Places and Technologies 2015

KEEPING UP WITH TECHNOLOGIES TO MAKE HEALTHY PLACES

Nova Gorica, Slovenia, 18.–19.6.2015

PT2015

BOOK OF CONFERENCE PROCEEDINGS

A healthy city is one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential.
Health Promotion Glossary (1998)

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Places and Technologies 2015

KEEPING UP WITH TECHNOLOGIES TO MAKE HEALTHY PLACES

BOOK OF CONFERENCE PROCEEDINGS

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Nova Gorica, Slovenia

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APPLICATION OF PV MODULES ON NOISE BARRIERS

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ABSTRACT

The aim of this research is to consider possibilities for improving the street lighting on the E75 highway, which passes through Serbia, using renewable sources of energy. In this paper, we analyzed the possibilities for installing sound barriers along the highway and integrating photovoltaic (PV) modules, which would generate electrical energy to power the lighting on the section of the highway running through Belgrade. Sound barriers are necessary along the highway running through populated areas, and they are identified as elements on which PV modules for power generation can be installed. The illumination of the highway powered by conventional sources of electricity is very expensive and has negative environmental impact, which is the reason why this paper investigates the connection between sound barriers and electricity generation from renewable energy sources.The paper seeks to show the hybridity of using sustainable technologies in solving environmental issues. This structure solves the problem of noise in populated areas and provides the electricity from renewable source.

***Keywords**: noise, PV modules, solar energy, sound barriers.*

INTRODUCTION

This paper presents the possibilities of using solar energy for illuminating the highway running through Belgrade, the capital of Serbia. Serbia has 267 sunny days per year, and each square meter of the earth's surface receives 1000 hours of solar energy. In Serbia there is a potential to generate electricity using solar power because the insolation is 20-30 per cent more than the European average. There is an average of 2096 hours of sunlight per year (which accounts for 45.48 per cent of potential/possible insolation). The highest insolation of about 10 hours per day is in July and August, while December and January are the cloudiest, with insolation of 2 to 2.3 hours per day (Fig. 1). The mean annual number of cloudy

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days is 103.8, most of them during winters. The mean number of clear days per year is 67. The application of photovoltaic (PV) modules for generating the electricity into sound barriers provides the electricity to illuminate the section of the highway using alternative sources.At the same time, the noise level is reduced in a populated area, as well as the level of CO2 in the air.The calculations and computer simulations of PV system for all variants of integrating modules into sound barriers were made in the software PVSYST version 4.37. Standard modules with mono-crystalline cells were used for the calculations.

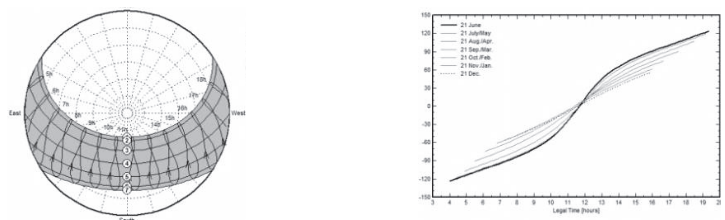


Figure 1: Annual Solar paths diagram and Sun's azimuth at Belgrade (44.4^0N, 20.4^0E).

Methods

The analysis presented in this paper is hypothetical and it aims to demonstrate the architectural and energy possibilities of using active solar systems by integrating PV modules on noise abatement elements on the section of the highway which runs through Belgrade. The results obtained were comparatively analyzed. Energy efficiency is treated through the consumption of electricity for powering the lighting on the highway using standard light sources – high pressure sodium and new technologies using LED technology.

NOISE BARRIERS

Reducing the negative impact of traffic noise on the environment can be successfully solved by installing appropriate barriers, structures that prevent direct noise transmission. Noise barriers interrupt the original straight line path of sound waves, thus reducing the noise level (Fig. 2a). The effect of noise reduction is reflected in creating an acoustic shadow behind the barrier and it reduces the sound level coming to the receiver.Traffic noise barriers are solid obstacles installed along the road to absorb, transmit or reflect sound. Barriers reduce the level of noise by 5 to 10 dB, thus reducing the level of traffic noise by as much as half. To effectively reduce the noise coming around the ends of the barrier, it should be 8 times as long as the distance between the receiver and the barrier itself. It is desirable to locate a noise barrier four times its height from settlements and provide landscaping near the barrier to avoid visual dominance. A barrier can achieve a 5dB noise level reduction when the line-of-sight is broken from the highway. After the line-of-sight is broken, the barrier may reduce the noise level by an additional 1.5dB for each one meter of barrier height (Fig. 2b). The level of noise generated by traffic on the highway through Belgrade is 70-90db. According to the law in Serbia, the maximum allowed noise level in residential areas is 55dB during the day, and 45dB during the night. In Belgrade, there are no noise barriers which meet the standard. The vicinity of the highway and the noise produced is a serious environmental issue for the analyzed area in Belgrade.

