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Improve Efficiency of An Automated Photovoltaic Solar Tracker with Cooling System for Renewable Energy Application

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Abstract: This project develop high efficiency of the solar tracker by adding cooling system because solar panel has temperature coefficient that output power will decrease by a half of a percent for every degree the temperature rises and cooling system will reduce the temperature of solar panel. The main objective of this project to utilize the maximum solar energy and generated high efficiency of solar system by using solar tracker with cooling system. This project use LDR sensor to determine the orientation of the sun rays and the input readings of the LDR sensor will read and analyzed through C++ programming. Servo motor has been used to control the movement and rotation of the solar panel when servo receive PWM signals from the micro controller programmer and servo moved the solar panel and tracked the sun light by using LDR sensor. The data has been collected base on the Voltage (V), Current (mA) and Power (mW) that solar tracker produce with cooling system and without cooling system. The differences data collected has been analyzed that solar tracker can generated high efficiency with cooling system or without cooling system. This project presented a means of to utilize the maximum solar energy by using solar tracker. Specifically, it demonstrated a solar tracker system solution for maximizing solar energy by using cooling system. This project system can be improved in the future by adding IOT system at solar tracker system or cooling system. The system can be remotely controlled the movement of solar tracker or control the operation of cooling system.

Keywords: Solar Tracker, Cooling System

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1. Introduction

Electricity plays a major role in our daily lives, making our lives simpler and more relaxed. Nevertheless, as demand increases, it needs to generate more electricity. As more electricity is generating, more pollution it will cause to the environment. Recently, solar energy has given more attention, it is a clean and renewable energy sources. The Photovoltaic (PV) cells are attained to convert solar energy from the sunlight directly to electrical energy. It is the cleanest energy source that is the least likely to pollute the environment.

For all its potential and significance, photovoltaic power still needs to be improved in some areas, especially in today's large-scale applications, to become competitive with conventional energy sources [1-15]. To increase the energy produced by solar modules or the network of solar panels, incorporation into the solar tracking system is important [3-7]. Solar tracking helps us to continuously direct solar panels to the sun in optimal position, thereby improving a photovoltaic system's overall efficiency. The theoretical potential excess energy that solar tracking can generate has been calculated. A complex system based on these preliminary calculations has been designed and built using single-axis positioning and at the same time electronically performed maximum power point tracking [11],[14],[15]. There are several factors that affect the efficiency of the collection process such as solar cell efficiency and source solar irradiance.

The materials used in the manufacture of solar cells limit a solar cell's efficiency [2]. This makes it particularly difficult to make significant improvements in cell performance, thus limiting the efficiency of the overall process of collection. Therefore, the most achievable way to improve solar power collection performance is to increase the mean irradiation intensity received from the source. There are three major approaches in medium and large-scale systems to maximize power extraction.

2. Project Methodology

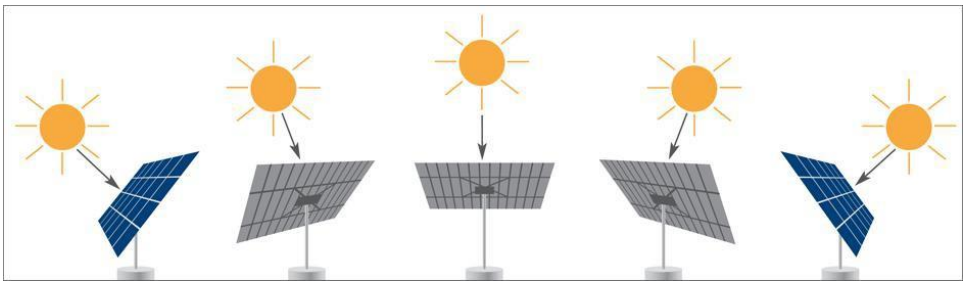

Figure 1: Movement of solar tracker

Based on the block diagram, this project start by sending the data from LDR sensor to microcontroller and microcontroller will process the data. The data will be interpreted at the microcontroller and transmitted the data in order to turn to the servo motor in the desired degree. At the end of the process, solar energy collected by the solar panel will then be moved to the charging panel where the stored energy will be used by other charges

2.1 Flow of the Project

Flowchart in Figure 2 shows the process taken to complete this project. The project started with several literature work to obtained the general idea of how the system works. The design of the system and simulation are then carried out before the construction work begin.

