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Potentials of solar power plant in Waru Tua

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ABSTRACT

Penajam Paser Utara Regency is located on the coast of East Kalimantan Province. This regency has a huge solar resource potential, but the agreement in this regency still lacks electricity networks and can be resolved by the people in this regency still in dire need of electricity for street lighting, and daily electricity needs. One of them is in the village of Waru Tua, where this area is in great need of lighting in the dock area because it requires residents to make A living as a fisherman. Waru Tua really needs electricity for lighting at night Waru Tua Pier because it has to be a gathering place for residents before going to sea to prepare everything that must be prepared before going to sea. Discussing the research carried out examining the potential of solar power in Waru Tua. Based on existing considerations, and the potential proposed by the area, the method used is to measure the sunlight at Waru Tua Pier using Lux meter, then the data is processed using the Simulink application in MATLAB to obtain the value of the amount of sunlight in the area, which is 16 KW with a total solar cell of 250 Wp.

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1. INTRODUCTION

Kalimantan Island is one of the islands in Indonesia which has excellent potential for the development of new renewable energy based on solar power, namely solar power plant because the island is crossed by the equator so that the potential of the sun is environmental and economic [1, 2]. Penajam Paser Utara Regency is a regency in the province of East Kalimantan, Indonesia [3]. The capital city is located in Sharpeners. This regency still needs electricity for daily survival, one of which is in the village of Waru Tua. This area is significant to install a solar power plant, especially in the dock area because the livelihoods of Waru villagers. Overall, only supporting ships, is also the main requirement for fishers, especially for fishers in the village of Waru Tua for activities at night [4]. At present, the condition of the Waru Tua pier still lacks in lightings, such as street lighting and the pier at night, as well as for other needs. Solar power plants can meet the electrical energy needs of the community at the Waru Tua pier [5, 6]. The construction of the solar power plant at the Waru Tua pier will use the MATLAB application to analyze the potential of sunlight in Waru Tua, and the measuring device used as a light intensity gauge is a Lux meter [7, 8]. The future development of this solar power plant is expected to be able to be used as a source of electricity to meet the needs of the community in the area, such as household electricity, street lighting at night, for charging ship batteries, for charging batteries, as well as for communication the other [9, 10].

a. Solar power plant

Solar power plant is a power supply (a device that provides power) and can be designed to supply small to significant electricity needs, during the day the solar panel receives sunlight which is then converted into electricity through the photovoltaic process, electrical energy produced by the sun the panel can be directly channeled to a load or stored in a battery before it is used for loading [11, 12] refer to Figure 1.

b. Solar cell

Solar cell is a device or component that can convert light energy into electrical energy using the principle of the photovoltaic effect [13] refer to Figure 2. Therefore, solar cells are often referred to as photovoltaic cells (PV). Electric current arises because of the photon energy of sunlight it receives successfully liberating electrons in the semiconducting relationship type N and type P to flow [14]. Just like a photodiode, this solar cell also has positive and negative legs that are connected to a circuit or device that requires an energy source [15]. At present, many have applied this solar cell device to a variety of uses. From electricity sources for calculators, toys, battery chargers to power stations and even as a source of electrical energy to move the satellites that orbit our earth [16].

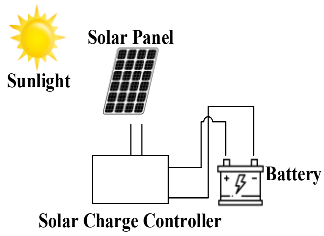

Figure 1. Installation solar power plant

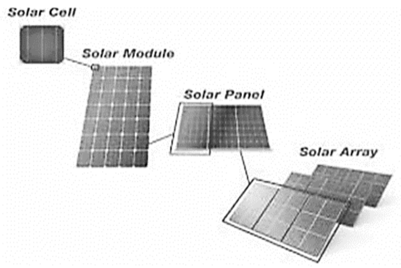

Figure 2. Detail of solar cell

c. Current-voltage (I-V) curve

A performance curve called the I-V curve characterizes the module output characteristics [17]. I-V curve shows the relationship between current and output voltage, where I represent the measurement of current and V represents the measurement of voltage [18]. Voltage plot (V) along the horizontal axis. The plot (I) is currently on the vertical axis. I-V curve is assessed in standard test conditions (STC) [19, 20]. STC is considered 1000 square watts of radiation or one hour of a solar peak, cell temperature 25 degrees Celsius, and 1.5 Spectral ATMs. There are four variables to carry out how to read an I-V curve, and you undertake the relationship between the voltage maximum power (Vmp), current at maximum power (Imp), voltage open circuit (Voc), and short circuit current (Isc) [21].

– Maximum power point (Vmp and IMP)

On the I-V curve, the maximum Vmp point and Imp are the operating points, where the maximum output or output produced by the solar cell panel during operational conditions. In other words, VPM and Imp can be measured when the solar panel is loaded at 25 degrees Celsius and radiation is 1000 watts per square meter [22].

– Open circuit voltage (Voc)

Open circuit voltage Voc is the maximum voltage capacity that can be achieved when there is no current. On the I-V curve, Voc is 21 volts. Power when the Voc is 0 watts. Voc solar cell panels can be measured in the field in a variety of circumstances. When testing the voltage with a digital multimeter from the positive terminal to the negative terminal. Open circuit voltage (Voc) can be measured in the morning and evening [23].

– Short circuit current (Isc)

Short circuit current Isc is the maximum output current from the solar cell panel that can be issued (output) below with no resistance or short circuit. The curve I-V above shows an estimated current of 2.65 amperes. The power at Isc is 0 watts. Short circuit current can be measured only when making direct and positive terminal connections from the solar cell panel module.

