

## The Effect of Luminous Intensity, Humidity, and Temperature on The Output Voltage of Solar Panels

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**Abstract**—Solar Power Plant is a power plant by utilizing sunlight. In this study, the focus is on the use of off-grid solar power systems. The purpose of this study is to determine the effect of luminous intensity, humidity, and temperature on the output voltage of a solar power plant. The research method used is experimental. The maximum output voltage of the solar panel is 19.2 V obtained at 01.00 pm. During these conditions, the luminous intensity value is 121000 lux at an air humidity of 52.4% with a temperature of 40.5°C. The results showed that (1) the greater the luminous intensity, the greater the output voltage of the solar panel. (2) If the greater the humidity, the smaller the output voltage of the solar panel. (3) If the greater the temperature, the greater the output voltage of the solar panel.

**Keywords:** solar panels, luminous intensity, humidity, temperature

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### 1 Introduction

The use of fossil energy sources is getting bigger as the need increases. This makes the reserves of fossil energy sources dwindle. For this reason, the transition from the use of fossil energy to New and Renewable Energy is something that is absolutely necessary. Without new energy alternatives, oil in Indonesia is expected to run out in the next 9 years, natural gas will run out in the next 22 years, and coal will run out in 65 years [1]. Currently, the condition of domestic energy sources is still relatively abundant. Especially for the natural gas and coal sector. It's just that changes in consumption without exploration have brought Indonesia closer to an energy crisis. To overcome this, renewable energy is needed.

One of the new and renewable energy is the Solar Power Plant. Solar Power Plant is a power plant that utilizes sunlight as the main energy source. Through solar cells (photovoltaic), sunlight in the form of photon radiation is converted into electrical energy [2]. Solar cells consist of thin layers of pure silicon (Si) semiconductor materials and other semiconductor materials that are designed in such a way as to produce electrical energy. Sunlight utilized by this Solar Power Plant will be converted into DC electricity. DC electrical energy generated by solar panels can be converted into AC electricity as needed.

Solar Power Plants are designed to meet electricity needs on a small or large scale, using both stand-alone and hybrid systems. Classification of Solar Power Plants can be divided into 2 types based on the system of supplying electrical energy to the load: decentralized and centralized systems.

The decentralized system is a Solar Power Generation system for self-consumption by installing the generator independently. An example of a decentralized system is the installation of a rooftop system in a residential building. Meanwhile, the centralized system is a Solar Power Generation system where the energy produced has a large capacity and is channeled to several customers. Solar Power Plant is one of the new and renewable energy sources, where sunlight is an endless source of energy. In addition, the Solar Power Plant is an environmentally friendly power plant because it does not use rotating components, so it does not cause noise, does not impact pollution (air, water, and sea), and does not emit emissions in the form of exhaust gases or waste [3].

Based on the configuration and application, in general, the solar power plant is classified into three, namely off-grid solar power plants (solar power plant systems that are not connected to the network), on-grid solar power plants (solar power plant systems that are connected to the network), and solar power plant hybrid systems. Based on data from the Institute of Electrical and Electronics Engineers (IEEE) standard 929-2000 the PLTS system based on the capacity of the electrical energy that can be produced is divided into 3 according to the following Table 1 [4][5].

**Table 1.** Solar power plant capacity

No.	Category	Capacity
1	Mini Grid	≤10 Kilo Watt
2	Medium Grid	10 Kilo Watt – 500 Kilo Watt
3	High Grid	≥500 Kilo Watt

In this study, a small-scale off-grid system solar power plant was designed. The maximum capacity of the solar panels used can generate electricity of 150 Watt peak (Wp).

**1.1 Off-Grid Solar Power Plant**

In this study, the focus is on the use of off-grid solar power systems. Off-Grid Solar Power Plant is a power generation system that utilizes solar radiation without being connected to the PLN network. The only source of electricity generation from Off-Grid Solar Power Plants is using solar radiation with the help of solar panels or photovoltaics. Off-Grid Solar Power Generation Systems are usually used for areas that are not reachable by electricity supply from a State Electricity Company (PLN) such as rural areas or outer islands or for secondary electricity needs [6].

Solar cells (photovoltaic) will produce electrical energy at the minimum limit of light needed by photovoltaics to produce electricity and electrical energy. Then the generated electrical energy is stored by the battery. The process of storing electrical energy from photovoltaics in the battery is fully controlled using a solar charge controller (SCC/BCU/BCR) with the aim of preventing excess charging (over-charging) and voltage spikes during the charging process [7]. The solar charge controller used has a working voltage specification of 12/24 V with a maximum current rating of 30A. An image of a solar charge controller is shown in Figure 1 below.



