

Effect of Using Monocrystalline 10 WP Full Under Body Solar Panel Heatsink Cooling Fan on Panel Performance

Pengaruh Penggunaan Heatsink Cooling Fan Full Under Body Panel Surya Tipe Monokristalin 10 WP Terhadap Kinerja Panel

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Abstract

In the Sibolga area, there is still a shortage of electricity supply, especially for street lighting, so accidents often occur, meanwhile there has a relatively large average solar radiation intensity is 4,784 Wh/m²/day so that potential for PLTS installation. This research aims to determine the performance of monocrystalline solar panels with the addition of a heatsink cooling fan in street lighting. The method used is an experimental. The test begins with the survey, potential calculation, design, testing, data collection and analysis. The solar panel used monocrystalline 10 WP with a heatsink cooling fan. The parameters are the panel temperature, voltage, and current from the solar panel. The results obtained are the temperature on the solar panel without heatsink cooling fan reaches 56.10°C with efficiency 11% and on the solar panel with heatsink cooling fan only gets 45.50°C with efficiency increases to 13%. This shows that the addition of a heatsink cooling fan has succeeded in cooling the temperature of the solar panels and increasing the efficiency level of solar panel performance for street lighting.

Keywords

Monocrystalline solar panel, haetsink cooling fan, and performance efficiency

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Submitted : December 27, 2022. Accepted : March 05, 2023. Published : March 08, 2023.

INTRODUCTION

Solar power plants use solar panels (PV Cells) made of conductor materials, these conductors are photovoltaic cells that can convert solar radiation energy into electrical energy. Solar cells or also called photovoltaic cells are semiconductor devices that can convert solar energy into DC electrical energy using Si (silicon) crystals. The working principle of silicon solar cells is based on the concept of p-n junction semiconductors. The cell consists of n-doping-and p-doping semiconductor layers that form p- n junction, antireflection layers and metal subtrates as a place where current flows from n-type layers [1]. The electric field that occurs in both pushes electrons back to the n-region and the hole to the p-region. In this process, a p-n junction has been formed, by adding metal contacts to the p and n areas, a diode has been formed that can generate electrical energy.

The solar panels used in this study for street lighting are solar panels with monocrystalline type crystalline silicon material. This type has advantages over other types

including having an excellent efficiency rate of converting sunlight into lysric energy of 13% to 20% [2], requiring a smaller space than other types, having a longer service life, and having better performance [3]. While in the field, the efficiency of solar panels is influenced by the temperature generated by solar heat, each 1°C increase in solar panel temperature (from 25°C) results in an efficiency decrease of about 0.4% [4]. In order for the efficiency of solar panels to remain stable below a peak temperature of 45 °C, the solar panel cooling method is carried out, namely by installing a heatsink cooling fan at the bottom of the solar panel.

Previous research by Pawawoi and Zulfahmi in 2019 added a cooling system using heatsinks and reflectors, the results showed that by adding an heatsink cooling system equipped with reflectors, an average temperature decrease of 18.26% and an average power increase of 10.14% compared to solar panels without a cooling system [5]. In another study also conducted by Sya'rani et al in 2019 conducted a study on solar panels with the addition of heatsinks to lower the temperature of solar panels, the results turned out that solar panels that use heatsinks alone are more effective than without the use of heat absorbers or heatsinks [6]. Then in the next study to improve the performance efficiency of the latest solar panels by Harafany et al in 2021 with the title "Comparison of Solar Panel Efficiency with Heatsink Utilization and the Effect of Sensor Installation on Solar Panels" conducted a study of solar panels using heatsinks with water cooling media and fan cooling media. Solar panels with water cooling efficiency of 1.90% and solar panels with fan cooling efficiency of 0.50% were measured at the same time at 11:09 [7].

