An Increasing the Output Power of PLTS by Using Cooler on the Panel Surface

Hermansyah Alam[1], Mahrizal Masri[2], Zulfadli Pelawi[3]

[1,2,3]Universitas Islam Sumatera Utara Medan, North Sumatera Indonesia

Corresponding Author: Hermansyah Alam

DOI: **https://doi.org/10.52403/ijrr.20240514**

ABSTRACT

A Growth in Indonesia is increasing and the energy sources needed by humans are also increasing. Therefore, more environmentally friendly and renewable energy sources are needed. One source of renewable energy is solar panels which use the sun as a source to produce electrical energy for human needs. Renewable energy that is now widely loved is solar energy, which can be converted into electrical energy with the help of solar panels. Solar panels are made of semiconductor silicon which absorbs photons from the sun's energy. However, the sun does not only produce photons which can be converted into electrical energy, but there is also heat energy which can increase the temperature of the solar panels which can reduce the performance of the solar panels. Therefor researchers conducted research to reduce the temperature of solar panels by using the monocrystalline solar panel cooling method using mineral oil with the immersion cooling technique. However, the solar panel itself has a maximum body temperature which affects the output of the solar panel. Solar cell panels experience a decrease in their ability to produce electricity if they get too hot or exceed their effectiveness limit. Therefore, a cooling system is needed to cool or reduce the temperature of the solar cell panels, so that they can produce electricity effectively and efficiently. If you look at the cooling process, solar cells remain good and stable at a temperature of 25ºC -35ºC because at this temperature the solar panels can produce the best power.

Keywords: Solar Cell Cooler, Power Efficiency, and Panel

1. INTRODUCTION

Electrical energy has become a primary need in human life, almost every aspect of human life has electricity involved in it. With the increasing population and increasingly rapid economic and industrial growth, the need for electrical energy in Indonesia has also increased significantly. To overcome this increasing need for electricity, there is a need for innovation in terms of renewable energy.

Indonesia has a very large potential source of solar energy because it gets sunlight all year round. Solar energy is a very large amount of energy and is still very little used. The average amount of solar heat that can be radiated to the earth is around 1KW/m2 or the equivalent of 1000 times the energy consumption throughout the world. Solar energy cannot be used directly. However, it is necessary to have an additional device called a solar panel.

A solar panel is made up of many solar cells. Cells are connected electrically to provide certain currents and voltages. However, the solar panel itself has a maximum body temperature which affects the output of the solar panel. Solar cell panels experience a decrease in their ability to produce electricity if they get too hot or exceed their effectiveness limit. Therefore, a cooling system is needed for cool or reduce the temperature of the solar cell panels, so that they can produce electricity effectively and efficiently. If you look at the cooling process, solar cells remain good and stable at a temperature of 25ºC -35ºC because at this temperature the solar panels can produce the best power. To compensate for the decrease in efficiency caused by the increase in surface temperature, a solar cell cooling system is implemented. The cooling system can be applied to the top surface of the solar panel. The cooling system on solar panels uses a water-based coolant to cool the surface of the solar panels using the water splash method. So that the solar panels can work optimally because the unstable temperature results in the solar panels not working optimally. By cooling the solar panels using water, you can optimize the temperature of the solar panels.

2. LITERATURE REVIEW

2.1. Solar Panels

Solar panels are electronic components that convert solar energy into electrical energy. Photovoltaics (PV) is a technology that can convert solar radiation into electrical energy. Standard PV is packaged in units called modules. In a solar module, there are many solar cells that can be arranged in series or parallel. At the same time, the so-called solar energy refers to semiconductor elements that can convert solar energy into electrical energy based on the photovoltaic effect. Apart from the depletion of fossil energy and global warming, solar modules have recently become popular. The energy produced is also very cheap because energy (solar energy) can be obtained for free (MUHAMMAD, 2020).

Solar panels produce DC current and then convert it into AC current using an inverter. Solar panels will always produce electrical energy as long as there is intense sunlight even in cloudy conditions. Electrical energy can be produced by a single solar panel or on a small scale, so several solar panels need to be combined to become a component called a solar panel or solar module. Therefore, by combining several solar panels into a component called a solar array, the benefit of this solar array is that it can increase the output power of solar panels. Solar panels with higher efficiency will produce more electricity than solar panels with lower efficiency.

