Power System Design Analysis for 150 WP Power Capacity

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Abstract. The main energy source is still predominantly using energy sources derived from oil, coal and natural gas. As it is known that this type of energy source is limited in number because it is a non-renewable energy source. The main result of this limited quantity is the increase in the price of petroleum in the market. The price of fuel in Indonesia, which continues to rise in line with world oil prices, is one of the causes of electricity tariffs in Indonesia to become increasingly expensive. Several studies have been conducted to overcome these problems, one of which is finding alternative energy sources as a substitute for non-renewable energy sources. One of the efforts made is by utilizing solar energy using solar cells. These solar cells can convert sunlight directly into electrical energy using the principle of "Photovoltaic Effect" without causing air pollution or water pollution. It cannot be denied that solar energy is one of the environmentally friendly energy sources and is very promising in the future, because no pollution is generated during the energy conversion process, and this energy source is widely available in nature. This paper is going to calculate the characteristics solar power plants using solar panels 150WP and calculate the maximum power generated by a solar power plant resulting from. So that it can be analyzed the performance of the system design the solar power plant for a power capacity of 150WP.

1. Introduction

The main energy sources are still dominated by energy sources that come from petroleum, coal, and natural gas. As it is known, this type of energy source is limited in number because it is included as a non-renewable energy source. The main result of this limited quantity is the soaring price of petroleum in the market. The increase in fuel prices in Indonesia, in line with world oil prices, is one of the reasons that electricity rates in Indonesia are increasingly expensive. Several studies have been conducted to overcome this problem, one of which is looking for alternative energy sources as non-renewable energy sources. One of the efforts made is by utilizing solar energy using solar cells. These solar cells can convert sunlight directly into electrical energy using the principle of "Photovoltaic Effect" without causing air pollution or air pollution. It cannot be denied that solar energy is one of the environmentally friendly energy sources and is very promising in the future because no pollution is generated during the conversion process. energy, as well as a source of energy, is widely available in nature [1].

The use of solar cells as an alternative energy source is considered very suitable for application in Indonesia. This is because Indonesia's position is on the equator so that the sun shines on the earth's surface for almost 12 hours a day. In clear weather conditions, the earth's surface receives about 1000 watts of solar energy per square meter. Unfortunately, this energy seems to be left wasted for natural purposes only [2]. With an energy source that uses a solar cell, there are several advantages including...
not being polluted, easy to move, close to the load center so that the energy distribution is very simple, there is no special maintenance, it can achieve long life.

Therefore, the application of Solar Power Plant (PV) technology by utilizing the potential of solar energy available in these locations is the right solution [3][4]. So this is deemed necessary for further study so that the study is technical in nature [5]. This study will analyze the results of the design of a solar power system with a power capacity of 150WP on a laboratory scale.

2. Research Methods

This study calculates the characteristics of solar power plants using 150WP solar panels and calculates the maximum power generated by solar power plants.

Solar Power (PLTS) that is made is as follows: the sun is shining, photovoltaic solar panels then capture the radiation produced from sunlight. This solar panel is a combination of several solar cells that are very small and thin in series, parallel or mixed (series and parallel). It becomes a solar panel that is large enough and can produce large currents and voltages as well. The working principle of the solar panel is that if sunlight hits the solar panel, the solar cell's electrons will move from N to P so that the terminal output from the solar panel will produce electrical energy. The amount of electrical energy produced by solar panels is different depending on the number of solar cells combined in the solar panel. The output of this solar panel is direct current (DC) electricity, which has a large output voltage depending on the number of solar cells installed in the solar panel and the amount of sunlight shining on the solar panel.

2.1. Tools and Materials

a) Tools

DC Multimeter

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![DC Multimeter](image-url)
A multimeter is a measuring instrument that measures electric current, electric voltage, and resistance or load. In this study, the multimeter used was a digital multimeter. Using 3 types of digital measurements:

1. Voltmeter
   A voltmeter is a measuring instrument used to measure the amount of voltage or electric potential difference between two points in an electric circuit energized by an electric current.

