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Research Paper

The Effect of Using Monocrystalline Solar Panels on Alternating Current (AC) and Direct Current (DC) Lamps

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ABSTRACT

Background: Fossil energy is an energy source that comes from nature and contains hydrocarbons such as gas, coal, and oil. Many other forms of renewable energy are available in Indonesia, such as solar, wind, and hydroelectric energy. We know that Indonesia is located on the equator. So it has a very abundant source of solar energy. However, in Indonesia, solar energy has not been utilized optimally. Even though solar energy has a source of heat energy that can be used as electrical energy using solar panels. The purpose of this study was to determine the effect of the effectiveness of using monocrystalline type 150-watt solar panels on AC and DC lamps on the electricity generated and to make learning media from the results of this research. This research was carried out at the Physics Education Laboratory on January 25–31, 2019 and at the East Lampung MAN 1 school on March 8, 2019.
Method: The data collection method uses the experimental method. The research design was carried out to determine the effectiveness of using monocrystalline-type 150-watt solar panels on AC and DC lamps.
Result: Based on the results of the research that has been done, it can be seen that the value of the effectiveness of using monocrystalline type 150-watt solar panels on AC lamps is 26.62%. While the value of the effectiveness of using a 150-watt solar panel-type monocrystalline DC lamp is 73.58%. In addition, the product of this research is in the form of media posters, which are used as learning media.

Keywords: *Fossil Energy, Renewable Energy, Solar Panels, Effectiveness of AC and DC Lamps, Media Posters.*

INTRODUCTION

Many other forms of renewable energy are available in Indonesia, such as solar, wind, and hydroelectric energy. If humans are able to utilize available energy sources creatively and innovatively, we can create renewable energy. For example, by utilizing solar energy sources.

We know that Indonesia is located on the equator. So it has a very abundant source of solar energy [1,2,3]. However, in Indonesia, solar energy has not been utilized optimally. [4,5] Even though solar energy has a source of light energy that can be used as electrical energy using solar panels. Solar panels can absorb and store energy from the sun by placing them in the sun.[6,7] So that solar panels can be used to help turn on the lights for people who don't have electricity in their homes.

Energy from the sun is a source of energy that will never run out, and this energy can also be used as an alternative energy that will be converted into electrical energy using solar cells from sunlight.[8,9] The working principle of solar cells is to use the theory of light as a particle, as it is known that visible and invisible light have two properties, namely as a wave and as a particle known as a photon.[10,11,12.]

The load greatly affects the performance of the solar cell, which has a module capacity of 50 watts. At a load of 3 watts, 6 watts, or 9 watts, the greater the load given, the smaller the performance of the solar cell, and vice versa. The maximum efficiency value obtained from the performance of the solar cell is 98%, with a capacity of 50 watts at a lamp load of 3 watts.[13] Indonesia already has a solar power plant (PLTS) that is used for electricity in rural areas; this system is commonly known as the solar home system (SHS).[4] SHS is a small-scale system using solar modules of 50-100 Wp (Watt peak) and produces daily electricity of 150-300 Wh (Watt hours).[14]

Therefore, the source of solar energy is very useful and has good potential in Indonesia, especially in Metro City, which is in Lampung province. The power generated by solar panels starting in the morning continues to rise until 12:00 PM. And then the value drops constantly until the afternoon. The highest power is generated at 12.00 PM, which is when the sun is directly above us.[15] The conditions during the day are only 12 hours and not always sunny; sometimes the weather is unstable, sometimes cloudy, and sometimes rainy. The energy generated by solar panels on cloudy days ranges from 0.6–0.8 amperes, 0.9–1.9 amperes when it is sunny, and 2.0–3.2 amperes when it is sunny. The amount of electrical energy that can be generated is 8%. However, if the conditions are sunny, it can produce twice as much.[16]

Because of these conditions, the optimal absorption of solar energy in one day does not even reach 12 hours.[17,18] Therefore, it takes average data and how long the optimal absorption of solar energy takes each day to plan the load to be installed on alternating current (AC) and direct current (DC) lamps so that no blackout or battery discharge occurs too fast due to overload.

From the explanation above, the researchers analyzed and measured the effect of using monocrystalline solar panels with the same load on AC and DC lamps of 15 watts.

MATERIALS & METHODS

Materials

The tools and materials used in this study were a 150-watt monocrystalline type solar panel, a 12-volt battery, connecting cable, digital multimeter, inverter, generator, and 15-watt AC and DC lamps.

