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EFFECTS OF THE TEMPERATURE ON THE OUTPUT VOLTAGE OF MONO-CRYSTALLINE AND POLY-CRYSTALLINE SOLAR PANELS

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Abstract -- *People can make solar energy alternative energy by employing solar panels to generate electricity. The utilization of solar energy on a solar panel to generate electricity is affected by the weather and the duration of the radiation, and they will affect the solar panel's temperature. There are various types of solar panels that can be found on the market today, including Mono-Crystalline and Poly-Crystalline. The difference in the material used needs to be observed in terms of temperature changes in the solar module. Our study's findings showed that a change in the temperature would impact the solar panel's output voltage, and the solar panel's output voltage would change when it was connected to the load, although the measured temperatures were almost the same.*

Keywords: *Solar Energy; Solar panel; Temperature; Voltage*

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INTRODUCTION

Electricity is now a primary need, and will increasingly feel its importance when it is gone (for instance, when a power outage occurs). Many researchers have conducted studies on how to maintain the availability of electricity [1, 2, 3, 4]. Likewise, to maintain the system security from various kinds of interference [5, 6, 7], in order that the sustainability of electricity supply to consumers can be enhanced. To increase the consumers' electricity supply, the producers are required to add the power supply to the system. The installed energy capacity can be increased by adding more power plants. Meanwhile, power can also be increased by optimizing the available power plants.

For the past 15 years, the new and renewable sectors have continued to rise [8, 9, 10]. People always do the best to increase the installed power capacity, and the net installed power capacity. Indonesia has such a huge solar energy potential. Since Indonesia is located on the equatorial line, Indonesia needs to take advantage of its solar energy potential [11, 12, 13]. Not only is solar panel efficiency determined by its materials [14, 15, 16], it is also determined by the sunlight's direction [17] [18], and the solar panel's temperature [19] [20]. The electricity generation on a solar panel can be optimized by improving one of those three factors. Various researchers have done their best to find the best materials in order to generate a higher efficiency [14] [15].

On the other hand, people try to get the sunlight to illuminate the solar panel perpendicularly [21]. A solar panel method with the help of a solar tracker is usually suitable to be applied in a small capacity [22, 23, 24]. If a solar panel is utilized in a centralized system, one will face difficulty in overcoming a problem of shadow appearing on the solar panel.

The effects of temperature on the solar panel's performance were already studied by [20] [25]. Chander et al. [26] compared the series and parallel circuits on the characteristics of I–V P–V curves on a mono-crystalline solar panel [26]. Meanwhile, other researchers made a simulation using a Matlab/Simulink [27, 28, 29].

METHOD

Since the mid-80s, various PV systems have been applied and utilized in Indonesia. The feasibility study on the application of the PV system started from the Solar Village Pilot Project (collaborating with TÜV Rheinland, Germany) in the early 80s. It was then continued with the Village Electrification & Pumping System Pilot

Project (collaborating with NEDO, Japan) in Kenteng, Yogyakarta, in 1987 [30]. In 1990, having successfully applied a Solar Home System (SHS) in Sukatani Village, West Java, the government started extending the PV system for village lights through Banpres (Presidential Assistance) Project by installing 3445 SHS units in 15 Indonesia's provinces [31]. Since that time, society has widely known PV system. In 1998, when the 50 MWp Photovoltaic Rural Electrification Project for one million homes was launched, the commercialization era of PV systems was commenced [32].

SHS is an independent Solar Energy Power Plant. It becomes a solution to practical and flexible electricity supplies to meet electricity needs in domestic installations. This electricity can be utilized for home appliances, lights, and computers. This system can be employed in regions where there are no PLN electricity services yet or even where there are already PLN electricity services.

SHS usually consists of one or more PV modules, a Solar Charge Controller (SCC) that distributes the current settings to protect the battery and devices from any damages. Moreover, the battery/accumulator is utilized to store the energy to be used at night or when the sun does not shine. Meanwhile, the inverter is utilized to transform the Direct Currents (DC) to Alternating Currents (AC) with its output voltage complying with the system that is used (for instance, 220V).

The study was aimed at recording the energy generated by a solar panel. This energy was then converted into electricity. We conducted this study since, so far, there had not been any data of solar energy in the region where we studied it. The stages are conducted by taking advantage of the sunlight's potential that could be generated by utilizing the building's rooftop.

