PHOTOVOLTAIC LIGHTING IN SERBIA

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Abstract
The paper provides information on the development and current state of photovoltaic lighting (PV lighting) systems in Serbia. Related to this are examples given of the installed PV lighting systems in Serbia as follows: at the Faculty of Sciences and Mathematics in Niš, on the Trim track in Košutnjak in Belgrade, at the Ada Huja in Belgrade and in Dorćol in Belgrade. Finally, perspectives of PV lighting systems in Serbia are given.

Keywords: photovoltaic lighting, solar module, LED lamp.

INTRODUCTION

Development of solar energy investigation and practical use in Serbia started in 1962. In connection to this, there are several research laboratories at the universities and scientific institutes in Serbia, where fundamental and applied research in the field of solar energy and education of younger generations is being conducted. In Serbia there are two 2 MWp PV solar power plants and a certain number of smaller PV solar power plants. Thus, the electricity generated is transmitted to the city grid, or used for personal needs by households for lighting, audio-visual devices, computers, etc. In Serbia, classic incandesent lamps, neon lamps, mercury bulbs, LED lamps, etc, are used for lighting. Since 2012 PV lighting with LED lamps has been introduced in Serbia [1-3].

Fig. 1. *PV solar power plant, 1.05 kWp*

Fig. 2. *Monitoring room*

SOLAR LIGHTING

Solar lighting at the Faculty of Sciences and Mathematics in Nis

Within the framework of the project *Ecological lighting*, won by the competition *Run for the Future - 1000 young Serbian leaders*, and under the auspices of Philip Moris, on the roof of the Faculty of Sciences and Mathematics in Niš, an off-grid mini PV solar power plant power of 1.05 kW_p was installed in 2014. PV solar power plant is intended for the alternative lighting of the faculty and consists of solar modules, control electronics, 24 V DC battery and inverter, with the output voltage of 220 V AC.

PV solar power plant collects solar energy in the daytime, solar modules transform it into electrical and stores it in batteries. In the evening, in accordance with the programmed dynamics, it runs partially the lighting of the yard and parking site of the faculty. The second part of electricity is used to light the interior of the faculty building. In accordance with the dynamics and seasonal change of daylight, lighting of key locations in the building, including stairways, entrance, corridor crossings, etc., is turned on. One group of lamps is in standby mode, and is turned on by the motion detector. Such lamps are installed in corridors and rooms where lower traffic is expected and most of the time they are turned off. For winter months, when the lighting is greatly reduced, it is envisaged that the batteries are recharged by the city network grid. In this way PV system is in operation throughout the entire calendar year.

Fig. 3. *Solar lighting of the Faculty courtyard*

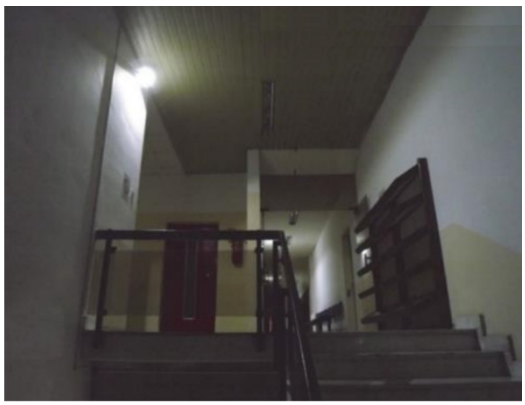

Fig. 4. *Solar lighting inside the Faculty*

PV solar power plant allows lighting of the faculty buildings and its surroundings and in situations where for any reason there is no energy in the electricity network. This is made possible by using the latest generation LEDs, and their total power does not exceed half of the PV solar power plant.

Trim track in Košutnjak in Belgrade

In the national park Košutnjak in Belgrade in January 2012, a 1200 m trim track was lit by electricity generated by solar modules and wind generators. On this occasion, a total of 59 lighting columns height of 450 cm were placed on the trim track. At the 53 lighting columns, one monocrystalline silicon solar module power of 100 W was installed, and on 6 lighting columns there are 2 solar modules of 50W and one wind generator of 450 W. As light sources, 20 W power LEDs are used, with a lifetime from 50 000 h, with floodlights. In the lighting system 118 accumulator stationary batteries voltage of 12 V and 70 Ah capacity are installed. The wind turbines have their own charging regulators. The light switches on and turns off using a photocell and a timer. The average daily operation of the system is about 5-6 hours, lights are switched off at 1 am, and in the winter at 21.00.

The lighting system on the trim track in Kosutnjak was installed by MiLED Co. in Belgrade (www.ledigps.rs).

