

TECHNICAL ANALYSIS OF PHOTOVOLTAGE POWER PLANT 10KWP

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Abstract: The paper presents designing and dimensioning of a photovoltaic power plant with an installed capacity of 10 kWp. In this paper are presented the results of the prediction of the produced electricity on the annual and monthly level of the photovoltaic power plant, calculated using the SAM (System Advisor Model) software tool,. The selection and arrangement of photovoltaic panels, as well as the selection of the necessary inverters for the specific microlocation of the planned photovoltaic power plant, are shown in detail.

Key words: photovoltaic power plant, solar energy, photovoltaic panel, electricity

1. INTRODUCTION

The increasing need for electricity as the most useful form of energy has led to the rapid development of the photovoltaic industry throughout the world, as well as in Serbia. The sun is, directly or indirectly, the source of almost all available energy on Earth. If there were no energy from the Sun, there would be no energy obtained from other forms of renewable sources.

Solar energy is free, but the parts that make up a photovoltaic system are not yet economically competitive with conventional power plants. If, in the future, the cost of environmental pollution is included in the price per kWh of electricity produced from solar energy, photovoltaic (PV) power plants will become competitive with conventional power plants. The Regulation on incentive measures for the production of electricity using renewable energy sources was adopted by the Government of Serbia as an incentive measure that significantly accelerated the increase in the installed capacity of photovoltaic power plants in Serbia. The first PV power plants on the ground, more significant installed capacity, were installed in Serbia starting in 2013. Rooftop PV power plants have been installed in the past few years on educational facilities, as well as on industrial facilities in Serbia.

Mathematical modeling of PV power plants enables the application of developed software tools by leading companies, all with the aim of more accurately estimating the electricity generated and the return time of the invested investment. Mathematical models for the analysis and design of PV power plants, as well as examples of built PV power plants similar to the power plant presented in this work, are presented in detail in the literature [1-5].

2. DESIGN AND DIMENSIONING OF THE PV POWER PLANT

A PV power plant is a complex system composed of PV panels, DC distribution cabinets, protection systems, inverters, AC distribution and measuring cabinets, as well as points of connection to the distribution network. Designing and sizing a PV power plant requires very complex and demanding work. DC distribution cabinets and protective systems contain type elements for overcurrent protection (protection of PV panels from inverse currents), for overvoltage protection (protection against overvoltage due to the occurrence of direct or induced atmospheric discharge), as well as a disconnect switch (the role of the disconnect function in the event of a fault).

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2.1. Description of location and insolation

The building on the roof of which the installation of the PV power plant will be built is a building in Eastern Serbia. In the WGS coordinate system, the location in question is at a latitude of 44.240 N and a longitude of 22.525 E. This roof is constructed as a double roof with two roofs, with an inclination to the horizontal of 13°. The ridge of the roof is oriented in relation to the south-east direction at an angle of 30°. The facility itself is located on flat ground and there are no buildings or trees nearby that could cast a shadow on the side where the photovoltaic panels are planned to be installed.

Figure 1 shows the position of the selected microlocation on a satellite image of the terrain (Google Earth).

