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The Effect Of Temperature And Intensity Of Sunlight On The Power Produced By Solar Panels From Data Logger

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Abstract

Solar cells are made of silicon, which generally has properties as an excellent absorber of solar radiation energy; as long as the solar panel operates under the sun. Solar radiation energy will always be converted into electrical energy by solar cells. Still, solar cells will also experience heat and affect the panel output voltage. Solar panels' voltage and electric current is influenced by the intensity of solar radiation and ambient temperature. This study aims to determine temperature changes to the sunlight intensity that can be seen in the data logger. The Effect of panel temperature on the power generated in the data logger measurement and the data regression analysis results show that as the panel temperature increases, the power generated also increases linearly. On the first day, the power increase was 1.0463_T; on the second day, the power increase was 1.2614T; on the third day, the power increase was 1.2901_T. As for the Effect of the intensity of sunlight on the power generated from the results of data regression analysis, with the rise in the intensity of the sun. The energy caused increases linearly. On the first day, the power increase was $0.0368I_T$; on the second day, the power increase was $0.0416I_T$; and on the third day, the power increase was $0.0441I_T$.

Keywords: Solar Panels, Temperature, Sunlight Intensity, Power.

1. Introduction

Solar cells are semiconductor materials that can convert solar energy into electrical energy with the photovoltaic principle. Solar cells will be arranged to become solar modules, commonly called solar panels. The wattage is adjusted according to the number of solar cells placed [1].

Solar cells are made of silicon material which generally has properties as an excellent absorber of solar radiation energy, as long as the solar panel operates under the sun. Solar radiation energy will always be converted into electrical energy by solar cells, which will also experience heat and affect the panel voltage [2].

The voltage and electric current generated by solar panels is influenced by two factors: the intensity of solar radiation and ambient temperature. Solar cells' power of solar radiation is proportional to the voltage and electric current produced. Suppose the ambient temperature is higher with a constant intensity of solar radiation. In that case, the voltage of the solar panel will decrease, and the electric current generated will increase [3]. Temperature and cloud conditions cause changes in the temperature of these solar cells and wind speed in the environment around the solar panel placement area [4, 5]. From previous studies, ambient temperature and intensity affect changes in the capacity of electrical energy in solar panels to produce voltage and current [6]. Even swift and extreme temperature changes can cause disruption of electricity production in a Solar Power Plant [7]. This study aims to determine temperature changes to the sunlight intensity that can be seen in the data logger. Therefore it is necessary to make a tool that can record the light intensity and temperature data to see the efficiency of the solar panel by optimizing the usability of the Arduino WiFi controller with the type ESP8266, Node MCUAT Mega 2560, and wemos DI using a system that is data logger expected to store light intensity and temperature data obtained from the sensor.

Arduino will process the data obtained from the sensor, and then the data from the sensor will be saved to the SD Card. Which is connected to the data logger; data retrieval stored on the SD Card is carried out directly (offline) — expected to facilitate human work in recording data in real-time for an extended period.

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2. Literature Reviews

2.1. Solar module characteristics

The power capacity of a solar cell or module is denoted in watt peak (Wp) and measured based on international testing standards, namely Standard Test Condition (STC). This standard refers to the intensity of solar radiation of 1000 W/m² perpendicular to the solar cell at 25°C, where photovoltaic modules have a relationship between current and voltage, When the variable resistance is infinity (open circuit), then the current is minimum (zero), and the voltage in the cell is at its maximum value, known as the voltage open circuit (V_{oc}) [8].