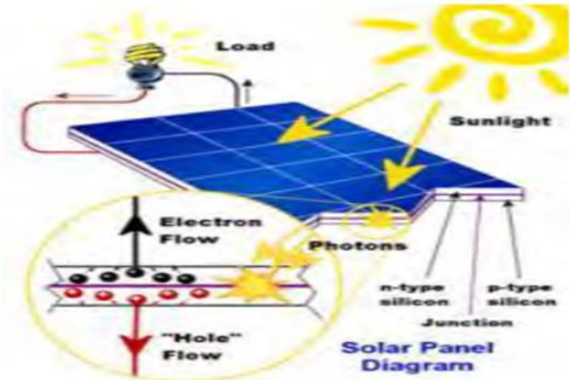

Figure 1. The process of changing light energy into electrical energy

From the image above, we can understand the process of changing light energy into electrical energy. The most common semiconductor material used in photovoltaics is silicon, a material commonly found in sand. All photovoltaic cells have at least 2 semiconductor layers, one with a positive charge and one with a negative charge. When a photovoltaic cell is exposed to sunlight, the electron charge will flow to a high potential charge. The connection between the two layers causes electricity to flow, generating a DC current. The stronger the light received, the stronger the electric current obtained.

Solar power plants or solar cells are one of the new and renewable energy sources. Solar cells utilize solar energy sources in the form of sunlight to be converted directly into electrical energy. Basically the sun carries energy which is divided into two forms, namely heat energy and light. These two forms of energy are divided into two solar power systems, namely solar thermal power systems and solar power systems. Solar thermal power systems capture heat for use as water heaters, while solar power systems convert sunlight directly into electricity. When a photovoltaic (PV) module is exposed to sunlight, the module will produce direct current (DC) electricity. DC electricity will be converted into alternating current (AC) electricity by the inverter, which is then distributed to buildings.

PLTS can effectively reduce dependence on electrical power, increase the production of new renewable energy, and improve environmental quality. The electrical energy produced by PLTS depends on several factors, namely the amount of solar radiation received by the photovoltaic module, the temperature around the module, and whether or not there is shading or shadows on the module. The solar radiation factor is the main factor for PLTS to produce electrical energy. Solar irradiation is determined by the geographic location where the PLTS is built, the greater the value of irradiation received, the greater the power that the PLTS can produce. In contrast to solar irradiation, the high temperature around the module will create electricity the output is getting smaller. In general, the temperature used for module testing is 25°C, but in bright and hot conditions, especially in equatorial areas, the temperature around the solar cell can reach 40 - 50°C.

The presence of shading factors in photovoltaic modules will cause the power produced by PLTS to decrease. This is because the modules are made of semiconductor material (solar cells) which are connected in series of 36, 60, or 72. So if shading occurs in several cells, the energy produced will be affected (Yonata, 2017).

2.2. Types of Solar Panels

The following are the types of solar modules, the types of solar modules are as follows.

a. Monocrystal (Mono-crystalline)

The monocrystalline type is the most effective panel with today's technology and obtains the highest electrical power per area. The monocrystalline design requires large electricity consumption in places with extreme climates. This solar panel has an efficiency of up to 15% -20%. This solar panel has a weakness, namely that it does not function well if placed in a place with less sunlight.

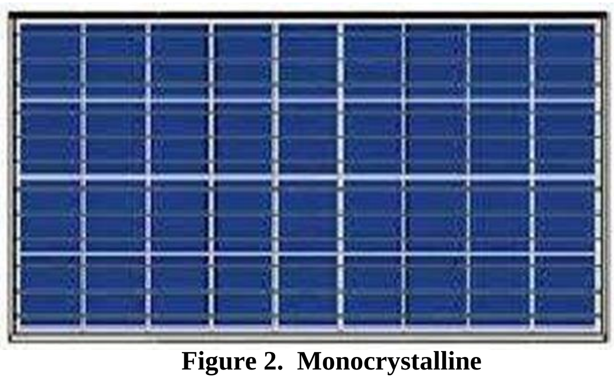

Figure 2. Monocrystalline

b. Polycrystal (Poly-Crystalline)

Polycrystalline itself is a solar panel with a random crystal arrangement, because it is fabricated using a casting process. This module requires a fairly large surface area compared to the monocrystal type to obtain comparable energy output. This type of solar module is less efficient than the monocrystal type, so it is sold at a lower price.