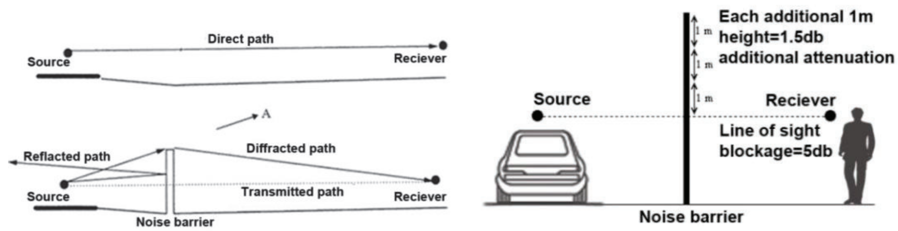


Figure 2: a) Path of sound waves without and with noise barrier b) High of noise barrier.

Illumination of the e75 highway

The E75 highway is the longest international route; class A, running north-south from Norway to Greece. The total length of this highway is 5639 km, and the section running through Serbia spans 239km and it is a part of the Pan-European corridor X. The lighting is provided using high-pressure sodium light sources, of 400W, featured by high luminous efficiency and limited spectrum of radiation peaking in the yellow-orange. The length of the highway running through Belgrade is 25km, and a section, 8.5km long, 2x12m wide, was chosen for detail analysis. This section of the highway is illuminated by 420 light sources mounted on 210 metal poles, each 12m high. The poles are arranged centrally, at the distance between each other of 40m and a slope of 5^0.

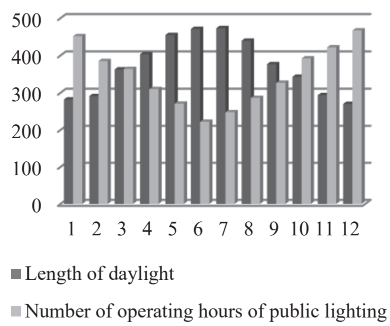
ANALYSIS OF POWER CONSUMPTION FOR ILLUMINATING

According to the valid calendar for switching public lighting on and off for the city of Belgrade (updated 16 October 2011), the total number of operating hours of public lighting in Belgrade is 4148.23 hours per year.

Table 1: Length of daylight for Belgrade and operating hours of public lighting of highway.

Month	Length of daylight for Belgrade	Operating hours of public lighting	Month	Length of daylight for Belgrade	Operating hours of public lighting
1	282.32	452.00	**7**	473.42	248.00
2	291.44	385.15	**8**	439.93	286.45
3	362.99	364.15	**9**	376.96	327.00
4	403.52	310.13	**10**	343.14	392.45
5	455.08	271.15	**11**	294.07	422.00
6	471.40	222.30	**12**	270.56	467.45

Total	4464.8	4148.23



The shortest number of operating hours of lighting is in June - 222.30 hours, and the highest is in December and it is 467.45 hours. Total length of daylight for Belgrade and total number of operating hours of public lighting of highway by month are shown in Table 1. The existing sodium lamps have 400W installed power/each. The number of lamps on the analyzed section of the highway is 420.The required amount of electricity to power this type of lighting, depending on the number of operating hours of public lighting, is 696902.64 kWh per year. There is a noticeable difference in reducing the electricity consumption by replacing the light source.The rationalization of electricity consumption for street lighting on the section of the highway is possible by replacing the existing 400W sodium lamps with more modern lamps for public lighting, with degree of protection IP66, 279 LED. Comparison of consumption of electricity for sodium lamp 400W and 279W LED lamp are shown in Table 2.

Table 2: Consumption of electricity for sodium lamp 400W and 279W LED lamp by month.

Month	Number of operating hours of lamp	Consumption of 400 W sodium lamp	Consumption of 279W LED lamp	Month	Number of operating hours of lamp	Consumption of 400 W sodium lamp	Consumption of 279W LED lamp
1	452	75936	52965	**7**	248	41664	29060
2	385	64705	45132	**8**	286	48123	33566
3	364	61177	42671	**9**	327	54936	38318
4	310	52102	36341	**10**	392	65931	45987
5	271	45553	31773	**11**	422	70896	49450
6	222	37346	26049	**12**	467	78531	54776
Total	4148	696902	486089				