This study contributed to recording the effects of a change in the temperature generated by the installed solar panel. The study was located at the 0°34'38.4"N 101°25'26.0"E (0.577342, 101.423876) coordinate. The solar panel was installed on the building's rooftop with a 10-degree slope. Figure 1 showed us the position of the roof where the solar panel was installed with a 10-degree roof slope. The modules installed on the east side were two Mono-crystalline, 200-WP modules, and two Poly-crystalline, 150-WP modules, and so were the modules installed on the west side with the same number and specifications. By employing the same modules on the east and west sides, it is expected to be able to record the potentials of the available energy.

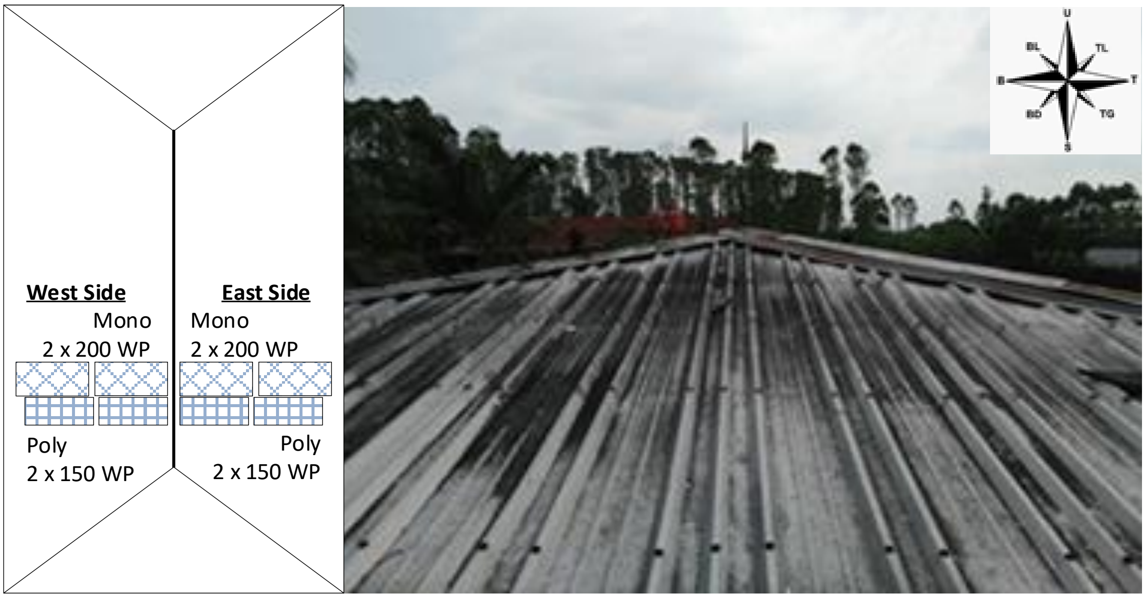

Figure 1. The position of the sun's trajectory on the object under study

The source of solar insulation energy was volatile, while the PV system configuration was flexible and had no standard. Therefore, it had to be handled carefully in order that we obtained an optimum system configuration in its design and in order that the output energy could be optimally generated.

Parameters that are measured in this study, namely currents, voltages, temperatures, and humidity around the solar panels placed on the building's roof. Then, the profile results of the solar energy which is converted through the four units of panels on the east side and four units of panels were observed on the west side.

RESULTS AND DISCUSSION

The system is built by using 2 (two) sets of Solar Home System, each of which was separated from each other. The first system was two units of mono-crystalline, 200-WP solar panels placed with the position towards the east, and 2 (two) units of 200-WP solar panels placed with the position towards the west. Meanwhile, the second system used a solar cell from the materials consisting of two units of poly-crystalline, 150-WP solar panels placed with the position towards the east, and 2 (two) units of 150-WP solar panels placed with the position towards the west. Hence, the total amount of energy that could be generated was 1,400 WP.