**Fig. 1.** Solar charge controller

The amount of electrical energy generated by photovoltaics is very dependent on sunlight shining on the photovoltaic surface and the specifications of the photovoltaic efficiency. Solar radiation and cell efficiency greatly determine the electrical energy produced by photovoltaics [8]. Electrical energy stored in the battery can be directly used to meet the needs of DC loads such as DC lamps or microprocessor equipment. In this study using a battery with a sulfuric acid electrolyte absorbed separator (VRLA) the capacity of the battery used is a 100 Ah VRLA type battery. Pictures of the batteries used in this study are shown in Figure 2 below.



**Fig. 2.** Battery

If electrical energy is to be used to supply AC loads, an inverter is needed to convert DC electricity into AC electricity. The inverter used in this study is an inverter with a capacity of 1000VA. The inverter image used in this study is shown in Figure 3 below.



**Fig. 3.** Inverter

As a tropical country, Indonesia has good potential to develop solar power plants as alternative energy. However, there are several factors that are thought to influence the output voltage of a solar power plant, including luminous intensity, humidity, and temperature. Based on this background, this study seeks to determine the effect of luminous intensity, humidity, and temperature on the output voltage of a solar power plant.

## 2 Methods

This study discusses the effect of luminous intensity, humidity, and temperature on the output voltage of a solar power plant. This study was conducted at the Laboratory of Mechanical and Electrical Power Systems, Faculty of Engineering, Universitas Negeri Yogyakarta. The tools and components used include solar panels, solar charge controllers (SCC), inverters, connecting cables, batteries, multimeters, temperature humidity meters, and lux meters. The research method used is experimental. The research steps included: a literature study, designing an off-grid system solar power

plant, installing an off-grid system solar power plant, conducting data collection, analyzing data, and drawing conclusions.

The working principle of the energy generation system in solar power plants is to convert energy from sunlight into electrical energy. Solar cells on solar panels work to separate the received electrical energy into positive (P) and negative (N). After being changed, then the electrical energy is stored in the battery/ACCU with the command Battery Charge Regulator (BCR), Solar Charge Controller (SCC), or Battery Control Unit (BCU) which then supplies the load (220 VAC). Before going to the AC load, the electric voltage and electric current are changed by the inverter from (12VDC) to (220VAC).

The sun is emerging as the main source and supplier of energy that will support almost all of these processes. Solar panels will absorb and receive energy channeled by the sun [9]. The solar panel is assisted by the Battery Control Unit (BCU) which functions as a regulator of the amount of energy produced by the solar panel. BCU will distribute the energy evenly among the existing batteries until all the batteries are fully charged.

The battery will then distribute the power it already has to the load, either a 12VDC load or a 220VAC load. However, for a 220VAC load, you must first go through the process of changing the current and voltage from the battery using an inverter. In night conditions, solar panels will no longer collect energy from the sun. The energy obtained comes from a battery that has stored solar energy during the day. In this Solar Power Plant unit, an off-grid Solar Power Plant system was developed. The designed Solar Power Plant work system can be shown in Figure 4 below.

