Progress in Engineering Application and Technology Vol. 2 No. 2 (2021) 357–366

PEAT

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Water Pump System with PV Solar Tracking

Fatin Najiha Abdullah[1], **Norain Sahari**[1]*

[1]Department of Electrical Engineering Technology, Faculty of Engineering Technology,
Universiti Tun Hussien Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2021.02.02.035
Received 28 January 2021; Accepted 01 March 2021; Available online 02 December 2021

Abstract: Solar energy is an essential resource for renewable energy. Solar tracking encourages intense solar energy to produce from the solar panel and allows the sun's rays to maintain a profile. The purpose of this project is to increase the amount of captured energy by using a computerized tracking system to capture the solar rays' maximum intensity. This project uses solar tracking to build an automatic water pumping system. The rapidly growing demand for energy calls for fossil fuel substitutes. Renewable energy sources show an outstanding figure for generating electricity without using any coal. Water Pump System with PV Solar Tracking can be used for water supply or irrigation. The diesel-powered pumping system has a low cost of capital, but maintenance and service are costly and troublesome. On the other hand, the solar-powered pumping system is quite the opposite. The initial price is high, but running is considerably cheaper. This project supports the idea of a small-scale concept that will help the user replace conventional ways of storing water in the water tank. Solar tracking system offers a sufficient amount of electricity to power the design and the battery to ensure that the system operates during the night without solar radiation for future work. The results indicate that a water pump will efficiently pump the water through a water tank by using the solar tracking system. A properly designed solar pumping will be efficient, simple, and reliable. This system should be cost-effective and will meet industrial water needs.

Keywords: Solar Tracking, Water Pump

1. Introduction

Energy demands in recent years have been recorded to be growing at an exponential rate by the commercial and as well as domestic markets. Although non-renewable resources are rapidly depleting, there is no other choice left but to use renewable resources to produce usable energy. One of these resources is solar energy which is the most abundant and easy resource to harness by solar panels. It converts into two types of energy that is thermal and electrical [1]. The amount of power generated in the solar system is dependent on the amount of sunlight to which it is exposed. As the location of the sun varies during the day, the solar system must be calibrated so that it is still tuned precisely to the sun and generates as much power as possible [2]. The performance of the photovoltaic (PV) system is

**Corresponding author: norains@uthm.edu.my*

dependent on the environmental conditions of solar radiation, ambient temperature and wind speed, system adjustment with the load and proper positioning of the solar panels [1].

Caton has made studied various single-axis and double-axis tracking cases while comparing them to fixed collectors. The authors reported that the vertical axis tracking results in the best performance of the different single-axis tracking and registered an increase in the solar collection of 17.6% due to hourly double-axis monitoring. The author even reported that there is a minor improvement in performance between seasonal and monthly tracking systems [3]. In the Gupta et al. research paper, the sun tracks that started from the sun rising in the East from 8 am to 4 pm had moved the solar panel by 120 degrees through the linear actuator to implement the experiment and to evaluate the effectiveness of the semiautomatic dual axis solar tracking system. The authors had used AT89S52 based microcontroller coupled with geared DC motors and programmed linear actuator using KEIL software [4]. Katan et al. have analyzed the efficiency of a solar water pumping consisting of a PV array, a sun tracker, a permanent magnet (PM) DC motor, and a helical rotor pump. It was found that the system is improved by addition of a maximum power point tracker (MPPT) and a sun-tracker. PV array analysis was performed using PSPICE tools. The theoretical findings are confirmed by field research [5].

The conventional solar panel is in static position could cause solar panels not to capture enough solar radiation to produce electricity because the sun's orientation keeps changing for entire days. Besides, the solar panel that is used is only in a one-way direction. Because of this problem, the power that can be generated is low. During not in sunny weather, the time taken for the water tank to full will become slow due to not enough intensity of the light to capture. Sometimes they used their energy to collect the water from the sources to fill the tank and use it for their necessity. It is essential to use solar tracking so that the accuracy and the precession of the water pump system can be maintained.

The paper aims to develop a solar tracker system for water pump power supply and compare energy harvesting between a solar tracker and a non-solar tracker system. The main purpose is also to investigate the effect of solar tracker on water pumping efficiency. The goal of this project is to track the sun to achieve the maximum sunlight incident on the solar panel during any time of the day and intended to provide energy for the water pumping system.

2. Methodology

A block diagram is used to represent the layout and structure of the system that is involved. The design of the project will be described. Figure 1 illustrates the block diagram for the project.

