The Effect of Solar Panel Efficiency Due to Temperature Changes Using Halogen Lamps on Polycrystalline Type Solar Modules

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ABSTRACT — Solar panels are a technology that utilizes solar energy to be converted into electrical energy. Solar panel technology can be used to generate electricity on a small scale to a large scale. The performance of solar panels depends on environmental factors, namely solar radiation and temperature. Environmental factors will reduce the electrical efficiency of solar panels due to the increase in operating temperature; the greater the temperature will affect their efficiency. Based on tests conducted on photovoltaic (PV) using halogen with different power, the greater the power value in halogen lamp light, the smaller the efficiency, while the more significant the temperature of the solar module, the smaller the efficiency. The more critical the increase in temperature, the more PV efficiency tends to decrease. The study's results show that a significant correlation between PV surface temperature and PV efficiency is inversely proportional. While the effect of temperature on efficiency can be said to be quite influential, in testing with a 300-watt halogen lamp, the error rate or R-value is 0.6339, while the 500-watt halogen R-value is 0.8493, which means it is more accurate and the effect is quite strong.

Keyword — Solar Energy, Efficiency, Temperature

I. INTRODUCTION

Electrical energy is a vital energy for human life. Almost everything is needed, ranging from basic needs such as household needs to business needs. Currently, the availability of electrical energy sources cannot meet the increasing consumption of electrical energy in Indonesia [1][2]. The temporary disconnections and rotational distribution of electrical energy are the impact of the limited electrical energy that PLN can distribute.

Energy needs are an indicator of increased prosperity. The use of solar energy in Indonesia has excellent prospects, considering the geographical area of Indonesia as a tropical country [3][4]. The use of solar energy through photovoltaic conversion is widely applied, including the application of individual systems and hybrid stem systems, namely combining conventional resources with renewable energy sources.

Around the world, energy is an essential issue for humans. Energy is classified into two different categories, namely non-renewable energy and renewable energy. As a result of world economic development, the world cannot continue to depend for long on fossil fuels (natural gas, oil, and coal) [4][5]. Most of the world's energy is produced from fossil fuels. Limited fossil fuel reserves cause fossil fuel prices to continue to rise. Renewable energy sources are becoming necessary because of their significant benefits. Among all renewable energy sources, *photovoltaic* (PV) energy is an efficient solution to renewable energy because it is non-polluting, abundant, and completely free of cost. PV energy is the energy that comes from the conversion of the sun into electricity. Today, PV systems are likely widely known and used in electric power [6][7]. This is because direct current electrical energy can be produced without environmental damage when exposed to solar radiation. One of the main obstacles facing the operation of PV panels is the conversion of PV cells, which are very low in electrical efficiency. It is also a significant obstacle for scientists and researchers to improve the electrical efficiency of PV cells.

One of the efforts to overcome the electrical energy crisis is to reduce dependence on fossil energy sources. This is because fossil energy is limited and cannot be renewed. Therefore, researchers are intensively finding alternative energy to meet electrical energy needs. Solar cells are one alternative that can be used because, in addition to easier maintenance, it is also friendly to the environment [8][9]. This solar cell utilizes sunlight that is converted into electricity; the intensity of light emitted from the sun is very influential on the efficiency of solar cells [9]. In addition, many other factors affect the performance of solar cells, such as wind speed, air mass, ambient temperature, solar cell temperature, and the characteristics of the solar cell material. The efficiency of PV plants is highly dependent on solar radiation and the operating temperature of PV panels. The cause of the low conversion of electric PV cells is overheating efficiency due to excessive solar radiation and high operating

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ISSN 0216-8685 (print); 2528-6889 (online)

temperatures. This is because in PV panels, only 15% of the sun's energy is converted into electricity, and the rest is converted into heat [10][11]. Therefore, in this study, the author will survey to determine the effect of increasing temperature on efficiency in *polycrystalline silicon-type* solar cells by simulating solar radiation using halogen lamp light.

The temperature of the upper solar panel changes during solar panel operation. The gradient of temperature increase is relatively large when the temperature of solar panels increases from the ambient temperature to the highest temperature. Solar simulators are needed to assist in solar energy experiments. Because many scientists simulate the performance of PV panels under controllable indoor testing facilities [12][14]. Solar simulators are light supplies that provide illumination near natural sunlight. Solar simulators can perform PV panel performance testing at a selected time, continue for 24 hours a day, and control for humidity and other aspects of the environment [13][15]. The goal of this study is to find out how much influence changes in light intensity have on the performance of solar modules and determine changes in the surface temperature of solar modules on the efficiency of *polycrystalline-type* solar modules.