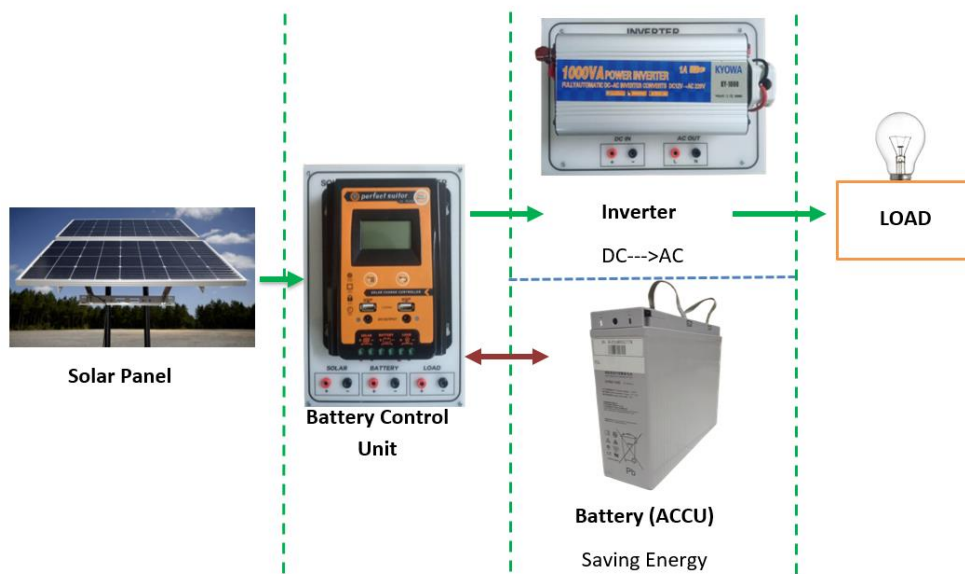


Fig. 4. The solar power plant schematic

In this study, three solar panels with a power of 50 Wp each were used. The maximum power generated by a series of solar panels in this study is 150 Wp. The working voltage on this solar power plant is set at 12 V. The solar panel characteristic parameters are shown in Table 2.

Table 2. The characteristics of solar panel

Product Name	Voltage Level	Rated Current	Quantity
Monocrystalline Solar PV Module 50 Wp	Working Voltage ( $V_w$ ) = 12 V Max Power Voltage ( $V_{MP}$ ) = 18 V Open Circuit Voltage ( $V_{oc}$ ) = 22,19 V	Max Power Current ( $I_{MP}$ ) = 2,78 A Short Circuit Current ( $I_{sc}$ ) = 3 A	3 Units

The working voltage of the solar cells used is 12 V with a maximum power voltage of 18 V and a maximum power current of 2.78 A. This study connects the solar cell modules in parallel to obtain the maximum current. Data collection was carried out from 10.00 am - 03.00 pm. Time of data collection with intervals of 20 minutes of data collection. The data generated from this study are output voltage, sunlight intensity, humidity, and temperature. Humidity and temperature data were obtained from measurements on the surface of the solar panel.

### 3 Result and Discussion

The data collection process was carried out on March 9, 2023, from 10.00 am - 03.00 pm. Data collection is attempted by adjusting the position of the solar panel perpendicular to the direction of sunlight. The first step is to prepare tools and practical materials. The measuring instruments used are voltmeters to measure voltage, lux meters to measure luminous intensity, and temperature humidity meters to measure temperature and humidity. The process when preparing tools and practice materials is shown in Figure 5.



**Fig. 5.** Preparation of tools and materials

After the practical tools and materials are prepared, the next step is to make a solar panel electrical circuit. In this experiment using off-grid solar panels. In order to produce maximum current, the solar panels are arranged in parallel. The process of assembling solar panels is shown in Figure 6.



**Fig. 6.** Solar panel assembly

After the process of assembling an off-grid solar power plant is complete, the next step is the data collection process. The data collected is in the form of luminous intensity, humidity, and temperature. The data collection process is shown in Figure 7.



Fig. 7. Data collection process

The results of data retrieval in detail can be seen in Table 3 below.

Table 3. The collection data of solar power plant performance

No	Times	Luminous intensity (Lux)	Air humidity (%)	Temperature (°C)	Voltage (V)
1	10.00 am	58000	69,6	34,2	16,2
2	10.20 am	60100	67,9	33,7	16,7
3	10.40 am	54300	66,2	33,9	16,9
4	11.00 am	63000	65,3	35,1	17,4
5	11.20 am	64800	64,6	35,4	17,8
6	11.40 am	76300	60,4	36,1	17,9
7	00.00 pm	96700	59,2	37,2	18,4
8	00.20 pm	103200	57,4	38,4	18,3
9	00.40 pm	117000	57,8	39,8	18,6
10	01.00 pm	121000	52,4	40,5	19,2
11	01.20 pm	114000	54,7	40,2	18,7
12	01.40 pm	73240	65,1	37,5	17,5
13	02.00 pm	80700	63,2	38,2	18,2
14	02.20 pm	76400	65,4	37,4	17,9
15	02.40 pm	76500	68,2	35,1	17,3
16	03.00 pm	68400	70,3	34,2	17,1

Based on Table 3 it can be explained that the maximum solar panel output voltage occurs at 01.00 pm with a value of 19.2 V. During these conditions the luminous intensity value is 121000 lux at an air humidity of 52.4% with a temperature of 40.5°C. From the results of data collection, the size of the generated voltage depends on the luminous intensity; if the luminous intensity is high, then the output voltage of the solar panel is high, if the luminous intensity is low, the output voltage of the solar panel will drop. In Figure 8 it can be seen that every time there is an increase in the luminous intensity, the output voltage of the solar panels is higher.



