

SOLAR RADIATION ATLAS IN BANJA LUKA IN THE REPUBLIC OF SRPSKA

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Abstract: The paper presents an atlas of solar radiation for the city of Banja Luka in the Republic of Srpska formed by PVGIS estimation utility. The atlas contains the results of calculating global and direct solar radiation falling on the horizontal surface and global solar radiation falling on the optimally placed surface in Banja Luka in the period from 2007 to 2016. In addition, the intensity of global, direct and diffuse solar radiation falling on the optimally placed surface in Banja Luka is given by months. It was found that 13.89% less solar radiation falls on the horizontal surface and 47.31% less on the vertical surface as compared to the solar radiation that falls on the optimally placed surface. The basic characteristics of fixed, one-axis and dual-axis tracking PV solar power plants power of 1 MWp and the amount of electricity that can be generated by them in Banja Luka, are also given. It was found that with the one-axis rotary solar power plant 30.18% more electricity can be generated, and with the dual-axis tracking solar power plant 33.37% more electricity can be generated as compared to the fixed solar power plant.

Keywords: PVGIS program, solar irradiance, solar energy, PV solar power plants

INTRODUCTION

Quantity of sun radiation intake on the surface of earth is influenced by numerous factors such as: geographical latitude of the given place, season of the year, part of the day, purity of the atmosphere, cloudiness, orientation and surface inclination, etc. These data are very important because of their use in calculations of the cost effectiveness of equipment using sun radiation. Very reliable data can be found in data basis PVGIS (Photovoltaic Geographical Information System–PVGIS © European Communities, 2001–2008, <http://re.jrc.ec.europa.eu/pvgis/apps3/pvest.php>).

PVGIS methodology comprises solar radiation data, PV module surface inclination and orientation and shadowing effect of the local terrain features (e.g. when the direct irradiation component is shadowed by the mountains), thus PVGIS represents immensely important PV implementation assessment tool that estimates dynamics of the correlations between solar radiation, climate, atmosphere, the earth's surface and the PV technology used. Several fast web applications enable an easy estimation of the PV electricity generation potential for selected specific locations in Europe.

This paper provides the results of calculating global, diffuse and direct solar radiation by means of PVGIS estimation utility for the city of Banja Luka. Moreover, the paper contains the results of calculating the electrical energy which can be generated by the fixed, one-axis and the dual-axis tracking solar power plants in Banja Luka.

GLOBAL SOLAR RADIATION

The energy of global solar radiation falling on the horizontal surface in Banja Luka is given in Figure 1. The energy of direct solar radiation falling on the horizontal surface in Banja Luka is given in Figure 2.