On the other hand, when the variable resistance is zero (short circuit), the maximum current is known as short circuit current (Isc). Suppose the variable resistance has a value that varies between zero and infinity. In that case, the current (I) and voltage (V) will be obtained with varying values [9]. To determine the input power of solar panels that are exposed to the intensity of sunlight, you can use the following formula:

$P_{in} = E \times A$#..equation 1

Where P_{in} is the incoming power to the solar panel (W), E is the sunlight intensity (W/m²), and A is the solar panel cross-sectional area (m²). Charging factor:

$FF = \frac{Vmax.Imax}{Voc.Isc}$#..equation 2

While the output from the solar panel is in the form of current and voltage, to determine the output power of the solar panel, the following formula can be used:

$P_{out} = Voc \times Isc \times FF$#........................equation 3

Where P_{out} Is the power coming out of the solar panel (*W*), V_{oc} Is the solar panel voltage (*V*), Isc is the solar panel output current (*A*), and Vmax is the maximum solar panel voltage (*V*). To find out the efficiency of the solar panel. It must first be determined Pmax (full output power) of the solar panel used with the formula:

$Pmax = Imp \times Vmp$#..............................equation 4

Pmax is the maximum output power, V_{mp} = the optimal operating voltage multiplication, and Imp is the optimal active current power [10, 11]. After that, determine the panel dimensions to be used in calculating the dimensions of this solar panel using units in meters with the formula length *x* width. After everything is obtained, we can calculate the efficiency of the solar panels that will be used with the formula:

$Solar\ Panel\ Efficiency = \frac{P_{out}}{p_{in}} \times 100\%$#
....equation 5

Where Solar panels are Solar Panel Efficiency Temperature (%).

2.2. Solar panel electrical voltage model against

The electrical voltage generated by solar panels can be defined as follows [4]:

$Ppv = Ppvstcfpvf\ temperature\ \frac{IT}{ITSTC}$
....equation 6

With Ppv, STC as voltage capacity solar panels at standard test conditions (*kV*), Fpv as shrinkage factor (%), IT as global solar radiation hitting the solar panel surface (kW/m2), IT, STC solar radiation at standard test conditions (1 kW/m2), and FTemp as a shrinkage factor due to temperature changes [12]. The shrinkage factor is the solar panel output voltage reduction due to dust/dirt on the panel surface and wiring losses. The impact of shadows covering the panels, service life, and other things can cause the solar panel output voltage to deviate from ideal conditions [7]. The shrinkage factor due to temperature changes can be calculated as follows:

$Ftemp = [1 + \alpha p\ Where\ p(Tc - TcSTC)$
....equation 7

İs the voltage temperature coefficient (%/˚C), Tc is the solar cell temperature (^{0}C), and Tc, STC is the temperature of the solar cell at standard test conditions (25˚C). The voltage temperature coefficient shows how strong the influence of solar cell temperature is on the panel's output voltage. This coefficient is negative because the output voltage of the solar panel decreases as the temperature of the solar cell increases. The value of the voltage temperature coefficient depends on the type of solar panel [13]. This coefficient value is zero if the Effect of temperature on the solar panel voltage is neglected. Solar cell temperature, Tc is the temperature measured on the surface of the solar panel. At night, the temperature value is the same as the temperature of the surrounding environment. Still, during the day, when the sun is hot, the temperature value can reach 34°C or more above the surrounding area's temperature. To calculate the temperature of this solar cell, you can use the following equation [4]:

$$Tc = Ta + IT\left(\frac{Tc,NOCT - Ta,NOCT}{IT,NOCT}\right)\left(1 - \frac{nc}{Ta}\right)$$
....equation 8

Ta as the ambient temperature (°C), Tc, NOCT as the nominal temperature of the solar cell (°C). Ta,NOCT as the temperature of the surrounding area where the nominal temperature of the solar cell is defined (25°C), IT,NOCT as the intensity of the sun at the nominal temperature of the solar cell is determined, c as the panel's electrical conversion efficiency solar energy (%), and Ta as the absorption rate of solar panels [14]. The absorption rate of solar panels is the ratio between the total radiation absorbed by the solar panels to the total radiation that hits the surface of the solar panels. Under normal conditions, solar panels must be able to absorb at least 90% of the solar radiation that hits them [15].