So that this study aims to develop research from before by applying the installation of heatsink cooling fans on solar panels for street lighting and re-calculating the performance of monocrystalline type solar panels using heatsink cooling fans by comparing them with solar panels without heatsink cooling fans. The heatsink cooling fan used in this study as a novelty is to use a heatsink to fill the body of the solar panel with a plus a small fan with a 12V DC source installed at the bottom of the heatsink, where the use of this small fan still makes solar panel performance efficient, does not add to the weight of the solar panel, does not interfere with the shape of the solar panel, and with 12V it will not add to the load or loss of power from the solar panel, and looks more practical and efficient compared to previous studies. The fixed variables in this study are the voltage and current generated by solar panels, then the free variables are measurement time, solar light radiation intensity, and solar panel temperature. Important parameters are the panel temperature, voltage, and current strength of the solar panels. With this research, it is hoped that it can improve the performance efficiency of solar panels.

Characteristics of Solar Panels

Power characteristics, are the result of multiplication between the voltage and current curves (V-I). Power characteristics indicate how much power solar panels can produce, in the intersection between the current and voltage curves will find a point called the Maximum Power Point (MPP)[1].

The I-V Curve chart above illustrates the state of a Solar Cell operating normally. To determine the yield of the values that come out of the solar cell system include:

Short circuit current (I_{sc}) is the maximum output current obtained from a solar cell under conditions of no resistance/resistance (R), $V = 0$. I_{sc} or maximum electric current at the value of volts = zero; I_{sc} is directly proportional to the availability of sunlight. Open circuit voltage (V_{oc}) is the maximum voltage capacity that can be achieved in the absence of current or zero current value. The V_{OC} rises logarithmically with increased sunlight, this character that allows Solar Cells to charge the battery. The maximum power (P_{max}) is at point A (V_{max} , I_{max}), the Solar Cell will produce maximum energy if the V_m and I_m values are also maximum. The Fill Factor (FF) is a price that is close to the constant of a particular solar cell. If

the FF value is higher than 0.7, then the solar cell is better. Figure 1 shows the solar panel characteristics.

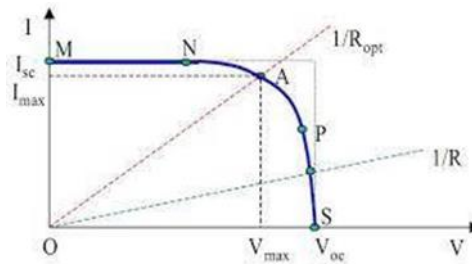


Figure 1. Characteristics of Solar Panels

Solar Panel Efficiency

The friction factor is a measure of the quality of solar cells can be known by comparing the theoretical maximum power and output power at open-circuit and short-circuit voltages [8].

$$FF = \frac{V_m \times I_m}{V_{oc} \times I_{sc}} \tag{1}$$

Power is a quantity derived from the value of voltage and current so that the value of the voltage and current produced is part of the electricity owned by the solar cell [9].

$$P = V \times I \tag{2}$$

Graphically, the maximum power on solar cells is at the peak that has the largest area. The maximum power of a solar cell can be calculated by equation 3.

$$P = V_m \times I_m \tag{3}$$

The incoming power (Pin) obtained from the multiplication between the intensity of the received sunlight radiation and the area of the solar cell can be calculated by equation 4.

$$P = I_r \times A \tag{4}$$

The output power (Pout) in solar cells is the value of the multiplication between the open-circuit voltage (Voc) and the short-circuit current (Ioc) and the filler factor (FF) generated by the solar cell [10].

$$P_{out} = V_{oc} \times I_{sc} \times FF \tag{5}$$

Solar Panel Efficiency, determining the efficiency (η) of solar panels is based on equation 6.

$$\eta = \frac{P_{out}}{P_{in}} \times 100\% \tag{6}$$

Solar Panel Cooling System

The cooling system in the solar power plant system can be done by adding cooling metal fins commonly called heatsinks. Heatsink is a solar panel cooling system in the form of metal fins that are attached to the bottom of the solar panel by transferring heat or heat on the solar panel convection to the environment. This cooling system method can be combined with additional tools in the form of a fan called a cooling fan.

According to this study, previously Rakino et al in 2019 "Passive Cooling System to Increase Solar Cell Panel Output Power", compared cooling systems including proposed coolants, water, and heatsinks. The result is that solar cell panels with proposed coolants produce an average output voltage greater than 21.49%; 4,66 %; and 8.34% of the panels with water cooling and heatsinks [11].