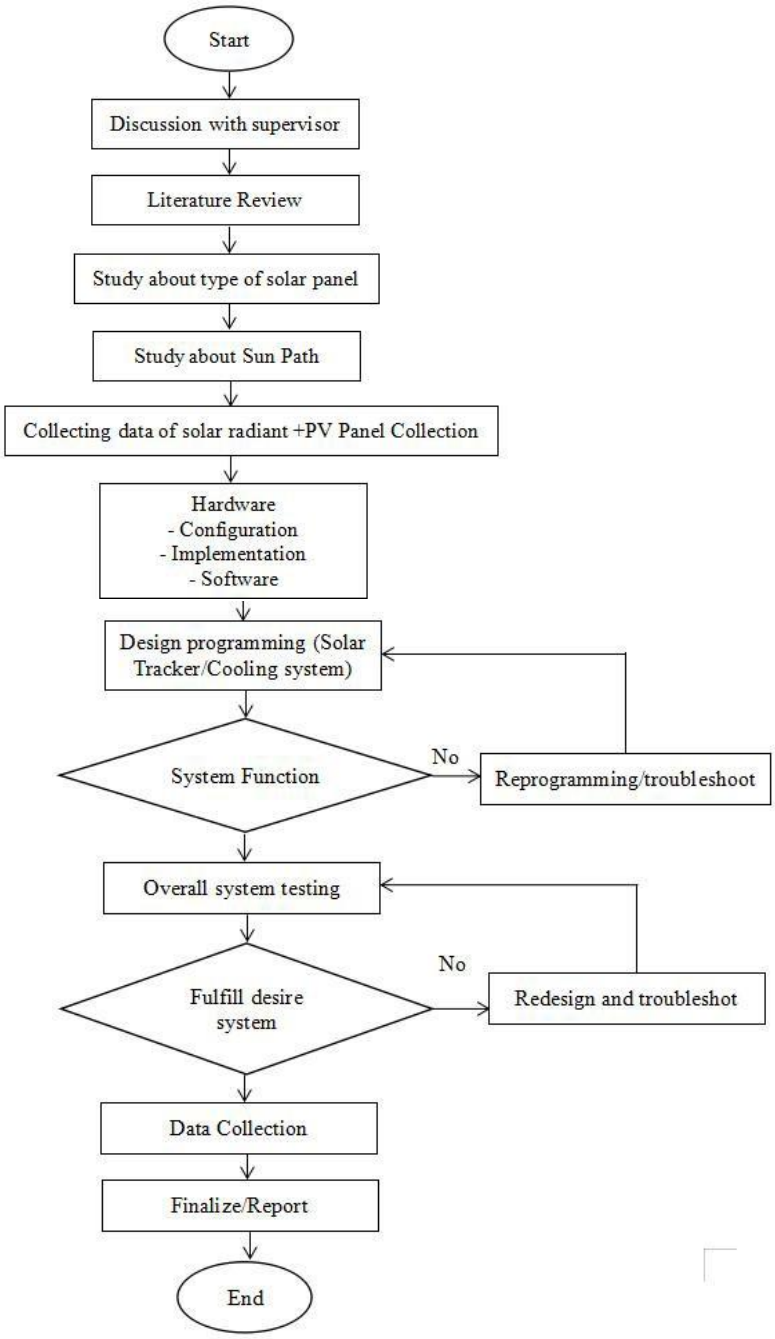

Figure 2: Project implementation process

2.2 Project Components

Table 1 shows the main hardware components used in developing the prototype of Solar Tracker and cooling system with their own functions and details of specifications.