Methods

This study used a 150-watt monocrystalline solar panel used in AC and DC lamps. In this study, researchers used the experimental method[19] with the variables, namely the independent variable and the dependent variable. The independent variables are input power and output power, while the dependent variable is time.[20] Quantitative research is one approach that is much demanded by using numbers, starting from data collection, interpretation to the appearance of the results.[21] Sources of solar energy obtained, namely from solar panels that are placed under the sun.[22,23] The research was conducted at the Physics Laboratory of Muhammadiyah Metro University, and for product results from poster media, the research was conducted at MAN 1 School in East Lampung.

The object used is a monocrystalline 150-watt solar panel used in AC and DC lamps. The sample for this study consisted of AC and DC lamps with a power of 15 watts for each lamp, for a total of 4 lamps. Researchers used two treatments, namely charging from solar panels to batteries and the effectiveness of AC and DC lamps.

The data collection method used in this research is the experimental method. Researchers made quantitative observations. The steps for collecting data in this study include the following:

PROCEDURE

The steps used in conducting the experiment include:

a. Prepare tools and materials.
b. Assemble the tool as shown in Figure 1.

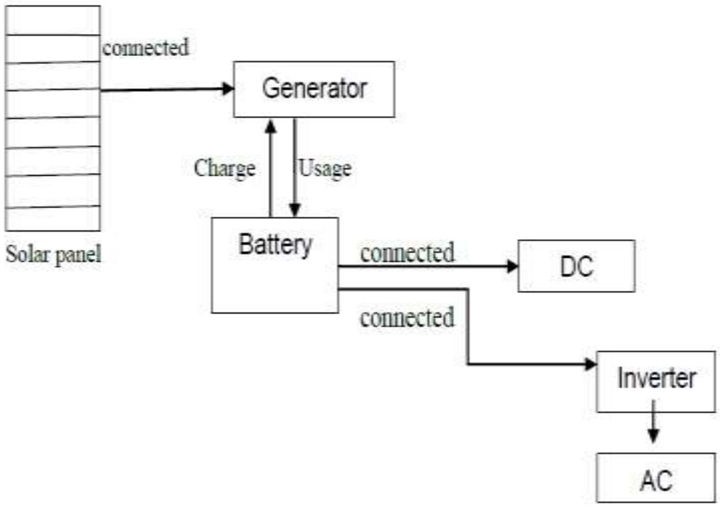

Figure 1. Solar panel design

c. Put the solar panel under the sun, then see how long it takes to charge from the solar panel to the battery.
d. Measuring the value of current, voltage, and power contained in a 150-watt monocrystalline solar panel.
e. Record the observed data in the table.
f. Make a diagram of the relationship between panel power and output power against time.
g. Draw conclusions from the experiment.

The data analysis used in this research is descriptive analysis. Researchers used data tabulations and experiments to analyze the data. Descriptive analysis aims to describe the results of the experimental data collection and the results of the feasibility assessment by looking at the average value. Researchers grouped data into two, namely in the form of numbers quantitatively and in the form of words qualitatively. The following is an analysis of direct observations, including:

a. The equation for determining the power on AC and DC lamps

$$P = I \; x \; V \qquad (1)$$

Where:

P = Power (W)
I = Current (A)
V = Voltage (V)

b. Equation to determine battery power

Battery power = Battery Capacity x 2 x time x Battery Voltage (2)

c. To fix the error

1) Error in solar panel charging

$$\Delta P = S_p = \sqrt{\frac{\sum \partial^2 P}{N(N-1)}} \qquad (3)$$

2)Error on AC and DC lamps

$$\Delta P = P_{maks} - P_{min} \qquad (4)$$

d. To determine the effectiveness value, the equation used is as follows:
The equation of the effectiveness of AC and DC lamps is:

$$Effectiveness = \left|\frac{P_{out} - P_{panel}}{P_{out}}\right| \qquad (5)$$

Where:

P_{panel} = Power of solar panel (Watts)
P_{out} = Power output on the lamp (Watts)

RESULT

Based on the results of the research that has been carried out, three types of data have been obtained: data on the results of charging solar panels, data on the results of voltage on AC and DC lamps, and data on the results of currents on AC and DC lamps. The data obtained are as follows:

Solar Panels

Based on the observations that have been made which contains charging data from the solar panel to the battery. It is known that if we look at the comparison between t and Ip (current in solar panels), the resulting Ip varies from time to time. This is due to the erratic weather conditions, which include sunny, cloudy, and sunny cloudy days. When it is sunny, the resulting Ip range is 3.7 amperes to 4.2 amperes; when it is cloudy, the resulting Ip range is 1.1 amperes to 1.7 amperes; and when it is cloudy, the resulting Ip range is 2.2 amperes to 2.9 amperes.

