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Analysis of System Degrees of Tilts of Solar Panel for Energy Utilization Using Solar Test Simulator

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ABSTRACT

The design of the Solar Panel Test Simulator by means of setting the solar panel placement stand so that the designed tool is able to provide a simulation of solar panel measurements based on actual conditions. The performance of the solar panels is shown through a monitor display placed on the design that will contain information about the solar panels as a whole. Limitations in placing the position of the solar panel will not provide a reference regarding measurement conditions based on the angle of incidence of the sun, so it is necessary to do further design regarding the position of the solar panel when the measurement is carried out. The development carried out in the design of this tool is in the form of setting the solar panel mount in the form of a solar panel mount tilt of 450, 900, 1350, and the distance of the halogen lamp 30cm as the energy source is measured. The measurement results are based on an average design temperature difference of 0.49% with a voltage of 1.55%.

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1. INTRODUCTION

1.1 Background

This invention relates to the design of the Ramp Solar Test Simulator Solar Panel Design. The design of the Solar Panel Test Simulator by means of setting the solar panel placement stand so that the designed tool is able to provide a simulation of solar panel measurements based on actual conditions. The design of the Solar Test Simulator design by providing light variation values through voltage settings and light distance according to conditions during measurement. The performance of the solar panels is shown through a monitor display and contains information about the solar panels as a whole.

The application of solar panel testing equipment with several methods using various existing light sources such as incandescent, LED and halogen lamps is carried out using equipment called a solar test simulator (Reichmuth et al., 2020). Tests are carried out to obtain the performance of solar panels according to installation requirements according to power capacity requirements (Frolova et al., 2019). The characteristics of sunlight in Indonesia, which is at the equator, make it possible to carry out a simulation process using halogen lamps (Tanesab et al., 2019). Recording of test data is often carried out through variations in lighting through conditioning of the supply voltage of the lamp.

2. LITERATURE REVIEW

2.1 The Equivalent Circuit of a Solar Cell

The way the solar module itself works is actually identical to the semiconductor diode device. When light comes into contact with the solar module and is absorbed by the semiconductor material, electrons are released which causes the flow of electric charges.To approximate the performance of solar modules, a mathematical model is developed to describe solar modules. The form of a series of solar cell equations, where the current (I) and voltage (V), the solar module (IL/cell's photocurrent), then the series resistance (Rs) and the shunt resistance (Rsh) can be seen in the following figure:

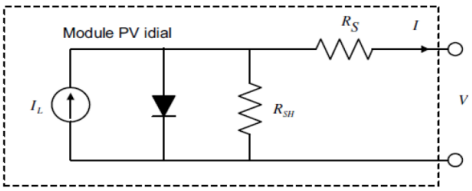

Figure 1. Solar Module Equivalent Circuit

The mathematical equation of the circuit above can be written as follows:

$$I = I_L - I_o \left[exp. \left(\frac{(V+IR_S)}{nKT/q} \right) - 1 \right] - \frac{(V+IR_S)}{R_{SH}} \quad (2)$$

Where:

I = Solar cell equivalent circuit current (Ampere)
io = Reverse saturation current (Amperes)
n = Diode ideal factor
q = Factorelectron charging (1.602 10-19 C)
k = Boltzman constant (1.3806.10-23 JK-1)
T = Solar cell temperature (oK)

2.2 The Influence of Environmental Factors on Solar Module Output

a. Temperature

Temperature affects cell performance and photovoltaic efficiency. If the solar module is in cold conditions it will produce more power. In general when irradiating the cell is 1kW/m2 the cell temperature is approximately 300C higher than the ambient air. The characteristics of temperature changes in solar cells are shown in the figure below:

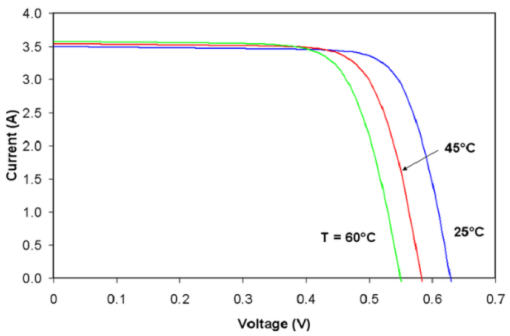

Figure 2. Characteristics of IV at Different Surface Temperatures of Solar Modules

b. Light Intensity

The influence on the amount of sunlight energy obtained by the solar module (photovoltaic) is reduced or the intensity of the light is weakened, so the amount of voltage and electric current generated will also decrease. The voltage drop is relatively smaller than the decrease in the electric current. The figure below shows changes in the current and voltage of the solar module (photovoltaic) based on the intensity of the sunlight obtained, changing in value.

