Computer Simulation and Investigations of the Roof Mount Photovoltaic System

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Abstract—The interest in the renewable energy sources is increasing due to the depletion of the conventional energy sources and the environmental pollution. In this paper we present a computer simulation and investigations of the roof mounted photovoltaic system. The results of the generated power of the 5kW built-in photovoltaic system by months over a period of 5 years are presented. Depending on the meteorological conditions, the investigated photovoltaic system generates year-round energy necessary for the needs of the household.

Keywords—Computational modeling; computer simulation inverters; photovoltaic systems

1 Introduction

Nowadays, the need for electricity is growing at an unprecedented rate. In the report of the World Energy Outlook 2018 (International Energy Agency's flagship publication) were presented global energy trends. According this report the governments will have a critical influence in the direction of the future energy system. Under current and planned policies, modeled in the New Policies Scenario, energy demand is set to grow by more than 25% to 2040 [1,2].

Current energy consumption in the world is highly predominated with fossil fuel-based sources such as oil and gas, and their limited reserves and hazardous environmental effects are unequivocal [3,4]. Intensive efforts and major transformations are underway for the global energy sector worldwide to narrow the gap between conventional energy (CER) sources and renewable energy sources (RES) [5,6].

The main advantages of RES are: inexhaustible sources of energy (sun, wind, rivers, organic matter, etc.) and contribute to reducing the dependence on CER (oil, natural gas, coal); constitute (together with energy conservation) the most ecologically sound solution for the effective reduction of carbon dioxide emissions and the combating of the greenhouse effect; domestic sources of energy and contribute to strengthening the energy independence and security of supply at the national level and etc. [7,8,9]. The sun is the largest fully RES. Therefore, photovoltaic technologies have the greatest future among all RES. Solar photovoltaic (PV) systems are the fastest growing energy systems and they represent a technology that plays a crucial role in global electricity generation [10,11,12].

The purpose of the present study is to design the basic elements of a photovoltaic installation, to simulate its operational characteristics and to build and investigate the operation of network-connected photovoltaic (PV) system under real operating conditions. The investigated PV system with a power of 5kW is located on the roof of an existing residential building in the village of Cherniche, Blagoevgrad, Bulgaria.

2 Computer Simulation of the Designed PV System

2.1 Selection of photovoltaic panels, inverter and design software

The Q-Cells SE Q, BASE-G2 235 Rev03 235 W panels are used to build the PV system. They have higher performance than other modules thanks to the positive sorting technology (Figure 1) [13-18].

Their design allows for higher power output even under low light conditions and better performance due to optimized cellular distances. The model has a high standard of safety that includes a watertight coupling box between the modules, as well as an extremely stable frame, bend resistant, strong wind and snow.

The connection box and connectors have an IP rating class 68. The maximum back-up load capacity is 20 A. It provides reliable protection to prevent power losses from unwanted current leakage, hot-spot protection, and prevents short-circuit between module cells and fire occurrence. the panel is made of 3.2 mm armored glass, which withstand heavy snow and strong wind. It weighs only 20 kg, which greatly facilitates installation work. The solar panel achieves good efficiency even at low solar radiation.

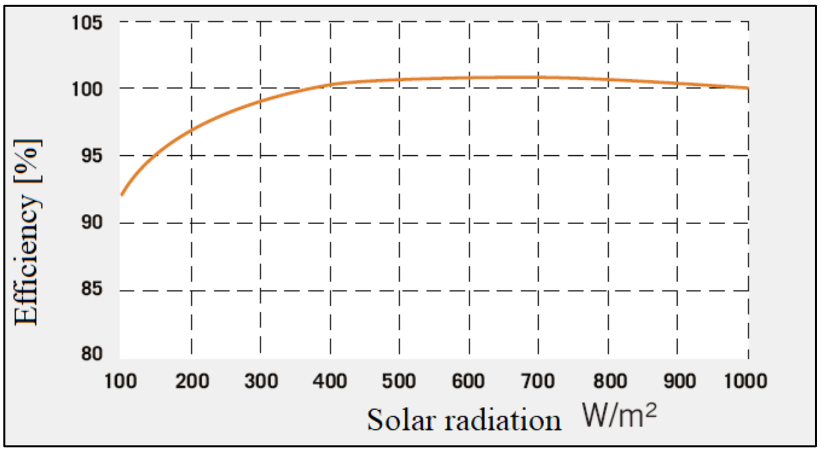

Fig. 1. Efficiency solar modules to solar radiation

The inverter used to realize the PV system is the Sunny Boy 5000TL (Figure 2). The three-phase inverter offers extremely high efficiency, up to 97%. It has a maximum input voltage of 750 volts, which expands the possibilities of installing a larger number of solar panels: max photovoltaic power 5250 W, max output power 240 - 5000W; frequency - 60Hz and max current -15A [15].