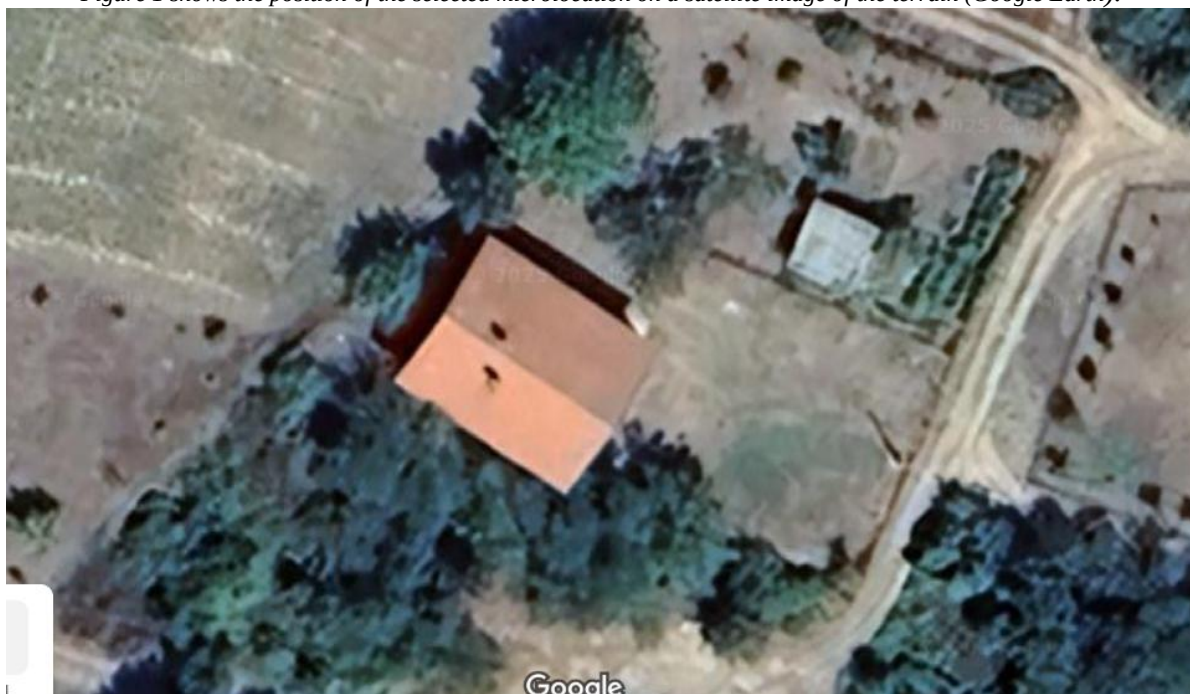


Figure 1 Object position

Figure 2 shows the distribution of surface solar radiation (W/m²) on an hourly basis, for a period of one year, for the Badnjevo location in Eastern Serbia, used in the SAM (System Advisor Model) software tool. SAM uses ASHRE meteorological input data in the form of so-called epw file, available on the Internet, and available in the software tool itself [6]. Figure 2 shows the total generated power (kW) from the photovoltaic power plant, in the territory of Badnjevo in Eastern Serbia. From Figure 2, it can be concluded that the generated power is the highest in the summer months, which is expected due to the length of the insolation. It is estimated that the existence of solar energy in the summer months is about 15h compared to the winter months when the same is estimated at about 9h.