3. Methods

This type of research is quantitative, namely analyzing data from numbers obtained on the device using several sensors. Namely, temperature sensors (DHT22) and current sensors (ACS712), light sensors, voltage sensors, and wind speed sensors (Anemometer). to see the Effect of temperature and intensity of sunlight on the power generated [16, 17].

This study uses a 20 Wp solar panel that researchers have designed to be able to record data to be used to find solar panel efficiency. by utilizing sunlight and temperature at the test location by monitoring the location using a data recording device in the form of data a logger that can be observed in real-time whose data can be stored on the SD card installed on the device [18-20]. This research was carried out with the procedure shown in the flow chart in Fig 1 below.

A data logger is a tool used to record data with a series, as shown in Fig 3. the electronic device records data from one time to the next. This device is connected to a sensor, or it can also be said that a data logger is a tool used for data logging. Data logging is collecting and recording data that runs automatically from a sensor for analysis and archiving purposes. Sensors are used according to needs; various types of sensors are used: anemometer, voltage, current, and temperature. The basic concept in designing a data logger is to know the various components and blog circuits that exist in the data logger.

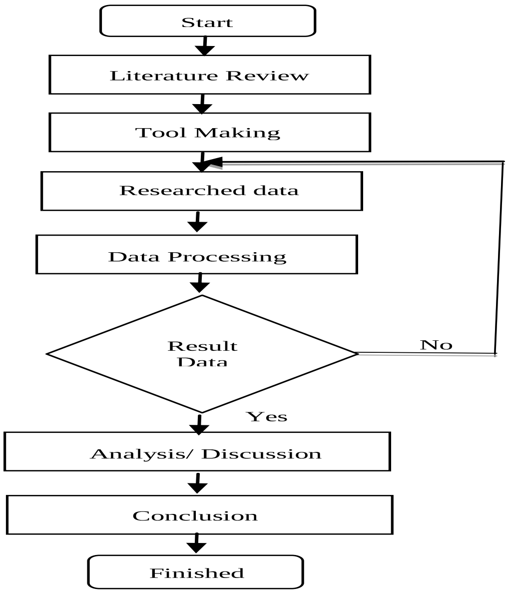

Fig. 1. Research flow.

3.1. Tes setup

The data logger test setup is shown in Fig 2 below.

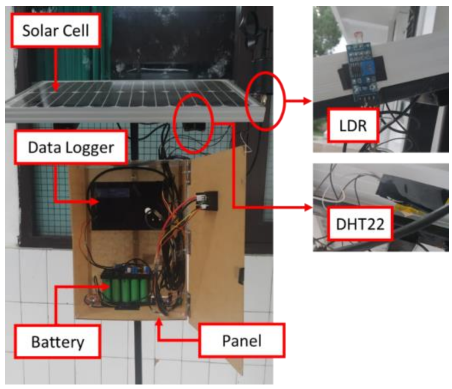

Fig. 2. Experiment setup.

Components used in data loggers such as Node MCUATmega 2560, ACS712 Current Sensor, Light Sensor (LDR), Temperature sensor, DS3231 RTC Module, and SD card module.

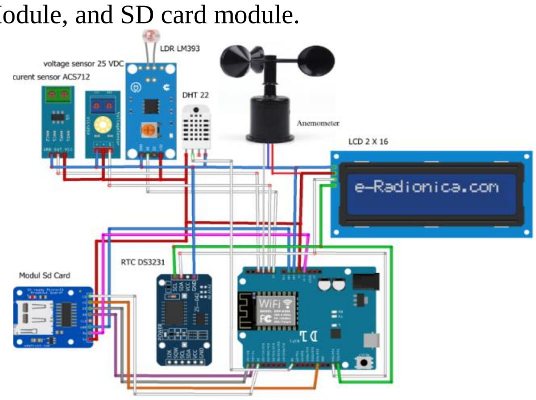

Fig. 3. Schematic of the tool circuit in the data logger.