II. Methods

First, tests were conducted in a closed room by varying the intensity of lamp light hitting solar panels using Halogen Lamps with several power variations. So, automatically, the surface temperature of the solar panel increases with the increase in time in testing. Data collection is carried out every minute until the 10th minute. Then, data collection is carried out every 3 minutes until the temperature reaches 100 ^{0}C for each different power on halogen lamps so that the data obtained is more specific. Furthermore, in this test, measurements were made on the parameters used to analyze the effect of lamp light and temperature changes on the efficiency of solar panels. Therefore, the measuring instrument is placed to be easier to remember and read. The parameters measured in the test are as follows:

1. Solar panel surface temperature (^{0}C)
2. The intensity of lamp radiation emitted to the surface of solar panels (Watts / m^2)
3. Current generated by solar panels (Amperes)
4. Voltage generated by solar panels (Volts)
5. Environmental Temperature.
6. This measured parameter then becomes input data from calculations to find the efficiency value produced by the solar panel.

The flow diagram of the research to be carried out is shown in the following Figure 1:

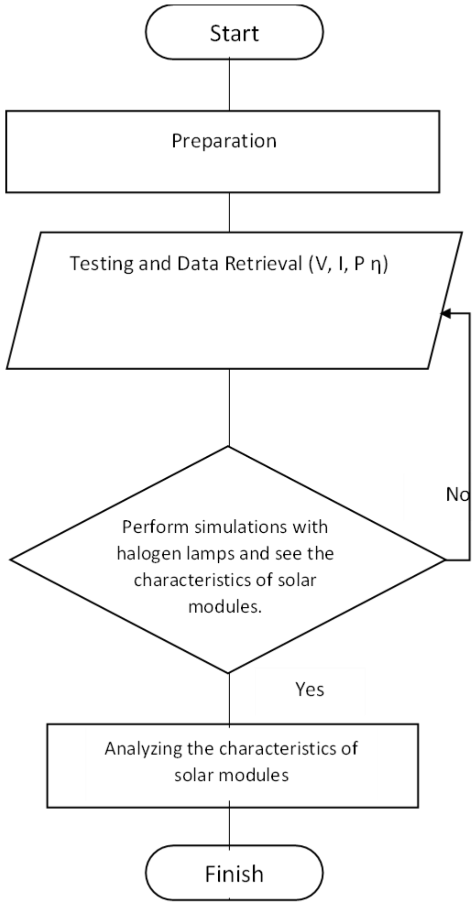

Fig 1. Research Flow Chart

III. Results and Discussion

In this study, before conducting testing and measurements, checks and inventories of equipment that will be used in testing include 1) Halogen lamp 300-500 watt; 2) Light holder post; 3) Polycrystalline Solar Module 100 wp; 4) Inverter; 5) Solar Charger Controller; 6) PV Cable and Connector; 7) Multimeter; and 8) Solar power meter.

The next stage is assembly and testing to see the magnitude of the irradiation value, current, voltage, and characteristics of solar modules; the measurements and tests carried out are seen in Figures 2, 3, and 4.

Fig 2. Testing

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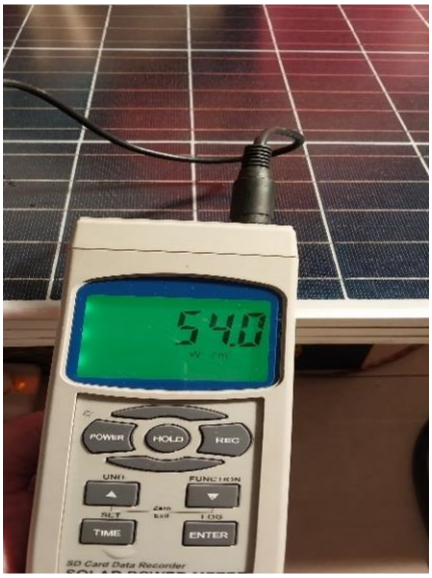