Table 1: List of material used

No	Component	Function	Specification
1	Solar Panel	Function as main source for the whole system. Collected the energy from sun light.	➢ Polycrystalline ➢ 10 watt. ➢ Non Continuous
2	Servo Motor	To move solar panel and follow the sun light.	➢ 180˚ Rotation ➢ 5-8V
3	Arduino Uno	Arduino read the data that received from LDR and process the data.	➢ Atmega 328 p.u
4	Charge Controller	Arduino read and process the data power going into the battery bank from cycle	➢ Bat voltage 12/24V ➢ Discharge Current 10A
5	Battery Storage	Storage the energy collected from solar panel.	➢ 12 V
6	LDR	Detect the sun light and transfer the data to arduino.	➢ 4 LDR
7	Water pump	When heat sensor triggered water pump will on and water will flow to solar panel.	➢ 3-5V

Before complete prototype is constructed, each of the sub-system are tested first to make sure the functionality of each function circuit. Figure 3 and Figure 4 show both microcontroller system simulation and solar tracker with cooling circuit and simulation. Each of the system is tested separately to achieve full working condition.

Description:
Solar Tracker
- LDR detect light .
- Arduino read and process the data.

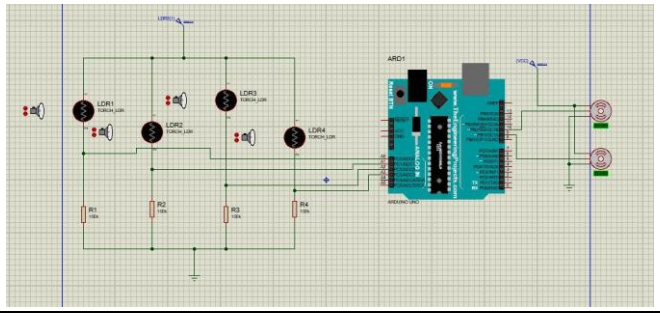

Figure 3: Solar tracker microcontroller and simulation circuit diagram

Description:
Cooling System
- Sensor detect heat (27˚C).
- Arduino read and process the data.
- Water will pump from tank and flow to solar panel.

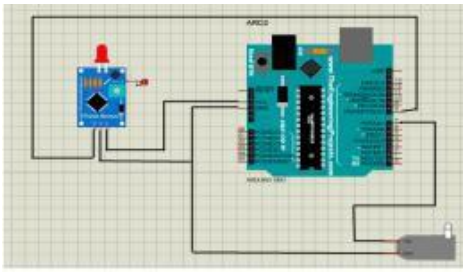

Figure 4: Solar tracker with cooling system and simulation circuit

2.3 Project Design

After simulation has been completed, the construction work is carried out. Prototype of the system is shown in the Figure 5. Several testing has been done to check the functionality of the system. These includes the motor functionality and the movement of the solar panel as well as the cooling system work. Next section will discuss the collected data from testing.