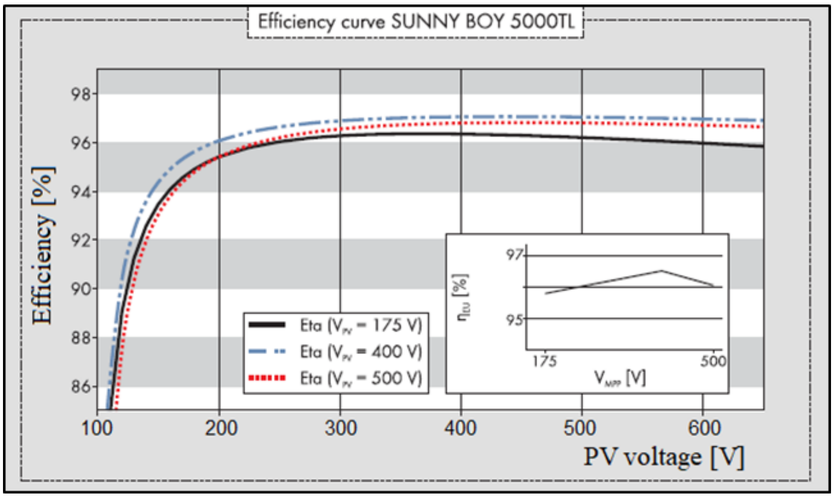

Fig. 2. Efficiency of the inverter performance against PV voltage.

An important advantage of the SB 5000TL inverter is the possibility of emergency power supply. In case of an accident in the power grid, the inverter redirects the generated energy from the photovoltaic system to service the home where it is installed [15-19].

The inverter has a shadow monitoring system called OptiTrac Global Peak. The system is based on an algorithm that monitors shading and adapts quickly to changes in solar radiation that mitigates shadow effects and leads to higher power. Through this system, we can reduce the impact of specific shaded areas on the performance of the photovoltaic system.

The SB5000TL enables real-time tracking of all recorded information from the installation of the inverter to the current moment. It has all the latest technologies for Internet connectivity.

The inverter collects information and records it on a cloud server of the manufacturer, which we can monitor and analyse at any time. The inverter collects information and records it on a cloud server of the manufacturer, which we can monitor and analyse at any time.

The system allows monitoring the status and readings of the inverter via the Internet from different devices such as laptops, tablets, phones.

2.2 Computer simulations

In the current work on the PV simulations, *PV Sol* software is used. The Blagoevgrad area was chosen for the computer design of the presented photovoltaic system. The investigated PV system is located in the village of Cherniche, Blagoevgrad (Figure 3).

The physical objects surrounding the PV system such as buildings, trees, and other parts can obstruct the light that is able to reach the PV array. One of the aims of the PV design is the minimization of shading, but some shading may be unavoidable, especially in residential rooftop systems.

The first stage of PV system design includes selecting and calculating the target power of the PV system; correct selection of solar panels and solar inverter; good planning of the overall investment; green energy prices survey for the specific region and preparation of all necessary legal documents and permits [15], [16].

The second stage involves computer simulations of the photovoltaic system that maximally reflect the specific features of the terrain and the roof structure in the computer model.

The results of the computer simulation of the PV system are presented in Figure 3. It shows that the maximum power that can generate the photovoltaic panels is 4.70 kW [15].

The program shows the operating range of the maximum power tracking system from 125V to 440V. It calculates the total power of the photovoltaic system - 4.6 kW [16].