Other instruments were placed in the energy conversion room located on the first floor just exactly below the solar panels. The energy was connected with an NYY-HY, 4-by-6-mm^2 cable for four 200-WP Mono-Crystalline solar panels, and it was connected with an NYM-HY, 4-by-2.5-mm^2 cable for four 150-WP Poly-Crystalline solar panels. Those cables were directly connected to the solar energy power plant system circuits as shown in Figure 2. Moreover, to control the electricity received by the solar panels, a Solar Charge Controller (SCC) from the Maximum Power Point Tracking (MPPT) type with its capacities amounting to 30 A and 40 A, and from the pulse width modulation (PWM) type with its capacities amounting to 20 A and 30 A used to control the electricity received by the solar panels were employed. This energy was then stored with the help of four 12-Volt DC batteries, each of which has a capacity amounting to 75 Ah. In this study, two types of batteries were employed, namely Maintenance Free (MF) and Hybrid types.

To observe the effects of the solar panel's temperature after receiving the sunlight, we recorded them from June 6^{th,} 2018 to June 10^{th,} 2018, from 07:00 a.m. to 06:00 p.m. Table 1 showed the results of the observation. In a graph, it could show the relations between the poly-crystalline, 150-WP solar panel's temperatures, and it is output voltages as shown in Figure 3 and Figure 4 different days and times of measurement.

However, at those times, the measured temperatures were almost the same. Table 1 showed us that, on June 7^{th,} 2018, the temperature was 50.2 °C, so the output voltage decreased by 1.435 Volt.

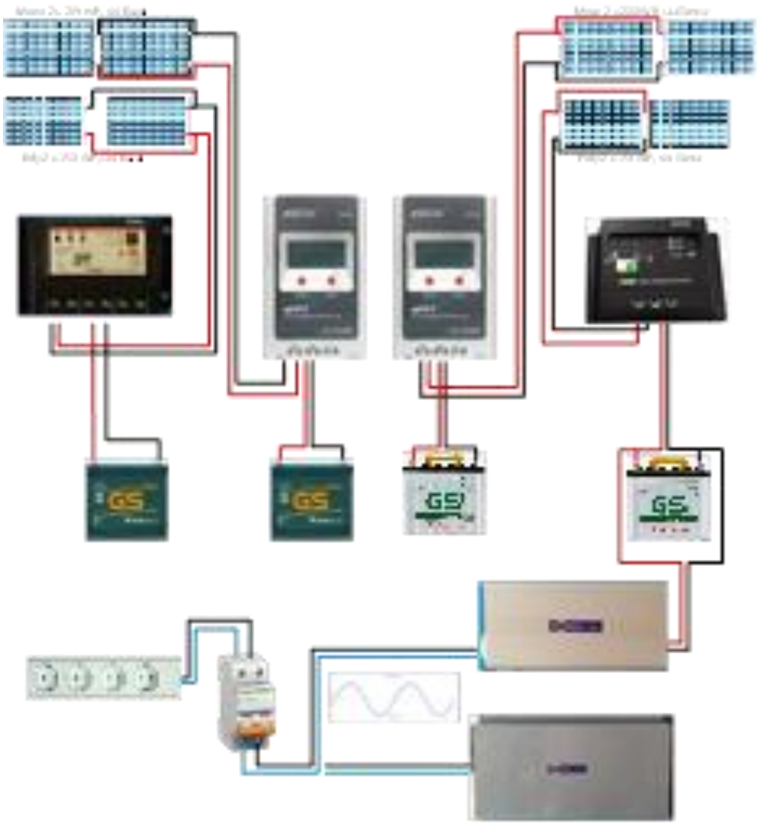

Figure 2. Solar Energy Power Plant Circuit

Table 1. Results of Measurement of the Solar Panel's Temperatures

Date & Time of measurement	Type of the Solar Panel	Capacity	Temperature (°C)			Voltage (Volt)	
			Max.	Min.	Ave	Ave	Max.
June 6th 2018 (07:00-18:00 WIT) East	*Poly-crystalline*	150 WP	69.6	28,9	51	15.363	20.11
June 7th 2018 (07:00-18:00 WIT) East	*Poly-crystalline*	150 WP	73.7	26,4	50.2	14.201	19.684
June 8th 2018 (07:00-18:00 WIT) West	*Mono-crystalline*	200 WP	89.9	25,9	59.9	30.227	40.330
June 9th 2018 (07:00-18:00 WIT) West	*Mono-crystalline*	200 WP	89.5	24,7	60.1	14.832	17.663