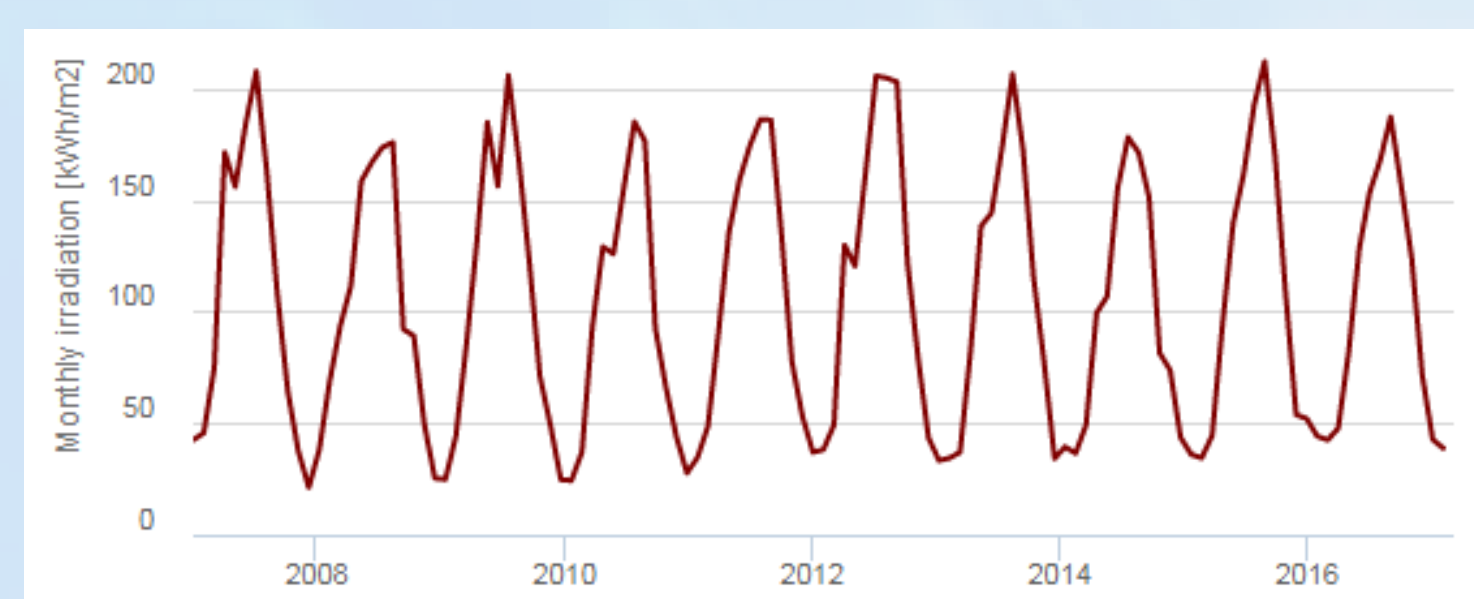


Fig. 1. The energy of global radiation falling on the horizontal surface in Banja solarLuka