The following is a diagram of the relationship between Vp (voltage on the solar panel) and Ip on the solar panel, as seen in Figure 2.

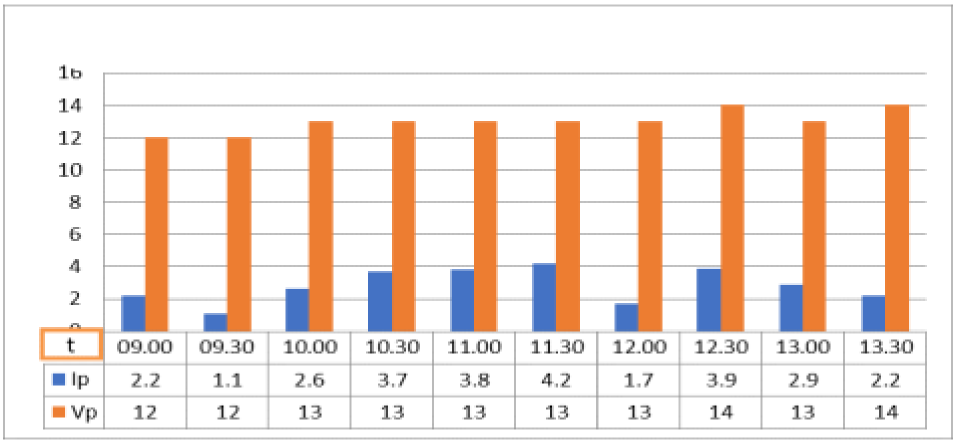

Figure 2. Current and Voltage Data Diagram on Solar Panels Against Time

When looking at t and Vp, Vp on solar panels ranges from 12 volts to 14 volts depending on the sky. But researchers cannot be sure that if the Vp on the solar panel is getting bigger, the Ip is also getting bigger. Sometimes a Vp of 14 volts produces an Ip of around 2.2 amperes and when a Vp of 14 volts produces an Ip of 3.9 amperes. Vp and Ip also depend on the sunlight received by the solar panels so researchers cannot control them because they occur naturally.

The following is a $V_{battery}$ diagram (voltage on the battery) and the percentage of the battery can be seen in Figure 3.

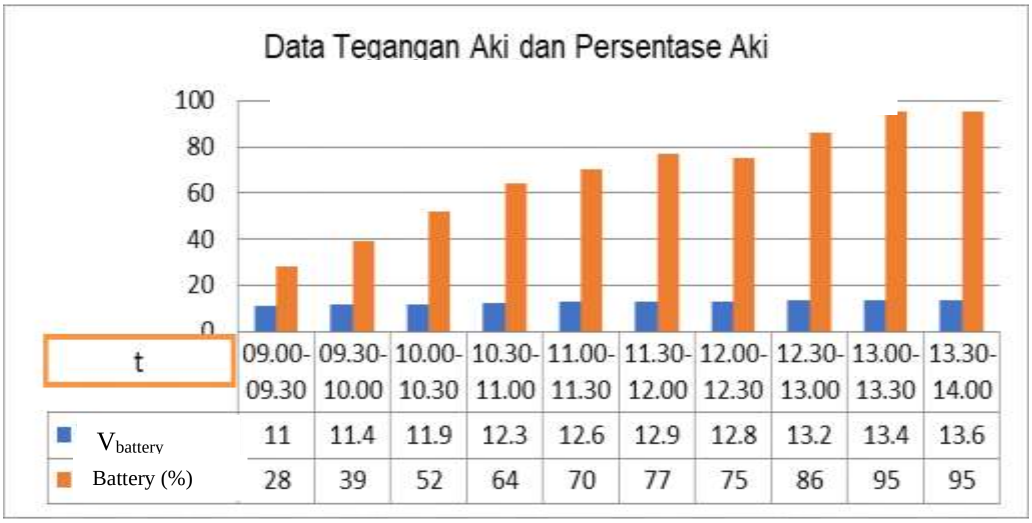

Figure 3. Battery Voltage Data Diagram and Battery Percentage

If you look at $V_{battery}$ and battery percentage, from time to time it has increased. At 09.00–09.30, the $V_{battery}$ was initially at 11 volts, with the battery percentage reaching 28% and continuing to increase. However, at 12.00–12.30, the $V_{battery}$ decreased, and the battery percentage was 12.8 volts and 75%. Then, at 13.30–14.00, $V_{battery}$ reached the highest peak of 13.6 volts with a battery percentage of 95%. $V_{battery}$ experienced a 67% increase in 4 hours and 30 minutes.

