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Comparative Analysis of Tilt And Illumination of Solar Panels in the Design of Solar Test Simulator

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A B S T R A C T

In order for the designed tool to simulate solar panel measurements based on real-world conditions, the solar panel placement holder was arranged in a specific way during the design process. A monitor display that is mounted on the design will show the effectiveness of the solar panels and provide general solar panel information. Limitations in the positioning of solar panels will not provide a reference to conditions for measurement depending on the angle of incidence of the sun so further design needs to be done regarding the position of solar panels when measurements are taken. The development carried out in the design of this tool is in the form of adjusting the solar panel holder in the form of a solar panel holder tilt of 0°, 90°, 180°, and a distance of 30 cm halogen lamp as an energy source that is measured. Measurement results based on design, temperature 46°C, and 100% light.

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INTRODUCTION

The Solar Panel Ramp's design The invention in question is a solar test simulator. The designed tool is able to simulate solar panel measurements based on actual conditions thanks to the arrangement of the solar panel placement stand. The Solar Test Simulator's design calculates light variations based on measurement conditions by adjusting voltage settings and lamp spacing. A monitor display provides information about the solar panels as a whole in addition to displaying the panels' performance.

A solar test simulator is a piece of equipment that is used to apply multiple methods for testing solar panels using different types of light sources that are currently in use, such as halogen, led, and incandescent lamps (Reichmuth et al., 2020). Testing is done to make sure solar panels perform as needed for the installation in accordance with power capacity requirements (Frolova et al., 2019). It is quite feasible to simulate the sunlight characteristics in Indonesia, which is located in an equatorial region, employing lighting from halogen lamps (Tanesab et al., 2019). It is expected that the process of variations in the output of solar panels on the market can be demonstrated by the design of solar panel testing equipment based on the specified conditions. Conditioning the voltage supply voltage on the lamp to record test data under different lighting conditions is a common practice.

LITERATURE REVIEW

An Equivalen solar cell circuit

In actuality, semiconductor diode devices and solar modules operate in exactly the same manner. Electric charge flows when light strikes absorbs by the semiconductor material in the solar module, releasing electrons in the process. A mathematical model was created to represent solar modules in order to approximate their performance. The circuit form of the solar cell equation is shown in the following figure. It comprises the following parameters: current (I), voltage (V), photocurrent (photocurrent in the solar module or cell), series resistance (Rs), and shunt resistance (Rsh).

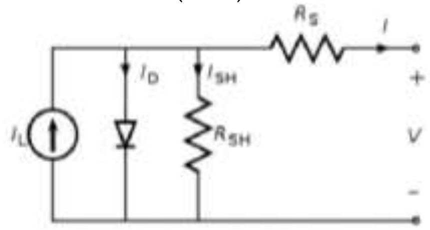

Figure 1. Solar module equivalent circuit

The circuit mentioned above has the following mathematical equation:

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

Where :

I = equivalent circuit current of a solar cell (Ampere)

I_O = current at reverse saturation (Ampere)

n = optimal diode factor

q = electron charging factor (1.602-10-19 C)

k = The constant of Boltzman (1.3806.10-23 J.K-1)
T = temperature of solar cells (°K)

Environmental Factors' Effect on the Output of Solar Modules

1. Temprature

Temperature has an impact on photovoltaic efficiency and cell performance; a cold solar module will generate more power. In general, at 1kW/m2, the cell temperature is approximately 30°C higher than the surrounding air. The following figure illustrates the features of temperature variations in solar cells:

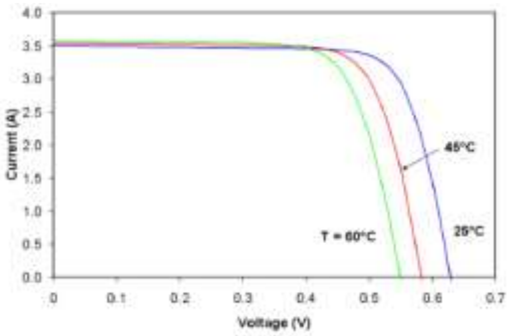

Figure 2. I-V features at various surface temperatures of solar modules.

2. Intensity of light

There will also be a decrease in the amount of voltage and electric current produced if the impact on the solar module's (photovoltaic) ability to absorb sunlight energy is lessened or the light's intensity is diminished. Compared to the decrease in electric current, the voltage decrease is comparatively smaller. The solar module's (photovoltaic) current and voltage variations are depicted in the figure below, which varies according to the amount of sunlight received.