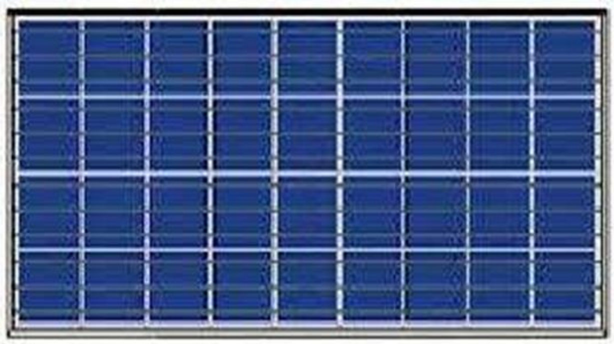

Figure 3. Polycrystalline Type Photovoltaic

c. Thin Film Photovoltaics

Photovoltaic film is a type of solar panel (two layers) with a thin layer structure of microcrystalline silicon and amorphous silicon, and a module efficiency as high as 8.5%. Therefore, the surface area required per watt of power produced is greater than single crystals and polycrystals. The latest innovation is thin film three-layer (three-layer) junction photovoltaics. This type of solar panel can work very efficiently in very cloudy air, and can produce up to 45% more electricity than other types of panels with the same power.

Figure 4. Thin Film Solar Cells

2.3. Photovoltaic Working Principle

Solar cells have the principle that if sunlight shines on the solar module, the electrons in the solar cell will move from N to P, so that the output terminal of the solar panel will produce electricity. The electrical energy obtained by solar panels depends on the number of solar cells combined in the solar panel.

The output of the solar panel is in the form of direct current (DC), and the output voltage is large, depending on the number of solar cells installed on the solar module and the amount of sunlight shining on the solar panel.

The output from the solar panel will be directly intended for loads that require a DC voltage source and low current consumption. For example, electricity is generated and can also be used at night (when the solar panels are not exposed to sunlight), then the output from the solar panels themselves is connected to a storage medium, in this case the battery. But it is not directly connected like switching from the solar panel to the battery, but must be connected to the regulator circuit, which has an automatic battery charger circuit. (Automatic charger). When combined, these two types of semiconductors will form a pn junction or pn diode.

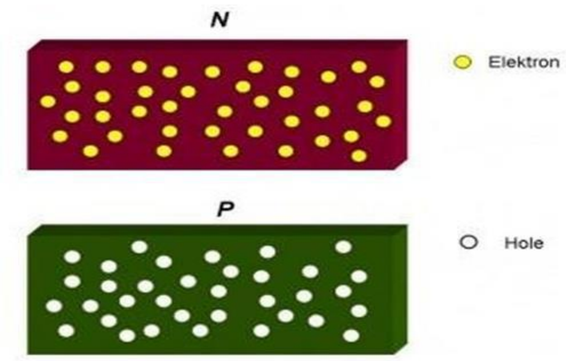

Figure 5. P and N Semi Conductors

1. If two types of semiconductors n and p are connected, electrons will flow from the n semiconductor to the p semiconductor and vice versa. But the initial connection distance n to p can be limited.
2. The number of holes in the p semiconductor will decrease if the n semiconductor combines with the p semiconductor, giving rise to a positive charge. In the same situation, if a p semiconductor combines with an n semiconductor, the number of electrons will become small, and this is called an excess positive charge.
3. There is an electric field due to the pn connection at the balance point, namely the moment when the number of holes moving from semiconductor p to n is compensated by the number of holes being attracted back towards semiconductor p due to the electric field E. Likewise with the number of electrons moving from n top semiconductor, compensation for electrons flowing into the n semiconductor results in an attractive electric field. Or, the electric field of electrons and holes is prevented from flowing to other semiconductors. It is at this pn connection that the process of converting sunlight into electricity occurs. For the purposes of solar cells, the n semiconductor is in the top layer of the p junction facing the direction of incoming sunlight, made much thinner than the p semiconductor, so that sunlight shining on the surface of the solar cell can be absorbed and enter the depletion area and the p semiconductor.