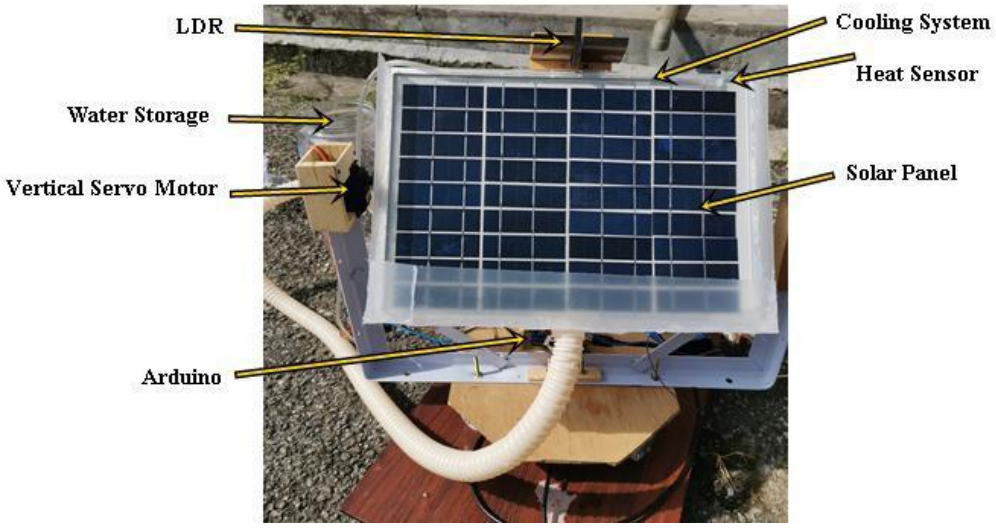

Figure 5: Solar tracker with cooling system prototype

3. Results and Discussion

The solar tracker system are then tested with and without cooling system at several condition to test the efficiency of the cooling. The performance of the system is then measured and recorded as discussed in the next paragraph.

Base from data collection at 6 July 2020 without cooling system, reading for voltage at 10 am to 2 pm is increase from 14.2 V to 17.0 V. The highest voltage recorded is 17V at 2 pm. But start 3 pm until 4 pm voltage has been drop from 17.0 V at 2 pm, 15.8 V at 3 pm and 13.8 V at 4pm. 13.8 V is the lowest voltage has been record.

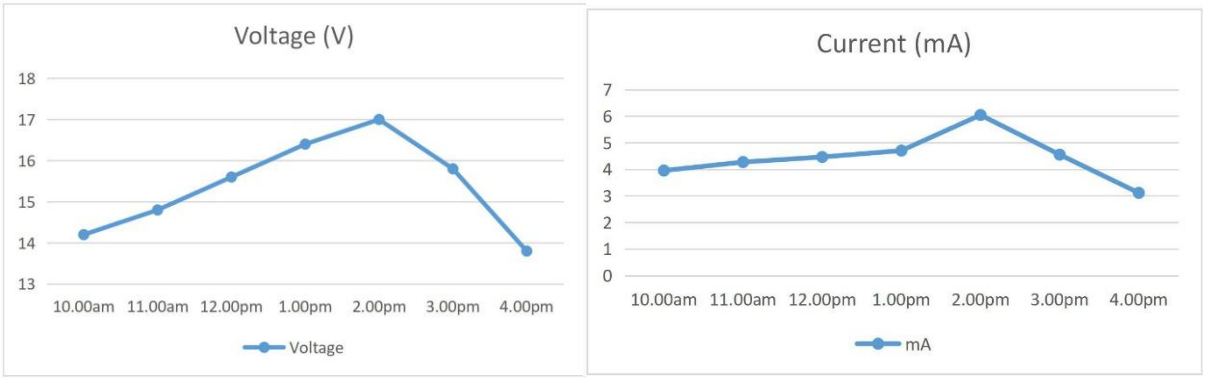

Figure 6: Data collection for Voltage and Current at 6 July 2020 without cooling system

Base from data collection at 6 July 2020 without cooling system, reading for current at 10am to 2pm is increase from 3.95 mA to 6.04 mA. The highest current recorded is 6.04mA at 2pm. But start 3pm until 4pm current has been drop from 6.04 mA at 2 pm, 4.55 mA at 3 pm and 3.11 mA at 4 pm. 3.11 mA is the lowest current has been record.

For power it requires manual calculation using PIV formula. As we can see the highest power has been recorded is 102.68 mW at 2 pm and the lowest power has been recorded is 42.918 mW at 4 pm as on the Figure 8.