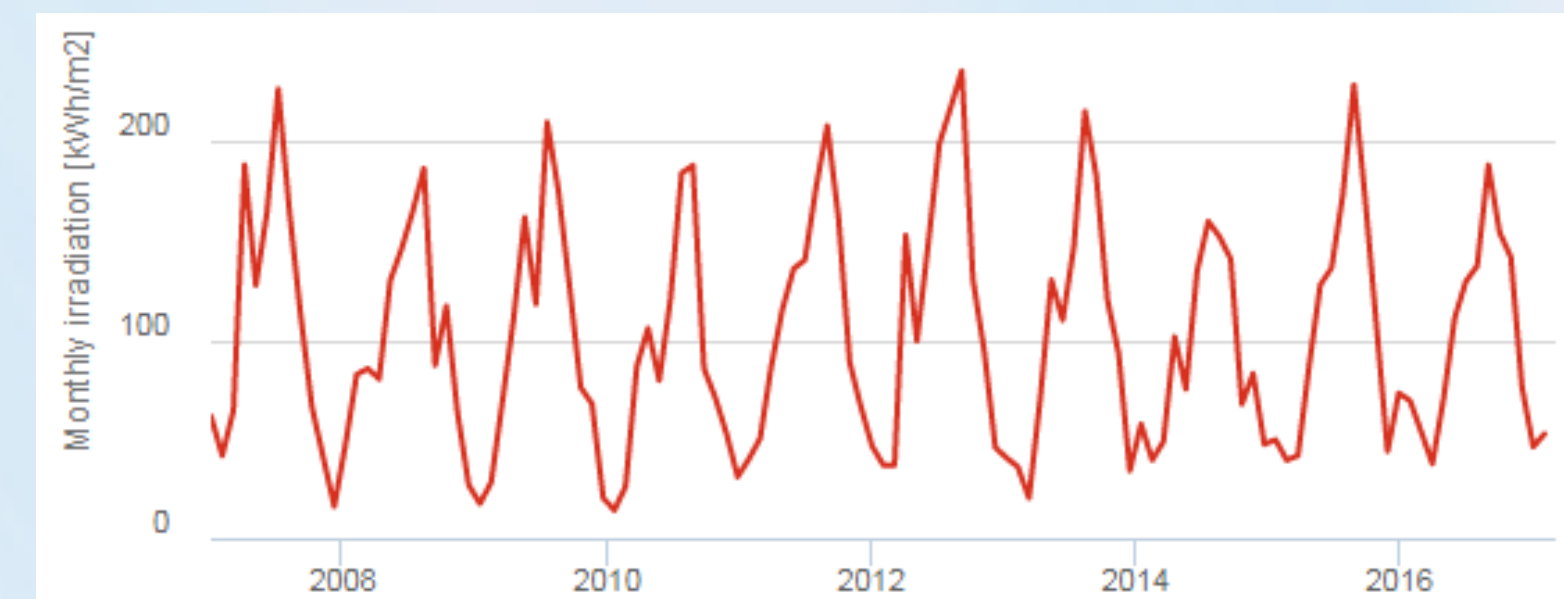


Fig. 2. The energy of direct solar radiation falling on the horizontal surface in Banja Luka

The energy of global solar radiation falling on a surface set at an optimal angle of 34° in Banja Luka is given in Figure 3.

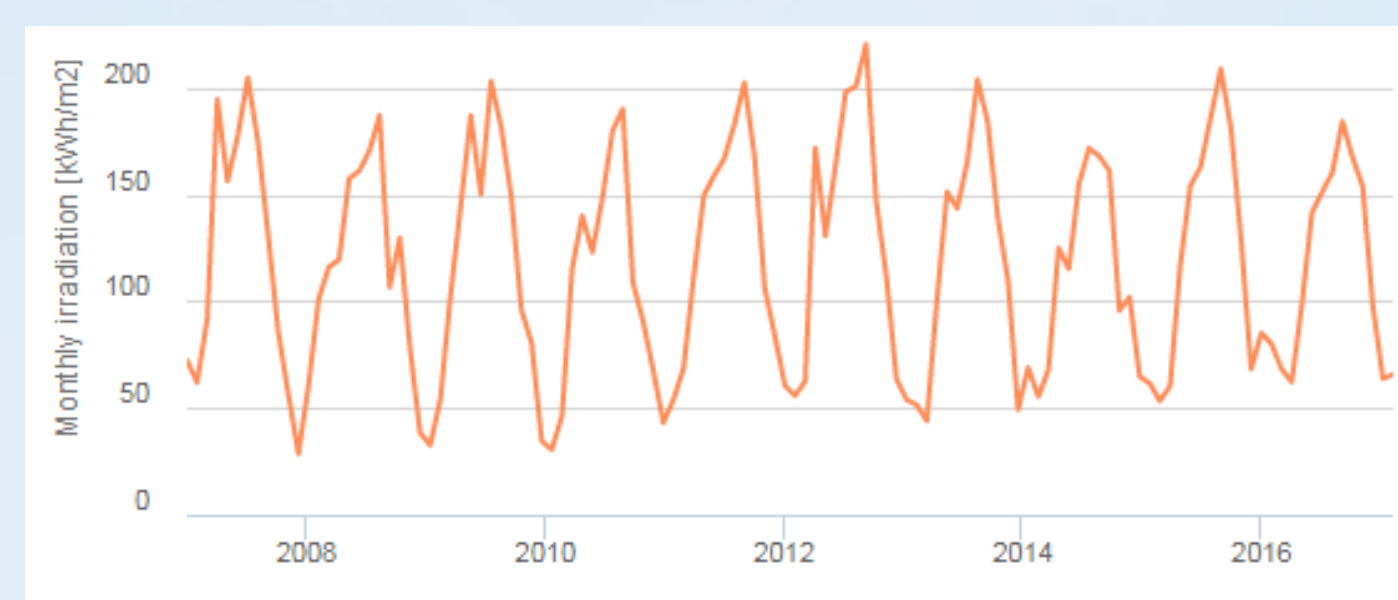


Fig. 3. The energy of global solar radiation falling on a surface set at an optimal angle of 34° in Banja Luka

GLOBAL, DIRECT AND DIFFUSE SOLAR RADIATION FALLING ON AN OPTIMALLY TILTED SURFACE

The intensity of global, direct and diffuse solar radiation that falls on the optimally placed surface in January and July in Banja Luka is shown in Figure 4. and Figure 5.