3. METHODOLOGY

This chapter includes the time and place of research, tools and materials, tool design, research methods, and research procedures. In the research procedure, several testing steps will be carried out to find out how the circuit works. The data collection method is one way to obtain material information about a fact that is true so that it can be accounted for. The data collection methods in this research are:

1. Field Study
   In this field study, a solar module cooling design was carried out using water splashes to increase the output efficiency (DC current) of the solar cell.
2. System Design
   This stage includes system design using literature studies and studying technological concepts from existing components. This stage is the most important stage where the initial form of

the series is formed will be designed. At this stage, system design and existing processes are designed

3. Implementation
   At this stage, the tool design that has been made is implemented. This stage realizes what was contained in the previous stage into an input that is in accordance with what was planned.
4. Testing and Evaluation
   At this stage, a trial is carried out on the series and measurements of working performance with some data involving several users and then corrections are made if there are errors so that an evaluation of the trial results can be carried out.
5. Literature Study (Literature)

Literature studies are carried out by collecting and studying files, documents and archives in the library as well as supporting books about the tools being designed. Furthermore, these data become references and at the same time try to apply existing theories.

A solar panel is a device or component that can convert sunlight energy into electrical energy using the principle of the photovoltaic effect. What is meant by the photovoltaic effect is a phenomenon in which an electric voltage appears due to the connection or contact of two electrodes which are connected to a solid or liquid system when receiving light energy.

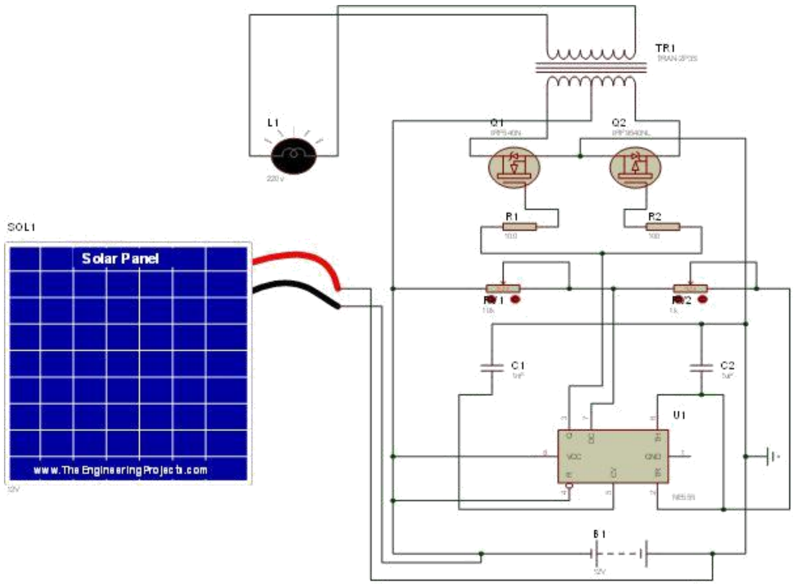

Figure 6. Solar Cell Circuit

The solar cell circuit is first connected to the solar charge controller. The function of the solar charge controller is to regulate the electric current entering the battery, so that the battery does not experience overcharging or overcharging which results in the battery draining or being quickly damaged. Then the Solar Charge Controller is connected to the inverter. The inverter functions as a voltage converter from DC to AC. Because the battery used is a battery, and the battery stores DC current and the load used is an AC lamp.

4. RESULTS

To maintain the power output (Power Efficiency) on the solar module to remain constant and produce good electrical power by using water splashes as a coolant. Requires a control to regulate the cooling process so that it continues to work well. The results of the experiment can be used as a comparison with all data taken for 6 consecutive days. The discussion begins with an experiment measuring the voltage at the solar panel output