Another study by Rahim et al in 2019 "The Use of Thermo-Electric Coolant (Peltier) to Lower Surface Temperature In Increasing Solar Panel Output Power" conducted 2 solar panels with the same specifications and 5 Thermo-Electric (Peltier) coolers under solar panels. The installation of coolant is varied i.e. installation with 2, 3, 4, and 5 pieces. The result can lower the panel surface temperature and increase the output power of solar panels by 4.705%, 5.34%, 6.044%, and 7.21% [12].

Along with the need for electricity in the Sibolga area, it is necessary to study the performance of solar panels for better lighting in terms of temperature, voltage, current, and power produced and increase the value of the efficiency of electricity flow so that in this research there will be complete elements of proof and experimentation regarding the decision making of the heatsink cooling fan cooling system on monocrystalline type solar panels, especially in the Sibolga area.

METHOD

The method used is an experimental method or true experimental research which is supported by supporting theories. This research was also developed with a design model action method that was adjusted to the results of field surveys and was carried out outdoors to collect real research data in the field.

The research begins with a literature study method, then a site survey via google maps and a field observation method to plan by calculating the amount of potential, then designing and assembling tools, then testing the performance of solar panels to get data to be processed and analyzed. The testing phase begins with solar panels without heatsink cooling fans and then testing solar panels using heatsink cooling fans. The solar panel used in this study is a monocrystalline type of 10WP. The drawings shown in Figure 2 and the specifications are listed in Table 1.



Figure 2. Monocrystalline Solar Panels with Heatsnik Cooling Fan

Table 1. Specification of Monocrystalline Solar Panel with Heatsnik Cooling Fan

Monocrystalline	
Model	GH10M-18
Rated Maximum Power (Pm)	10W
Tolerance	+_3%
Voltage at Pmax (Vmp)	17.82V
Current at Pmax (Imp)	0.57A

Open-Circuit Voltage (Voc)	21.96V
Short-Circuit Current (Isc)	0.63A
Normal Operating Cell Temp (NOTC)	47 + 2C
Maximum System Voltage	1000VDC
Maximum Series Fuse Rating	7A
Operating Temperature	-40 to - 85C
Application Class	Class A
Cell Technology	Mono-Si
Weight	1.0 KG
Dimension (mm)	350*255*17mm = 0.08925m ²

RESULTS AND DISCUSSION

Results of Studies on Land Determination of Research Objects & Their Potential

Location determination is carried out in the Sibolga Area, precisely in villages that have not received street lighting and have natural potential that can be used to produce new renewable electrical energy. The location of the solar power plant design installation chosen is on the Sibuluan River, Ramba Goring-goring Village, located in the Central Tapanuli Regency, North Sumatra, at the coordinate point 1°43'40.0"N 98°49'38.0"E. Data retrieval of location objects and lighting paths is carried out via Google Maps whose results are shown in [Figure 2](#). The study was conducted at an open field site above the river. Then the calculation of energy potential, especially the energy of sunlight, is carried out. The calculation of the potential on the object of study is carried out through the Global website.

Solar Atlas and manual measurements using measuring instruments. As a result, the intensity of sunlight radiation or the value of Peak Solar Hour (PSH) was determined through Global Solar Atlas data on the basis of Global horizontal irradiation (GHI) obtained in the area based on data of 4,784 Wh / m² per day or equal to 1103.4 kWh / m² per year. GHI is used because the position of the solar panel is perpendicular to the sky or its position is horizontal, not tilted, this can be done in areas around the equator.

The average temperature of the Sibolga area is shown in [Figure 3](#) in the per day of 27.6 °C, while in a one-year period, the temperature in the Sibolga area generally ranges in the range of 25°C to 30°C and is very rarely below 25°C or above 30°C. Meanwhile, the average temperature of the study site based on AccuWeather is shown in [Figure 3](#), in each hour it ranges in the range of 25 °C to 31 °C and is very rarely below 25 °C or above 30 °C.