The following is a diagram of the relationship between Ppanel (power on solar panels) and T, as seen in Figure 4.

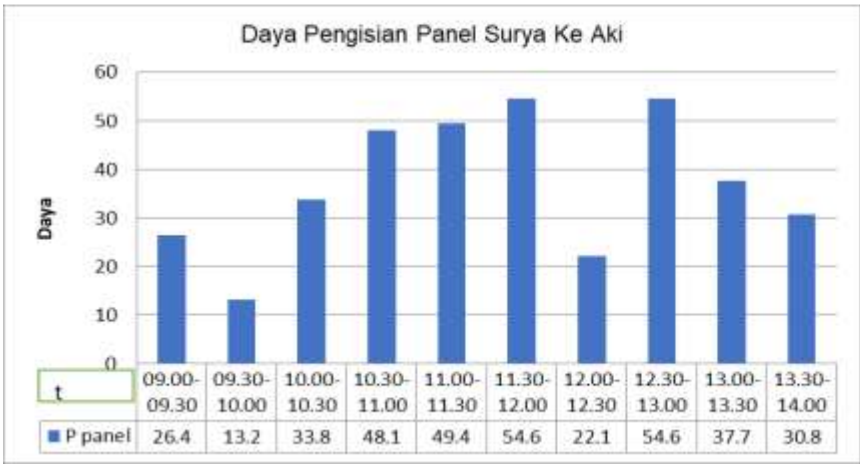

Figure 4. Solar Panel Charging Data Diagram to Battery

The panels produced an average of 37.07 watts. The highest Ppanel reached 54.6 at 11.30–12.00 and 12.30–13.00 with clear skies, while the lowest Ppanel was 13.2 watts at 9.30–10.00 with overcast skies. So that the error value obtained from Ppanel is 4.53 watts.

Data on the results of voltage, current, and power on AC lamps In the implementation, 4 AC lamps are arranged in parallel, with each lamp powering 15 watts, so that the overall lamp power load is 60 watts. The results of the data summary can be seen in Figure 5. Based on the diagram, the average value of Ip (current on the panel) is 2.65 amperes, and the average value of Vp (voltage on the panel) is 11.57 volts. The average value of Ika (current out of the battery) is 3.78 amperes. The average value of $V_{battery}$ (the voltage on the battery) is 11.03 volts.

The relationship between Ip and Ika and Vp and $V_{battery}$ can be seen in Figure 5.

Figure 5. Incoming and Outgoing Current Data Diagram and Incoming and Outgoing Voltages on AC Lamps

The following is a diagram of the relationship between Ppanel and Pout (output power on AC lamps) to t on AC lamps, as shown in Figure 5.

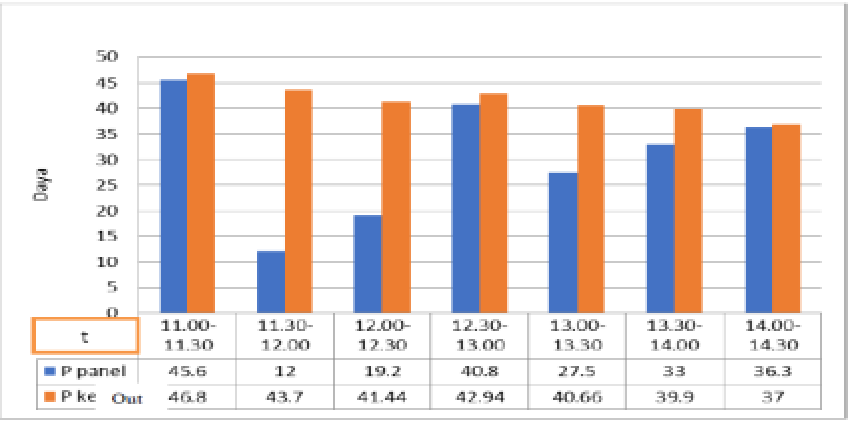

Figure 6. Incoming Power and Outgoing Power Diagram for an AC Lamp

Based on the diagram in Figure 6, the resulting average Pb (load power) is 33.46 watts. Ppanel's average reaches 30.62 watts. The resulting average output reaches 41.77 watts. It turns out that from the average results, Pout is bigger than Ppanel, meaning that the power is overloaded by 11.14 watts. So that the effectiveness value of the AC lamp is 26.62%. The percentage value of the effectiveness of the power on the solar panel versus the output power on the lamp means that the 150-watt monocrystalline solar panel is not effective for use on AC lamps.

