Матеріали XXIV Міжнародної науково-практичної конференції «Екологія. Людина. Суспільство» (5 червня 2024 р., м. Київ, Україна)

Handbook of the XXIV International Science Conference «Ecology. Human. Society» (June 5, 2024, Kyiv, Ukraine)

ISSN (Online) 2710-3315
https://doi.org/10.20535/EHS2710-3315.2024.305035

MEASURED PERFORMANCE ANALYSIS OF A 5.04 KW GRID CONNECTED SOLAR PHOTOVOLTAIC POWER PLANT

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Abstract

This article analysis the performance of the 5.04 kW grid connected solar PV power plant mounted on the roof of the demonstrational pavilion. The facility is located on Sofia, Bulgaria. The aim of this study is to show the amount of energy produced by the PV power plant in different seasons and conditions. This PV power plant was mounted and grid-coonected to the National grid and monitored since October 2019. In this article we are going to show the total annual amount of energy produced in 2022 and we are going to show the performance of the PV plant during different seasons and weather conditions. This report was prepared using the data available thanks to the InDeWaG Project documentation.

Keywords: *renewable sources, solar energy, PV systems, PV performance, data analysis.*

1. Introduction

The ambitious plan for carbon-neutrality by 2050, set out in the European Green Deal require large-scale action in all economic sectors: investment in new environmentally friendly technologies; innovations in industry; cleaner and cheaper transport; decarbonization of the energy sector; renovation of the building stock. Improving existing buildings and striving for smart solutions and energy efficient materials can reduce energy losses.

Producing energy using fossil fuels is becoming harder and also it has a negative effect on the environment. Recent studies show that these resources are coming to an end and we have to keep them as long as possible. Therefore, scientists and business must focus on developing renewable energy sources (RES) and find a way to store the energy produced by them so it can be used when needed.

RES such as solar PV, wind and water power plants must be projected to cover more and more of the future energy need not only in Bulgaria, but also worldwide [1]. Not only PV plants are capable of producing free energy from the sun, they are also responsible for the decreasing of the CO_2 emissions. It is known that 1 kWh of the electrical energy generated by a solar PV plant decreases the emission of 0.6 kg CO_2 into the atmosphere [2].

The usage of solar power generators has been encouraged in recent years owing to various environmental benefits [3]. PV Solar energy is concerned as the most efficient renewable energy for buildings and homes. Next images show the annual average radiation in Bulgaria. The installed solar capacities in our country are already 1.72 gigawatts and in 2022 they have produced a total of 2 terawatt hours of electricity [4]. It is expected that Bulgaria will double is production from PV plants during the next 5 years.

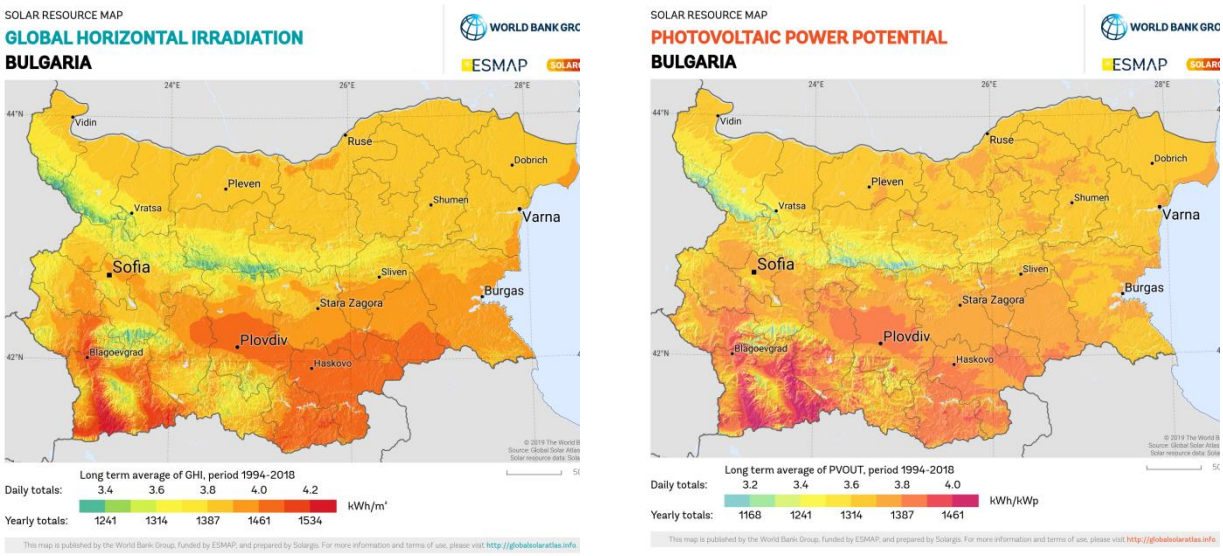

Figure 1. Global solar radiation and PV potential for Bulgaria. [5]

Bulgaria is now one of the most renewable energy countries in EU. During the last 3 years our country has tripled the energy produced from solar power plants, and now they produce over 20% of the energy in the energy mix of the country.

