, including the space close to the building or even to the urban and landscape scale.

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GGE svojim klijentima na jednom mestu obezbeđuje celovitu uslugu efikasnije proizvodnje i potrošnje energije uz garanciju ušteda i bez investicije od strane klijenta.

GGE ESCO model obuhvata:

- analizu energetskih potreba i potrošnje energije kod klijenta
- razvoj tehničkog rešenja
- finansiranje projekta u celosti od strane GGE-a
- garantovane rezultate projekta
- upotrebu savremenih tehnologija i OIE

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