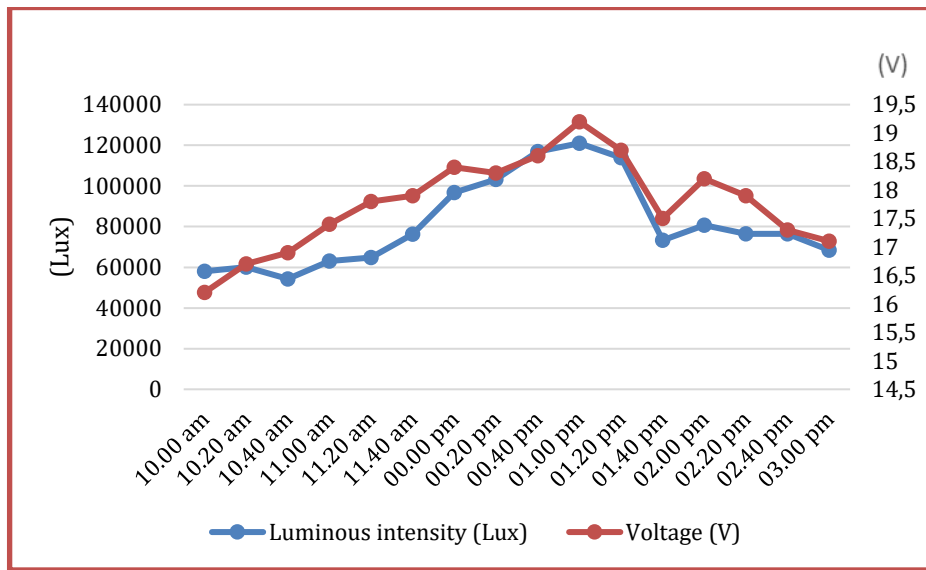


Fig. 8. Data collection of the effect of luminous intensity on the output voltage

Based on Figure 8 it can be explained that the greater the light intensity, the greater the output voltage of the solar panel. Whereas the smaller the luminous intensity, the smaller the output voltage of the solar panel. At a luminous intensity of 121000 lux the solar panel can generate a voltage of 19.2 V. This agrees with [10] which explains that the greater the luminous intensity, the greater the power generated by the solar panel.

From the results of the data collection, the size of the humidity has an impact on the output voltage generated by the solar panel. The greater the humidity, the smaller the output voltage of the resulting solar panels. In Figure 9 it can be seen that every time there is an increase in humidity, the output voltage is lower.

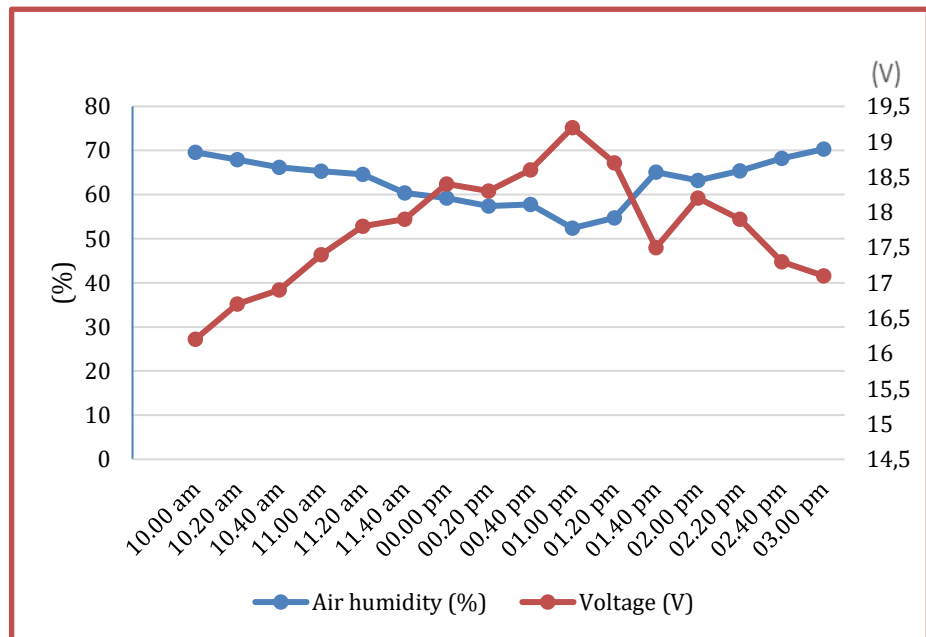


Fig. 9. Data collection of the effect of humidity on the output voltage

Based on Figure 9 it can be explained that the size of the humidity is inversely proportional to the output voltage of the solar panel. The greater the humidity value, the smaller the resulting solar panel output voltage. While the smaller the humidity, the greater the output voltage generated by the solar panel. At a humidity percentage of 70.3%, it produces an output voltage of 17.1 V. This is in accordance with research results from [11] which explain that the greater the humidity value, the smaller the output voltage value of the solar panel.