4. Results

From the tests carried out, it can be seen that the created data logger tool can be used precisely, the sensors installed on the data logger tool can be read without errors, and from some established sensors, the researchers focus only on the temperature sensor (DHT 22). The intensity of the sunlight or light detector is programmed with Arduino with a real-time clock program (RTC) [21]. The data will be periodically stored on the SD Card.

The data stored on the SD Card, which contains data sent by the temperature sensor and the intensity of sunlight programmed by the Arduino researchers, took three days; the data on the SD Card will be stored in real-time for 11 seconds. The results of these data are shown in Fig 4 and Fig 5 below.

Table 1
Specifications of the 20 Wp solar panels used.

Font	Font Type
Max. Power (Pmax)	20 Wp
Max. Power Voltage (Vmp)	18.2V
Max. Power Current (Imp)	1.09A
Open circuit Voltage (V_{oc})	21.51V
short circuit Current (Isc)	1.08A
Nominal Operating Cell Temp (NOCT)	45±2 ºC
Max. System Voltage	1000V
Max. series fuse	10 A
Weight	1.63Kg
Dimension	350 x 465 x 25 mm

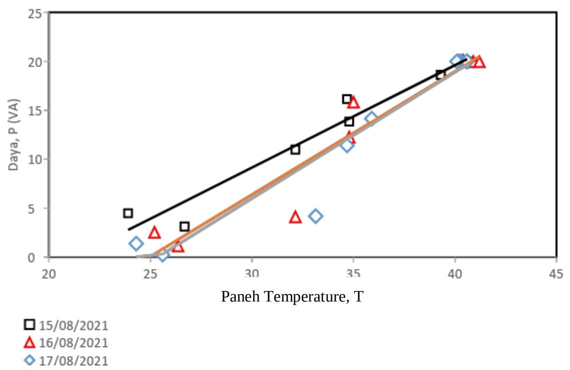

Fig. 4. Effect of panel temperature (T) on the power generated (P).

Fig 4 shows the Effect of panel temperature on the power generated by measuring the data logger and the results of data regression analysis. The results are displayed by increasing the panel temperature; the energy generated increases linearly. On the first day, the power increase was 1.0463_T; on the second day, the power increase was 1.2614T; on the third day, the power increase was 1.2901_T.

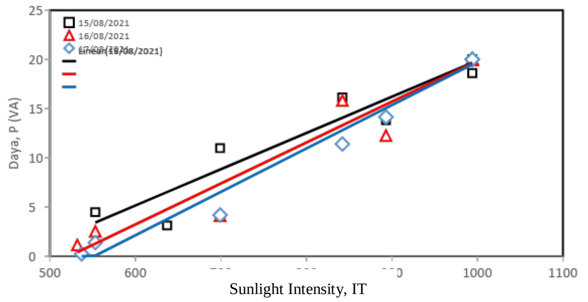

Fig. 5. The effect of sunlight intensity ($_{IT}$) on the power produced (P)

Fig. 5 shows the Effect of sunlight intensity on the power generated in the data logger measurement and the data regression analysis results. In this figure, it can be seen that as the intensity of sunlight increases, the power generated also increases linearly. On the first day, the power increase was $0.0368I_T$; on the second day, the power increase was $0.0416I_T$; and on the third day, the power increase was $0.0441I_T$.

5. Conclusions

The Effect of temperature of the panel against the generated power to the measurement data logger and data regression analysis results are shown in the panel temperature rise generated power also rises linearly. On the first day, the power increase was 1.0463_T; on the second day, the power increase was 1.2614T; on the third day, the power increase was 1.2901_T. As for the Effect of the intensity of sunlight on the power generated from the results of data regression analysis, with the rise in the sun's passion, the energy caused increases linearly. On the first day, the power increase was 0.0368_{IT}; on the second day, the power increase was 0.0416_{IT}; and on the third day, the power increase was 0.0441_{IT}.

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