Fig. 5. *Lighting column with solar module*

Fig. 6. *Lighting colums on trim track in Košutnjak*

Fig. 7. *Trim track in Košutnjak at night*

Fig. 8. *Lighting column with solar modules and wind turbine*

The specificity of this system is reflected in the fact that it is located in the forest, with some solar modules occasionally in the shade. For this reason, the solution was used to connect the pillars into one ring, so that the columns with a smaller amount of electricity are supplied with energy from the adjacent pillars. This connection facilitates the management of the lighting system.

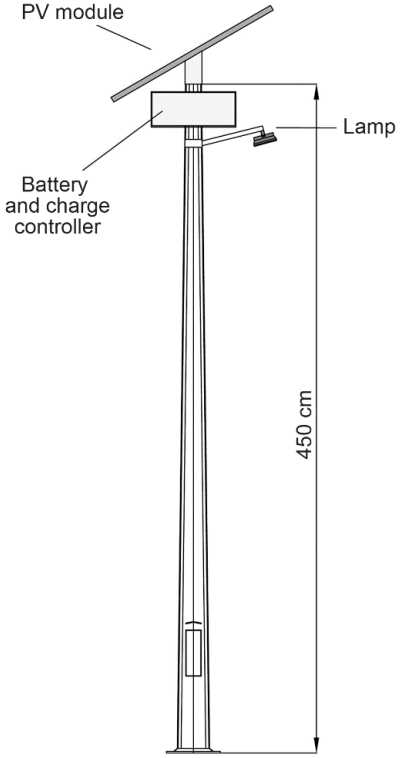

Fig. 9. *A schematic diagram of a lighting column with a solar module*

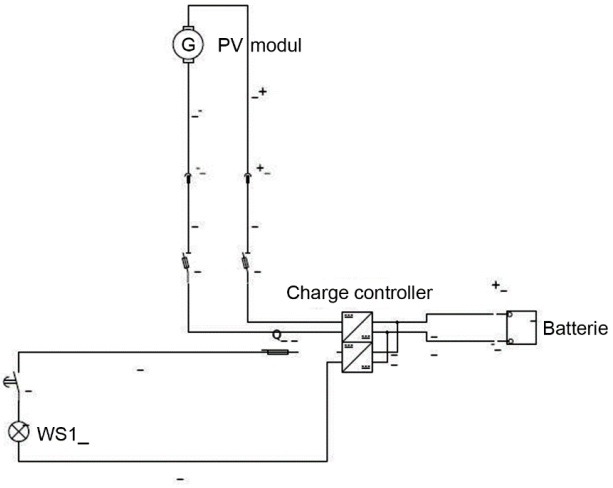

Fig. 10. *Schematic view of solar installation for lighting*

Fig. 11. *LED spotlight*

Ada Huja in Belgrade

Solar lighting at Ada Huja was installed in 2011 and consists of 43 pillars with PV solar modules and 28 W LED lamps.

Fig. 12. *Solar Lighting at Ada Huja in Belgrade, 2011*

Dorćol in Belgrade

In Dorćol, in Belgrade, near the sports center *Milan Gale Muškatirović*, in 2017, a solar lamp was installed, and it is shown in Figure 13.

Fig. 13. *Solar lighting in Dorćol, in Belgrade*

The solar lamp was set up by the Municipality of Stari grad in cooperation with *Lightinus* and business incubator *Impact Hub Belgrade*.

Solar street lighting lamp from Jagodina

In Serbia, in the period 2002-2017, Feman Co., Ltd. from Jagodina, produced light bulbs similar to the "Minel-Schreder" program. In Jagodina Feman Co. produces the solar lamp shown in Figure 14.

Fig. 14. *Solar street lamp lighting Feman company from Jagodina*

The solar lamp consists of a support pillar, a 100 W solar module, a battery charging

regulator, a 150 battery, Ah and a 30 W LED lamp. The specified lamp in this system can work continuously for 5-6 hours [4-10].

CONCLUSION

Based on the aforementioned, it can be seen that the development of PV solar energy investigations and practical utilization of PV systems in Serbia began in 1962. Since then two 2 MWp PV solar power plants and a certain number of smaller PV solar power plants have been installed. Development and practical utilization of PV lighting in Serbia started in 2012. Since then in Serbia have been installed a number of private household PV lighting systems and public systems such as: at the Faculty of Sciences and Mathematics in Niš, at the Trim track in Kosutnjak in Belgrade, at the Ada Huja in Belgrade and in Dorcol in Belgrade. There are good opportunities in Sebia for the wider use of PV lighting systems. First of all, it refers to the lighting in weekend houses, rural settlements, stationary military facilities, roads, tunnels, meteorological stations, special purpose vehicles, etc., which are not connected to the power system.

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