From the results of data collection, the size of the environmental and surface temperatures of the solar panels has an impact on the output voltage of the resulting solar panels. If the temperature is getting higher, the output voltage of the solar panel is also high. If the temperature gets lower, the output voltage of the solar panel decreases. The results of data collection on the effect of temperature on the output voltage of solar panels are shown in Figure 10 below.

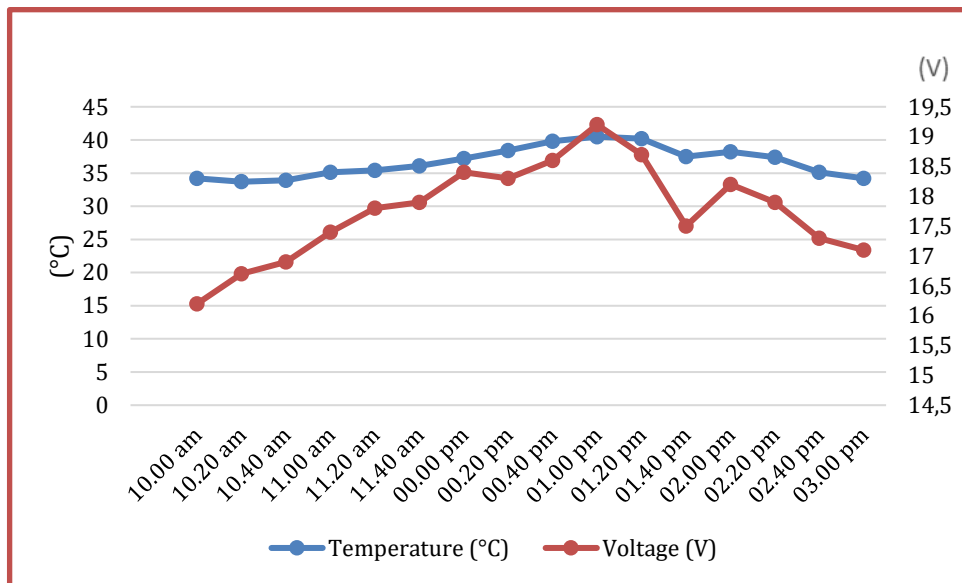


Fig. 10. Data collection of the effect of temperature on the output voltage

Based on Figure 10 it can be explained that the greater the temperature above the surface of the solar panel, the greater the output voltage generated by the solar panel. Meanwhile, the smaller the temperature, the smaller the output voltage of the solar panel. At a temperature of 40.5°C, solar panels can produce an output voltage of 19.2 V. This agrees with [12], [13] which explains that the greater the temperature, the greater the output voltage generated by the solar panel.

Based on the data collection, it can be explained that the luminous intensity and temperature are directly proportional to the output voltage of the solar panel. The greater the luminous intensity and temperature, the output voltage of the resulting solar panels will also be greater. Meanwhile, humidity is inversely proportional to the output voltage of the solar panel. The greater the humidity, the smaller the output voltage from the solar panel.

Based on 3 factors, namely luminous intensity, humidity, and temperature, in this study, it can be proven that these three factors have an impact on the output voltage of the solar panel. However, the factor that has the most significant impact on the output voltage of solar panels is the luminous intensity of the sun.

#### 4 Conclusions

One of the renewable energies is the Solar Power Plant. Solar Power Plant is a power plant by utilizing sunlight. In this study, the focus is on the use of off-grid solar power systems. Experimental test results show that the maximum output voltage of the solar panel occurs at 01.00 pm with a value



of 19.2 V. During these conditions the luminous intensity value is 121000 lux at an air humidity of 52.4% with a temperature of 40.5°C. It can be concluded that (1) the greater the luminous intensity, the greater the output voltage of the solar panel. (2) If the greater the humidity, the smaller the output voltage from the solar panel. (3) The greater the temperature, the greater the output voltage of the solar panel.

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