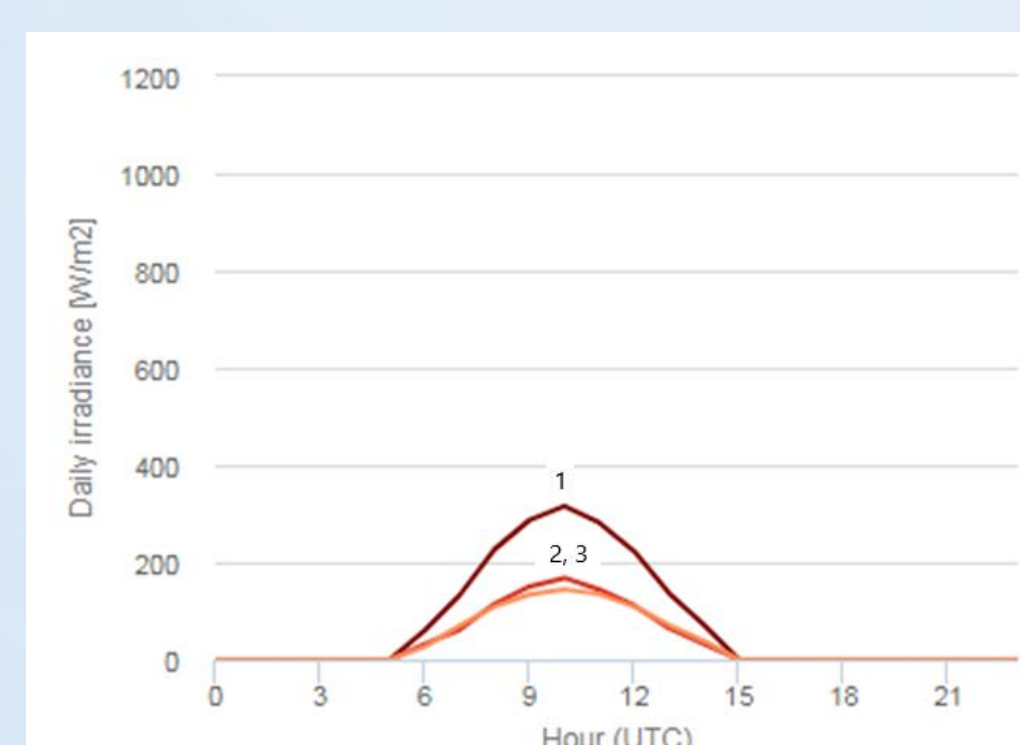


Fig. 4. Intensity of global (1), direct (2) and diffuse (3) solar radiation in January in Banja Luka (34°)

