STUDY AND POTENTIAL UTILIZATION OF SOLAR POWER PLANT AS A SOURCE OF ENERGY AT UNIVERSITY OF PEMBANGUNAN PANCA BUDI

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ABSTRACT

Indonesia is located on the equator so it has two seasons, namely the rainy season and the dry season. Indonesia has the potential to utilize this energy to be converted into electrical energy. PLTS (Solar Power Plant) is a power plant that utilizes solar energy using the main tool, namely solar modules. Solar modules are devices that can convert solar energy into electrical energy, this process is called the photovoltaic effect. PLTS can be installed in buildings, apartments, houses, factories and vacant land. The purpose of installing PLTS is to reduce electricity consumption from the network to reduce monthly electricity bills. PLTS On-Grid is a PLTS configuration system that is connected to the network with the KWh EXIM tool which functions to send excess electricity generated by PLTS to the network. In general, On-Grid PLTS is installed on the roof of the house. This aims to save land and no objects that will block the solar modules. There are many requirements for installing PLTS on the roof of a house such as the location of the area, the direction of the roof of the house, the roof area where the solar module will be installed, and the tilt of the solar module. These conditions serve to optimize the performance of solar modules. Panca Budi Development University is one of the universities that implements the use of green energy, various efforts have been made to realize the green energy program, one of the innovations that needs to be done is the use of PLTS as a substitute for generating sources. This rationale is supported by government policies regarding the utilization of environmentally friendly energy so that it becomes one of them106This research indicator is very important to provide/offer solutions to the problems experienced by the community. Research with a basic research method approach is carried out through an approach of observation, analysis, of existing conditions regarding data on wind conditions, weather, sunlight, and analysis of the required power requirements to facilitate energy needs in Building I, Panca Budi Development University.

INTRODUCTION

Increased growth and infrastructure development will increase the demand for electricity use. With the increase in the need for electrical energy will lead to reduced reserves of fossil energy. To reduce the use of fossil energy sources, namely by utilizing alternative energy sources to maintain the availability of fossil energy sources so that they can be used someday. Indonesia is a tropical country and a country located on the equator. Indonesia has great potential to utilize alternative solar energy sources because it has an average temperature of 28oC. PLTS or the abbreviation of solar power plant is a technology that is developing in the field of power generation that utilizes solar energy sources and is converted into electrical energy with the help of solar modules. PLTS has been widely installed with various locations such as buildings, hotels, business premises, vacant land and rooftops. The solar power generation system has three

types of configuration systems, namely off-grid, on-grid and hybrid configuration systems. Among these systems that are more widely used by consumers is the on-grid configuration system because the system is simple and does not require batteries. For independent or home PLTS users, it is recommended to use an on-grid configuration system because it is connected to a 24-hour network, electricity consumption during the day is relatively lower than electricity usage at night, so it can reduce the electricity usage of the PLN network. The solar power generation system has three types of configuration systems, namely off-grid, on-grid and hybrid configuration systems. Among these systems that are more widely used by consumers is the on-grid configuration system because the system is simple and does not require batteries. For independent or home PLTS users, it is recommended to use an on-grid configuration system because it is connected to a 24-hour network, electricity consumption during the day is relatively lower than electricity usage at night, so it can reduce the electricity usage of the PLN network. The solar power generation system has three types of configuration systems, namely off-grid, on-grid and hybrid configuration systems. Among these systems that are more widely used by consumers is the on-grid configuration system because the system is simple and does not require batteries. For independent or home PLTS users, it is recommended to use an on-grid configuration system because it is connected to a 24-hour network, electricity consumption during the day is relatively lower than electricity usage at night, so it can reduce the electricity usage of the PLN network.(Febri, Arif, & Amir, 2015)

In this plan, the installation of solar modules will be placed on the roof of the house to get optimal electricity results in addition to saving space and avoiding objects covering the solar modules and determining the costs of installing PLTS On-Grid. This rationale is supported by government policies regarding the utilization of environmentally friendly energy so that it becomes one of them107This research indicator is very important to provide/offer solutions to the problems experienced by the community regarding the use of environmentally friendly energy. Research with a basic research method approach is carried out through an approach of observation, analysis, of existing conditions regarding data on wind conditions, weather, sunlight, and analysis of the required power requirements to facilitate energy needs in Building I, Panca Budi Development University.(Handayani & Ariyanti, 2012).

