Comparison Study of Solar Panels with Horizontal Turbine as an Alternative Electric Energy Source

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1. Introduction

The electricity demand in Indonesia is increasing due to population growth and infrastructure development across the nation. This resulted in the State Electricity Company (PLN) implementing electricity saving programs by rotating power outages in several areas. PLN applies this for reasons of efficient use of energy. According to Nehring (2009) estimates that the use of energy until 2050 still uses a lot of fossil fuels, namely petroleum, natural gas and coal. Although coal reserves are still abundant, if you continue to use coal fuel, carbon dioxide emissions will cause global warming. The existence of the effects of global warming raises public awareness to look for energy sources that do not damage the environment and can be renewed such as renewable energy (Fauzi et al., 2018).

Renewable energy is an energy source that comes from nature, this energy can be renewed such as water, wind, and sun. Renewable energy is easily applied anywhere like in people's homes. In addition, the use of renewable energy can overcome the high use of electricity. In addition, Indonesia is a tropical region that has enormous solar and wind energy (Rif'an et al., 2012).

Renewable energy that is practically applied in people's homes, namely the sun and wind. Solar energy sources also have the disadvantage of not being able to produce large amounts of energy in the rainy or cloudy season, so we need to find a solution. One solution is to utilize wind energy (Harmini & Nurhayati, 2018).

Utilization of solar energy by using solar panels can convert solar energy into electrical energy. Most solar cell uses are static or silent. This results in less optimal absorption of solar energy by solar cells. To get optimal solar energy, the solar cell position must always be perpendicular to sunlight. This research has designed a mechanical system that can adjust the position of the solar panel so that it always...
follows the direction of the coming of sunlight which is named the solar tracking system (Fauzi et al., 2018).

Some regions in Indonesia have sufficient wind potential as opportunities to be converted into electrical energy. The small gust of wind becomes an obstacle in the process of electricity conversion. Mechanical energy generated from wind turbine turns is not sufficient to meet the needs of generators. Therefore, high-efficiency wind turbines are needed, including horizontal axis turbines. The increase in the efficiency of this turbine is influenced by variations in the number of blades and materials used. In this study, the turbine to be made is a horizontal axis type turbine, or commonly known as HAWT (Horizontal Axis Wind Turbine) (Aryanto et al., 2013).

The purpose of this study is to compare the voltage, current and power generated by solar panels using a solar tracker with horizontal type wind turbines. Solar energy sources also have a weakness, namely that they cannot produce large amounts of energy in the rainy or cloudy season, so a solution needs to be found. One solution is to utilize wind energy.

2. Method

Data collection methods in research must use methods that are appropriate to the research to be carried out. The method that will be used in this research is quantitative research method. The data collection process in this study uses primary data. Primary data is data obtained directly from measurements at the time of testing. This data will be obtained during testing.

Data collection in this study will be carried out for 30 days starting at 8:00 to 16:00 with an interval of 1 minute every day. Measurement of light intensity is done by using a lux meter placed parallel to the solar panel. While the measurement of wind speed is done by using an anemometer that is placed parallel to the wind turbine. The height of the both measurement tools are 1 m from the ground. This is done in order to get accurate data of light intensity and wind speed.

Data collection on solar panels is done by measuring electrical current and voltage using ammeters and digital voltmeters. The data obtained is entered into the solar panel data collection table. While taking data on a wind turbine is done by measuring the wind speed produced. The data obtained is then entered into the turbine data collection table. (Oh & Jo, 2009).

2.1. Solar panel

Solar panels are devices used to convert solar energy into electrical energy.

![Figure 2.1. Solar Panels](image-url)
Table 1. Solar Panel Specifications

| Specification                        | Information |
|--------------------------------------|-------------|
| Max. Power (Pmax)                    | 50W         |
| Max. Power Voltage (Vmp)             | 16.5V       |
| Max. Power Current (Imp)             | 3.34A       |
| Open Circuit Voltage (Voc)           | 21.1V       |
| Short Circuit Current (Isc)          | 4.23A       |
| Nominal Operating Cell Temp (NOCT)   | 45±2°C      |
| Max. System Voltage                  | 1000V       |
| Max. Series Fuse                     | 16A         |
| Weight                               | 6.5Kg       |
| Dimension                            | 60 53 cm    |

2.2. Horizontal type wind turbine

A wind turbine is a device used to convert wind energy into electrical energy through generators. The number of blades used is three blades.

Figure 2.2. Horizontal type wind turbine
Table 2. Wind Turbine Specification

| Specification                  | Information |
|-------------------------------|-------------|
| Tower height / tower          | 1000 mm     |
| Generator (PMG type)          | 200 watt    |
| Diameter of the rotor         | 800 mm      |
| Blade length                  | 350 mm      |
| Blade width                   | 55 mm       |
| Edge blade width              | 35 mm       |
| Number of Blades              | 3 buah      |
| Blade material                | Fiberglass  |

3. Discussion

3.1. Description of Data

The data obtained from this study are the results of measuring electric current and electric voltage on solar panels using a solar tracker and non solar tracker, besides that, wind speed measurements are...
carried out as a comparison. Data collection is done by measuring using a lux meter measuring instrument to measure light intensity, anemometer to measure wind speed, a multimeter to measure current and voltage (DC). This research was conducted in campus area V Mechanical Engineering Education Study Program, Teacher Training and Education Faculty, Sebelas Maret University, Jl. Ahmad Yani No. 200 Pabelan, Kartasura, Sukoharjo.