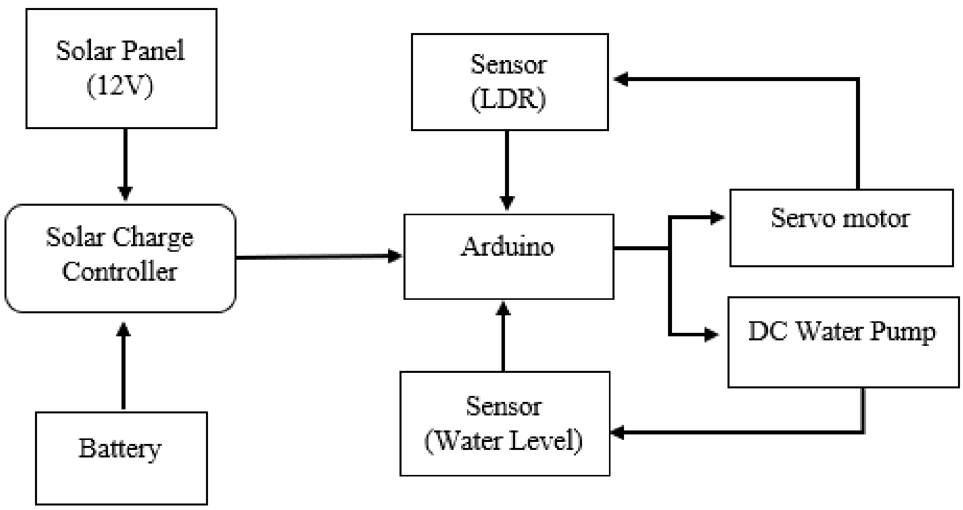

Figure 1: The block diagram of the project

The solar panel must have the maximum direct exposure to solar energy to achieve the maximum output voltage value. This can be achieved by manipulating the solar panel using a servo motor with a higher torque and power output value to make it travel efficiently to the sun's position. Besides, Arduino Uno is also used as a microcontroller for the entire system, since it uses C-based language programming that is easier to create and design. The Light Dependent Resistor (LDR) is also used as a sensor component to track solar energy. The solar panel can travel across a double-axis using four LDRs. Whenever the presence of solar energy is observed by one of the LDRs, there will be light. The project will be easier to assemble and set up in rural areas worldwide to generate electricity daily.

Four of the LDR must be directed directly to the sun so that the light will stop as the sun travels. The sensor is placed in the sun position detection panel. This system uses two servo motors for the horizontal and vertical position, and the servo motor controls the panel movement. The LDR provides information on panel position and motor direction.

The water pump system operates in automatic mode by stipulating water level sensor values. If the sensitivity value is lower than the specific value, the water tank is low, and the water pump will be activated.

2.1 Flow Chart

The flow chart in Figure 2 and Figure 3 show the operation of the Water Pump System with PV Solar Tracking from the beginning to end.