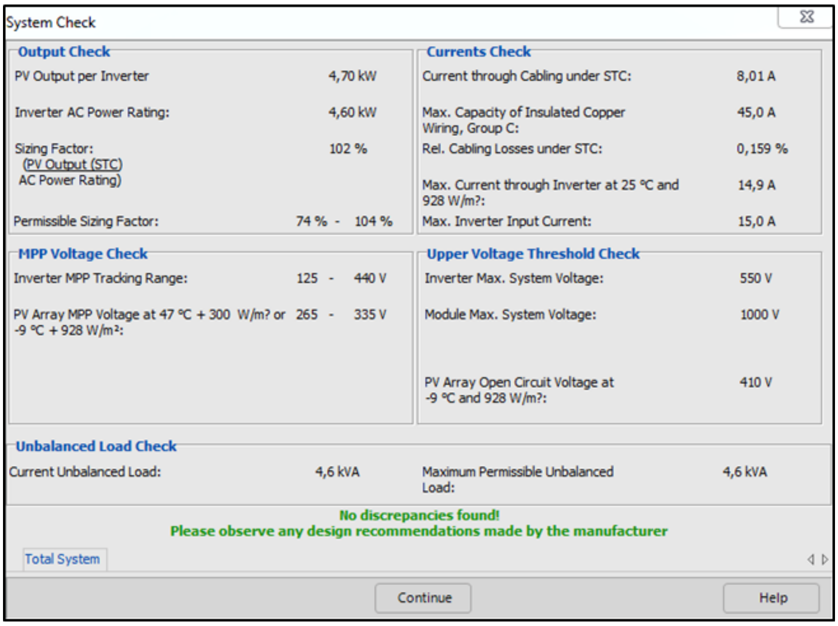

Fig. 3. Computer simulation of the PV system

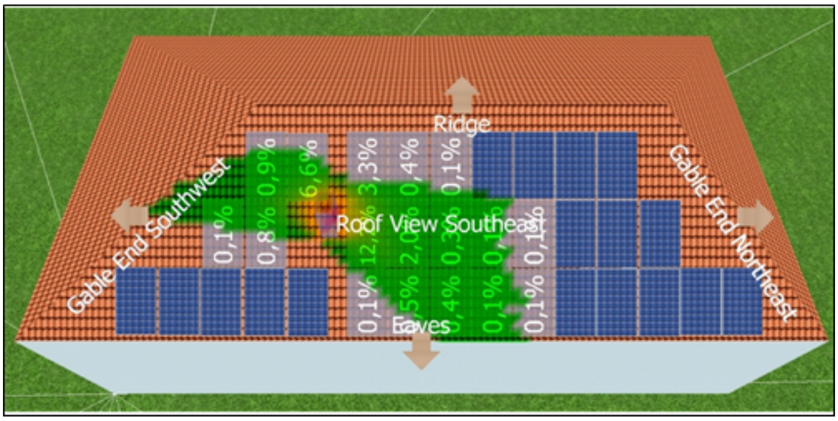

Fig. 4. Simulation showing percentage shading of solar panels

In the photovoltaic installation, 20 solar panels are installed. At the request of the Employer they have power 235Wp. Computer simulation of the PV system showing percentage shading of solar panels is shown in Figure 4. A block diagram of the built PV system is presented in Figure 5.

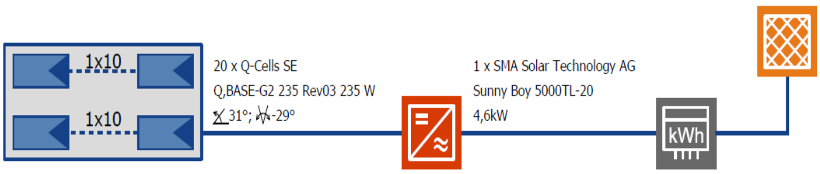

Fig. 5. Block diagram of the PV system

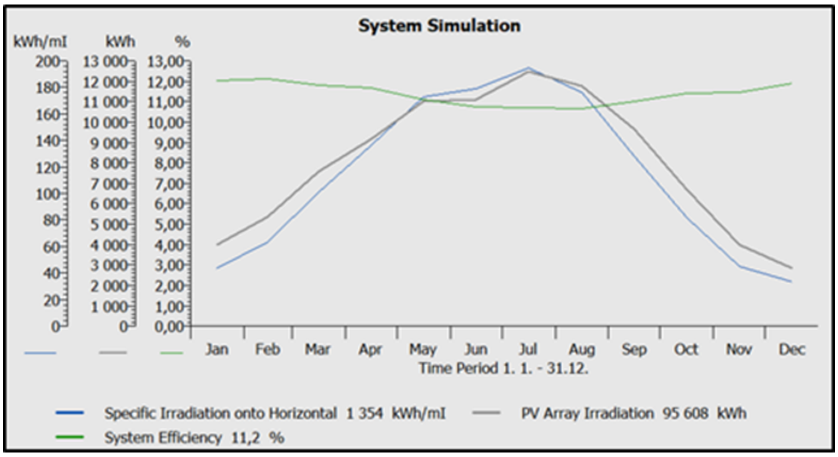

Fig. 6. Amount of energy generated by the PV system in 2018.

The results of the generated power of the 5kW built-in photovoltaic system by months over a period of 5 years are presented in Table 1.

The amounts of energy generated by the photovoltaic system and the percentage distribution of energy for 2018 are presented in Figure 7 and Figure 8.

Table 1. Generated power from the pv system for a period of 5 years

Months	2014	2015	2016	2017	2018
January	177,22	351,14	222,82	199,13	283,18
February	490,14	482,22	373,67	348,38	234,37
March	666,29	464,71	497,22	511,65	402,32
April	609,96	788,78	630,06	617,71	232,07
May	773,29	859,81	654,50	652,43	720,00
June	848,83	864,58	728,41	703,02	634,60
July	898,51	969,64	779,47	741,12	778,75
August	873,63	845,29	729,98	711,13	751,75
September	587,67	525,04	563,51	545,04	700,90
October	432,02	417,73	394,18	529,75	582,03
November	255,55	165,03	273,23	241,83	308,54
December	190,98	0,00	323,47	225,71	220,77
Total	6804,07	6733,97	6170,51	6026,89	6285,77

Percentage distribution of energy produced by the PV system for 2018 year is presented in Figure 7.