2. Ammeter
   An ammeter is a tool used to measure the strength of an electric current.

3. Ohmmeter
   An ohmmeter is a measuring tool for electrical resistance, namely the power to withstand electric current flow in a conductor. The amount of resistance measured by this tool is expressed in ohms.

b) Materials
The materials that need to be prepared in research on the process of solar power generation systems for a power capacity of 150 WP solar panel with dimensions of 148cm x 67cm x 3.5cm.

![150 WP Solar Panel](image)

Fig. 3. 150 WP solar panel

Solar cells directly convert sunlight into electrical energy without producing air or water pollution. Solar cells consist of two layers of semiconductor material. The first layer is positively charged, and the other layer is negatively charged. When sunlight enters the cell, some photons that come from sunlight are absorbed by atoms in the semiconductor layer, which frees electrons from the negatively charged cell layer to flow through a series towards the positively charged cell layer.

30A Solar Charge Controller Module
Solar Charge Controller is an electronic device used to regulate direct current, charged to the battery, and taken from the battery to the load. The solar charge controller regulates overcharging (because the battery is 'full') and the solar cell module's overvoltage. Overvoltage and charging will reduce battery life. The charge controller applies Pulse width modulation (PWM) technology to regulate charging the battery and releasing current from the battery to the load. 12 Volt solar modules generally have an output voltage of 16-21Volt, a regulator of output, and battery charging from solar panels is 12 Volt 40 Ah battery (2 x 12V / 20Ah battery)

The batteries used in solar power plants are the accumulator and LiFePo4 battery and accumulator. Lithium Iron Phosphate Battery (LiFePo4), also called LFP ("lithium ferrophosphate") battery, is a type of rechargeable battery, particularly lithium-ion battery, which uses LiFePo4 as its cathode material 500W DC to AC inverter
The inverter functions to convert the DC and voltage generated by solar panels into AC power current and voltage that can be utilized according to household electrical equipment (120 or 240 Vac, 50 or 60 Hz). There are several types of inverters, including the Grid-Tie Inverter (GTI) type. This type of inverter must match the frequency to the existing grid's input frequency, namely 50Hz or 60Hz, using a standard oscillator and limiting the output voltage so that it does not exceed the voltage of the network.

2.2. The Circuit Analysis Design Process
   a. Determination of the solar panels used so that there is no damage to the solar panels themselves in their use.
   b. Determination of the regulator's components to be used so that there is no misuse in the application that results in unfavorable or damaging solar panels and electrical equipment installed later.
   c. In terms of component use, it is also considered from an economic point of view and conditions in the market, so that the search for components will not experience difficulties.
   d. In terms of aesthetics, the tool's design can be made so that it is neat, attractive, and safe in use.
   e. Choose components according to system qualifications and requirements, such as BMS, BCR, or Solar Charge Controller and inverter.

2.3. Testing and Data Collection Process
   This study, testing the effect of the angle of incidence of the sun on the output of solar cells. This aims to determine how much influence the sun's angle of incidence is and how much influence the angle can be ignored. How the test is carried out, such as:
   a. Installation of a solar cell panel in a position perpendicular to the direction of the sun is done to determine the maximum output, while to determine the effect of the direction of the sun on the output of the panel is done by changing the direction of the solar cell panel until it reaches an angle of 90o to the angle of incidence of the sun. From these steps, the effect of the direction of sunlight on the output of the solar cell panels can be seen.
   b. Collecting data on the position/angle of the sun is very necessary. This aims to determine how much the angle of the sun shifts at certain intervals.
   c. This data collection is carried out from 8.00 to 16.00. The test results can be seen in the results table.