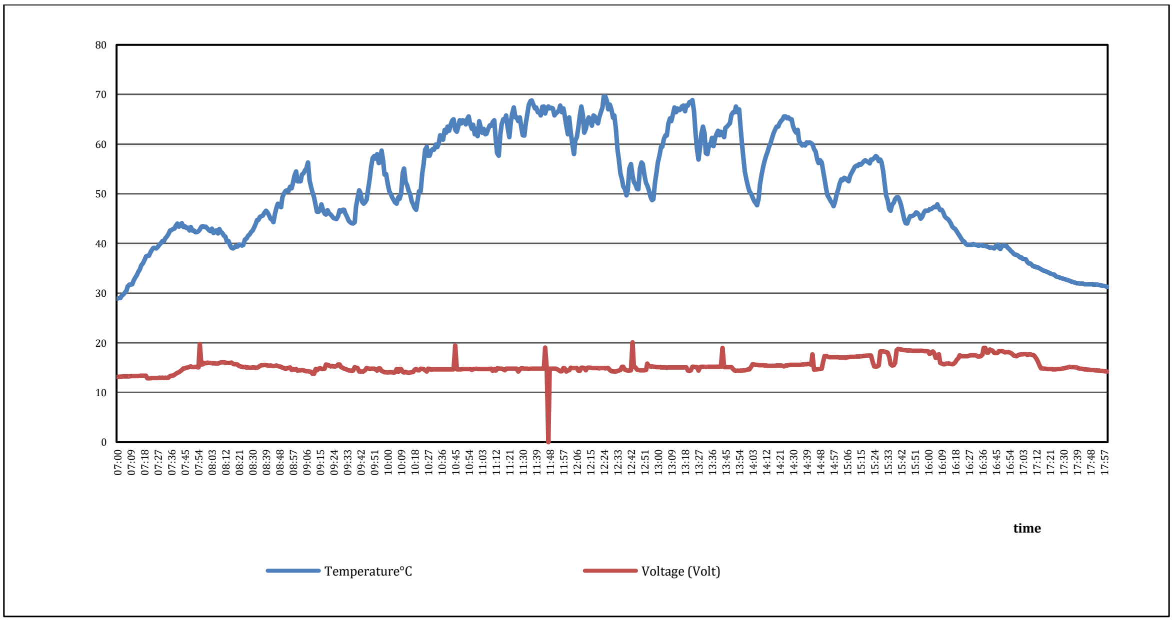

Figure 3. the 150-WP solar panel's temperatures and its output voltages in the West measurement

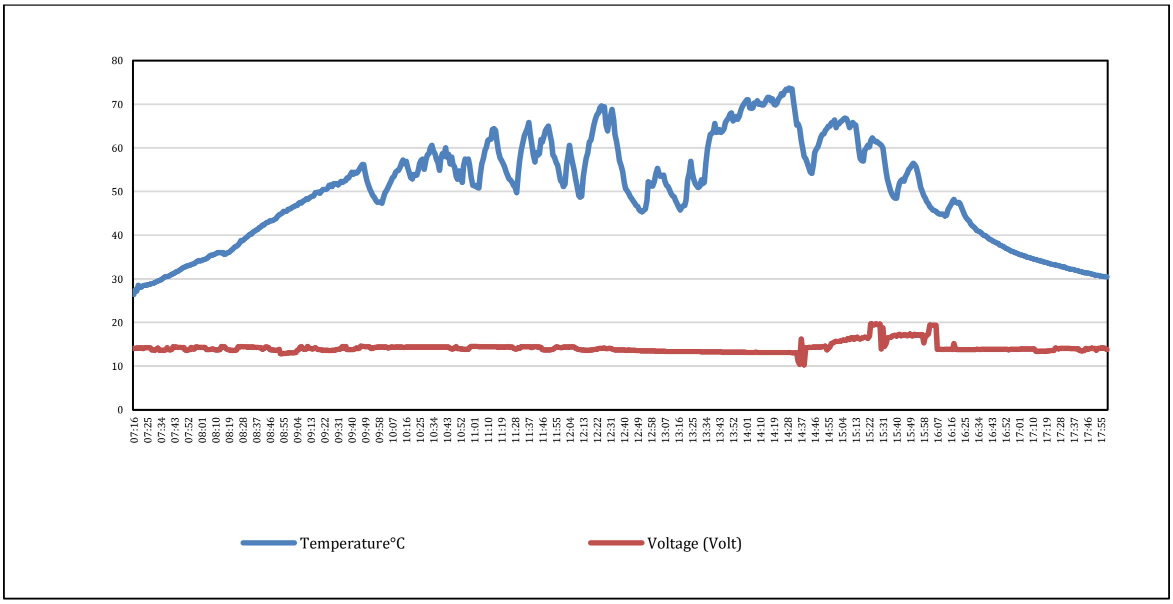

Figure 4. the 150-WP solar panel's temperatures and its output voltages in the East measurement

Figure 5 and Figure 6 showed us that the relations between the mono-crystalline, 200-WP solar panel's temperatures, and its output voltages. The figures showed us that they were almost the same during different times and days of measurement, as also shown in Table 1.