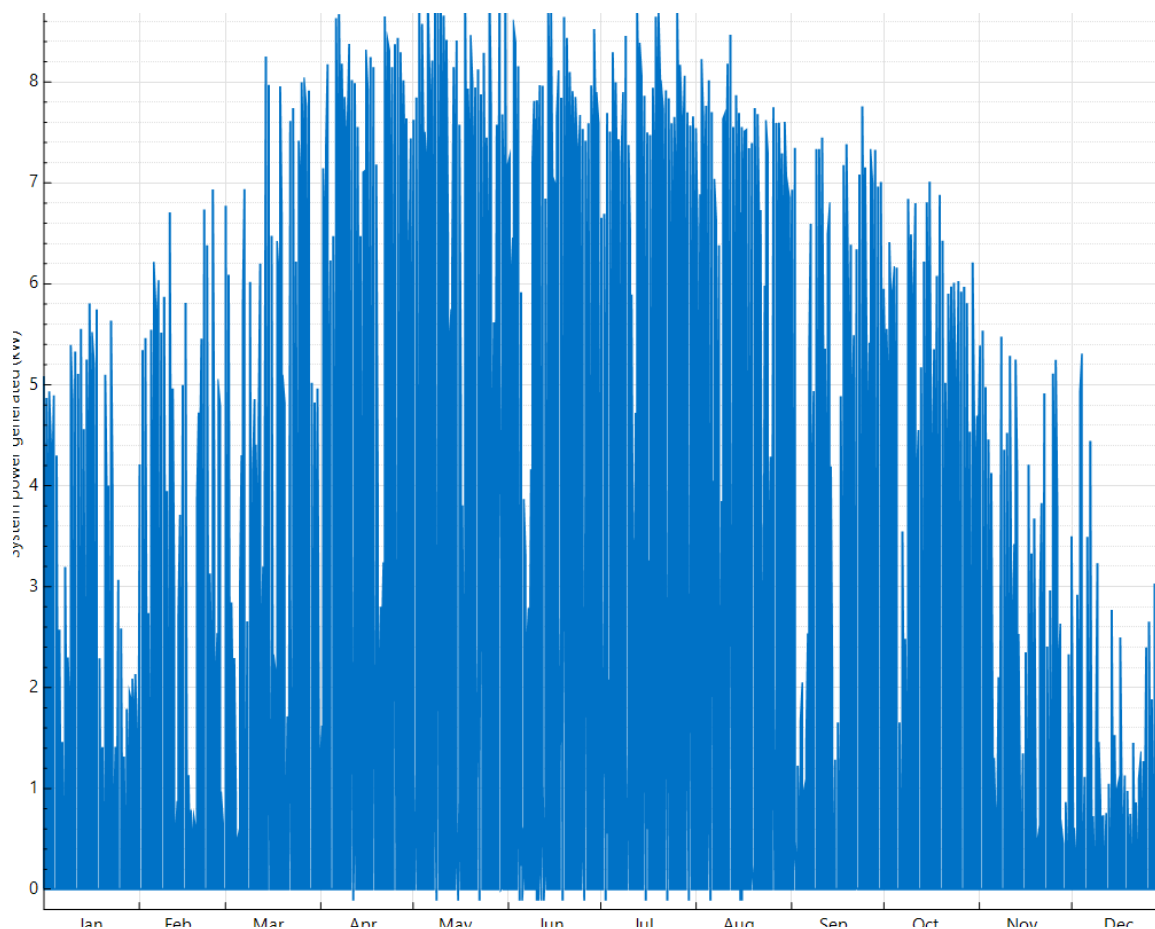


Figure 2 Total power generated (kW) from the photovoltaic plant

Figure 3 shows the average monthly electricity production (kWh) for an average one-year period compared to the previous ten-year period. From Figure 3, it can be concluded that the production of electricity is the highest in the month of July and amounts to about 2200 kWh, while it is the lowest in the month of December and amounts to about 250 kWh for a specific location. It can also be concluded that in the month of December, the amount of electricity produced is about 9 times smaller than in the month of July for an average year at the specific location. For an average four-person household, it can be concluded that the amount of electricity produced would be higher than needed in the summer, and insufficient to cover the required amount of electricity in the winter. That is why the producer-consumer category was introduced to enable the surplus of produced electricity to be injected into the distribution system, while the deficit is compensated from the distribution system when there is a need for it.