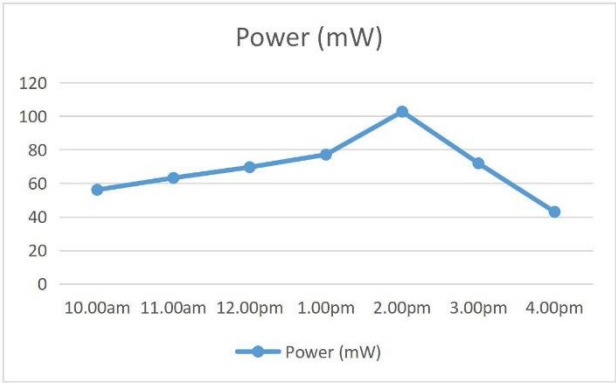

Figure 7: Data collection for Power at 6 July 2020 without cooling system

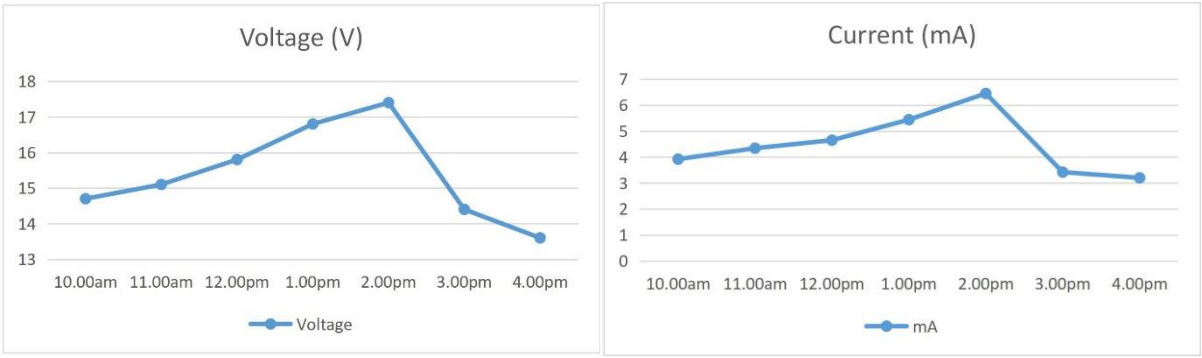

Figure 8: Data collection for Voltage and Current at 7 July 2020 without cooling system

Base from data collection at 7 July 2020 without cooling system (Figure 8), reading for voltage at 10 am to 2 pm is increase from 14.7 V to 17.4 V. The highest voltage recorded is 17.4 V at 2 pm. But start 3 pm until 4 pm voltage has been drop from 17.4 V at 2 pm, 14.4 V at 3 pm and 13.6 V at 4 pm. 13.6 V is the lowest voltage has been record. Meanwhile, reading for current at 10 am to 2 pm is increase from 3.92 mA to 6.45 mA. The highest current recorded is 6.45 mA at 2 pm. But start 3pm until 4pm current has been drop from 6.45 mA at 2 pm, 3.42 mA at 3 pm and 3.2 mA at 4 pm. 3.2 mA is the lowest current has been record. In terms of power, the highest power has been recorded is 112.23 mW at 2 pm and the lowest power has been recorded is 43.52 mW at 4 pm as on Figure 9.