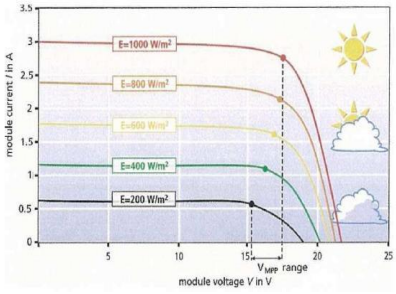

Figure 3. IV Curve Against Fixed Irradiance and Temperature

c. Movement of The Sun

There are several ways to get more solar radiation, namely by adjusting the position of the solar module. The position of the solar module can be adjusted to follow the movement of the sun by determining the position of the tilt angle, declination angle, latitude, zenith angle, incidence angle of the sun, azimuth surface angle, and sundial angle to the movement of the sun. The second way is to use a mirror reflection. The following describes several important angles of solar energy.

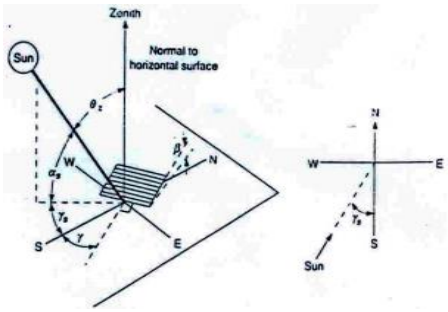

Figure 4. An Important Angle of Solar Energy

3. RESEARCH METHOD

3.1 Solar Panels

The solar panels used are 2 pieces which are arranged in series to show whether the performance results are in accordance with the capacity of the panels. The 20 WP solar panel used with the specifications is shown in the following figure.

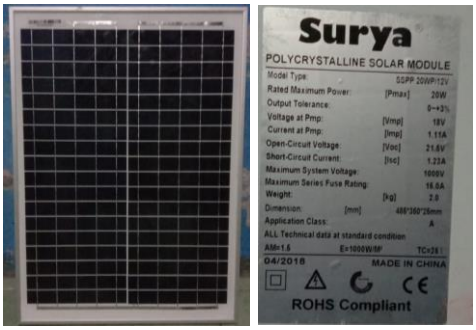

Figure 5. Solar Panel Specifications

3.2 Solar Panel Testing Design

The development carried out in the design of this tool is in the form of setting the solar panel mount in the form of the tilt of the solar panel mount and the distance of the halogen lamp as an energy source which is measured using a solar meter, thermometer and multi meter manually as shown in the following figure.

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Figure 6. Solar Test Simulator Solar Panel

4. RESULTS AND ANALYSIS

The measurement results show results that are in accordance with the solar panel datasheet. The test uses two solar panels arranged in series with the following results:

Table 1. Solar Test Simulator Solar Panel

Tilt		angle 45o			angle 90o			angle 135o		
No.	**Reff light (W/m2)**	**Light (W/m2)**	**Temperature (oC)**	**Voltage (V)**	**Light (W/m2)**	**Temperature (oC)**	**Voltage (V)**	**Light (W/m2)**	**Temperature (oC)**	**Voltage (V)**
1.	5	6,7	31,7	24,1	6,4	32,1	24,1	5,7	31,9	27,9
2.	10	14,4	32.0	28,7	11,6	32,1	27,2	11,9	32,2	31,2
3.	20	20,9	32.0	31,1	21.0	32,1	30,1	20,8	32,2	33,3
4.	30	33,9	32,4	32.5	33,1	32,3	32,2	30,3	32,6	34,6
5.	40	40,2	32.5	33,7	43,6	32,7	33,3	40,9	32,3	35.5
6.	50	53,3	33,3	34,4	50.5	32,7	33,8	51.0	33,1	36.0
7.	60	65,4	33,9	34,9	62,1	32,8	34.5	60,7	33,7	36.5
8.	70	70,3	34,3	35,3	70,8	33,3	34,9	70,6	34,1	36,7
9.	80	80.6	34,9	35,8	88.1	34.5	35.5	80.8	35,1	37,1
10.	90	90.5	35.5	36,7	94,2	34,9	35,6	90.5	35,7	37,3
11.	100	104.0	36,2	36,9	102,2	36,7	35,7	101.3	36,4	37.5
12.	110	115,3	36,8	36,9	111.9	37,7	35,8	110.8	37.5	37.5
13.	120	125.6	35,8	37.0	125.3	38,4	36.0	120.4	37.0	37,9