Figure 1. Example of using a rooftop solar power plant

LITERATURE REVIEWS

State of The Art of Research

In this study there are several journals used as references:
Indonesia is located on the equator so it has two seasons, namely the rainy season and the dry season. Based on the solar insolation map, Indonesia has the potential to use electrical energy from alternative solar sources. This has the potential to be utilized in meeting primary needs, namely electricity and in addition to reducing the use of limited fuel energy sources.

The supply of oil and gas resources in the 21st century is running low. Meanwhile, the need for electrical energy is increasing. In 2017, the need for electrical energy is 25.4 trillion kWh. The Indonesian mainland has an area of around ±2 million km2 and can utilize solar energy to generate solar power plants of

5.10 mW or the equivalent of 112,000 GWp with an irradiation of 4.8 kWh/m2/day. From a technical point of view, in totality, it is said that it is feasible to operate the PLTS system and synchronize KWh EXIM with a performance ratio of 81%. Based on the technical aspect, it can be realized(Laksana et al., 2021).

Rooftop PLTS or rooftop PLTS are small-scale PLTS that usually have a capacity of 20kW and there are several commercial buildings that have a capacity close to 1 MW. PLTS on the roof of the house has several advantages such as reducing the cost of monthly electricity bills and saving land or land. In addition, it is easier and cheaper to connect to existing electrical systems.

Government Regulation Regarding Utilization of Environmentally Friendly Energy

The government has regulated the use of energy sources in Law No. 30 of 2007. The supply of EBT primary energy in the primary energy mix in 2025 is 23.0% (92.3 MTOE) and in 2050 it is 31.2% (315.7 MTOE)) Apart from being used as primary energy for generators, EBT is also developed as energy that is used directly by the user sector based on:

1) Electricity needs with a target of electricity utilization per capita in 2025 of 2,500 kWh/capita and in 2050 of 7,000 kWh/capita, and non-electric EBT development plans based on current production realization, and plans for optimal utilization of biofuels in the user sector; and
2) Balancing the sides of energy demand and supply so that the target of the EBT mix in 2025 is at least 23% and in 2050 of at least 31% is still achieved

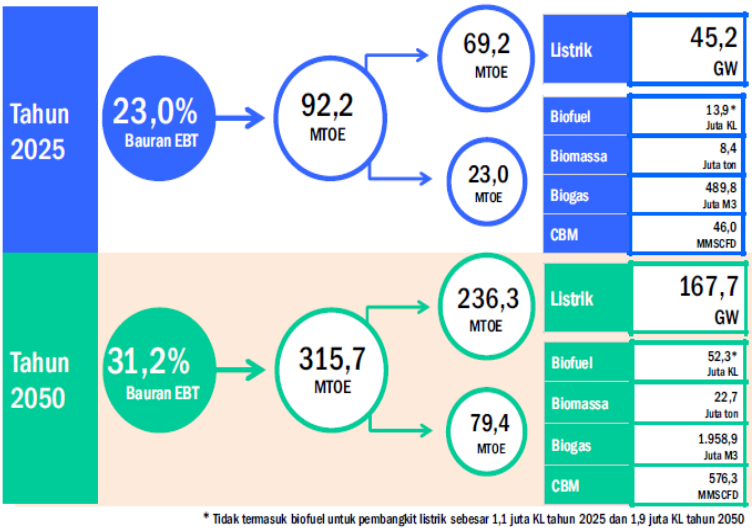

Figure 2. Renewable Energy usage targets

Solar Power Plant (PLTS)

Solar energy always reaches Earth, 24 hours a day, seven days a week. Sunlight contains so much energy that even a fraction of it falling on the Sahara desert would be sufficient to meet the energy needs of all of humanity. During the midday sun, solar power reaches the Earth's surface at a peak energy value of one kilowatt (1 kW) per square meter per hour. So, if all this energy can be accommodated, it will be able to provide all the electricity needs in every country on this earth. In short, solar power is energy that comes from the sun(Sukerayasa, 2021).