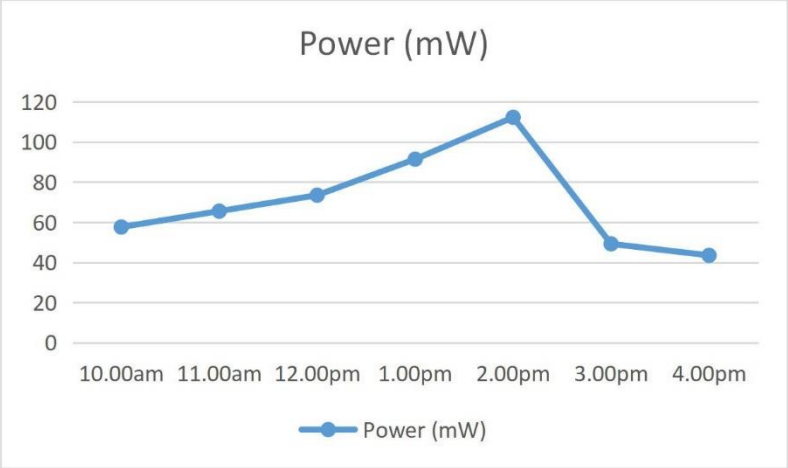

Figure 9: Data collection for Power at 7 July 2020 without cooling system

With cooling system attached, below result has been obtained. Reading for voltage at 10 am to 2 pm is increase from 15.8 V to 18.1 V. The highest voltage recorded is 18.1 V at 2 pm. But start 3 pm until 4pm voltage has been drop from 18.1V at 2pm, 16.4 V at 3pm and 14.5 V at 4 pm. 14.5 V is the lowest voltage has been record. On the other hand, reading for current at 10am to 2pm is increase from 4.34 mA to 7.05 mA. The highest current recorded is 7.05 mA at 2pm. But start 3pm until 4pm current has been drop from 7.05 mA at 2 pm, 4.88 mA at 3 pm and 3.66 mA at 4 pm. 3.66 mA is the lowest current has been record (Figure 10). Figure 11 shows the variation of power output from solar panel when the cooling system is attached.

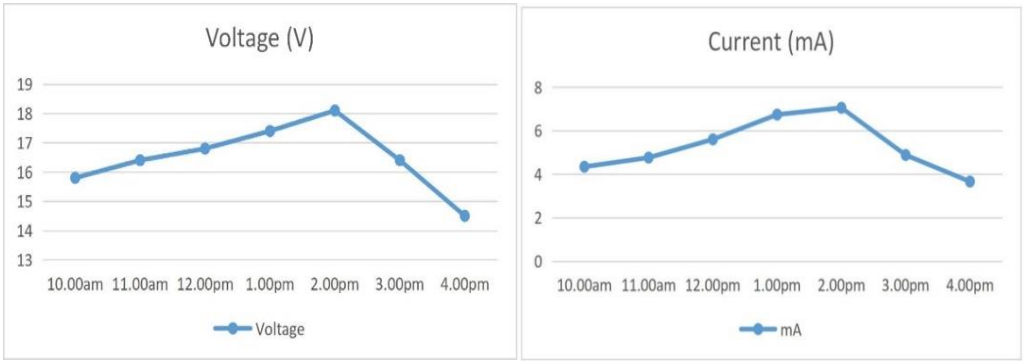

Figure 10: Data collection for Volateg and Current at 9 July 2020 with cooling system attached