• Solar Tracking

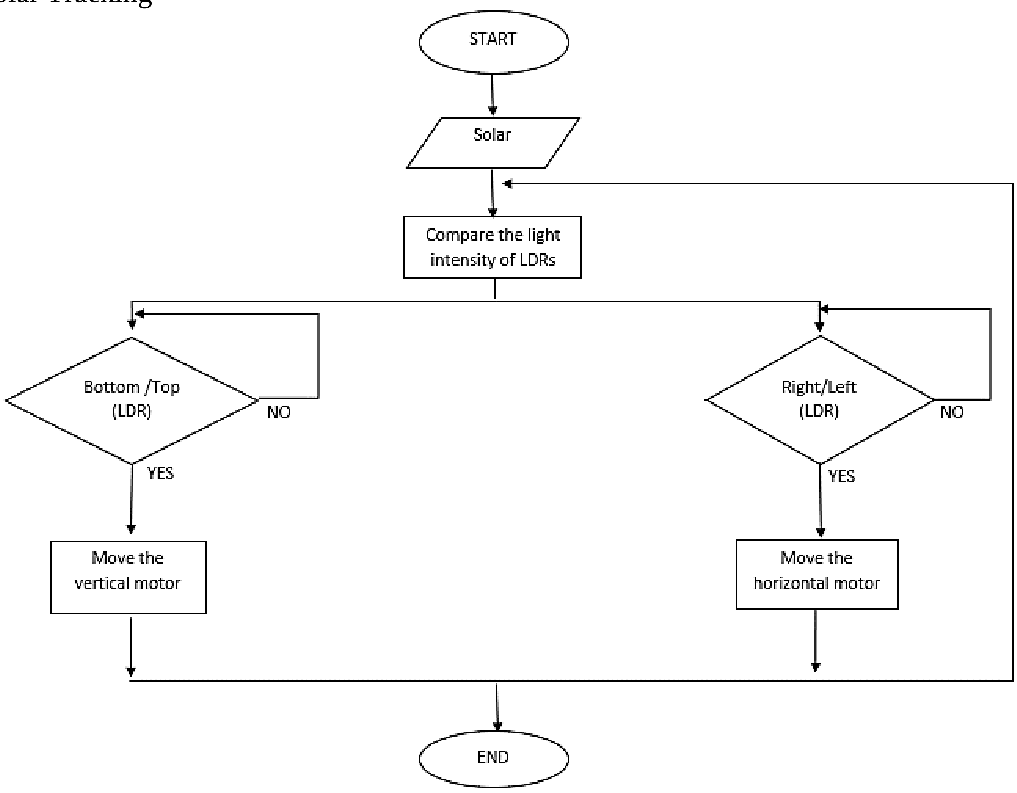

Figure 2: Flowchart of the solar tracking

• Water Pump System

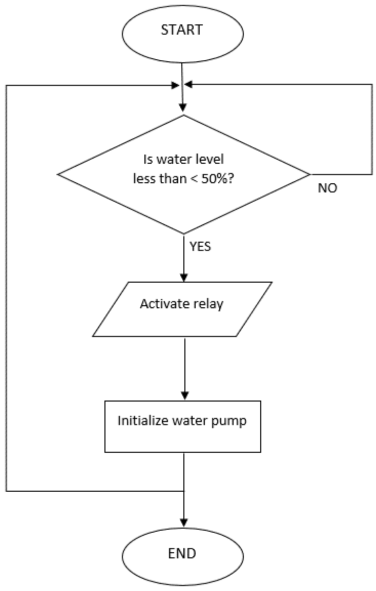

Figure 3: Flowchart of the water pump system

2.2 Hardware Development

Table 1 shows the list of the component for electrical parts and mechanical parts.

Table 1: List of components

Component	Item	Description
Electrical Component	Solar Panel	12 V
	Arduino	Arduino Uno
	Battery	12 V
	Servo motor	Operating voltage: 4.8-6.6 V
	LDR sensor	Input voltage: DC 3.3-5 V
	Resistor	1k Ω
	Water level sensor	Operating voltage: 3-5 V
	DC Water pump	Operating voltage: DC 6-12 V

2.2.1 Circuit Diagram

Figure 4 illustrates the circuit diagram of the project.

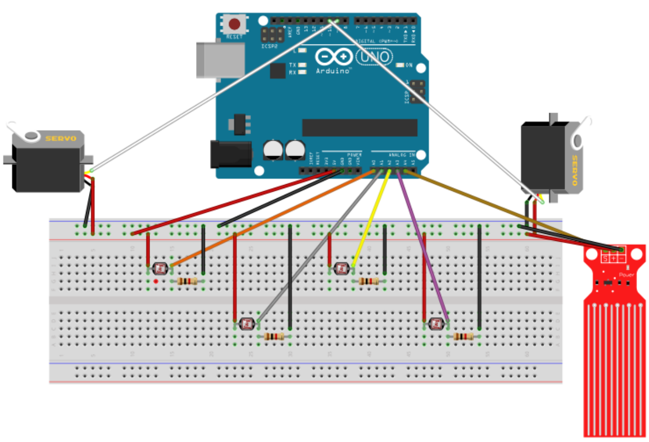

Figure 4: The illustration circuit of the project

LDR acts as a light detector for this project. Light Dependent Resistor (LDR) is a light-sensitive device also known as photo-resistor. The program works by comparing the resistance of the four sensors and the rotation of the servos. The sensor sensitivity depends entirely on the code. It is the same thing with the servos. The resistance will decrease as the light enters the LDR. In addition to the solar panel, the LDR will be installed, and the servo motor will rotate the solar panel. The servo motor pushes the solar panel towards the LDR, which reduces the resistance. LDR works by changing their resistance level depending on how much light they hit. The more light they are, the less resistance they have.

After that, the servo motor will not rotate if it has the same light intensity that decreases both LDRs. The servo would attempt to shift the solar panel to a location that is both LDR consisting of the same resistance, ensuring that the amount of light would fall to both resistances. If the resistance of the one LDR increased, the motor would rotate in the direction.