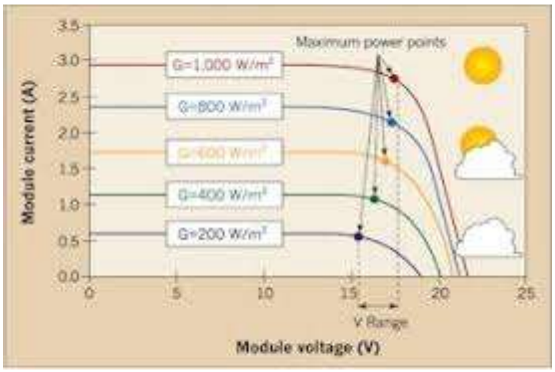

Figure 3. I-V Curve against Constant Temperature and Irradiance

3. Sun direction movement

The location of the solar module can be changed in a few ways to increase solar radiation. The tilt, declination, latitude, zenith, solar incidence, azimuth surface, and sundial angles can all be measured in relation to the sun's movement to determine how to adjust the solar module's position to follow its path. Using a reflecting mirror is the second method. Some key solar energy angles are shown in the following.

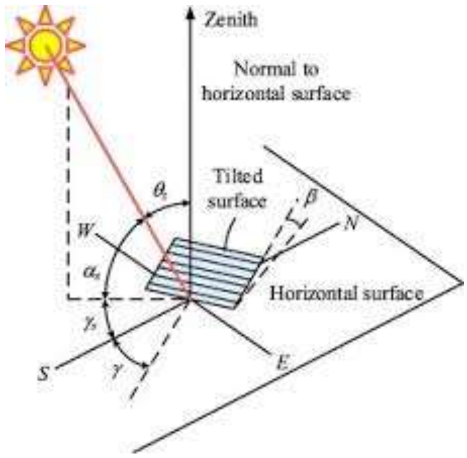

Figure 4. Sudut penting energi surya

METHODOLOGY

Solar Panels

The solar panels were mounted in two sections and assembled in series to display the performance outcomes, regardless of the panel's capacity. The following figure displays the 20 WP solar panel that was used according to specifications.

Figure 5. Solar panel specifications

Design for Testing Solar Panels

The development of this tool's design consists of adjusting the solar panel holder's tilt and the halogen lamp's distance from the source of energy, which are measured manually with a solar meter, thermometer, and multimeter as indicated in the following figure.

RESEARCH RESULT

The measurement results are consistent with the datasheet for the solar panel. The following outcomes of a test with two solar panels connected in series were obtained:

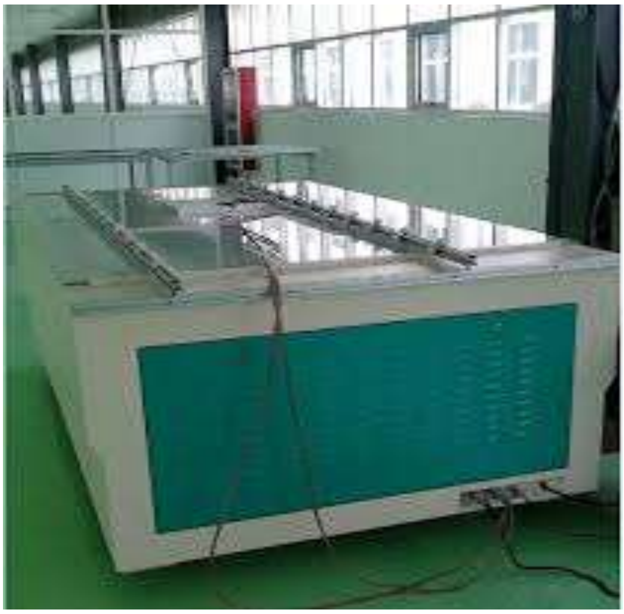

Figure 6. Solar Test Simulator solar panel

Tilt		Angles 0°			Angles 90°			Angles 180°		
No.	Light Reff (W/m2)	Light (W/m²)	Temprature (°C)	Voltage (V)	Light (W/m²)	Temprature (°C)	Voltage (V)	Light (W/m²)	Temprature (°C)	Voltage (V)
1.	5	100	46	23,9	100	46	19,85	100	46	19,4
2.	10	100	46	23,9	100	46	19,85	100	46	19,4
3.	20	100	46	23,9	100	46	19,85	100	46	19,4
4.	30	100	46	23,9	100	46	19,85	100	46	19,4
5.	40	100	46	23,9	100	46	19,85	100	46	19,4
6.	50	100	46	23,9	100	46	19,85	100	46	19,4
7.	60	100	46	23,9	100	46	19,85	100	46	19,4
8.	70	100	46	23,9	100	46	19,85	100	46	19,4
9.	80	100	46	23,9	100	46	19,85	100	46	19,4
10.	90	100	46	23,9	100	46	19,85	100	46	19,4
11.	100	100	46	23,9	100	46	19,85	100	46	19,4
12.	110	100	46	23,9	100	46	19,85	100	46	19,4
13.	120	100	46	23,9	100	46	19,85	100	46	19,4

DISCUSSION

The parameters that can be observed through the tilt of the solar panel are explained in the above table at three different angles: 0°, 90°, and 180°. At a light of 5 W/m2, the parameters are at 100 W/m2, 46 °C, voltage of 23.9 V, and temperature. At an angle of 90°, the parameters are at 100 W/m2, 46 °C, voltage of 19.85 V, and temperature. At an angle of 180°, the parameters are at 100 W/m2, 46 °C, and voltage of 19.4 V. We can therefore conclude that light, temperature, and voltage will change when the solar panel is tilted at 0°, 90°, or 180°. We can therefore conclude that light, temperature, and voltage will change when solar panels are positioned at 0°, 90°, and 180° angles.