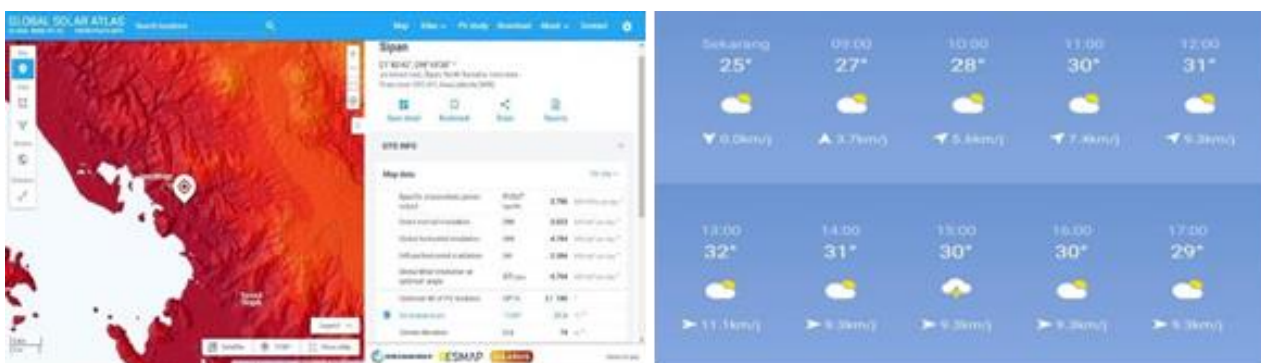


Figure 3. Location Temperature Research Based on Global Solar Atlas and AccuWeather

Solar Panel Performance Results

To get the results of the work of solar panels, the test of solar panels that is first carried out is to test the condition of the panels whether they are in good or normal condition and according to the characteristics listed in the Solar Panel Data Sheet on the back of the panel. Then testing the performance of monocrystalline solar panels using a heatsink cooling fan cooling system, The test parameters are temperature in Celsius units, solar panel voltage in V units, and current strength in mA unit, the results of this test were obtained based on the results of experiments that have been carried out using various instrumentation measuring instruments.

Before being used for research, solar modules must first be checked whether they are working properly or not and whether they are in accordance with the power characteristics of the panels. Power characteristics, are the result of multiplication between the voltage and current curves (V-I). The result is that the number of the measured output voltage is 20.21 Volts, current I_{sc} 0.60A with a module temperature of 40 °C and an ambient temperature of 27 °C. The friction factor (FF) is a parameter that expresses the magnitude of $I_{oc} \times V_{oc}$ of the maximum power $V_m \times I_m$ produced solar cell.

From these results, it shows that the monocrystalline solar panels used in this study are in very good condition, this is because the FF value is 0.837 or more than 0.7, which is according to the literature study that has been listed that if the FF value is higher than 0.7, then the solar cell is better.

Solar panel performance testing is carried out for 4 hours from 10.00 WIB to 14.00 WIB. Data is retrieved using instrumentation of measuring instruments. The result data that has been obtained is then processed into a graph, then analyzed descriptively.

The relationship between the intensity of radiation of light sun and temperature

The following graph in [Figure 4](#) shows the relationship of sunlight radiation intensity to solar panel temperature and environmental temperature, at a solar radiation intensity of 900 which rises to 910 and 920 causing the ambient temperature and panel temperature to rise.