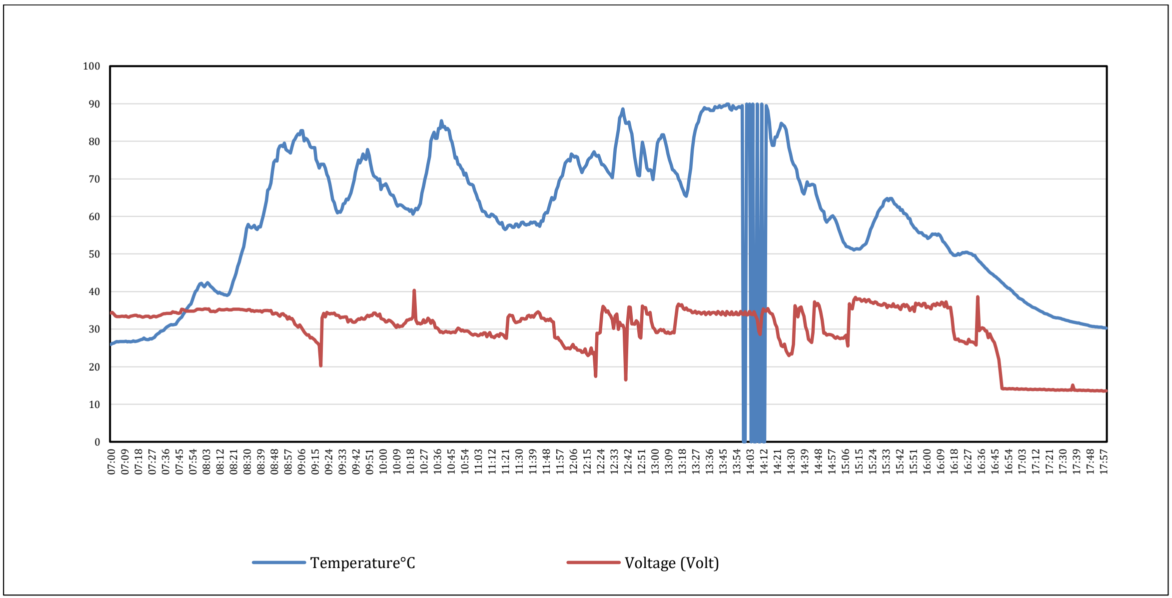

Figure 5. the 200-WP solar panel's temperatures and its output voltages in the West measurement