How Solar Power Works

Solar power comes in the form of heat and light. Energy in the form of heat can be used directly or indirectly. Another term used for heat energy that comes from the sun is Solar Thermal Energy. Light is another form of energy radiated from the sun. Every activity uses sunlight to carry out our daily activities; This is the direct use of light from the sun.(Patel, 2020). There is an interesting thing, light can also be converted into electricity using photovoltaic modules called PV modules or solar panels. The principle of converting light into energy (which is useful) is also carried out by nature through a process called photosynthesis, where green leaves on plants convert sunlight into energy that plants need to grow, and if consumed by humans, this is how humans obtain energy to our body. Actually the sun can be the perfect source of energy to provide the electrical power needed around the world. Unfortunately the energy that

comes from the sun is not homogeneous. Value not only depends on the weather every day, but varies throughout the year. It means,(Junior, Nyoman, Kumara, Ayu, & Giriantari, 2022)

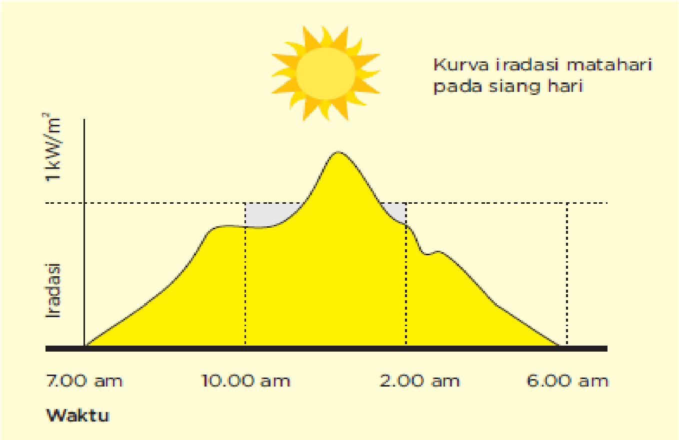

Figure 3. Solar Irradiation Curve

Source: PNPM Mandiri Renewable Energy Sources, 2010

The maximum solar irradiance value is used in system design to determine the peak level of energy input entering the solar system. If storage is included in the system design, it is important to know the variations in solar irradiance over that period to optimize the system design. Furthermore, it is necessary to know how much solar power has been captured by the module (collector) over a period of time such as a day, week or year. This is known as solar radiation or irradiation. The unit of measurement for solar radiation is joules per square meter (J/m2) or watt-hours per square meter (Wh/m2).(Sitepu & Gunadhi, 2014).