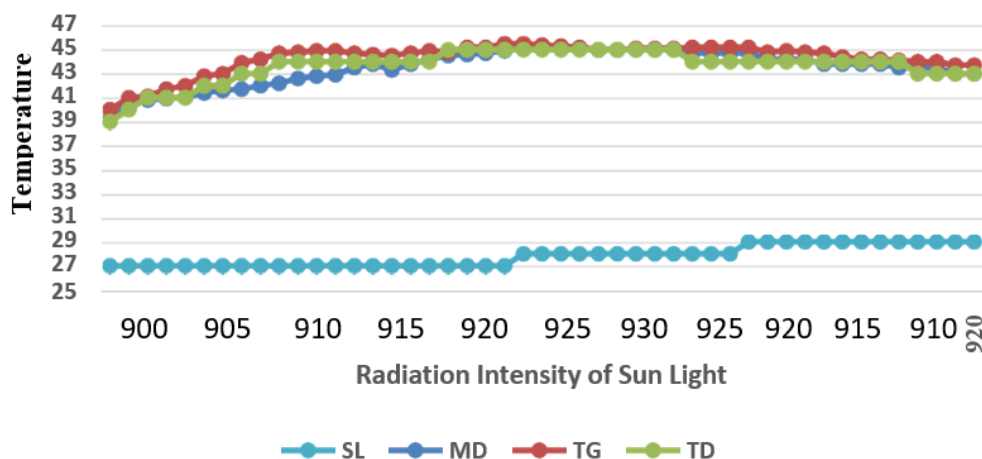


Figure 4. Relationship Intensity Radiation Light Sun Towards Ambient & Panel Solar temperature

The results of temperature measurements include the ambient temperature (SL) of 27°C rising to 28°C, while the temperature of solar panels using a manual digital temperature sensor (MD) of 39.2°C rises to 44.6°C and 45.1°C, using a thermo gun (TG) readable 40°C rises to 41.7°C and 44°C, and on a digital thermometer (TD) 39°C rises to 43°C and 45°C.

From the trend of the chart, it can be seen that the ambient temperature and the temperature of the solar panels are influenced by the intensity of sunlight radiation, where the ambient temperature and panel temperature will also rise along with the increase in the

intensity of sunlight radiation. This is in line with research conducted by Arisandy in 2017 where the highest temperature occurred at 12.00 – 12.20 exactly at the highest intensity of solar light radiation, this was influenced by the angle of incidence of sunlight irradiation perpendicular to the earth's surface which made temperature hotter [13].

Influence Heatsink Cooling Fan Towards Temperature Panel On already

From the chart shows in Figure 5, it can be seen at the beginning of the measurement, exactly at 10.00 WIB, based on the values listed on the measuring instrument, including using a thermogun (TG) on TG1 solar panel 1 (using a heatsink cooling fan cooling system) of 40 °C while on TG2 solar panel 2 (not using a heatsink cooling fan cooling system) as a comparison) of 41.7°C. and at 12:00 at TG1 the temperature was 45°C while at TG2 the temperature was 53.3°C. From the data obtained that the temperature on the solar panels that use heatsink cooling fan the temperature is below the temperature of the solar panels that do not use heatsink cooling fans. The results obtained are the peak temperature of solar panels without heatsink cooling fans reaching 56.10 °C and on solar panels with heatsink cooling fans the peak temperature only reaches 45.50 °C.