3. Result
   After testing and collecting data on the Analysis of Solar Power System Design for 150w Power Capacity, the data is calculated according to the research methodology procedures. The calculated data is the power data generated from the 150w solar panel. The following is a table of test results for a Solar Power Plant with a Power Capacity of 150w, which has been tested for five days with different time durations:
Table 1. Testing result on day 1

| Testing Time | Voltage (Volt) | Current (Ampere) | Average Power (Watt) |
|--------------|----------------|------------------|----------------------|
| 08.00        | 17.89          | 3.98             | 71.20                |
| 08.30        | 17.86          | 4.4              | 78.58                |
| 09.00        | 18.4           | 4.09             | 75.26                |
| 09.30        | 18.4           | 4.62             | 85.01                |
| 10.00        | 18.63          | 4.47             | 83.28                |
| 10.30        | 17.94          | 5.27             | 94.54                |
| 11.00        | 17.2           | 4.47             | 76.88                |
| 11.30        | 19.08          | 5.48             | 104.56               |
| 12.00        | 19.1           | 5.6              | 106.96               |
| 12.30        | 19.25          | 5.62             | 108.19               |
| 13.00        | 18.95          | 5.49             | 104.04               |
| 13.30        | 19.18          | 5.57             | 106.83               |
| 14.00        | 18.6           | 4.46             | 82.96                |
| 14.30        | 18.24          | 3.6              | 65.66                |
| 15.00        | 18.05          | 3.44             | 62.09                |
| 15.30        | 17.45          | 2.02             | 35.25                |
| 16.00        | 17.1           | 1.2              | 20.52                |
| 16.30        | 17.04          | 0.93             | 15.85                |

Fig. 7. Power yield efficiency graph day 1

The panel's position forming an angle of 90° with the sunshine's direction, will produce a maximum power of 120 watts (the sun's position when it is hot at 11.30 to 14.00). The maximum voltage in the test is 18.24 volts. The maximum current in the test is 5.1 Ampere. Next, we can use the Solar Charge Controller with a minimum current capacity of 19 Ampere. Next, the battery charging capability and the battery capacity when given a load will be carried out.

Table 2. Testing result on day 2

| Testing Time | Voltage (Volt) | Current (Ampere) | Average Power (Watt) |
|--------------|----------------|------------------|----------------------|
| 08.00        | 17.04          | 3.82             | 65.09                |
| 08.30        | 17.6           | 4.45             | 78.32                |
| 09.00        | 17.96          | 4.15             | 74.53                |
| 09.30        | 18.8           | 4.6              | 86.48                |
| 10.00        | 18.88          | 4.61             | 87.04                |
### Table 3. Testing result on day 3

| Testing Time | Voltage (Volt) | Current (Ampere) | Average Power (Watt) |
|--------------|----------------|------------------|---------------------|
| 08.00        | 16.97          | 3.98             | 67.54               |
| 08.30        | 17.4           | 4.36             | 75.86               |
| 09.00        | 17.87          | 4.22             | 75.41               |
| 09.30        | 18.98          | 4.32             | 81.99               |
| 10.00        | 18.92          | 4.5              | 85.14               |
| 10.30        | 18.96          | 5                | 94.80               |
| 11.00        | 18.57          | 5.02             | 93.22               |
| 11.30        | 18.66          | 5.08             | 94.79               |
| 12.00        | 18.99          | 5.43             | 103.12              |
| 12.30        | 19.12          | 5.5              | 105.16              |
| 13.00        | 19.16          | 5.3              | 101.55              |
| 13.30        | 19.17          | 5.34             | 102.37              |
| 14.00        | 18.89          | 4.88             | 92.18               |
| 14.30        | 18.43          | 3.56             | 65.61               |
| 15.00        | 18.04          | 3.38             | 60.98               |
| 15.30        | 17.45          | 3.39             | 59.16               |
| 16.00        | 17.06          | 0.98             | 16.72               |
The panel's position forms an angle of 90° with the direction of the sunshine will produce a maximum power of 120 watts (the position of the sun when it is hot at 11.30 to 14.00). The maximum voltage in the test is 18.29 volts. The maximum current in the test is 4.18 Ampere. Next, we can use a Solar Charge Controller with a minimum current capacity of 19 Ampere. Next, the battery charging capability and the battery capacity's capacity will be carried out when given a load.