According to the Institute of Hydrology and Meteorology (IHM) of the Bulgarian Academy of Sciences (BAS) and its data for solar radiation Bulgaria is divided in 3 zones depending on the amount of the fallen solar radiation on 1 m^2 horizontal space. Sofia (the capital of Bulgaria and also where the described PV plant is situated) is situated in zone with average solar radiation approximately Sofia is situated on the South-West region of Bulgaria (zone 1), where the average theoretical solar radiation is < 1450 kWh/m^2/year. [6].

2. Analyzed system configuration

2.1. PV plant description

The plant is located in Sofia, Bulgaria. It was built to cover the energy needs of the experimental building called demonstrational Pavilion, as a part of the InDeWaG project [7].

On the roof of the pavilion are installed 18 photovoltaic (PV) modules URECO F6E280H3A connected to solar inverter Huawei sun-2000 ktl. Power output of the solar generator is 5.04 kWp with an area of 29.3 m^2. PV modules are mounted with a tilt angle of 10 degrees facing south. (fig. 2.). The pavilion is connected to the grid and the excess energy from the solar generator is being exported to the local electric grid. When electricity from PV panels is more than the consumption of the Pavilion, this amount of energy is delivered to the electric grid and when the pavilion needs more electricity, it is taken from the electric grid. In order to monitor power consumption of the pavilion smart meters have been mounted in the main electrical box. This gives us a chance to collect and analyze data for all electrical consummators. All data is stored in a cloud and can be accessed via web browser and mobile application [8].

3. Data analysis

Monitoring, and researching of the pavilion during its operation helps to improve the work of PV system and create a complete analysis on its work. With the help of this analyst, we can create a complete view on the work of the PV under different weather conditions and in different seasons.

The data logger collects data from different measurement sensors and inverters through and transfers it to the cloud from where it can be exported in different files, so it can be easily analyzed. Data logger records solar irradiance, voltage, current and power at input and output of each inverter as well as wind speed and module temperature at an interval of every 5 min.

PV module data:
Model - STC F6E280H3A
Maximum Rating Power (Pmax) [W]: 280
Module Efficiency [%]:17.2

Figure 2. PV system on the roof of the innovative demonstrational pavilion in Sofia with installed capacity 5.04 kWp

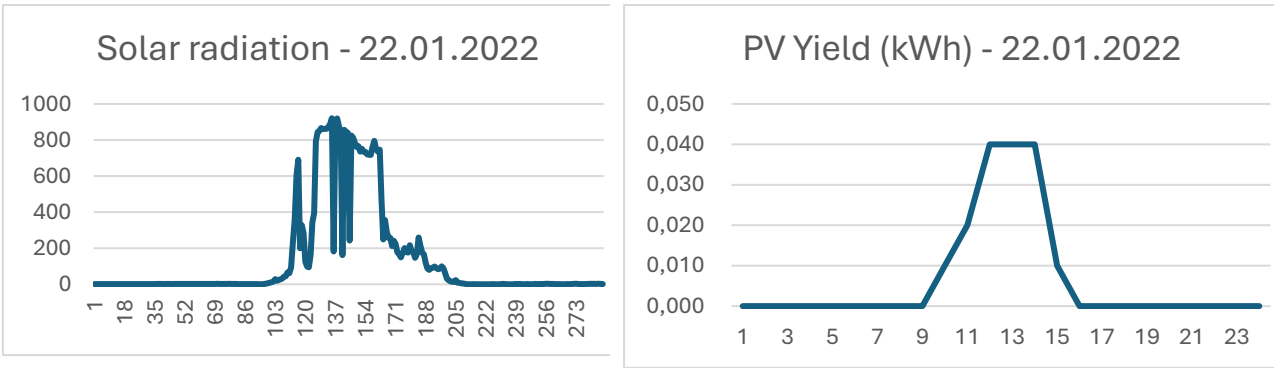

Figure 3. Energy production and solar radiation on 21.01.2022
Average solar radiation (solar radiation during active hours) – 405, 82 W/m²K, produced energy on 22.01.2022 – 0.16 kW, energy produced on January, 2022 - 216,82 kWh