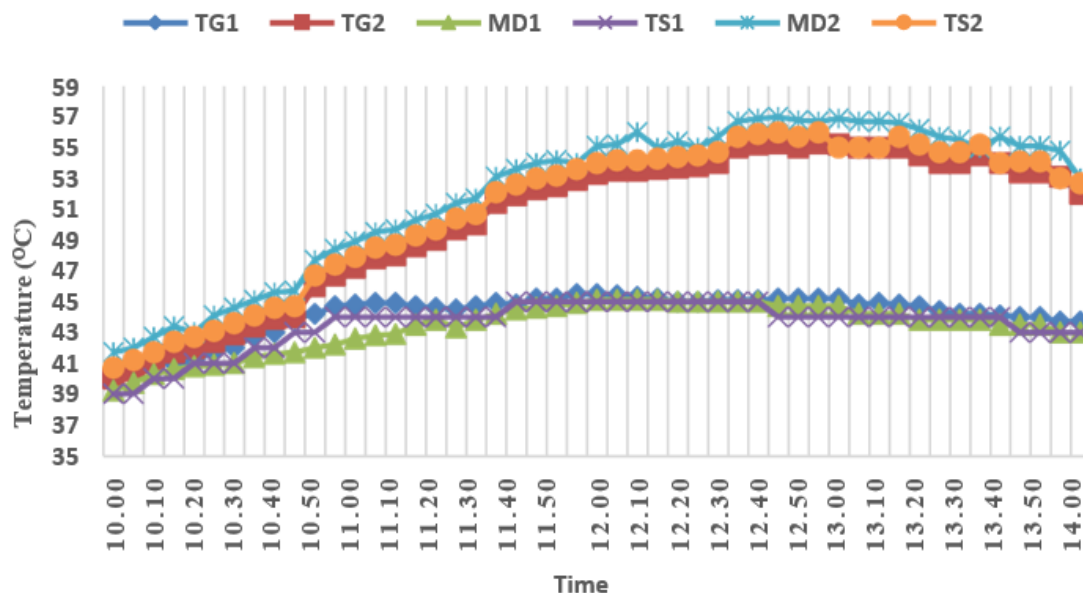


Figure 5. Influence System Cooling Heatsink Cooling Fan Towards Temperature Solar Panel

This shows that the solar panel cooling system, namely the heatsink cooling fan, can successfully cool and maintain the temperature of the solar panel at a predetermined optimum limit temperature in order to maintain the efficiency of solar panel performance, especially on monocrystalline solar panels. This is in line with previous studies where cooling systems such as the heatsink air cooling fan air media cooling system are very helpful in reducing heat at solar panel temperatures [11][12][7].

Effect of Heatsink Cooling Fan on Solar Panel Output

The output of solar panels is the parameters measured in this study, including voltage (V), current (A), power (W), and efficiency Panel Solar (%). From the chart at Figure 6, where on the X axis is from the chart above, where on the X axis is the average temperature of each panel, where the average temperature is taken from three types of temperature measuring instruments including MD, TG, and TS. On the Y axis is the voltage generated from both panels.

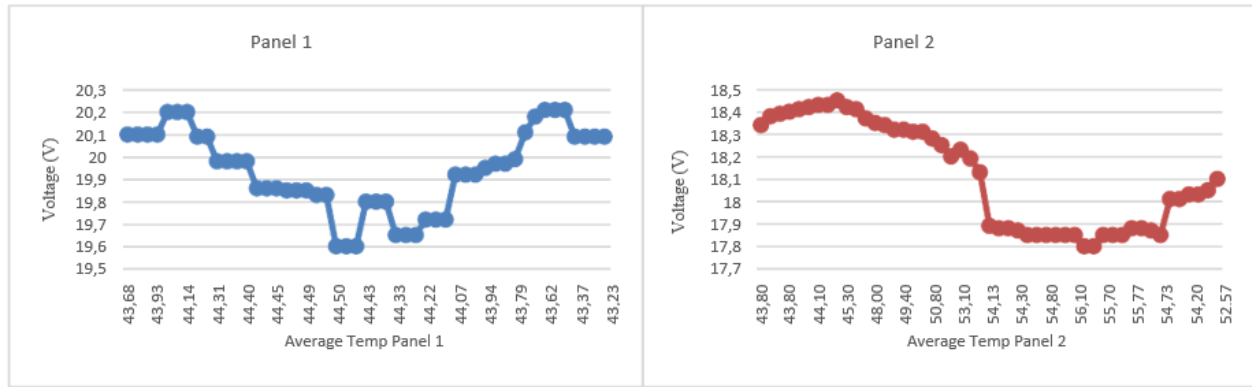


Figure 6. Voltage Measurement on both Solar Panels

Panel 1 voltage is the voltage generated from solar panels using a heatsink cooling fan, and panel voltage 2 is the voltage generated by solar panels without a heatsink cooling fan.

From the graph it can be seen that on the graph, the two panels produce different voltages. At the beginning of the voltage measurement, panel 1 is able to produce 20.1V, while panel 2 only produces a voltage of 18.3V. Panel voltage 1 produces voltages in the range of 19V to 20V, while panel voltage 2 only ranges from 17V to 18V. This shows that the heatsink cooling fan installed on the solar panel is able to maintain the solar panel voltage in the proper range (Voc) which is 21.96V.

From the chart at Figure 7, where on the X axis is the average temperature of each panel, where the average temperature is taken from three types of temperature measuring instruments including MD, TG, and TS. On the Y axis is the voltage generated from both panels. Panel 1 current is the current generated from solar panels using a heatsink cooling fan, and panel 2 current is the current generated by solar panels without using a heatsink cooling fan.