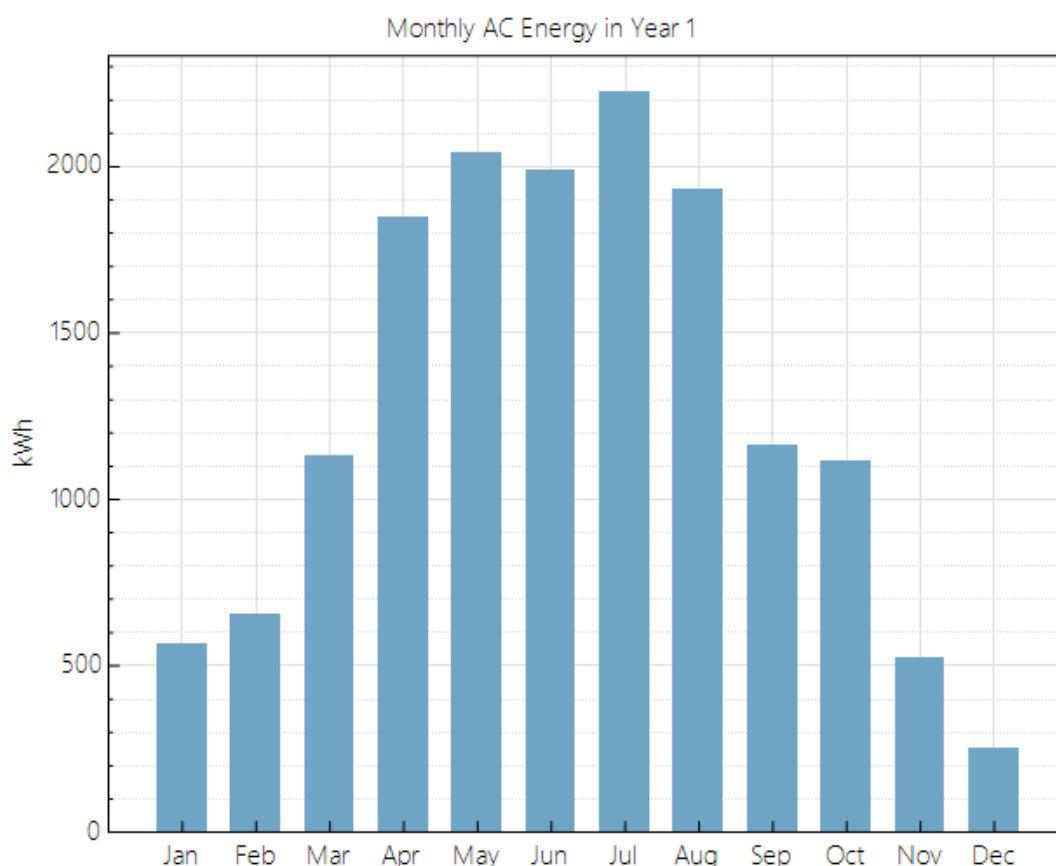


Figure 3 Average monthly production of electricity (kWh) for a one-year period

2.2. Description of the elements used in the photovoltaic power plant

By applying the SAM (System Advisor Model) software tool, calculations on the sizing of a 10 kWp PV power plant are obtained [9]. Figure 4 shows the characteristics of the selected 400Wp photovoltaic panel of the SunPower SPR-400 Wp type.

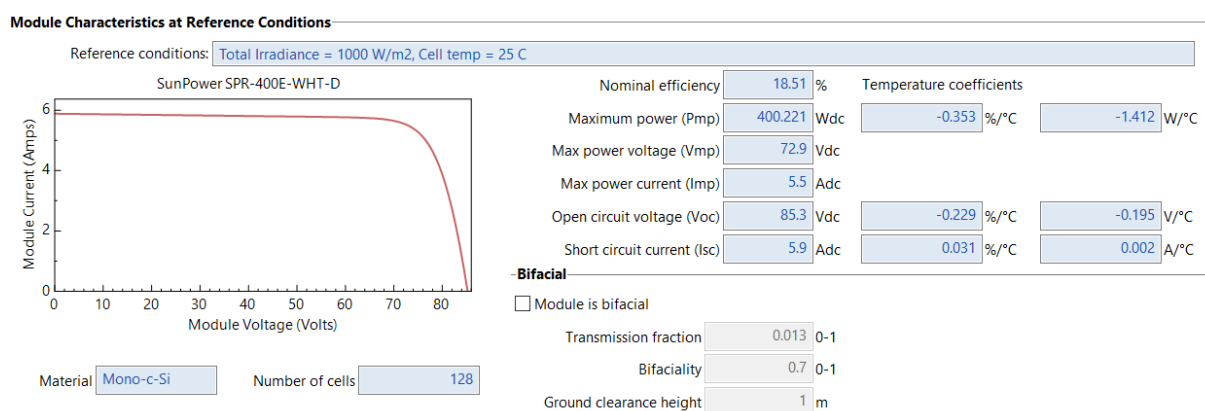


Figure 4 Characteristics of the selected photovoltaic panel SunPower SPR-400 Wp

For the photovoltaic power plant, 2 Tigo Energy type 5kW inverters were selected, the characteristics of which are shown in Figure 5.