Voltage, Current, and Power Result Data on DC Lamps

In the treatment using 4 DC lamps. The DC lamps are arranged in parallel, with each lamp having a power load of 15 watts, so that the total power of the lamp is 60 watts. From the observations, it can be seen in Appendix 8. From Figure 10, it is obtained that the average Ip value reaches 2.57 amperes. The average value of Vp is 12.62 volts. The average battery value is 12.22 volts. Ika's average value is 1.55 amperes. The average value of Vb is 11.82 volts. The Ip and Ika diagrams, as well as Vp and Vbattery on DC lamps, can be seen in Figure 7.

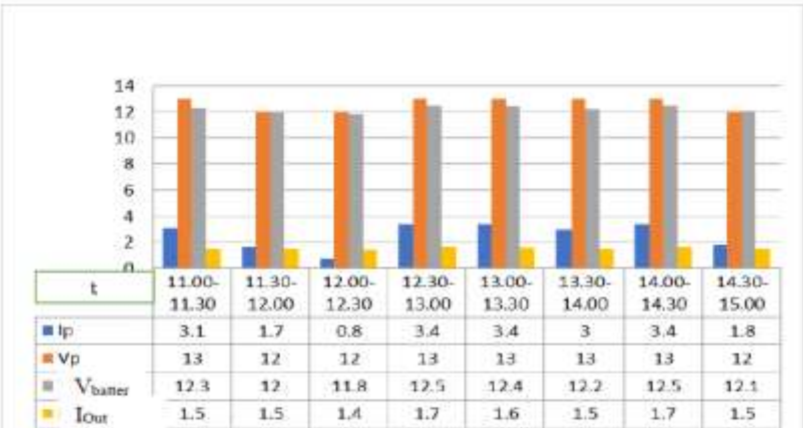

Figure 7. Diagram of incoming current, outgoing current, input voltage, and output voltage on a DC lamp

The following is a diagram of the battery percentage and Vbattery as shown in Figure 8.

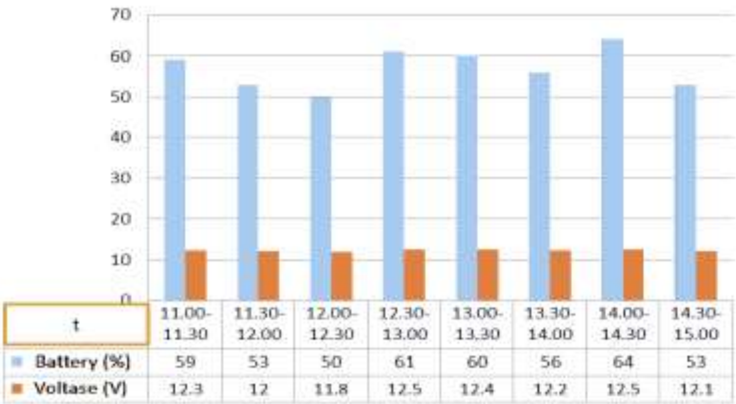

Figure 8. Battery Percentage and Battery Voltage Diagram on DC Lamps

Based on Figure 8, the average battery percentage value is 57%. In contrast to the resulting $V_{battery}$, which is unstable from 11.8 volts to 12.5 volts. The $V_{battery}$ that is produced each time is uncertain. As can be seen in Figure 9, the connection diagram of Ppanel and Pout to t on the DC lamp