The table above describes the parameters seen through the tilt of the solar panel at light 5 W/m2 with an angle of 45o where the light is at 6.7 W/m2, the temperature is 31.7oC, and Voltage 24.1 V, at an angle90owhere light is at 6.4 W/m2, temperature is 32.1oC,and voltage24.1 V and onangle 135othe light is on5,7W/m2, temperature31.9oC, and Voltage27,9V. We can conclude that the solar panel is at a tilt angle45o, 90o angle, 135o light angle, temperature and voltage will change.

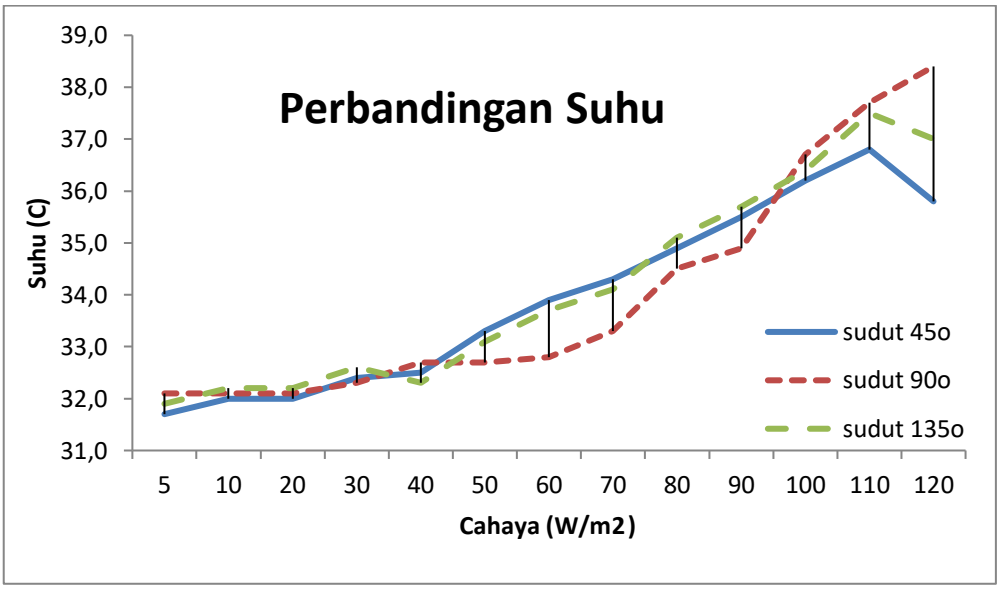

Figure 7. Solar Test Simulator Solar Panel

From the picture above the temperature comparison that occurs in the Solar Test Simulator solar panels at an angle45o, 90o angle, 135o angle where light and temperature are at the lowest slope of 0.13, the highest slope is at 1.73 with an average slope of 0.49. It can be seen that the angle of inclination of the light will affect the high and low temperatures produced.