The water level sensor consists of two samples that are used to measure the water level content. Both instances allow the current to pass through the water level, and the resistance value is obtained to determine the water level in the tank.

2.3 Software Development

The software development is required to be a part of the collecting data and information for this project. The software that is used in this project is Arduino software (IDE), and Proteus software. The Arduino IDE is used to construct and design the coding of the programming code and Proteus used to do the simulation circuit project.

2.3.1 Proteus 8 Software

This software used to implement the simulation by using Proteus professional design software. Proteus is an electronic circuit design software that includes schematic capture, simulation and PCB (Printed Circuit Board). The tools in this software provide with a powerful, integrated and easy to use for the beginner. The symbol of the Proteus 8 software is shown in Figure 5.

Figure 5: Proteus Software Application

2.3.2 Arduino IDE Software

The programming coding for this project was developed by using this software for controller Arduino Uno. The programmer can make the simulation of the coding and upload the coding to the Arduino controller board. Windows, macOS and Linux are the operating systems for this program. This software's open-source makes it easy to write the code and upload the program to Arduino compatible boards. Figure 6 shows the symbol of the Arduino IDE software.

Figure 6: Arduino IDE Software

3. Results and Discussion

The Water Pump System developed with PV Solar Tracking for water supply and irrigation systems in crops has been completed. Its function has been thoroughly tested, which aims to achieve the main objectives of the project. Figure 7 (a) and (b) show the hardware prototype of the Water Pump System with PV Solar Tracking. The solar panel tracks the sunlight in the dual-axis, which is the horizontal and the vertical axis. The solar tracking uses the LDR sensor and servo motor to rotate the panel to the angle with the highest light intensity. Figure 7 (a) shows a water tank using a regular container that does not have water levels, while Figure 7 (b) shows a water tank with a water level measurement in litres.

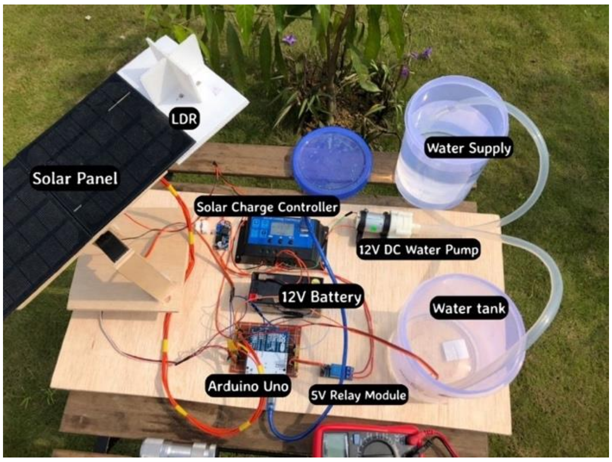

Figure 7 (a): A water tank using a regular container that does not have water levels

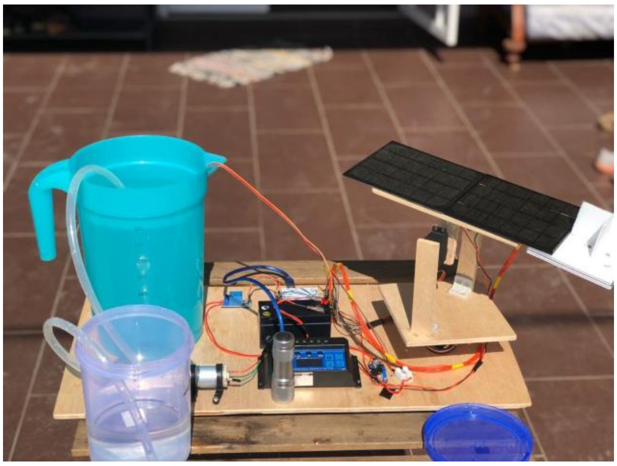

Figure 7 (b): A water tank with a water level measurement in litres

3.1 Output Voltage of PV Solar Tracking

The test was conducted for four days; two days for a static solar panel and two days for solar tracking system. The irradiance of the sun might be one of the differences between these systems due to cloudy and sunny days while testing a static solar panel and solar tracking system in different days. Thus, the measured results may not be as accurate and illogical to compare. It must be done simultaneously for future work.

Two different conditions were used to analyze the project. In the first condition, the solar tracker is tested without the LDR sensor. The second condition is tested with the LDR sensor. The data from the evaluated results are shown in Table 2. The results were shown every hour, and the voltage reading is increasing for both; a static solar panel and the solar tracking system. The measured voltage for a static solar panel and solar tracking system was at a specific point value.