The orientation of the equipment used to convert or absorb energy from the sun is very important. Let's consider the use of a photovoltaic (PV) solar module that converts sunlight into electricity. The amount of electrical energy generated by a PV module depends on the available solar power, and in particular, on the direction of the solar module towards the sun. If the solar module is installed south of the equator, it must face north and vice versa. The PV module will produce the most output if it is directed directly at the sun. Giant installations of PV Modules in countries that fall off the equator are built using solar trackers to ensure that the modules follow the sunlight thereby ensuring an optimal situation. The pictures on this page show a diagrammatic form of why the amount of energy available to the solar module increases when it is facing directly to the sun. The first image (under geometric effect) shows sunlight hitting a horizontal plane one meter square to the surface of the earth. This diagram shows the nine rays that land on its surface. In the second image, we can see that the same one-meter-wide surface is tilted so that it is perpendicular to the direction of the sun, and now we see that the number of rays has increased from 9 to 12. This is similar to what happens with the amount of energy that available on a solar module: energy increases when the module is pointed directly at the sun. The location of the sun is determined by two angles The first image (under geometric effect) shows sunlight hitting a horizontal plane one meter square to the surface of the earth. This diagram shows the nine rays that land on its surface. In the second image, we can see that the same one-meter-wide surface is tilted so that it is perpendicular to the direction of the sun, and now we see that the number of rays has increased from 9 to 12. This is similar to what happens with the amount of energy that available on a solar module: energy increases when the module is pointed directly at the sun. The location of the sun is determined by two angles The first image (under geometric effect) shows sunlight hitting a horizontal plane one meter square to the surface of the earth. This diagram shows the nine rays that land on its surface. In the second image, we can see that the same one-meter-wide surface is tilted so that it is perpendicular to the direction of the sun, and now we see that the number of rays has increased from 9 to 12. This is similar to what happens with the amount of energy that available on a solar module: energy increases when the module is pointed directly at the sun. The location of the sun is determined by two angles we can see the same one square meter wide surface is tilted in such a way that it is perpendicular to the direction of the sun, and now we see that the number of rays has increased from 9 to 12. This is similar to what happens with the amount of energy available in a single module solar: energy increases when the module is pointed directly at the sun. The location of the sun is determined by two angles we can see the same one square meter wide surface is tilted in such a way that it is perpendicular to the direction of the sun, and now we see that the number of rays has increased from 9 to 12. This is similar to what happens with the

amount of energy available in a single module solar: energy increases when the module is pointed directly at the sun. The location of the sun is determined by two angles(Rizkasari, Wilopo, & Ridwan, 2020a).

1. The sun elevation angle (á) is the angle between the sunlight and the horizontal plane
2. Solar azimuth(â) is the angle between the projection of sunlight on the horizontal plane (module tilt angle) and north (in the southern hemisphere) or south (in the northern hemisphere).

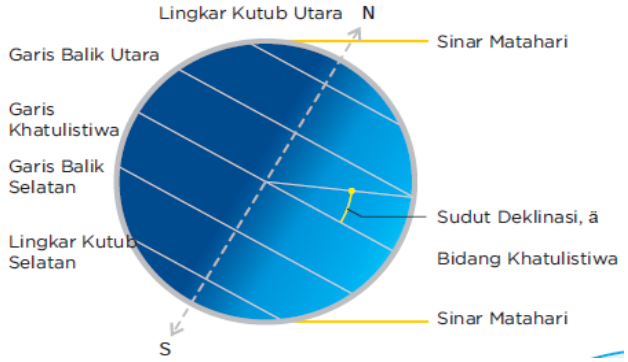

Figure 4. Position of Sunlight

Source: PNPM Mandiri Renewable Energy Sources, 2010

a. Solar Photovoltaic (PV)

The photovoltaic process was discovered in the 19th century and refers to the generation of electricity (volts) from the energy in the sun (photons). In the 1950s, the first PV modules were developed commercially, although the industry started to grow especially since the seventies.

Solar PV Modules add several practical uses in a short time. Conversion of solar PV modules, as mentioned above, is energy from sunlight converted into electrical energy. In other words, photovoltaics (PV) is a technology based on semi-conductors in the solid state that converts solar energy directly into electrical energy, with no rotating parts, no noise, and no exhaust emissions. These modules are available in various capacities, from 1 watt to 300 watts(Irwan et al., 2015).