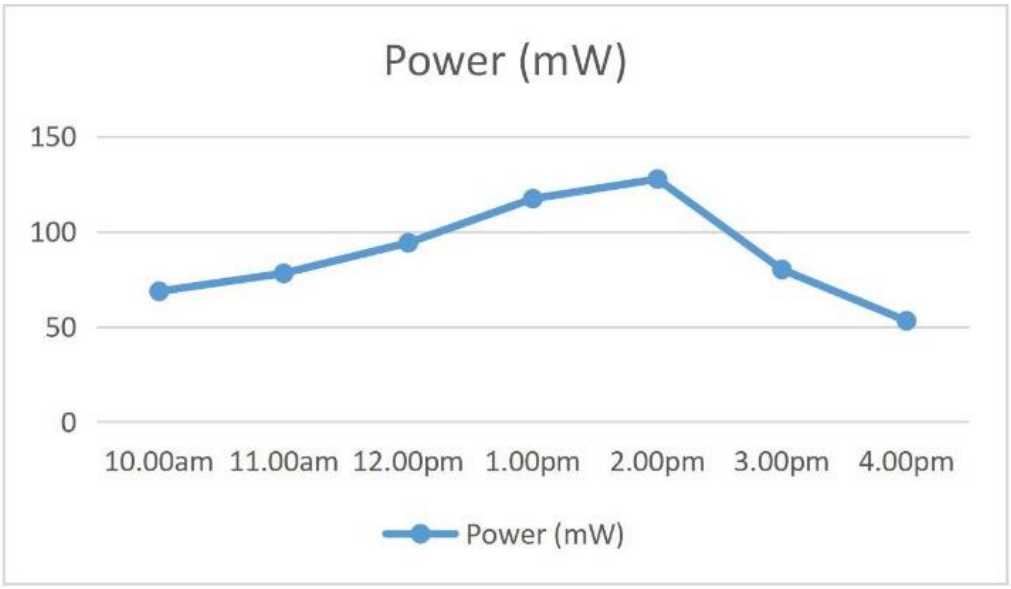

Figure 11: Data collection for Power at 9 July 2020 with cooling system

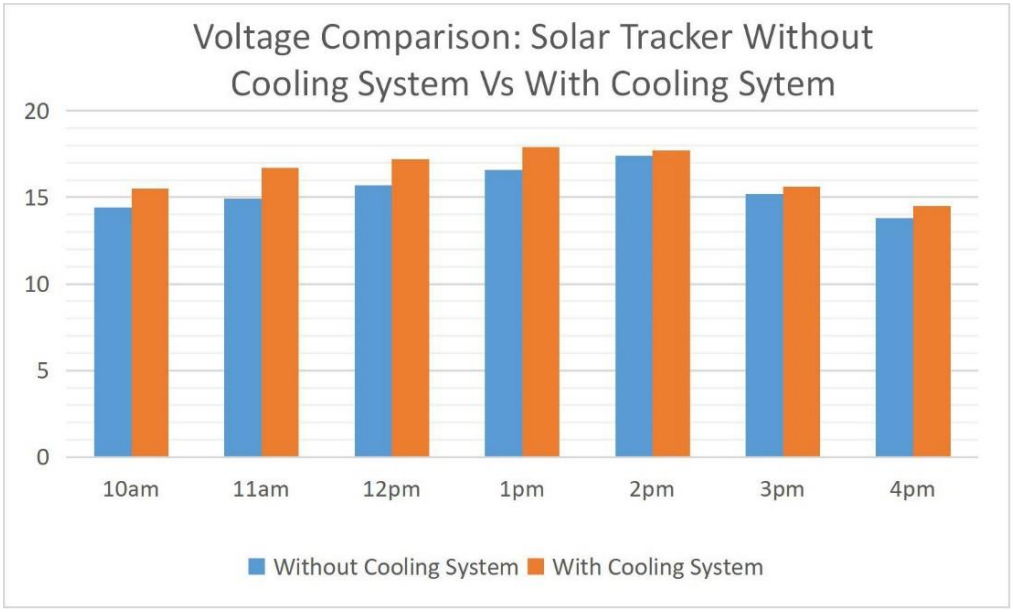

Figure 12: Comparison of Solar Tracker Voltage Output without Cooling System vs with cooling system

The graph chart in Figure 12 show the comparison of differences output for the Solar Tracker without cooling system and Solar Tracker with cooling system. This shows that the output reading using cooling system is more efficient than the Static Solar Panel without cooling system.

4. Conclusion and Recommendation

The Photovoltaic cell less productive when not pointed directly at sun and operate at maximum efficiency when pointed directly towards the sun. This project presented a means of to utilize the maximum solar energy by using solar tracker. Specifically, it demonstrated a solar tracker system solution for maximizing solar energy by using cooling system. This project also presented a means function the solar tracker hardware and get same result as result in simulation.

Measuring the solar radiation and temperature of photovoltaic surface is important especially in solar tracker system because the data in this project can be more accurate. However, because the

limitation due to lockdown, work have to be carried without these devices is difficult to complete the work. The project system also can be improved in the future by adding IOT system at solar tracker system or cooling system. The system can be remotely controlled to control the movement of solar tracker or control the consumption of cooling system and it will make this system more efficient and easy to use.

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