Table 2: The data of voltage performance of a static solar and solar tracking system

Time	Voltage (V)	
	Static solar	Solar tracking system
8.00 am	11.82	12.61
9.00 am	12.00	12.65
10.00 am	12.67	12.86
11.00 am	13.06	13.29
12.00 pm	13.48	13.50
1.00 pm	13.23	13.52
2.00 pm	12.80	13.50
3.00 pm	12.74	13.47
4.00 pm	12.65	13.33
5.00 pm	11.70	13.01
6.00 pm	11.54	12.96

As shown in Figure 8, the plot of the reported data is plotted. From the graph, it can be observed that after 10 am the fixed panel will start generating its highest voltage, i.e. above 12 V. It keeps the same voltage until 1 pm. Whereas the solar tracking with dual-axis generated the 12 V before 9 am and held the same until 5 pm. Besides, the dual -axis solar tracking system will generate constant voltage than the single-axis solar tracking system.

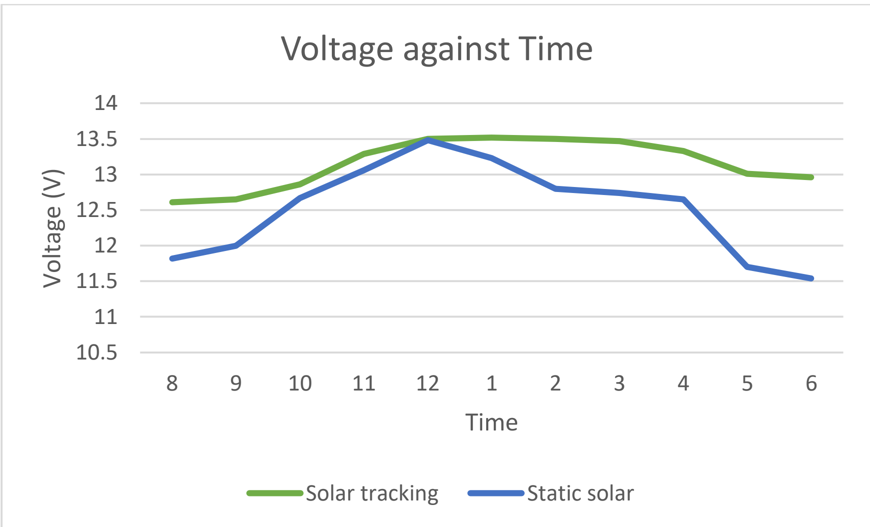

Figure 8: The voltage performance of a static solar panel and a solar tracking system

3.2 The volume of water for the water pump system

Figure 9 (a) and (b) show the water level of the water pump system after 5 hours of being tested. Once the solar energy is obtained, it is made to store in the lead-acid battery for the future scope. For battery protection, the power trapped by the panel is made to pass through the solar charger circuit and then towards the battery. Meanwhile, the water level sensor situated on the water tank keeps sensing the water levels. Once the sensor detects that the water level is low, the water pump is turned on with the relay protection circuit, powered by the lead-acid battery storing the solar energy. When a water level reaches the highest level in the tank, the sensor detects and automatically switches the pump off.

Figure 9: (a) The water level value for the water tank without solar tracking and (b) with solar tracking and water level sensor

Table 3 shows the data collected from observing the volume of water by the water pump system. The results were demonstrated every half an hour, the water level in the water tank is increasing. From this test, it can be concluded that the water pump with solar tracking is performed better than without solar tracking. Without solar tracking, the volume of water can be obtained and increase quickly during peak hours. This is because, during this hour, the sunlight produces the highest irradiance than the other hours. According to this test, the irradiance of the sun depends on the weather of the day, whether it is cloudy or sunny. The sunny day will generate more voltage and pump the water quickly. The cloudy day, vice versa.

The result of a Water Pump System with PV Solar Tracking shows three times the volume of water than a water pump system without solar tracking, depending on the weather of the day solar tracking has been tested. The weather of the day is affecting the flow of water through the water tank. Hence, for future work, the test must be conducted simultaneously to compare the volume of water with the same weather.

Table 3: The data of the output volume of the water pump system

Time (in Hour)	Volume (in ml)	
	Without solar tracking	With solar tracking
0.5	300	1400
1	500	1800
1.5	800	2000
2	1000	2400
2.5	1500	2800
3	1700	3000
3.5	2300	3400

4	2800	3800
4.5	3500	4000
5	3800	4400

The time required to fill the water tank for 5 hours shows that the solar tracking raises the water level faster than static solar. This is because the voltage generated by the solar tracking is more efficient compared to a static solar panel. Figure 10 shows the time taken for water to fill up the water tank observed by both without solar tracking and with solar tracking.