At the beginning of this chapter, it was noted that the energy that the soil has on our earth has a maximum value of 1000 watts per square meter. This is called peak solar and the PV module rate is the peak power that can be supplied by the module when the energy from the sun is 1,000 watts per square meter. The output of the solar module also depends on the module (or cell), the temperature so that the power output as described by the solar module manufacturer is 25oC cell temperature. Various cell technologies are available in the market, such as mono (single) crystalline, poly (multi) crystalline, amorphous silicon (a-Si) (thin film) solar modules, copper-indium diselenide (CulnSe2 or CIS), cadmium-telluride (CdTe) , gallium arsenide (GaAs), organic solar cells (using titanium oxides and organic dyes), and others including amalgamation of these technologies(Rizkasari, Wilopo, & Ridwan, 2020b).

b. Solar Module

A solar module or PV is a device composed of a collection of solar cells that converts solar energy in the form of light into electrical energy. The solar module contains solar cells arranged in series and parallel. The solar module will generate electricity as long as it is exposed to the sun but when it is cloudy it will produce little because the radiation received by the small module. Solar modules if only one module will produce less than 1 kW, therefore to produce large electricity it is necessary to combine the modules and arrange them in series or parallel.

a) Frame or photovoltaic frame
b) Protection glass of the photovoltaic module
c) Encapsulation and lamination
d) Solar cells or photovoltaic
e) Insulation sheet (backsheet)
f) Contact liaison (junction box)

METHODS

The stages of research to be carried out in the first year can be seen as follows:

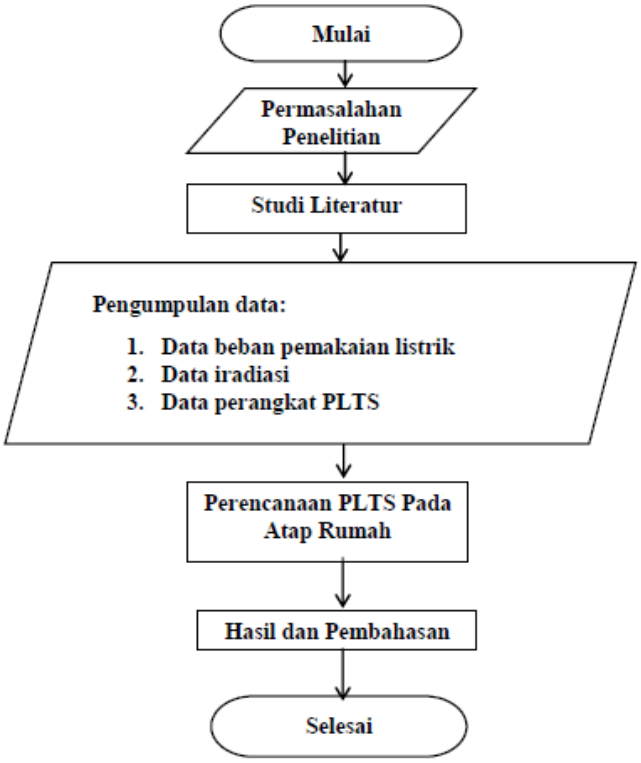

Figure 5. Research Method

RESULTS AND DISCUSSION

Testing this loaded solar module using a 12V/5 Watt DC led light load with the installation scheme shown in the figure:

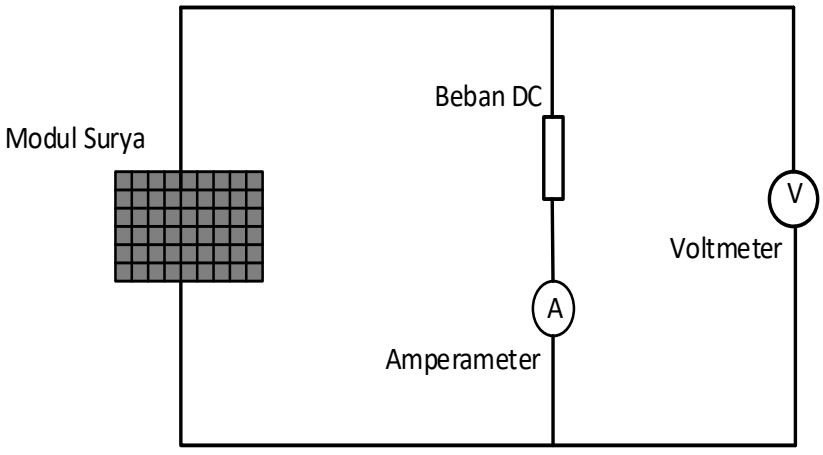

Figure 6. Schematic drawing of the Berberban Solar Module Testing Installation

Measurement of sunlight intensity using the Lux light meter application on a mobile phone with measurements in units of lux so that it is converted 1 W/m² = 179 Lux.