Fig 3. Irradiation Measurement

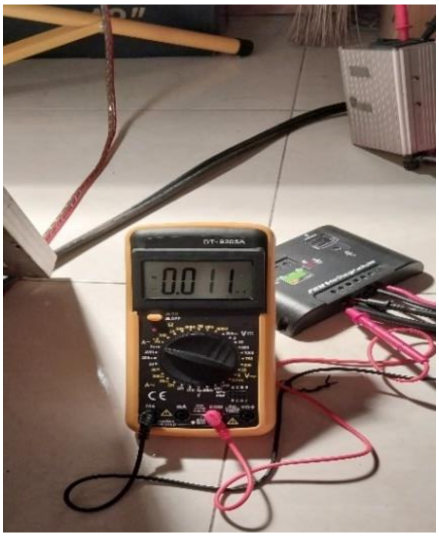

Fig 4. Current Measurement

Tests were conducted to determine several parameters to see the extent and how much influence changes in light intensity produced in 500-watt and 300-watt halogen lamps on the performance of solar modules and determine changes in the surface temperature of solar modules on the efficiency of *polycrystalline* solar modules. In this study, after making or assembling the module to be tested, it is measured to see the extent of changes in the parameters produced; this test is carried out for 120 minutes, where every 10 minutes will be calculated and recorded.

Tests using halogen lamps with a power of 500 watts and 300 watts were tested respectively; in the first test, we want to see the extent of temperature changes in solar panels with test times ranging from 10 minutes to 120 minutes, from the results of this test obtained results that can be seen in Figure 5 of the temperature measurement graph on solar panels.

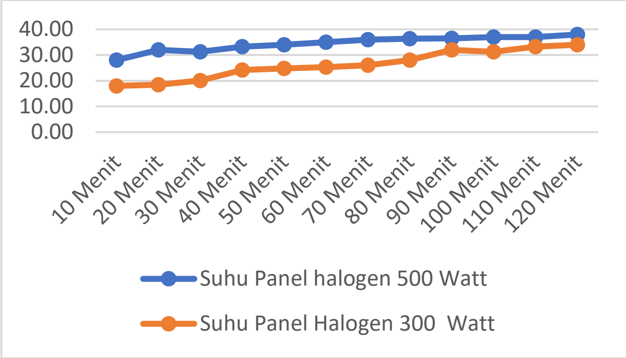

Fig 5. Temperature Measurement on Solar Panel

Based on the graph shown in Figure 5, when testing using 500-watt and 300-watt halogen lamps, the longer the exposure to light irradiation produced from halogen lamps causes the temperature on the surface of the solar module to increase. This is the same when the power from halogen lamps is getting bigger the surface temperature produced in solar modules increases.

While the irradiation produced by solar modules is increasing along with the amount of irradiation produced in halogen lamp light, it is shown in Table 1.

TABLE 1. TEMPERATURE AND IRRADIATION MEASUREMENT RESULTS

Halogen	Time (Menit)	Panel Temperature (°C)	Environmental Temperature (°C)	Solar Panel Radiation Intensity (W/m^2)
500 Watt	10	28,00	29,00	12,80
	20	32,00	29,00	13,50
	30	31,30	29,10	14,90
	40	33,20	29,10	15,80
	50	34,00	29,10	54,00
	60	35,00	29,30	60,00
	70	36,00	29,40	60,80
	80	36,40	30,00	74,90
	90	36,50	30,30	155,30
	100	37,00	31,00	155,30
	110	37,00	32,00	178,40
	120	38,00	32,00	218,80
300 Watt	10	18,00	24,00	10,80
	20	18,50	25,50	11,20
	30	20,10	25,90	11,70
	40	24,20	26,55	11,05
	50	24,75	26,90	11,28
	60	25,35	27,20	11,80
	70	26,00	27,45	11,45
	80	28,00	28,65	12,80
	90	32,00	29,00	13,50
	100	31,30	27,60	14,90
	110	33,20	28,10	15,80
	120	34,00	29,10	34,00

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ISSN 0216-8685 (print); 2528-6889 (online)

Furthermore, to determine the magnitude of the influence of temperature on efficiency on polycrystalline type solar modules, it is necessary to know the amount of current and voltage produced in the solar module to see the extent of the efficiency produced, based on the results obtained in the effects seen in table 2.