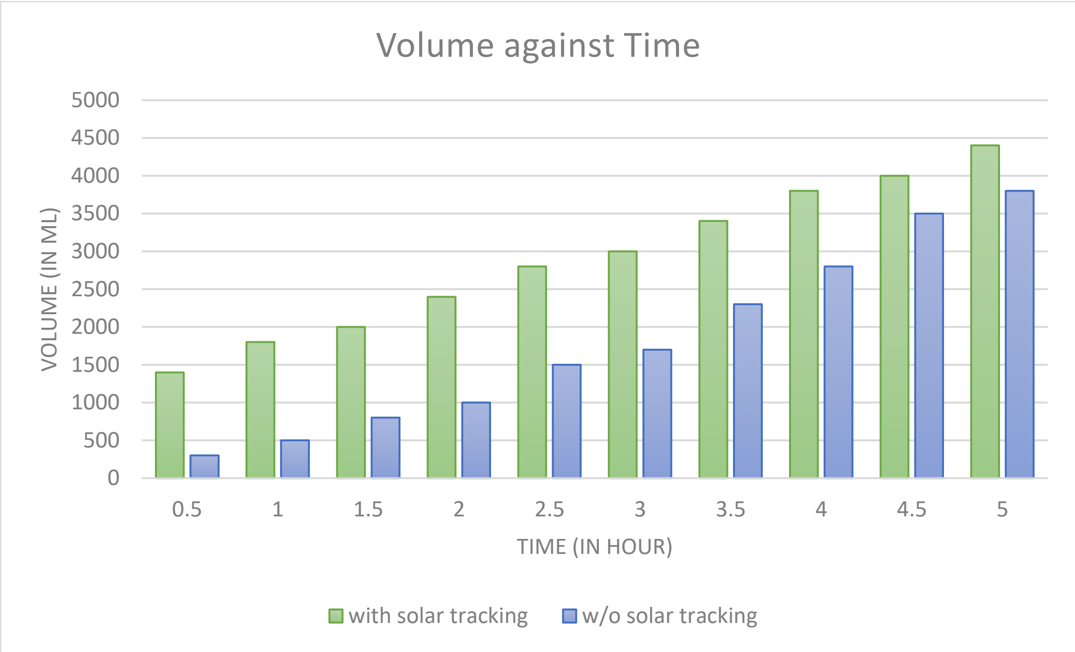

Figure 10: The time taken for water to fill up the water tank

4. Conclusion

In a conclusion, a solar tracker system for the water pump power supply has been successfully developed. This system was developed by using five main parts which are solar panel, solar charge controller, servo motor, DC water pump, and by implementing the usage of the Arduino IDE platform.

From this project, it also has been shown that the energy harvesting by using solar tracker was maintained at the highest energy almost all the day time. While the energy harvesting without a solar tracker only highest during peak time, which is at noon. It reveals that a solar tracker can generate more productive energy than a static solar panel.

Besides that, the effect of solar tracker on water pumping efficiency also has been investigated. It shows that more voltage is generated when it has the highest intensity of light from the solar tracking. Thus, the water pump will efficiently pump the water into the water tank compared to using static solar.

Acknowledgement

The authors would also like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] L. Guo, P. Curtis, A. Barendregt, and A. Surillo, “Design and implementation of a sun tracking solar power system,” *ASEE Annu. Conf. Expo. Conf. Proc.*, 2009.

[2] S. Abdallah and S. Nijmeh, “Two axes sun tracking system with PLC control,” *Energy*

Convers. Manag., vol. 45, no. 11–12, pp. 1931–1939, 2004, doi: 10.1016/j.enconman.2003.10.007.

[3] P. Caton, "Design of rural photovoltaic water pumping systems and the potential of manual array tracking for a West-African village," *Sol. Energy*, vol. 103, pp. 288–302, 2014, doi: 10.1016/j.solener.2014.02.024.

[4] N. Gupta, R. Arya, A. Khare, and N. Diwakar, "Design and Fabrication of Semi Automatic Dual Axis Solar Tracking and Experimentally Analysis Its Efficiency," vol. VI, no. V, pp. 201–210, 2019.

[5] NE, "Solar Water Pumping System Design & Features," no. 042, pp. 81–87, 2016.