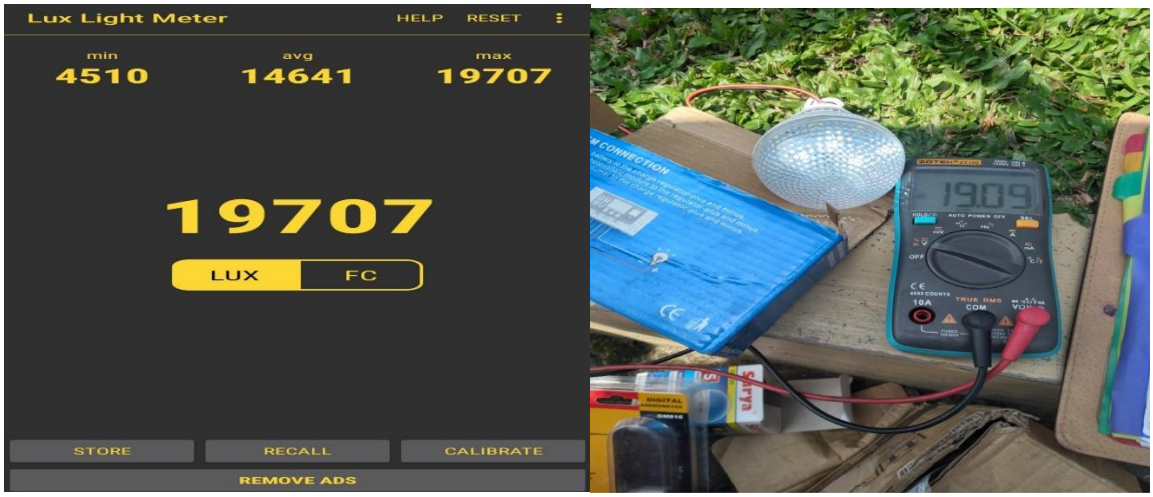

Figure 7. Voltage Measurement in Loaded Solar Module Testing

Loaded solar module test results data is shown in the following table

Table 1. Loaded of Solar Module Testing

Time (t)	Sunlight intensity (W/m²)	Solar Module				μ(%)
		Voltage (V)	Current (V)	Pins (W)	Pouts (W)	
11.00	110,055	18.87	0.58	74,881	10.94	14 %
11.20	110,091	19.36	0.57	74,905	11.03	14 %
11.40	110,061	19,27	0.56	74,885	10.79	14 %
12.00	110,094	19.80	0.58	74,907	11,484	15 %
12.20	110,055	19,72	0.56	74,881	11.04	14 %
12.40	110,067	19.76	0.58	74,889	11.46	15 %
13.00	101,698	19.30	0.56	69,195	10.808	15 %
13.20	100,642	18.84	0.55	68,476	10.36	15 %
13.40	100,363	18,46	0.56	68,286	10.33	15 %
14.00	97,234	18.50	0.57	66,158	10.54	15 %
14.20	82,804	18,38	0.55	56,339	10,10	17 %
14.40	76,044	18,18	0.53	51,740	9,63	18 %
15.00	80,703	18.02	0.52	54,910	9.37	17 %

The efficiency of solar panels is obtained from the electrical power that comes out in watts compared to its surface area. Currently on the market the efficiency of circulating solar cells is in the range of 14 - 17%. This means that a solar panel can only convert around 14-17% of all solar energy received by the solar cell, and the rest will be reflected into the air.