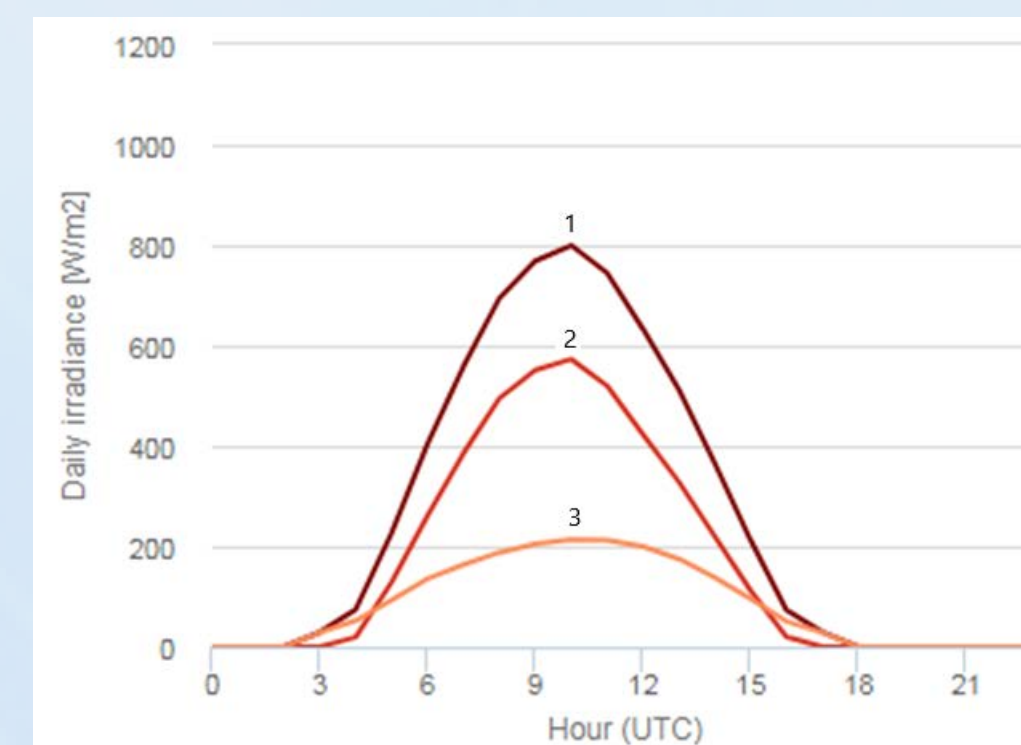


Fig. 5. Intensity of global (1), direct (2) and diffuse (3) solar radiation in July in Banja Luka (34°)

The geographical position, optimal angle and the energy of the solar radiation falling on the horizontal, optimally tilted and vertically placed surface in Banja Luka are given in Table 1.

Tab. 1. Geographical position, optimal angle and the energy of the solar radiation falling on the horizontal, optimally tilted and vertically placed surface in Banja Luka

Location	Geographical position	Optimal angle (°)	Energy of solar radiation falling		
			on the horizontal surface (Wh/m ²)	on the optimally tilted surface (Wh/m ²)	on the vertically placed surface (Wh/m ²)
Banja Luka	44°46'0" North latitude 17°10'59" East longitude	34	3449,92	3929,42	2667,42

FIXED SOLAR POWER PLANT

Tab. 2. PVGIS characteristics of a fixed solar power plant power of 1 MWp that would be installed in Banja Luka

Location	Banja Luka
Power of photovoltaic solar power plant (MWp)	1
Power plant losses (%)	14
Tilt angle (°)	34
Azimuth angle (°)	0
Annual electricity production (kWh)	1112301,85