TABLE 2. CURRENT AND VOLTAGE MEASUREMENT RESULTS

Halogen	Time (Menit)	Present on solar panels (Ampere)	Panel Voltage (Volt)
500 Watt	10	0,50	14,23
	20	0,62	16,20
	30	0,70	16,40
	40	0,84	17,80
	50	1,13	17,00
	60	1,14	18,00
	70	1,20	18,45
	80	1,35	19,51
	90	1,45	19,87
	100	1,70	20,10
	110	1,82	21,20
	120	1,94	22,32
300 Watt	10	0,28	11,23
	20	0,30	11,80
	30	0,35	12,30
	40	0,41	13,53
	50	0,45	13,75
	60	0,46	13,80
	70	0,48	14,03
	80	0,50	14,23
	90	0,62	16,20
	100	0,70	16,40
	110	0,84	17,80
	120	1,13	17,00

In Table 2, with the value of current and voltage increasing, if exposure to light irradiation of halogen lamps hits solar modules, halogen lamps that have greater power, the present and voltage produced are also significant. In measurements with a 500-watt halogen lamp, the measured current is 1.94 Amperes when the exposure time to halogen lamp light irradiation is 120 minutes, while the measured voltage is 22.32 volts. For a 300-watt halogen lamp, a current of 1.13 Amperes and 17-volt voltage values are read with a test time of 120 minutes. The greater the power in halogen lamps, the faster irradiation received in solar modules, where when the power of 500 watts is significant, the current is measured by 0.50 Amperes within 10 minutes, while using a 300-watt halogen lamp, the wind is 0.28, which means half of the power value in a 500-watt halogen lamp.

To see the efficiency value of the effect of temperature changes on solar modules, data in Table 1 of the measurement results are used, and calculations are obtained, as shown in Figure 6.

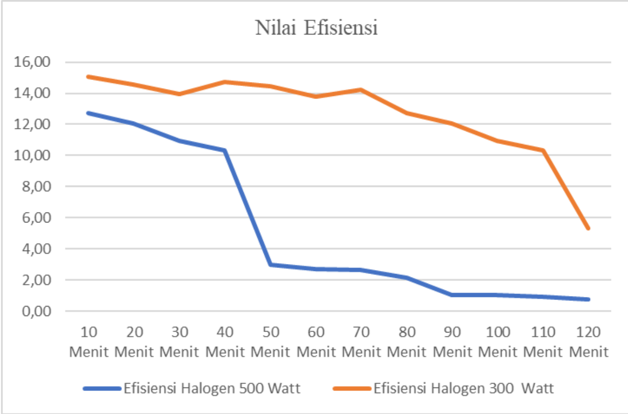

Fig 6. Solar Module Efficiency Value

From Figure 6 of the graph of the efficiency value of the solar module, it can be said that significant power in a 500-watt halogen lamp has a lower efficiency value than that of a 300-watt halogen lamp. Based on the data obtained, the amount of energy in halogen lamps affects the efficiency value of solar modules. The next stage is to determine the extent of the influence of temperature on efficiency by modeling the time of the relationship between the input variable, in this case, temperature, and the efficiency output variable. The results that have been done are obtained results shown in graphs in Figures 7 and 8.

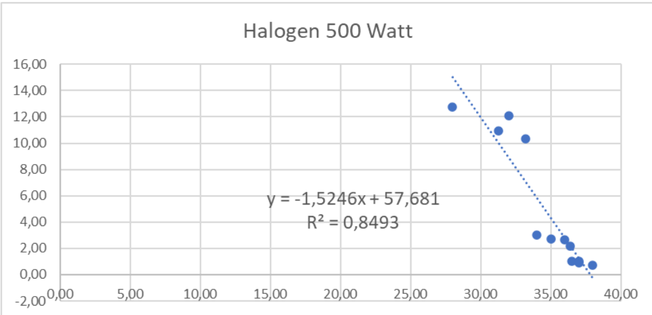

Fig 7. Graph of the Value of the Effect of Temperature on Efficiency

Based on the graph in Figure 7, from the model that has been carried out, the R-value is 0.8493, which means that from the modeling carried out the error is quite good; in other words, the temperature of the 500-watt halogen light hitting the solar module has a strong enough influence on the efficiency value. In another test, the same thing was done using a 300-watt halogen, shown in the graph in Figure 7; the effect of temperature on efficiency was obtained with an R-value of 0.6339, meaning that in a 300-watt halogen, it is said that the impact is there but not too large.