4.1. Design a Programming Language

In designing a programming language using Arduino Uno programming. The Arduino functions as a controller to turn on the pump, when the temperature sensor on the solar panel reaches > 40° C, the Arduino orders the pump to turn on, the pump will flow water through the nozzle and splash water on the surface of the solar panel. The pump will turn off and the temperature will return to normal, namely <39 °C. The program to activate the pump is as follows.

```
#include <DHT12.h>
#include <Wire.h>
#include "DHT.h"
#include <LiquidCrystal_I2C.h>
#define DHTPIN 2

#define DHTTYPE DHT11
LiquidCrystal_I2C lcd(0x27,16,2);
#define DHTPIN 2 // define the pin used for the DHT11 sensor
Determine the type of DHT used (choose one)
Currently selected is DHT11
#define DHTTYPE DHT11 // DHT 11

DHT dht(DHTPIN, DHTTYPE);
#define RELAY_ON 0
#define RELAY_OFF 1
#define RELAY_1 7    // the pin used is pin 7
#include <Wire.h>
#include <LiquidCrystal.h>
#include <DHT.h>
#define DHTPIN 2
#define DHTTYPE DHT11
#define temperature 11
#define temperatureoff 12
void setup()
{
Serial.begin(9600);
dht.begin();
lcd.init();
lcd.backlight();
lcd.setCursor(0,0);
lcd.print("HELLO... MY NAME ");
lcd.setCursor(0,1);
lcd.print("TONI SBR");
delay(1000);
Serial.begin(9600);
Serial.println("CHECK TEMPERATURE!");
dht.begin();
Set the output pin. pinMode(RELAY_1, OUTPUT); pinMode(temperature, OUTPUT); pinMode(temperatureoff, OUTPUT);
Initialize relay one as off so that on reset it would be off by default
digitalWrite(RELAY_1, RELAY_OFF);
lcd.begin(16, 2);
lcd.setCursor(1,0);
lcd.print("info");
lcd.setCursor(1,0);
lcd.print("I AM A STUDENT");
delay(5000);
lcd.clear();
lcd.setCursor(1,0);
lcd.print("THE WORLD IN");

lcd.setCursor(2,1);
lcd.print("YOUR HAND");
delay(5000);
lcd.clear();
}
void loop() {
Read humidity and temperature float h = dht.readHumidity(); float t = dht.readTemperature();
lcd.setCursor(0,0);
lcd.print("Temperature ");
lcd.print(t);
lcd.setCursor(0,1);
lcd.print("Humidity ");
lcd.print(h);
delay(1000);
Check the reading results, and display if ok
if (isnan(t) || isnan(h)) {
Serial.println("Failed to read from DHT");
returns;
}
if (t>40.00)// ON
{
digitalWrite(RELAY_1, RELAY_ON);
digitalWrite(suhuon, HIGH);
digitalWrite(temperatureoff, LOW);
}
else if (t<39.00)//OFF
{
digitalWrite(RELAY_1, RELAY_OFF);
```

```
digitalWrite(temperatureoff, HIGH);
digitalWrite(temperature, LOW);
}
Serial.print("humidity: ");
Serial.print(h);
Serial.print(" %t");
Serial.print("temperature: ");
Serial.print(t);
Serial.println(" *C");
lcd.setCursor(0,0);
lcd.print("humidity: ");
lcd.print(h);
lcd.print(" %   ");
lcd.setCursor(0,1);
lcd.print("temperature: ");
lcd.print(t);
lcd.print(" C    ");
}
```

4.2 Tool Test Results

To find out the power output on the solar panel, we will measure the voltage at the solar panel output using a multitester measuring instrument.

a. Voltage measurement

Figure 7. Voltage Measurement Using a Multitester

The picture above shows the results of measuring the open voltage on the SCC using a multister with a voltage produced by the solar panel of 13.14 volts.

b. Current Measurement

Figure 8. Current measurements using a multitester

In the picture, the picture above shows the results of measuring the current on the SCC using a multister with a current produced by a solar panel of 0.36 Amp.

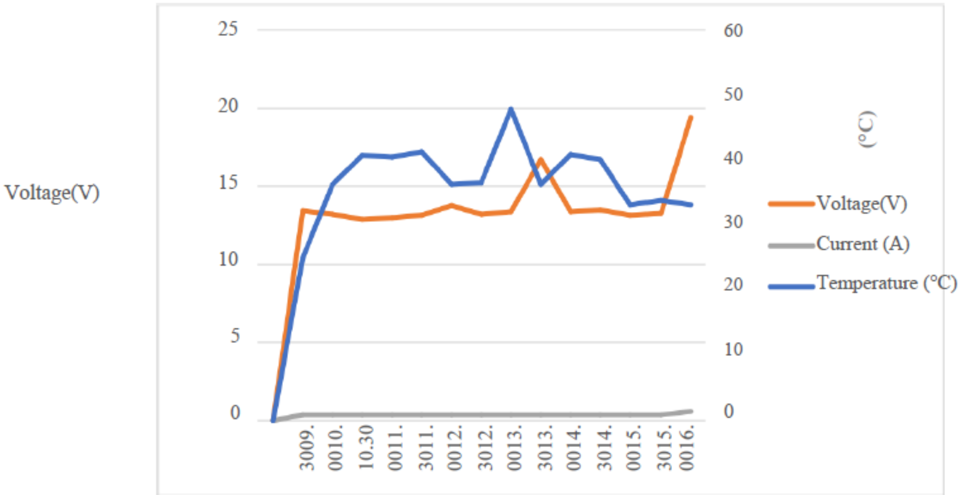

Figure 9. graphs of solar cell cooling tests on day 1
Source: Author 2022

Based on the picture above, there are DC results obtained when using a cooler. Where the effect of temperature on voltage is influential. It can be seen in the graph above that from 12.00 to 14.00 the temperature experienced a quite large increase and at 15.30 the temperature decreased, but the voltage value experienced a quite large increase. The blue line is the result of measuring the temperature on the solar panel module, while the red line is the result of the DC voltage on the solar module.