Table 4. Testing result on day 4

| Testing Time | Voltage (Volt) | Current (Ampere) | Average Power (Waatt) |
|--------------|---------------|------------------|----------------------|
| 08.00        | 16.04         | 4.08             | 65.44                |
| 08.30        | 16.87         | 4.32             | 72.88                |
| 09.00        | 16.98         | 4.21             | 71.49                |
| 09.30        | 18.32         | 4.12             | 75.48                |
| 10.00        | 18.57         | 4.39             | 81.52                |
| 10.30        | 18.98         | 4.95             | 93.95                |
| 11.00        | 18.5          | 5.08             | 93.98                |
| 11.30        | 18.6          | 5.02             | 93.37                |
| 12.00        | 19.1          | 5.24             | 100.08               |
| 12.30        | 19.21         | 5.4              | 103.73               |
| 13.00        | 19.12         | 5.54             | 105.92               |
| 13.30        | 19.24         | 5.42             | 104.28               |
| 14.00        | 19.02         | 4.79             | 91.11                |
| 14.30        | 18.65         | 3.66             | 68.26                |
| 15.00        | 17.86         | 3.29             | 58.76                |
| 15.30        | 17.33         | 3.41             | 59.10                |
| 16.00        | 17.03         | 1.19             | 20.27                |
| 16.30        | 16.44         | 0.87             | 14.30                |
The panel's position forming an angle of 90° with the sunshine's direction, will produce a maximum power of 120 watts (the sun's position when it is hot at 11.30 to 14.00). The maximum voltage in the test is 18.10 volts. The maximum current in the test is 4.16 Ampere. Next, we can use a Solar Charge Controller with a minimum current capacity of 19 Ampere. Next, the battery charging capability and the battery capacity's capacity will be carried out when given a load.

![Power Yield Efficiency Graph Day 4](image)

**Table 5.** Testing result on day 5

| Testing Time | Voltage (Volt) | Current (Ampere) | Average Power (Watt) |
|--------------|---------------|-----------------|---------------------|
| 08.00        | 16.56         | 4.21            | 69.72               |
| 08.30        | 17.36         | 4.23            | 73.43               |
| 09.00        | 16.98         | 4.4             | 74.71               |
| 09.30        | 18.07         | 4.6             | 83.12               |
| 10.00        | 18.69         | 4.73            | 88.40               |
| 10.30        | 18.14         | 5.5             | 99.77               |
| 11.00        | 17.99         | 4.45            | 80.06               |
| 11.30        | 19.16         | 5.45            | 104.42              |
| 12.00        | 19.11         | 5.61            | 107.21              |
| 12.30        | 19.19         | 5.52            | 105.93              |
| 13.00        | 18.98         | 5.5             | 104.39              |
| 13.30        | 19.22         | 5.6             | 107.63              |
| 14.00        | 18.64         | 4.2             | 78.29               |
| 14.30        | 17.84         | 3.35            | 59.76               |
| 15.00        | 18.07         | 3.49            | 63.06               |
| 15.30        | 17.24         | 2.51            | 43.27               |
| 16.00        | 17.18         | 1.5             | 25.77               |
| 16.30        | 17.24         | 1.08            | 18.62               |
4. Conclusion

From the test results and test analysis, it was found that sunlight affects the solar cell's output. The brighter the sunlight received by the solar cell output, the greater and vice versa, the dimmer the output's light is getting smaller. This solar cell is a polycrystalline type which has an efficiency between 13-18%. So the maximum efficiency value is 17.56, so the solar cell is working optimally.

The following conclusions can be drawn from the analysis of the design of a solar power generation system with 150 WP solar panels: (a). The characteristics of the design are the position of the tilt angle of the solar module, namely forming an angle of 90° towards the sun according to the time, which results in an average open-circuit voltage (Voc) of 18.30 V and an average short circuit current (Ioc) of 4.15 A; The position of the tilt angle of the solar module when forming an Angle of 90° towards the sun produces an average Output Power (Pout) of 77W.

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