Based on table 4. The amount of intensity received by the solar module in the form of photon energy is not completely absorbed, some is reflected depending on the energy and frequency of the photons needed to release electrons from their bonds. The relationship between sunlight intensity and solar module voltage is shown in the following graphic.

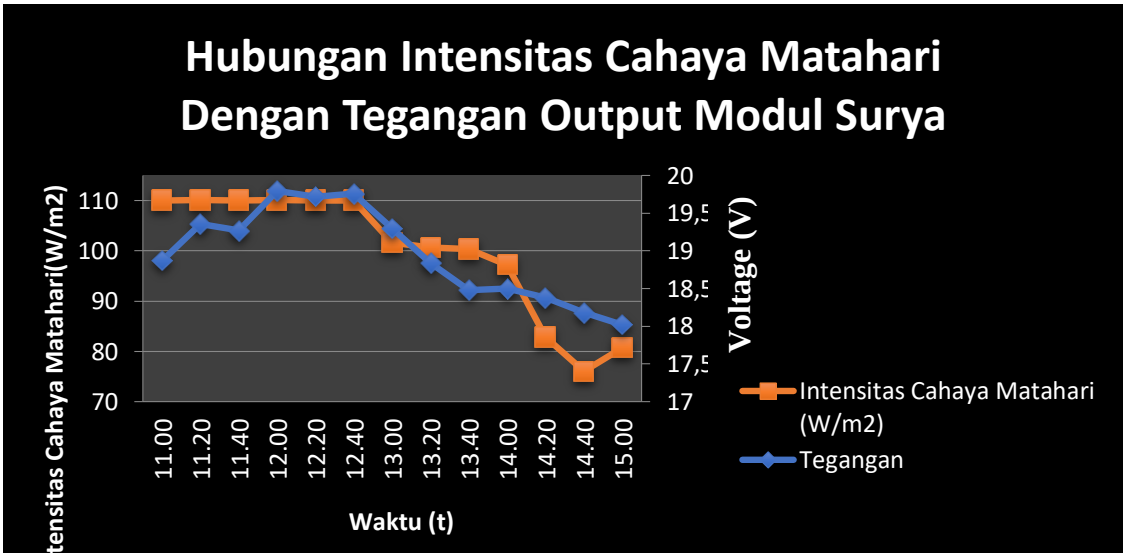

Figure 8. Image of the relationship between the intensity of sunlight and the output voltage of the solar module

The voltage on the photovoltaic cell is influenced by several factors, including the intensity of irradiation on the solar module. Variations in irradiation time greatly affect the current and voltage strength, the better the sunny weather conditions, the greater the current and voltage strength. The most optimal irradiation at 12.00 WIB, was measured at 110.094 W/m² where the measured voltage was 19.80 Volts and the measured current was 0.58 Amperes. The lowest irradiation was at 14.40 WIB, measuring 76.044 W/m² where the measured voltage was 18.18 Volts and the measured current was 0.53 Amperes. Based on the graph, the irradiation time is very influential on the output voltage, the later in the evening, the lower the output voltage.

Calculation of the efficiency value aims to determine the percentage value of sunlight energy that can be absorbed by solar modules, here are some equations to determine input and output power.

$$P_{in} = \text{Intensitas matahari} \times \text{Luas daerah modul}$$
$$= 110{,}094\ W/m^2 \times (63\ cm \times 54\ cm) + (63\ cm \times 54\ cm)$$
$$= 110{,}094\ W/m^2 \times 0{,}6804\ m^2$$
$$\text{Watt} = 74{,}907$$

CONCLUSION

Based on the results of the study it can be concluded that:

1. The intensity of sunlight is very influential in testing the solar module with a 5 V/DC load which produces an input power (Pin) of 74.907 Watts, an output power (Pout) of 11.484 Watts with an efficiency of 15%.
2. The highest intensity of sunlight in the unloaded solar module test was measured at 100.096 W/m² at 12.10 WIB which resulted in an open voltage (Voc) of 19.86 Volts.

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