TEMPERATURE COMPARISON

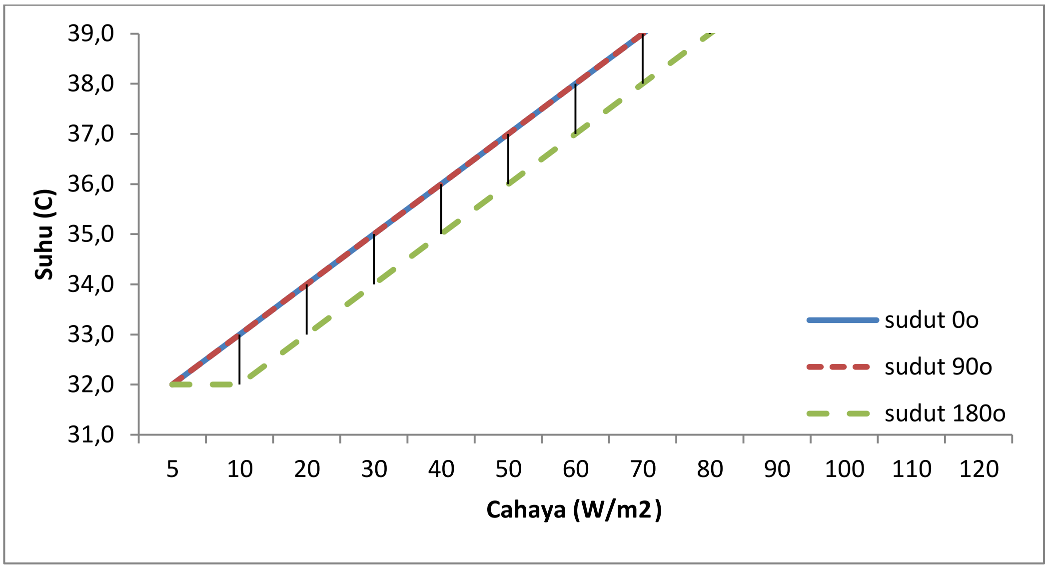

Figure 7 Solar panel simulator for testing

VOLTAGE COMPARISON

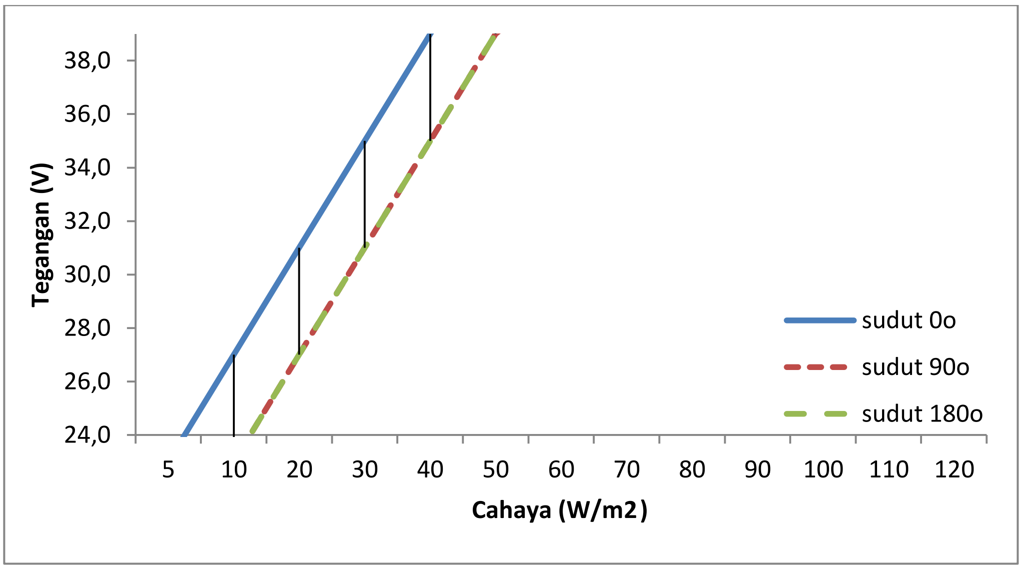

Figure 8. Solar panel simulator for testing

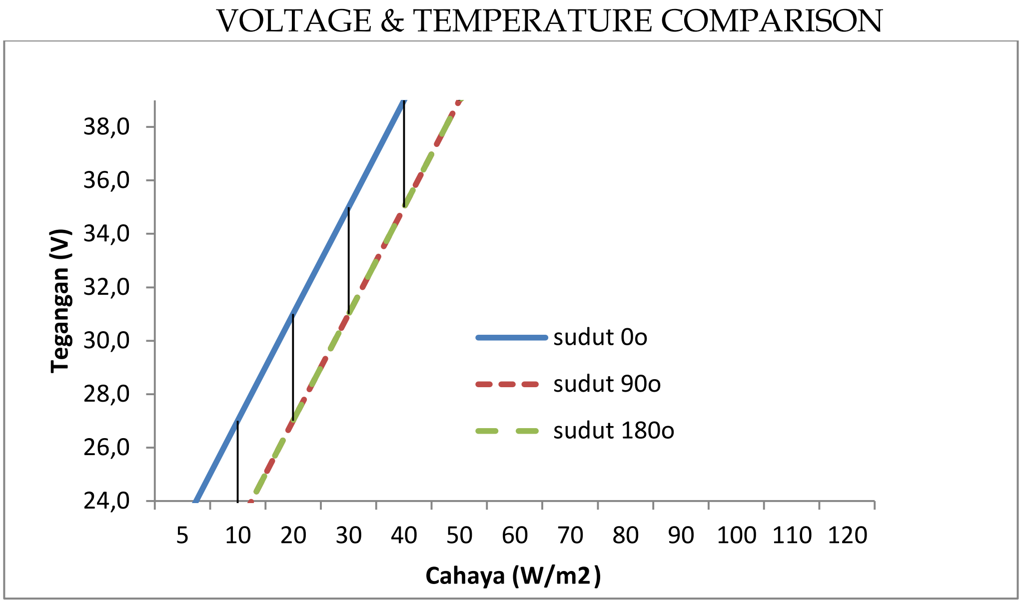

Figure 9. Solar panel simulator for testing

As seen in the above image, the solar panel tilted at 0° degrees, 90° degrees, and 180° degrees produces a voltage of 19.4 at the lowest, 23.9 at the highest, and 0.79 at average. It also produces the lowest temperature of 46, the highest temperature of 46, and the average temperature of 46.

CONCLUSIONS

The outcomes of data collection development are implemented with a number of planned considerations. Results of testing with two solar panel plates connected in series match the datasheet's estimate of the energy capacity produced by the panels. The design of this tool has been developed to allow for the adjustment of the solar panel holder to be tilted at 0°, 90°, and 180°, as well as the measurement of a halogen lamp at a distance of 30 cm as an energy source. Results of the measurement based on the average temperature differential of 0.79% at 46% voltage.

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