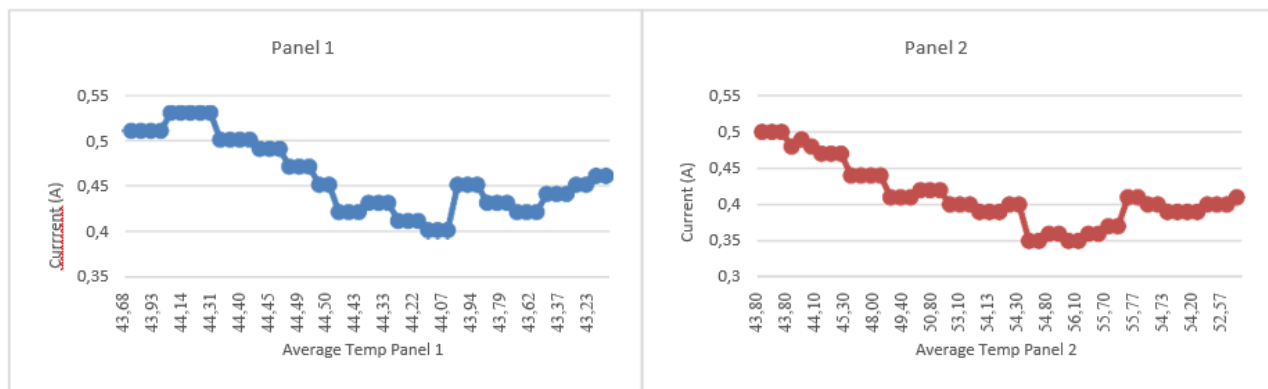


Figure 7. Measurement Current at Solar Panel

Visible deep from graphic that it is second panel produce current that different at the beginning Measurement beginning current panel 1 can produce 0,5A, While at panel 2 only produce current 0.4A. judging from the graph, panel current 1 produces a current in the range of 0.4A to 0.5A, while panel current 2 only Range Among 0,3A until 0,4A. This shows that the heatsink cooling fan installed on the solar panels is able to increase the current on the solar panels.

From the chart at Figure 8, where on the X axis is the average temperature of each panel, where the average temperature is taken from three types of temperature measuring instruments including MD, TG, and TS. on the Y axis is the voltage generated from both panels. Panel 1 power is the power generated from solar panels using a heatsink cooling fan, and

panel 2 power is the power generated by solar panels without a heatsink cooling fan. In panel 1, the power produced ranges from 8-10W with a maximum power of 10.25W, while in panel 2 the power produced ranges from 6-9W with a maximum power of 9.17W.