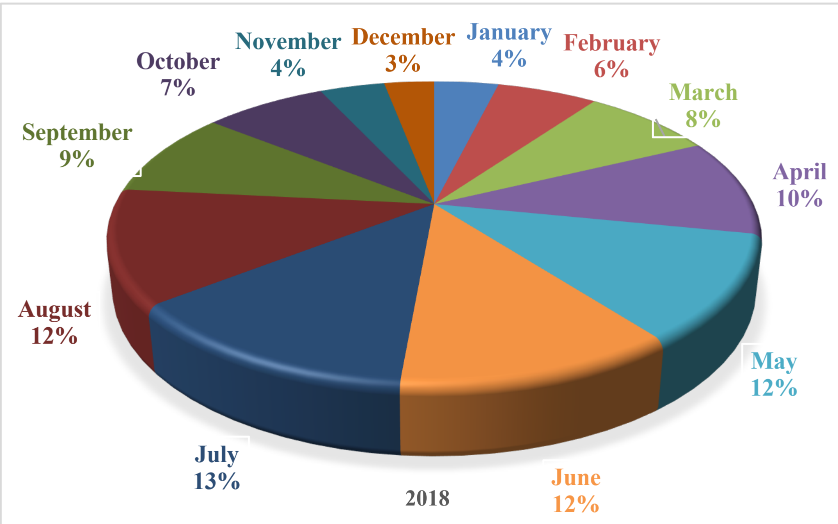

Fig. 7. Percentage distribution of energy produced by the PV system for 2018.

From these results, it can be seen that in May, June, July and August, the highest power generated by the PV system was generated (Figure 7). This is expected due to the power of solar power during this time of the year.

For the real-time monitoring of the PV system, the Sunny Portal monitoring platform was used. Through this software, the measured values are visualized and analyzed, a comparison of the extracted power over the years, which makes it possible to detect deviations in the operation of the photovoltaic system. The produced energy by the investigated PV system for 2013-2018 years is presented in Figure 8.

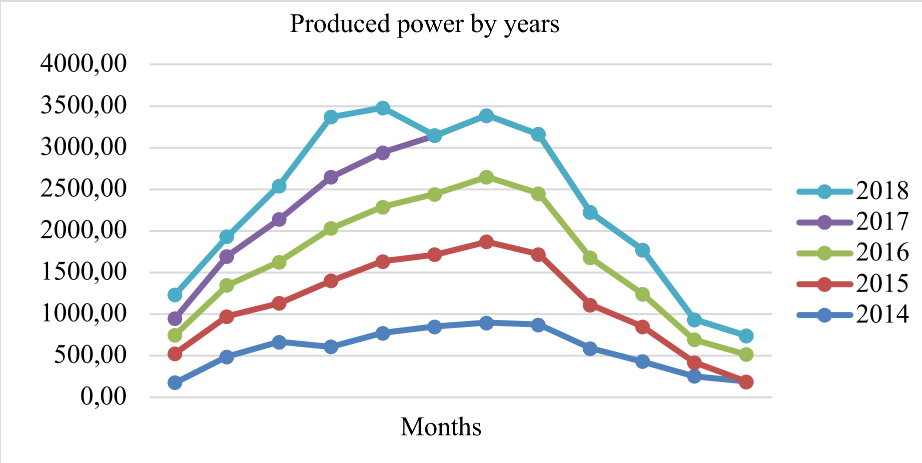

Fig. 8. Produced power by the PV system for five years.

PV-system for a household to supply electricity. According to Köhler et al. the green roofs and PV system can be used together and there is no clash between them [20]. These systems could bring positive effects to building energy conservation and improving of the urban environment [21-25].

3 Conclusion

A simulation study was carried out to determine the technical performance of 5kW grid-connected rooftop solar. The major findings of the present study are as follows:

- The annual energy yield determined for the system is a good indicator that grid-connected system installations in this region of Bulgaria are technically viable energy solution.
- The annual energy requirement from the electrical grid is reduced by using the proposed PV system.
- The grid-connected rooftop PV system in Cherniche, Bulgaria is technically viable, and the wider implementation of these systems will have substantial benefits in energy savings and CO_2 emission reduction.

Depending on meteorological conditions it can be concluded that year-round system generates power necessary for the needs of a household. The analysis of PV industry developments in recent years shows an approximate growth of around 40% per year.

In this work are presented results from the simulation and experimental research of photovoltaic system. The development of technology for the production of photovoltaic panels and rapidly changing climate tends to change, we can conclude that a photovoltaic system will have a better performance in operation than in the simulation. These technologies have enormous potential in countries with high solar resource.

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