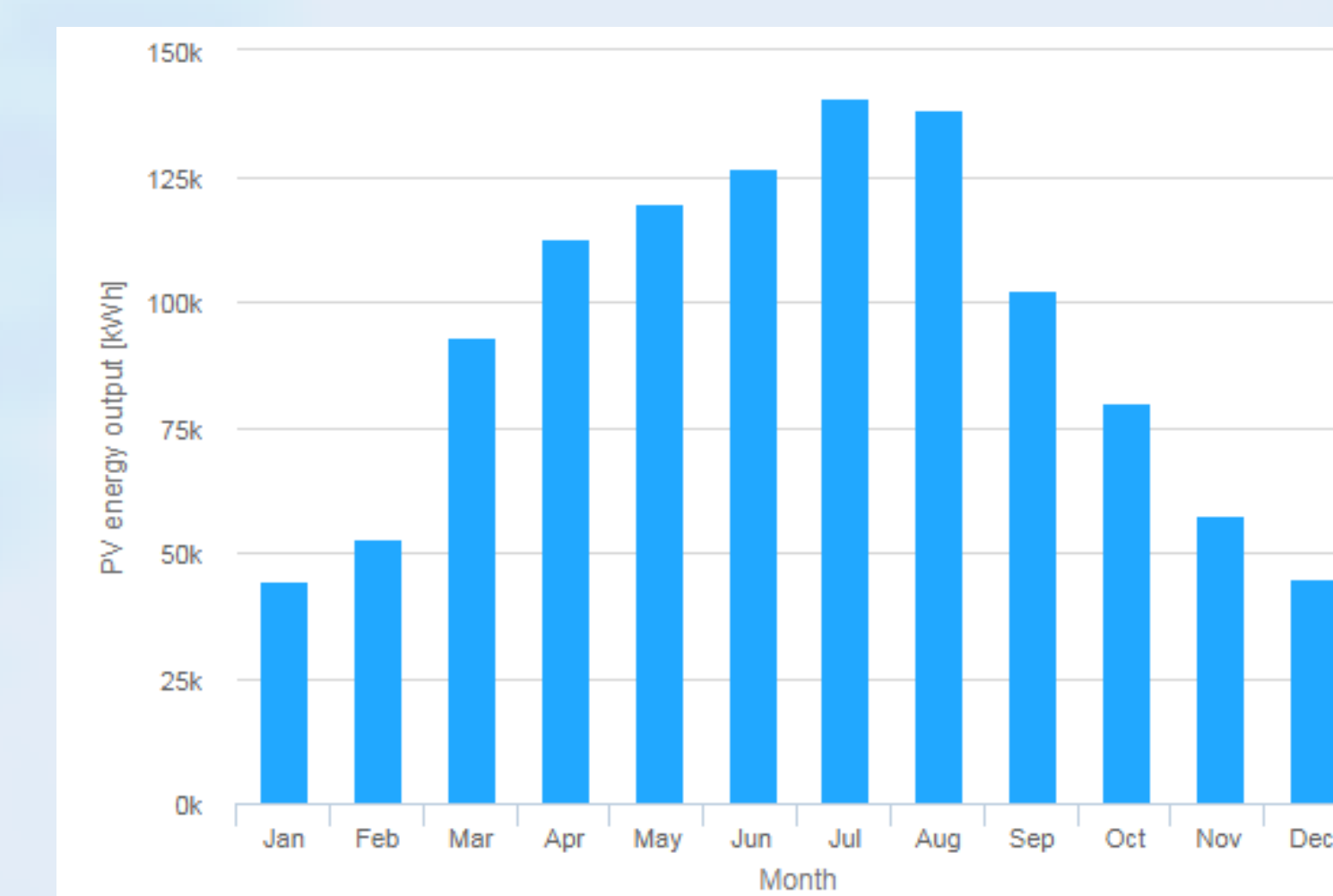


Fig. 6. PVGIS data for monthly electricity production by a fixed solar power plant with monocrystalline silicon solar modules total power of 1 MWp in Banja Luka

ONE-AXIS TRACKING PV SOLAR POWER PLANT

Tab. 3. PVGIS characteristics of the one-axis tracking PV solar power plant power of 1 MWp that would be installed in Banja Luka

Location	Banja Luka
Power of photovoltaic solar power plant (MWp)	1
Power plant losses (%)	14
Tilt angle (°)	36
Annual electricity production (kWh)	1448040,88