RESULTS AND DISCUSSION

For a comparative analysis of the integration of photovoltaic modules into sound barriers, different positions of PV modules were proposed giving different results of total annual electricity generation. For the analysis, 6 variants of positions of photovoltaic modules were adopted (Fig. 3): Variant 1 – PV modules in vertical wall, opaque; Variant 2 – PV modules in vertical wall with sheds disposition; Variant 3 – PV modules in vertical wall with sun-shield disposition; Variant 4 – PV modules in vertical wall, semi-transparent (50%); Variant 5 – PV modules in vertical wall with sheds disposition, semi-transparent (50%); Variant 6 – PV modules in vertical wall with sun-shield disposition, semi-transparent (50%). All the variants of the integration of PV modules into sound barriers were analyzed for the same surface area of the barrier, i.e. 4900 sq.m. Photovoltaic modules integrated into the noise abatement element (Variant 1), covering the total area of 4900 sq.m. monthly generate the amount of electricity ranging from min 24379 kWh in December to max 88147 kWh in July. The total annual electricity production is 698229 kWh in Variant 1. The required electricity to power lighting using sodium lamps is 696902.64 kWh, and for LED lamps 486089.59 kWh.

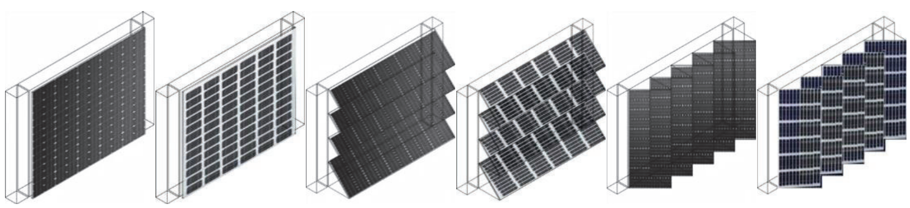


Figure 3: Design of 6 different variants of integrated PV modules.

Photovoltaic modules integrated into the noise abatement element (Variant 2), covering the total area of 4900 sq.m., monthly generate the amount of electricity ranging from min 23414 kWh in December to max 86285 kWh in July. Photovoltaic modules integrated into the noise abatement element (Variant 3) monthly generate the amount of electricity ranging from min 20036 kWh in January to max 71073 kWh in August. Photovoltaic modules integrated into the noise abatement element (Variant 4), monthly generate the amount of electricity ranging from min 12190 kWh in January to max 44073 kWh in July. Photovoltaic modules integrated into the noise abatement element (Variant 5), generate monthly the amount of electricity ranging from min 11707 kWh in December to max 43142 kWh in July. Photovoltaic modules integrated into the noise abatement element (Variant 6), monthly generate the amount of electricity ranging from min 10018 kWh in January to max 35537 kWh in August. Comparative review of monthly and annual production of electricity for all 6 variants of PV modules is shown in Table 3.

Table 3: Comparative review of monthly and annual production of electricity for different variants of PV modules.

Month	Variant 1	Variant 2	Variant 3	Variant 4	Variant 5	Variant 6
1	24675	23869	20036	12338	11934	10018
2	37130	36280	30892	18565	18140	15446
3	57834	56565	48429	28917	28282	24215
4	67037	65494	54976	33518	32747	27488
5	81244	79402	60057	40622	39701	30028
6	81077	79215	54186	40538	39607	27093
7	88147	86285	61079	44073	43142	30539
8	86293	84640	71073	43146	42320	35537
9	69141	67800	59835	34571	33900	29918
10	52368	51327	44807	26184	25663	22404
11	28903	28103	23861	14452	14051	11931
12	24379	23414	20117	12190	11707	10058
Total	698228	682394	549348	349114	341194	274675

CONCLUSION

The contribution of renewable sources of energy to electricity production using PV modules was evaluated through comparative analysis of variant solutions for integrating PV modules into noise barriers. Annually, integrated photovoltaic modules can generate the amount of electricity ranging from min 274675 kWh (Variant 6) to max 698228 kWh (Variant 1). The analysis showed that only Variant 1 can generate enough electricity for lighting. The percentage share of obtained electricity from hypothetical models in relation to the annual demand is the following: Variant 1 – 100 per cent, Variant 2 - 97.92 per cent, Variant 3 – 78.83 per cent, Variant 4 – 50.01 per cent, Variant 5 – 48.96%, Variant 6 – 39.41%. It is noted a significant difference in amounts of generated electricity by variants. It may be concluded that standard opaque mono-crystalline PV modules, placed vertically, generate the most electricity. Standard semi-transparent mono-crystalline PV modules with sun-shield disposition are the least efficient.

Adequate orientation, choice and position of PV modules may contribute to their greater energy efficiency. It is necessary to further analyze the combination of individual variants to meet shaping and visual aspects of the application of noise barriers in populated areas. In implementing such systems, the adaption of PV modules to the designed type of noise barrier could pose a problem.

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