3.2. Measurement of Electric Current in Solar Panels

The electric current generated by this solar panel is direct current (DC). The results of the data from the electric current were obtained by measuring it with a digital ammeter measuring instrument. This measurement of electric current is carried out to determine the amount of power generated by the solar panels. The data from the measurement of electric current is seen in Figure 3.1.

![Electric Current vs Light Intensity](image)

Figure 3.1. The relationship of the intensity of sunlight to electric currents in solar panels

Based on Figure 3.3 shows the electric current obtained by solar panels at different sunlight intensities. The higher the intensity of sunlight will produce a large electric current. When the light intensity is less than 16500 lux, no significant difference is seen in the resulting current. Meanwhile, when the light intensity is higher, the solar panels that use it will generate a larger electric current. When the intensity of sunlight reaches 27000, the solar panels generate an electric current of 1.72 Ampere.

3.3. Measurement of Electric Voltage on Solar Panels

The electric voltage generated by this solar panel is direct current (DC). The result of data from electric current is obtained by measuring it with a digital voltmeter. This measurement of electric voltage is carried out to determine the amount of power produced by the solar panels. Data results from measuring the electric voltage are seen in Figure 3.2.
Based on Figure 3.2 shows the electric voltage obtained by solar panels at different sunlight intensities. The higher the intensity of sunlight will produce a large electric current. When the light intensity is less than 22000 lux, a significant difference is seen to the voltage generated.

The highest light intensity of 28000 lux on the solar panel produces 15.17 volts. The resulting electric voltage tends to be not constant, ranging from 12.92 volts to 15.17 volts.

3.4. Measurement of Electrical Power in Solar Panels

The electric power generated by this solar panel is direct current (DC) electric power. The results of data from electric current are obtained by measuring using a formula. This measurement of electrical power is carried out to determine the amount of power generated by the solar panels. Data from the measurement of electric power is shown in Figure 3.3.
Based on Figure 3.3 shows the electrical power obtained by solar panels at different times. In the time span from 09.00 to 12.50, the condition tends to experience a very significant increase. The highest electric power occurred at 12.36 WIB. The power produced by solar panels is 26.42 Watts. The higher the intensity of sunlight will produce a large electric current. When the light intensity is less than 22000 lux, a significant difference is seen in the electric power generated.

3.5. Measurement of Electric Power in Turbines

Based on previous research conducted by an equation has been obtained to determine the electrical power in wind turbines using wind speed data, by using the equation:

\[ Y = 5.55X - 12.63 \]

Information:
- \( Y \): Power (Watt)
- \( X \): Wind Speed (m / s)

Wind speed data is measured at 20-minute intervals from 08.00 to 16.00 WIB. Based on the above equation and the wind speed data that has been obtained, it can be seen the amount of electric power generated by the turbine. Data from the measurement of electric power is shown in Figure 3.4.

![Figure 3.4](image-url)

Figure 3.4. The Relationship of Wind Speed to Electric Power in the Turbine

Based on the picture above, it shows that the wind turbine starts to produce electric power at a wind speed of 2.2 m / s of 0.02 Watt. The highest power obtained at a wind speed of 5 m / s is 6.46 Watt. This shows that the wind speed affects the electric power generated by the wind turbine.
Based on the picture above, it shows that the electric power generated in the turbine is different every time due to different wind speed conditions. The highest electric power is generated at 14.00 WIB at 6.46 Watt. This shows that the effectiveness of the turbine in obtaining electrical power between 11.40 s.d. 16.00 WIB. Wind speed tends to increase at this time.

3.6. Comparison of Solar Panels with Wind Turbines

Based on research data from solar panel testing, further research is carried out on solar panels to determine the electric power produced. Meanwhile, wind turbine testing is carried out by measuring wind speed to determine the electrical power produced. Then from the two test results a graph of the relationship between time and the electric power is generated (as in Figure 3.6.).

Based on figure 3.7. proved that solar panels generate electrical power that is more effective and optimal when compared to horizontal wind turbines. The highest electric power generated by solar panels is 26.42 Watt at 12.37 WIB while the horizontal wind turbine produces the highest electric power of 6.46
Watt at 14.00 WIB. This proves that solar panels produce optimal electrical power in a long period of time when compared to wind turbines. This shows that solar panels are more suitable to be used as alternative energy in the campus area Universitas Sebelas Maret Surakarta.

4. Conclusion
4.1. The highest electric power produced by solar panels is 26.42 Watt at a light intensity of 28000 lux.
4.2. The highest electric power generated by the horizontal wind turbine is 6.46 Watt.
4.3. The most effective use of alternative renewable energy sources in the campus area Universitas Sebelas Maret Surakarta to generate electricity is solar panels. Compared to wind turbines, solar panels generate more electric power.

5. Reference
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