In the table above, the results of the 2nd day of testing have been obtained. On the 2nd day of testing, the highest temperature was at 13.30 with a temperature of 40.70° and at this temperature the solar panel produced a voltage of 13.19 with the pump status being Active. And the lowest temperature that day was 33.20° with a measured voltage of 13.36 Volts, and the pump status was inactive.

In the calculations shown above, the maximum output power of each solar module has a different value, with the largest average power output produced by a solar module that uses a cooling system, namely 133.42 W with an average efficiency value of 26.27% and which does not use a cooling system of 108.01 W with an average efficiency value of 18.95%. It can be concluded that when the temperature increases on the solar module the power produced will decrease, but if the solar module uses a cooling system on the surface of the solar module the power generated Yield will increase and efficiency will also increase.

CONCLUSION

From the results of testing the design of a solar cell module surface cooling circuit using the water splash method as an effort to increase power efficiency that has been made, it can be concluded as follows.

1. Researchers succeeded in designing a series of surface cooling systems for solar cell modules using the water splash method as an effort to increase power efficiency using a DHT11 temperature sensor and Uno microcontroller.
2. Based on the test results, when the solar cell is at a temperature of 40°, the microcontroller will give a command to turn on the pump and will turn it off when the temperature is below 40°.
3. An increase in the working temperature of the solar module results in a decrease in the efficiency level of the solar module. The lowest decrease in efficiency occurred in the average solar module without cooling at 18.95% with a power of 108.01 at a temperature of 44.56 °C. And the increase in the

efficiency of solar modules that use cooling is an average of 26.27% with a power of 133.42 W at a temperature of 41.54 °C.

4. The DHT11 temperature sensor functions as a temperature reader on the surface of the solar cell and the SCC functions to control the voltage produced by the solar cell.
5. Based on the test results, the tool functions well according to the program that has been created.

Declaration by Authors

Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

REFERENCES.

1. Aryza, S., Irwanto, M., Lubis, Z., Siahaan, APU, Rahim, R., & Furqan, M. (2018). A Novelty Design Of Minimization Of Electrical Losses In A Vector Controlled Induction Machine Drive. In IOP Conference Series: Materials Science and Engineering (Vol. 300, No. 1, p. 012067). IOP Publishing.
2. Aryza S. (2022). Implementasi Artificial Neural Nethwork Dalam Pengaturan Kualitas Produk Biodiesel dari minyak jelantah. Senatika Vol 6 no 3 pp 173-184
3. Hamdani, H., Tharo, Z., & Anisah, S. (2019, May). Comparison of the Performance of Solar Power Plants Between Mountain Areas and Coastal Areas. In Uisu National Engineering Seminar (Semnastek) (Vol. 2, No. 1, pp. 190-195).
4. H. Alam., Habibi, A. K., & Widya, H. (2022, July). Penggunaan Algoritma Vigenere Cipher Dan One Time Pad Untuk Keamanan Pesan Teks. In *Prosiding Seminar Nasional Teknik UISU (SEMNASTEK)* (Vol. 5, No. 1, pp. 160-166).
5. Putri, M., Wibowo, P., Aryza, S., & Utama Siahaan, APRussiandi.(2018). An implementation of a filter design passive lc in reducing a current harmonic. International Journal of Civil Engineering and Technology, 9(7), 867-873.
6. Rahmaniar, R. (2019). Flash-nr Model in Electrical Power System Analysis (Doctoral Dissertation, Padang State University).
7. Tarigan, AD, & Pulungan, R. (2018). The Effect of Using Unbalanced Loads on the Lifespan of Electrical Equipment. RELE (Electrical and Energy Engineering): Journal of Electrical Engineering, 1(1), 10-15.

How to cite this article: Hermansyah Alam, Mahrizal Masri, Zulfadli Pelawi. An increasing the output power of PLTS by using cooler on the panel surface. *International Journal of Research and Review*. 2024; 11(5): 112-121. DOI: *https://doi.org/10.52403/ijrr.20240514*

******