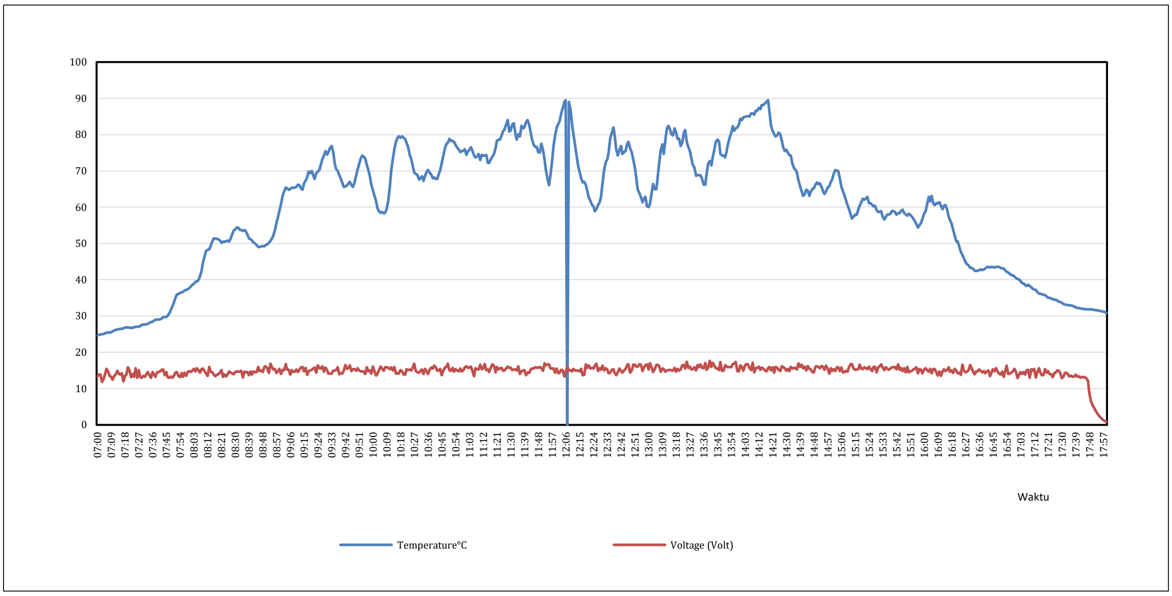

Figure 6. the 200-WP solar panel's temperatures and its output voltages in the East measurement

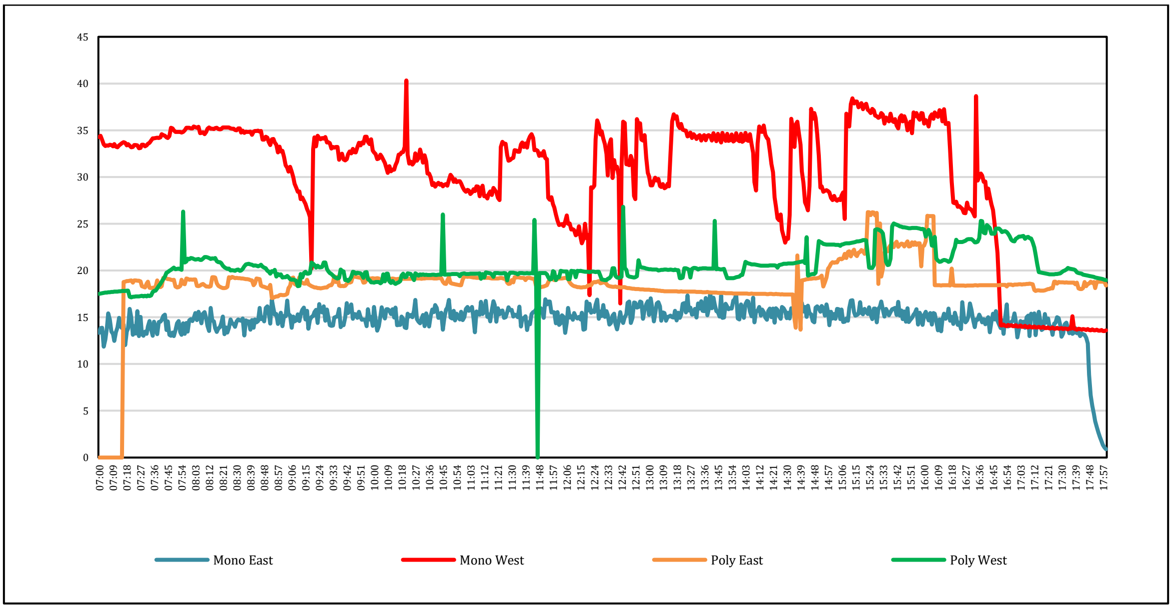

Figure 7. the 200-WP solar panel's temperatures and its output voltages in the East measurement

Figure 5, a graph of measurement on June 9th, 2018, showed us that there were different voltages from that of June 10th, 2018, as shown in Figure 6 since on June 10th, 2018, the Solar Panel Power Plant was already loaded and the solar panel's output voltage decreased by 15.395 Volts.

In Figure 7, it can be seen that the Mono-Crystalline solar module located on the west side (Mono West) produces an average output voltage higher than other modules. It also shows that the energy produced by solar modules on the west side is relatively greater than the east side.

CONCLUSION

The results of the study showed that a change in the temperature would impact on the solar panel's output voltage. If the solar panel's temperature decreased, the generated output voltage would decrease by 1.435 Volt, and the solar panel's output voltage would change when it was connected to the load, although the measured temperatures on the different days were almost the same; the output voltage decreased by 15.395 Volts.

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