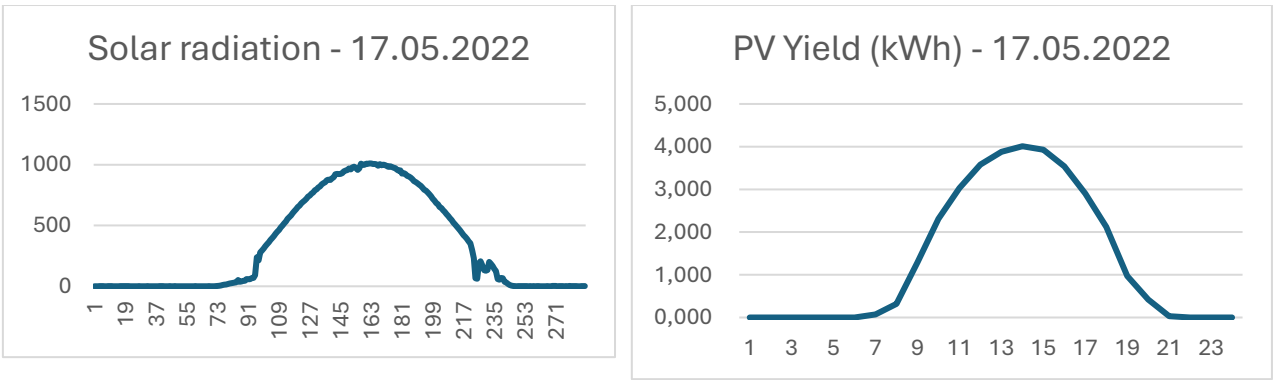

Figure 4. Energy production and solar radiation on 17.05.2022.
Average solar radiation (solar radiation during active hours) – 681, 24 W/m²K, produced energy on 17.05.2022 – 32,4 kW, energy produced on May, 2022 - 866,530 kWh

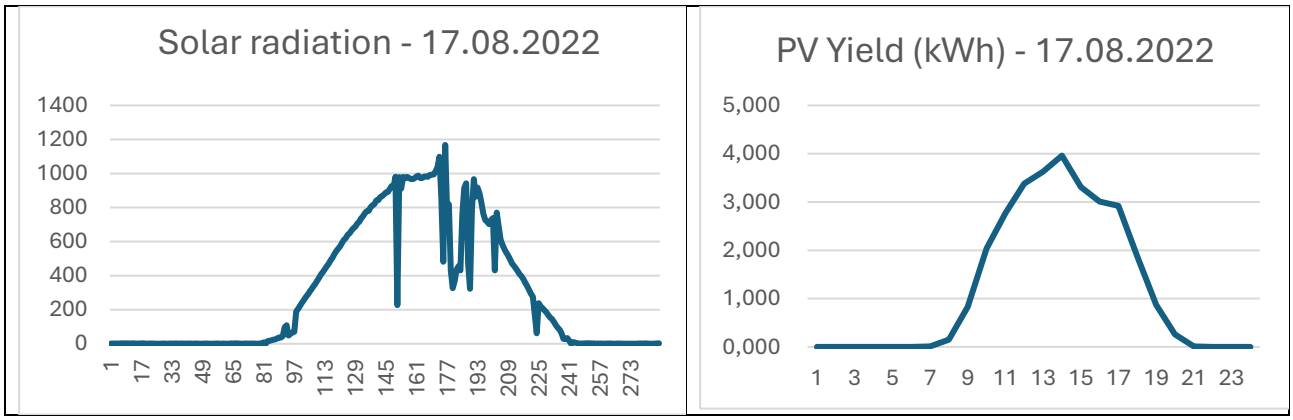

Figure 5. Energy production and solar radiation on 17.08.2022

Average solar radiation (solar radiation during active hours) – 594,08 W/m²K, produced energy on 17.05.2022 – 29,02 kWh, energy produced on August, 2022 - 714,80 kWh