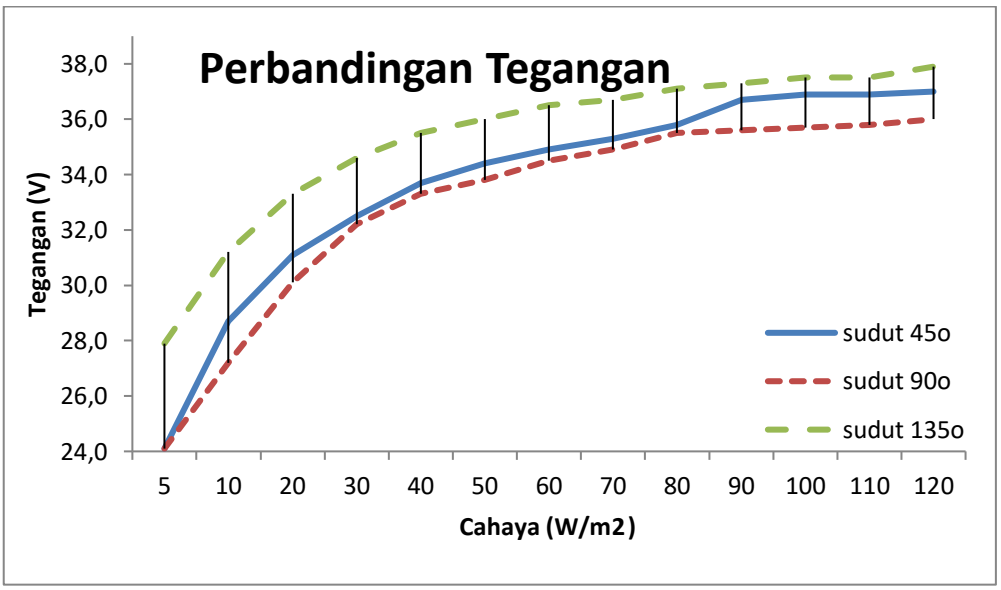

Figure 8. Solar Test Simulator Solar Panel

From Figure 8. Solar Test Simulator solar panels can be concluded that the voltagecorner45o, 90o angle, 135o angle produces the lowest voltage 1.07, the highest voltage is 2.67 and the average voltage produced by light from different angles is 1.55. If the light that we use is greater, the resulting voltage will also be higher.

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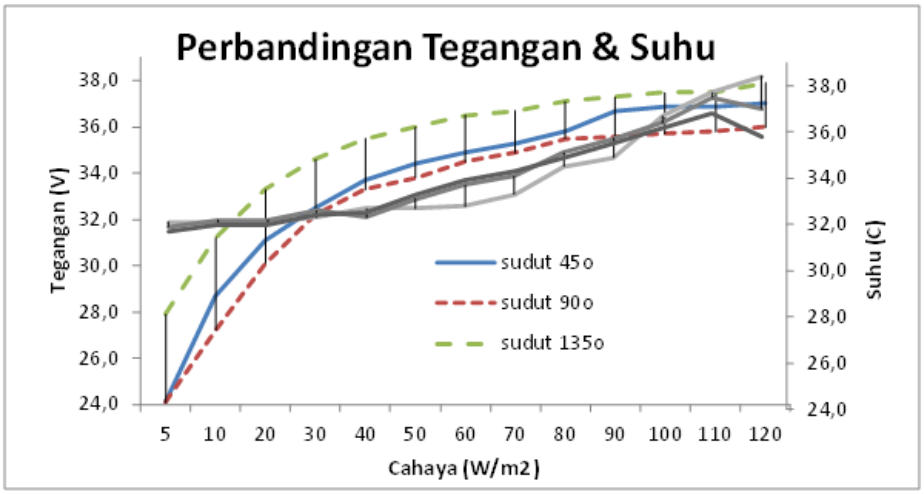

Figure 9. Solar Test Simulator Solar Panel

From the picture above we can see that the tilt of the solar panel is at an angle45o, 90o angle, 135o angle produces the lowest voltage 0.13, the highest voltage is 1.73 and the average voltage is 0.49 while the lowest resulting temperature is 1.07, the highest temperature is 2.67 and the resulting average temperature is 1, 55.

5. CONCLUSION

The results of the development of data collection are carried out with several considerations that have been designed. Tests using two solar panel plates connected in series show results that are in accordance with the energy capacity generated by solar panels based on the data sheet. The development carried out in the design of this tool is in the form of setting the solar panel mount in the form of a solar panel mount tilt of 450, 900, 1350, and a halogen lamp distance of 30cm as an energy source which is measured. The measurement results are based on an average design temperature difference of 0.49% with a voltage of 1.55%.

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