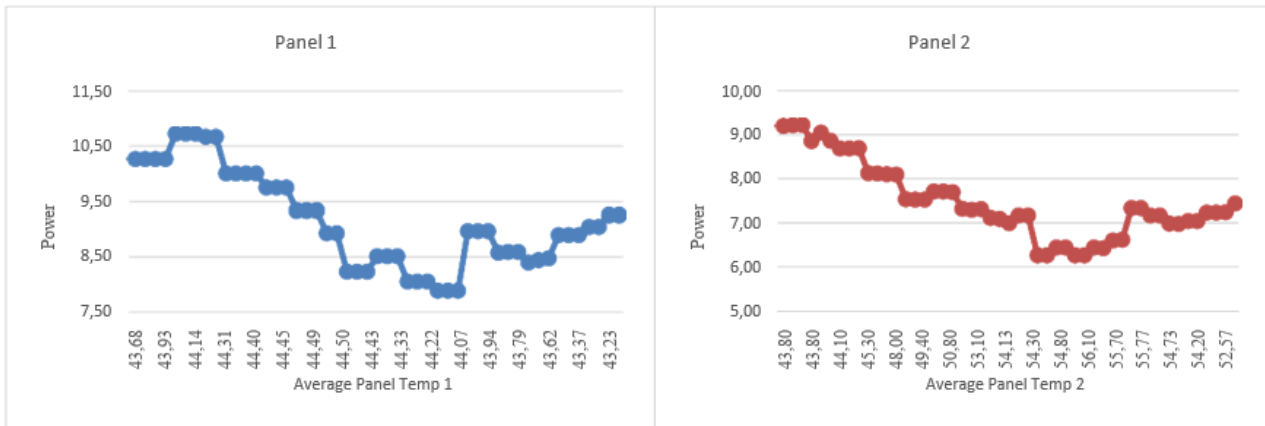


Figure 8. Power at second panel

Relationship of Solar Panel Temperature With Solar Panel Efficiency

In the Figure 9, it shows the efficiency of solar panels. Efficiency is determined using equation (6). From the chart, it can be seen that the lysric efficiency of non-cooling solar panels ranges from 9-11% while for solar panels using heatsink cooling fan the lysric efficiency ranges from 11-13%.

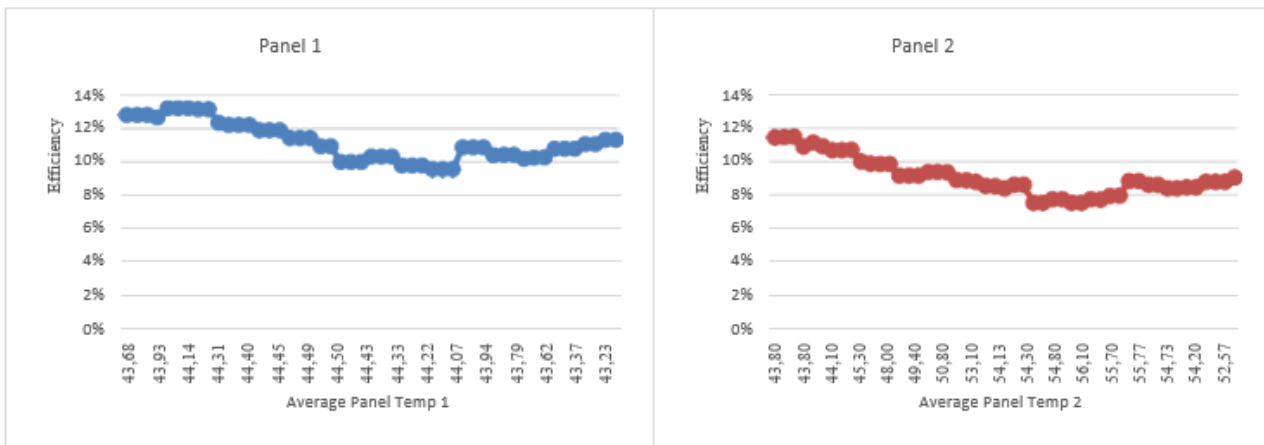


Figure 9. Efficiency at Solar Panel

From the results of the solar panel efficiency calculation data, it can be seen on the graph of the efficiency of solar panels to the average temperature of solar panels, showing that the use of heatsink cooling fan efficiency is greater than that of panels without heatsink cooling fans. It can be seen in the efficiency of solar panels using heatsink cooling fans by 13% at the same time the efficiency of solar panels without using heatsink cooling fans is 11%. This shows that solar panels that use heatsink cooling fans have higher efficiency than solar panels that do not use heatsink cooling fans. It is also stated that heatsink cooling fans can improve the efficiency of solar panels.

CONCLUSION

From the results of this study, the performance of monocrystalline solar panels using heatsink cooling fans for street lighting was obtained, the conclusions were obtained, that is:

Solar panels that use heatsink cooling fans manage to lower the heat temperature on solar panels and keep their condition below 45°C so that their efficiency is maintained and better than solar panels that do not use heatsink cooling fans. The temperature of the solar panel affects the output of the solar panel, on panel 1 the power produced ranges from 8-10W with a maximum power of up to 10.25W, while on panel 2 the power produced ranges from 6-9W with a maximum power of up to 9.17W. The efficiency of solar panels using heatsink cooling fans is 13% at the same time the efficiency of solar panels without using heatsink cooling fans is 11%.

In the application of research results, it needs to be carried out massively and monitored in real time, then further research development is needed in improving the performance of the heatsink cooling fan and streamlining its shape.

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