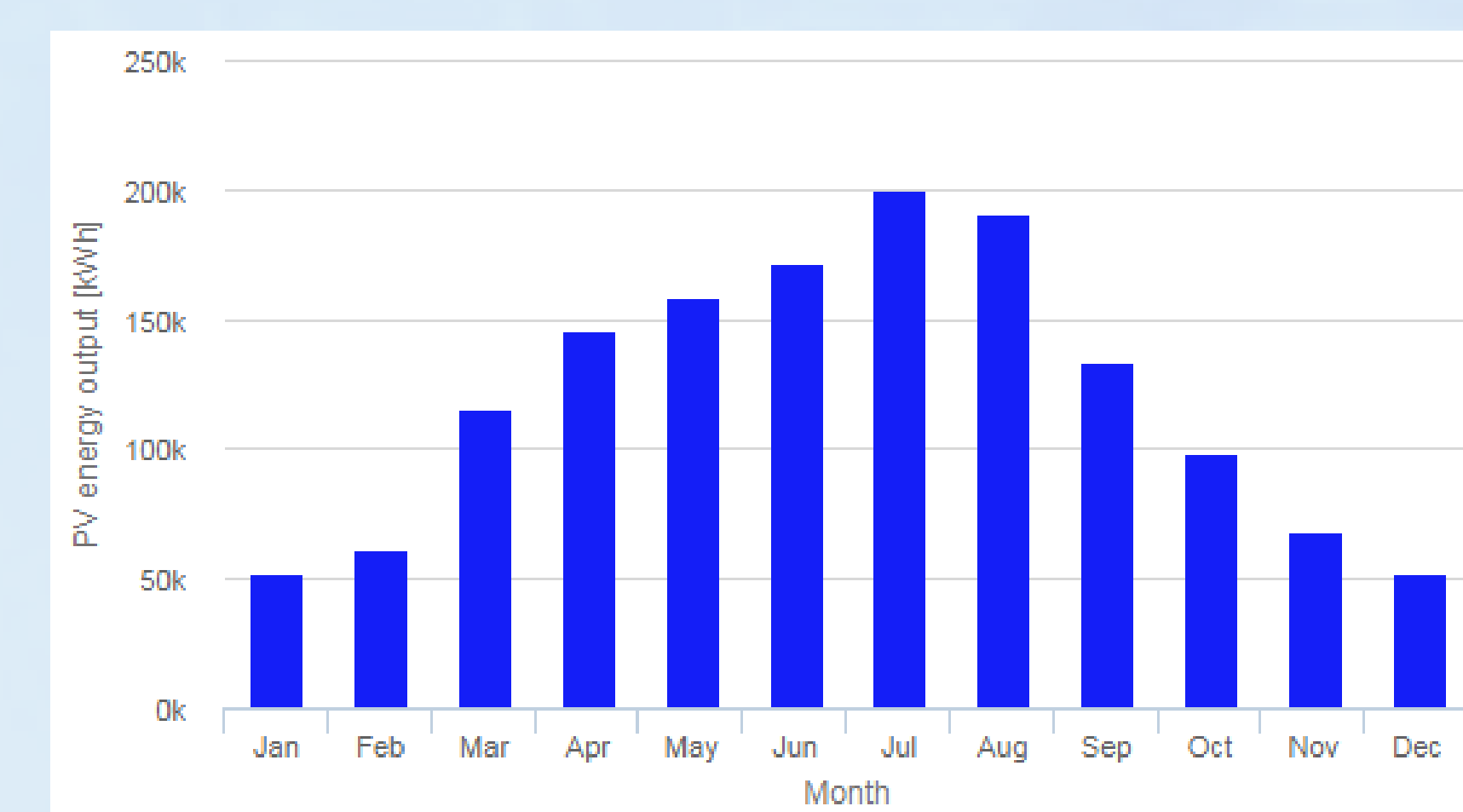


Fig. 7. PVGIS data for monthly electricity production by the one-axis tracking PV solar power plant with monocrystalline silicon solar modules total power of 1 MWp in Banja Luka

DUAL - AXIS TRACKING PV SOLAR POWER PLANT

Tab. 4. PVGIS characteristics of the dual - axis tracking PV solar power plant power of 1 MWp that would be installed in Banja Luka

Location	Banja Luka
Power of photovoltaic solar power plant (MWp)	1
Power plant losses (%)	14
Annual electricity production (kWh)	1483486,84