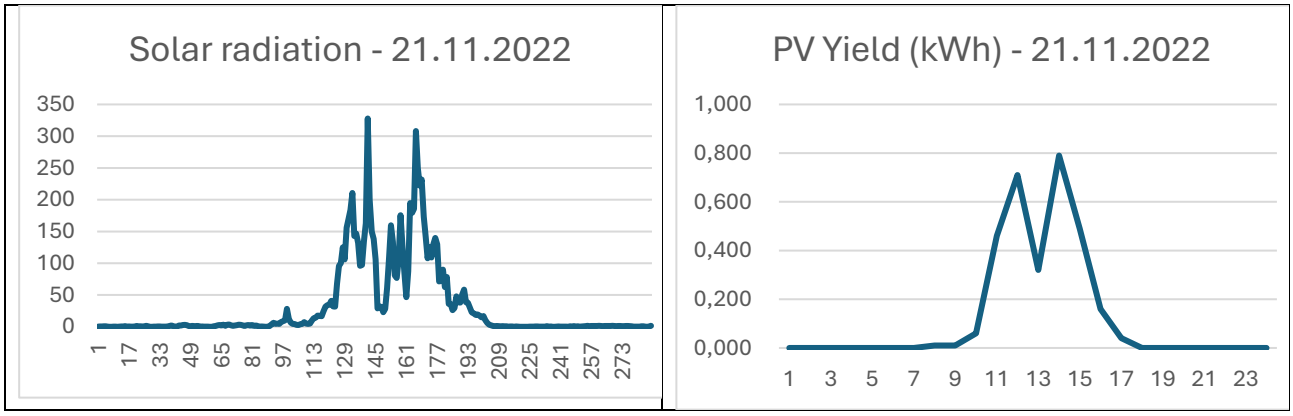

Figure 6. Energy production and solar radiation on 21.11.2022

Average solar radiation (solar radiation during active hours) – 109,22 W/m²K, produced energy on 21.11.2022, energy produced on November, 2022 - 3,05 kWh

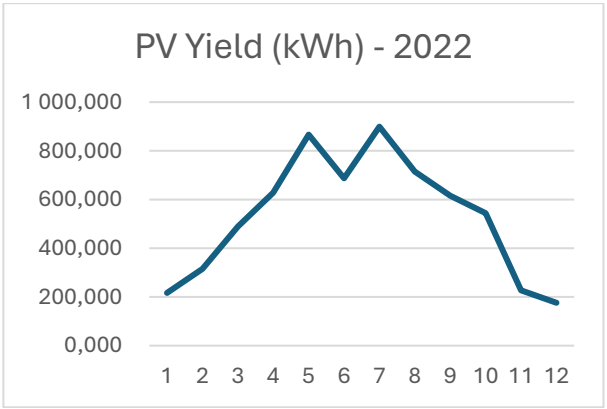

Figure 7. Energy produced during the whole 2022 – 6378,46 kWh

Conclusions

A detailed performance analysis based on monitored data and operating experience of PV systems is required for large scale integration of grid PV systems in future.

During the monitored year 2022 this PV plant produced 6, 38 MWh

In this paper, the performance analysis of 5.04 kW PV system mounted on the roof of the demonstrational Pavilion was performed. After analyzing the data from the PV power plant, we can state that:

- Bulgaria with its situation has a great potential for developing renewable source section.
- These small PV power plants are suitable for covering the electricity need for households and small residential buildings.
- These PV plants can deliver over 5000 kW and they can be useful when there is solar radiation during the daylight.
- This energy should be stored and used during the rest time of the day to meet the need from electricity.
- Even though there is enough solar radiation not always the PV plant manages to produce enough energy to fulfil the needs of the pavilion. This is due to the angle the solar panels are mounted on the roof.

It must also be stated that photovoltaic systems are a source of clean energy, since they do not contribute to carbon gas emissions and are accessible by many households and countries.

Acknowledgements

The author would like to acknowledge Central laboratory for solar energy and new energy sources from Bulgarian academy of sciences for being part of the InDeWaG project and for the ability to use the data from the demonstrational pavilion in this article.

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АНАЛІЗ ВИМІРЯНИХ ПОКАЗНИКІВ СОНЯЧНОЇ ФОТОЕЛЕКТРИЧНОЇ ЕЛЕКТРОСТАНЦІЇ ПОТУЖНІСТЮ 5,04 КВТ, ПІДКЛЮЧЕНОЇ ДО ЕЛЕКТРОМЕРЕЖІ

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DOI: https://doi.org/10.20535/EHS2710-3315.2024.305035

Ключові слова: *відновлювані джерела, сонячна енергія, фотоелектричні системи, продуктивність фотоелектричних систем, аналіз даних.*

Анотація
У цій статті проаналізовано продуктивність підключеної до мережі сонячної фотоелектричної електростанції потужністю 5,04 кВт, встановленої на даху демонстраційного павільйону. Об'єкт розташований у Софії, Болгарія. Мета цього дослідження - показати кількість енергії, виробленої фотоелектричною станцією в різні пори року та за різних умов. Ця сонячна електростанція була змонтована і підключена до національної електромережі, а моніторинг проводився з жовтня 2019 року.
У цій статті ми покажемо загальний річний обсяг енергії, виробленої у 2022 році, а також покажемо продуктивність фотоелектричної станції в різні сезони та погодні умови.