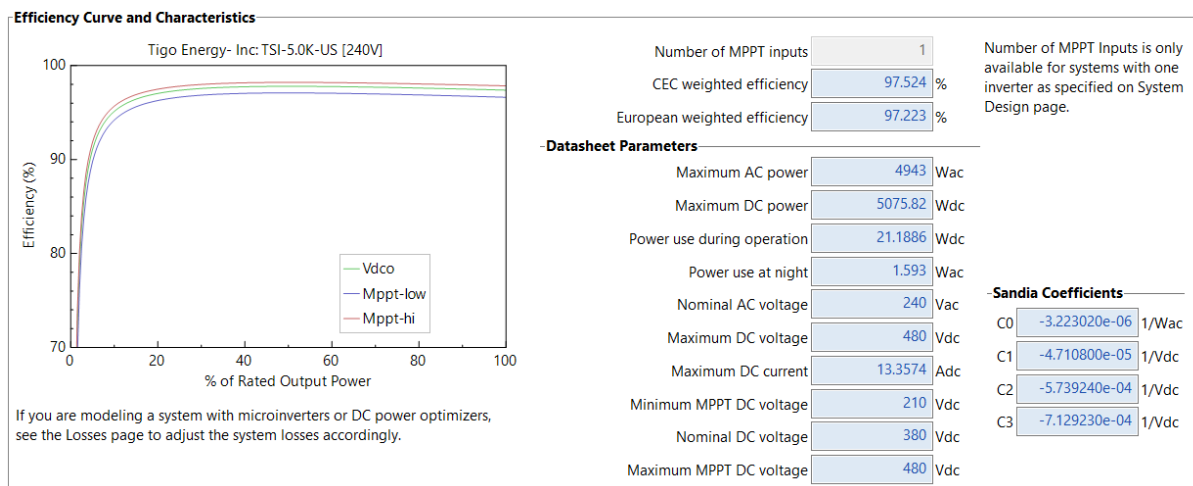


Figure 5 Characteristics of the selected Tigo Energy 5kW inverter

The total power of the inverter was chosen to correspond to the total power of the photovoltaic power plant and to make it possible at any time that the current DC power at the output of the photovoltaic power plant could be converted into alternating power by means of the inverter and be ready for consumption.

Figure 6 shows the arrangement of all 25 photovoltaic panels and the ratio of DC to AC power. From Figure 6, it can be concluded that the layout of the photovoltaic panels was implemented so that five panels were placed in five rows.

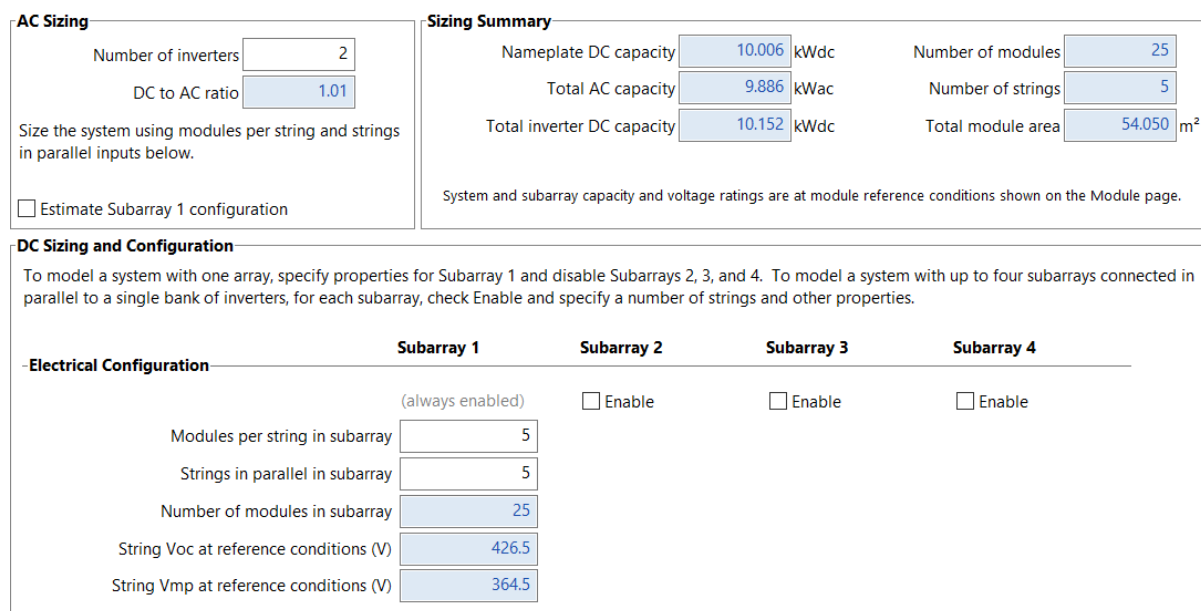


Figure 6 Characteristics of the photovoltaic system

In addition to the selected types of PV panels and inverters, the required elements of the PV power plant are also a DC junction box with overvoltage protection, a distributor on the alternating (AC) side, a substructure for mounting PV panels on a pitched roof, cables for solar installation (DC side), a measuring connection cabinet, a system for remote monitoring, diagnostics and monitoring of the operation of the power plant with an application license and a lightning protection installation (protection level II).

When mounting the PV panel support system, it is necessary to take into account the mechanical durability of the system, while taking into account all possible loads (mass of PV panels, snow, possible gusts of wind...). Therefore, in practice, a third of the load-bearing elements are buried and filled with concrete.

3. CONCLUSION

Designing and installing photovoltaic power plants requires detailed analysis and knowledge from various fields of technology and economics. In this paper, a part of the technical aspect and the selection of the basic elements that make up a photovoltaic system are analyzed. The number of installed systems that use renewable energy sources is increasing every day and represents a great challenge for the electric power system of each country as well as the electric power systems in the interconnection of neighboring countries.

4. REFERENCES

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