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ISSN 0216-8685 (print); 2528-6889 (online)

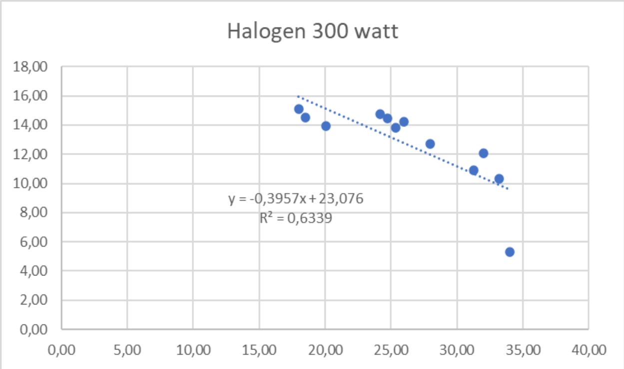

Fig 8. Graph of the Effect of Temperature on Efficiency

Based on modeling made and known, it can be said that 500-watt halogens have a more substantial influence on temperature and efficiency than 300-watt halogens. The greater the power from halogens, the greater the solar module's temperature affects its efficiency.

From the model carried out, we need to look at the Mean Absolute Percentage Error (MAPE) value, which measures relative error; in other words, MAPE is a measure of relative accuracy used to determine the percentage deviation of prediction results. This approach is practical when the size or size of the forecast variable is essential within the estimated range of estimates. MAPE shows how big the error in a forecastle is compared to the actual value. The smaller the MAPE, the more accurate the forecasting. This means that a model that has a MAPE value of 5% is a better model for predicting than another model that has a MAPE of 10%. MAPE values are interpreted from the value intervals in the table.

TABLE 3. MAPE VALUE INTERVAL

Nilai MAPE	**Interpretasi**
≤ 10	Forecasting results are very accurate
10 - 20	Good forecasting results
20 - 50	Forecasting results are decent (good enough)
> 50	forecasting results

To get the MAPE value based on the data obtained and the equation in Figures 5.6 and 5.7, we can calculate the value of % absolute error and get the value of Mean Absolute Percentage Error (MAPE) obtained from the results shown in Table 4.

Table 4 shows the magnitude of the Mean Absolute Percentage Error (MAPE), where the more significant the error value, the greater the deal, which means there is no significant influence between the variables. With the tests that have been done, the power of the 30 and the power of the 300-watt halogen lamp is high in error or accuracy is good, compared to 500-watt halogen, but efficiency exists in the two tests carried out.

TABLE 4. RESULT OF MAPE VALUE EFFECT OF TEMPERATURE ON EFFICIENCY

Halogen	MAPE
500 watts	44,22
300 watts	13,37

In research that has been carried out, the test time is limited to only 120 minutes or 2 hours; this is a start to see the characteristics of solar modules when exposed to halogen lamps, where testing is carried out using halogen lamps with different power. Further testing can be done with the development and power variation of halogen lamps that are larger or can also use other types of solar modules.

IV. Conclusion

Based on the tests and results obtained in this study stated that, when testing using a 300-watt halogen lamp, the efficiency of a polycrystalline type solar module was 5.33 when the test time was 120 minutes with a temperature of 34 0C while testing using a 500-watt halogen lamp obtained the efficiency results of a polycrystalline type solar module worth 0.74 when the test time was 120 minutes with a temperature of 38 0 C So that in the research that has been done by looking at the comparison of testing using a larger halogen lamp capacity, the more power efficiency that polycrystalline type solar modules have, the smaller the efficiency value, otherwise if the power of halogen lamps is small, the greater the efficiency.

The study found that the greater the significant temperature increase, the lower the latency. Based on the study results, a substantial correlation between PV surface temperature and PV efficiency is inversely proportional. While the effect of temperature on efficiency can be said to be quite influential, where in testing with a 300-watt halogen lamp, the error rate, or R-value, is 0.63R-valuable the 500-watt halogen R-value is 0.84R-value means it, is more accurate and the effect is quite strong.

Acknowledgment

The author would like to thank LPPM through the PLN Institute of Technology for funding and supporting this trial. Hopefully, this article will be helpful.

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ISSN 0216-8685 (print); 2528-6889 (online)

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ISSN 0216-8685 (print); 2528-6889 (online)