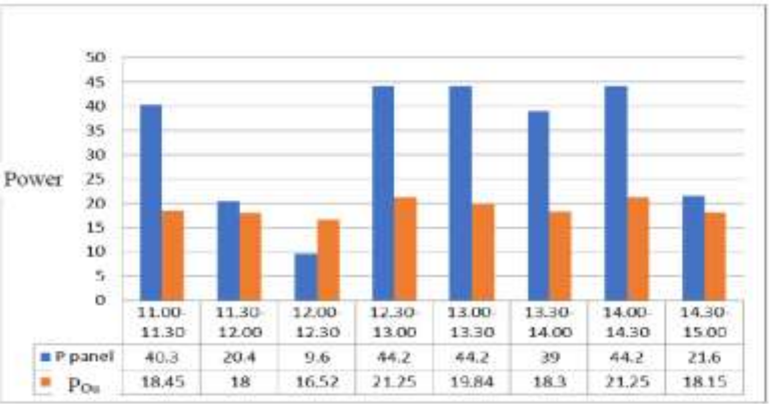

Figure 9. Panel Power Diagram and Power Out on DC Lamps

In figure 9, the average value of Ppanel reaches 32.93 watts. Meanwhile, the average output value reaches 18.97 watts. From these average results, Ppanel is bigger than Pkeluar, meaning that the power is not overloaded by 13.96 watts.

The effectiveness value produced by the DC lamp is 73.58%. The percentage value of the effectiveness of the power on the solar panel compared to the power that comes out of the lamp means that the monocrystallin type 150-watt solar panel is more effective for use on DC lamps.

DISCUSSION

Experimental research has been carried out, to determine the effectiveness of using 150-watt monocrystalline solar panels on AC and DC currents. The method used is the experimental method. The research location is at the UM Metro Physics Education Laboratory.

The research was conducted when the sun was bright and not cloudy or overcast. Data collection was carried out from 09:00 to 13:30, resulting in 10 data on AC current and DC current. Uses AC and DC currents are used in AC and DC lamps. The circuit used is a parallel electric circuit, because in AC current, if you use a series circuit, only one lamp lights up and the resistance becomes very large. The lamps used are AC and DC lamps with a value of 15 watts each of 5 pieces. The results of data collection can be explained as follows:

In AC lamps, the Ip produced by solar panels is unstable, which ranges from 1 ampere to 3.8 amperes. Likewise with the resulting Vp. The resulting Ip has an average of 2.65 amperes and an average Vp of 11.57 volts. At first the Vaki used was 12 volts with a battery percentage of 52%, but the longer it was used the Vaki decreased to 10 volts and the battery percentage was 0%. The average of Ppanel and Pkeluar is 30.62 Watt and 41.77 Watt respectively. The average value of the power generated between Ppanel and Pout turned out to be greater than the Pout value, meaning that the power on the AC lamp was overloaded by 11.14 Watts.

The effectiveness value of the AC lamp is 26.62%. The percentage value of the effectiveness of the power on the solar panel < the output power on the lamp, meaning that the 150 Watt monocrystallin type solar panel is not effective for use on AC lamps.

Ip values range from 0.8 amperes to 3.4 amperes. So that the average Ip is 2.57 amperes. Ip value from 0.8 amperes to 1.8 amperes with cloudy skies, for sunny conditions the range is 3 amperes to 3.4 amperes. while the resulting Vp value is in a stable state, with an average Vp of 12.62 volts. Ika value. And the resulting Vaki is stable, with an average of Ika. And Vaki of 1.55 amperes and 12.22 volts. Ppanel and Pkeluar have an average power of 32.93 Watts and 18.97 Watts. This can be interpreted that the value of Ppanel is greater than Pkeluar. So that the power on the DC lamp is not overloaded.

The effectiveness value produced by the DC lamp is 73.58%. The percentage value of the effectiveness of the power on the solar panel > the output power on the lamp, meaning that the 150-Watt monocrystalline type solar panel is more effective for use on DC lamps

If you compare the value of the effectiveness of using solar panels on AC and DC currents, it is found that the value of using DC current is much more effective than using AC current on solar panels. With a percentage of 73.58% on DC current and 26.62% on DC current. this shows that solar panels, will be much more effectively used on DC currents. With this effectiveness, the power generated by solar panels for use in DC currents and energy storage will be much better. Because if you use AC current, you still have to use an inverter, so the output current can be much greater than the incoming current.

CONCLUSION

- Charging a 150-watt monocrystalline solar panel to the battery produces an average Ip value of 2.83 amperes, an average Vp value of 13 volts, and an average Ppanel value of 37.07 watts.
- Charging time from solar panels to batteries ranges from 4 hours to 6 hours, with a battery capacity of up to 604,800 watts for two batteries.
- The effectiveness value of using monocrystalline 150-watt solar panels on AC lamps is 26.62%. While the value of the effectiveness of the use of monocrystalline type 150-watt solar panels on DC lamps.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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