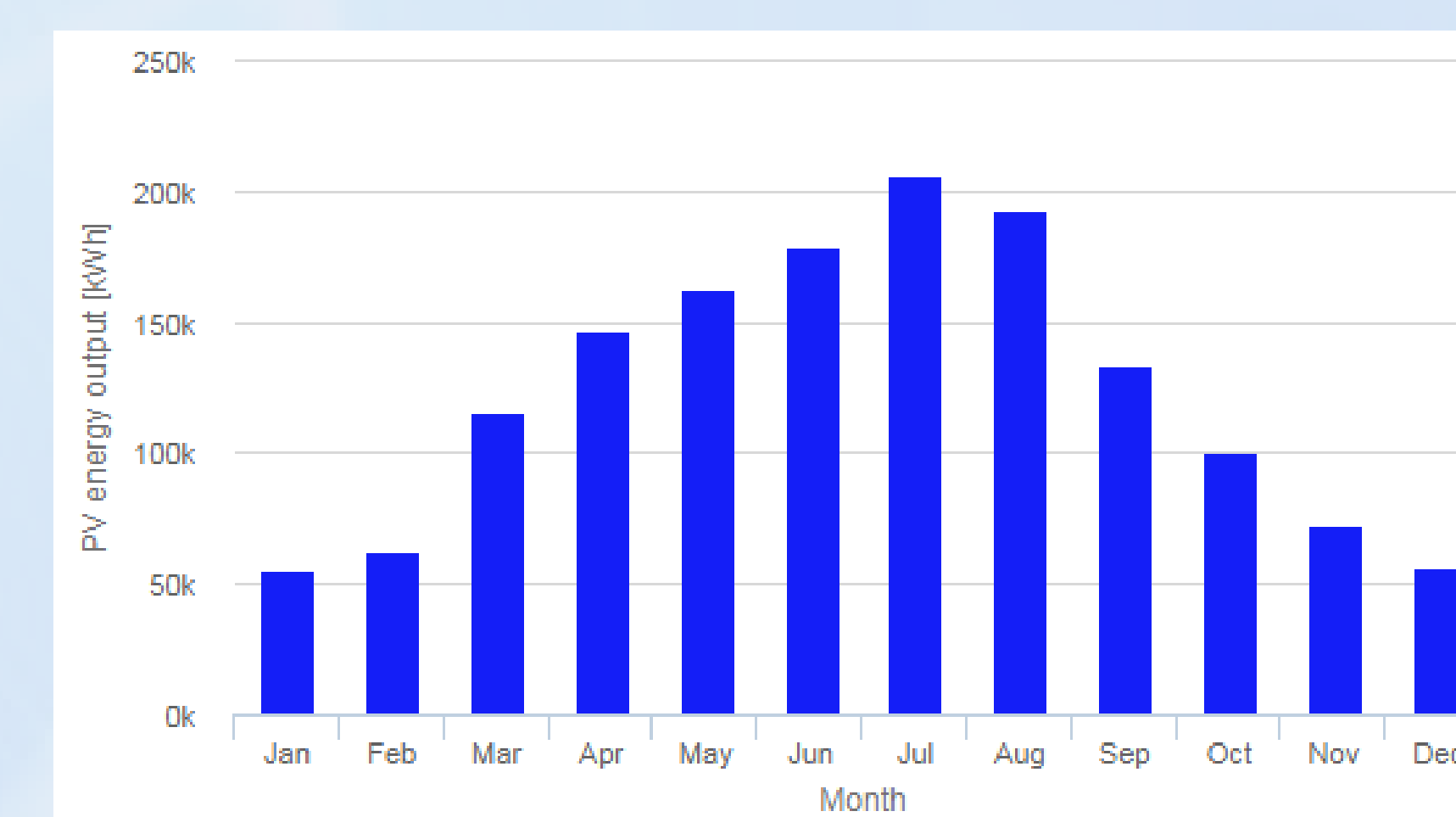


Fig. 8. PVGIS data for monthly electricity production by the dual-axis tracking PV solar power plant with monocrystalline silicon solar modules total power of 1 MWp in Banja Luka

CONCLUSION

In the light of all said, it can be concluded that:

- in the period 2007-2016 there is no significant deviation of the energy of global and direct solar radiation respectively that falls on a horizontal and optimally placed surface;
- the intensity of global solar radiation increases from 320 W/m² in January to 800 W/m² in August and it decreases from August to December when it is 320 W/m²;
- the intensity of direct solar radiation increases from 180 W/m² in January to 580 W/m² in August and it decreases from August to December when it is 190 W/m²;
- the intensity of diffuse solar radiation increases from 170 W/m² in January to 220 W/m² in August and it decreases from August to December when it is 130 W/m²;
- the values of the intensity of direct and diffuse solar radiation are almost the same in January, February, November and December, respectively;
- in the period from March to November, the curves of direct and diffuse radiation intensity do not coincide, whereby the intensity of direct radiation is always higher than the intensity of diffuse radiation.
- 13.89% less energy of solar radiation falls on the horizontally placed surface, and 47.31% less on the vertical placed surface in relation to the optimally placed surface;
- the one-axis tracking solar power plant generates 30.18% more electricity and the dual-axis tracking PV solar power plant generates 33.37% more electricity as compared to a fixed solar power plant.