2. RESEARCH METHOD

2.1. Research scope

The scope of the study is limited to "Application of MATLAB in Analyzing the Development of solar power plants in Waru Tua," namely:

– Light intensity analysis using a Lux meter with Lux units.
– Analysis of the potential of solar power plant construction at the Jetty in Waru Tua Village using the MATLAB application.

2.2. Research tools and materials

Analysis of solar power plants construction in Waru Tua, using several tools, and the main constituent components, and supporting, as follows: Lux meter suche, Lux meter krisbow, MATLAB applications, and laptops.

2.3. Research and data collection flow chart

A research flow chart is a procedure for conducting research in which the procedure starts from the study of literature to make a report or conclusion of the research. Figure 3 is an example of a research flow chart, and the method of analysis carried out during the study takes place in the data collection display in Figure 4. In Figure 3, the research flow chart starts from:

- The literature study discusses the underlying theory.
- Data collection is carried out three (3) times a day, ie at 09.00, 12.00, 03.00. The place of data collection is done at Waru Tua Village Pier. Waru Kab. North Paser Sharpeners.
- Testing the data of sunlight intensity then made with the design method using the MATLAB application.
- If the test data is suitable, then the design simulation design will be made with the MATLAB and Simulink applications and if the results are not appropriate, then the data will be retrieved again.
- Analysis and conclusions that the Waru Tua Pier has an excellent potential for solar energy sources and is feasible to make solar power plants to meet the needs that exist in the Waru Tua Village Pier or not.

The following is an explanation of the data collection flow chart in Figure 4:

- "Start" is used to start a process that will be done.
- Then assembling the solar cell system and measuring devices using sensors.
- Furthermore, testing the solar cell system when charging the battery.
- There are two first processes when testing a solar cell system by the procedure, and the measurement analysis data of voltage, current and temperature detected by the sensor are by the standards of measuring devices such as digital multimeters so the data can be analyzed.
- Whereas the second process, if in this solar cell system test, the solar cell does not operate properly and the measurement of voltage, current and temperature that the sensor reads does not match the digital multimeter measuring instrument standards, this solar cell system testing must repair the sensor circuit and calibration.
- Voltage, Current, and Temperature measurements are carried out for five experiments, and data retrieval is taken every one minute.
- "Completed" in the data collection flow chart indicates the end of the process that has been carried out.

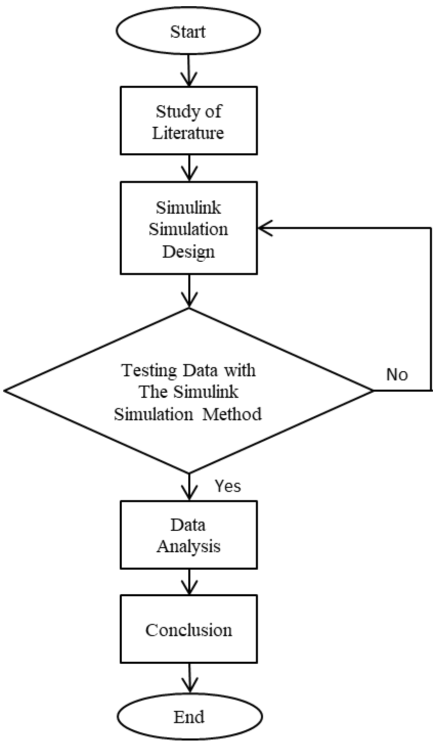

Figure 3. Research flow chart

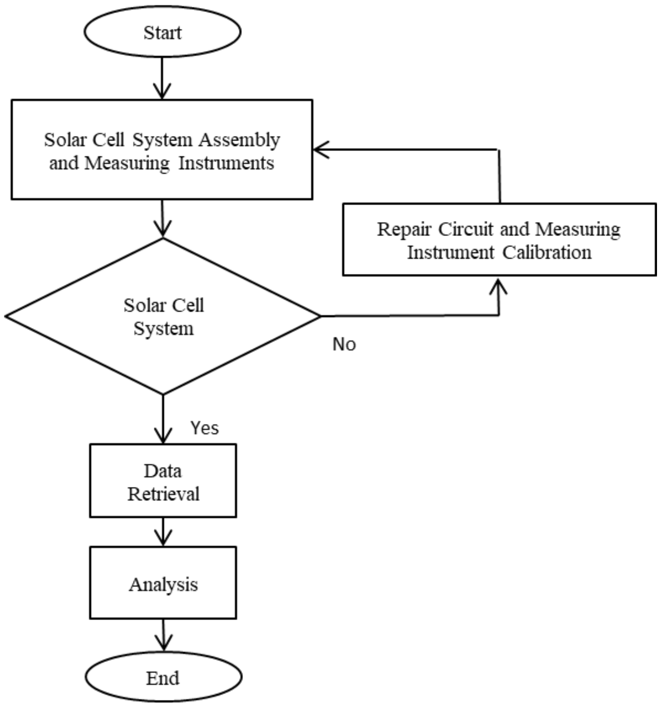

Figure 4. Data collection flow chart

3. RESULTS AND ANALYSIS

3.1. Light intensity measurement results

The following are the results of the data collection diagram that I did from March 13-April 15, 2019, in the village of Waru Tua. Based on Figure 5 shows that the average level of results from the light intensity data is 90,000 Lux. It can be concluded that the solar energy in the Waru Tua Pier is very capable of being used as an energy source for solar power plants. The standard light intensity data to be utilized is 80,000 Lux, and if the resulting data is less than 80,000 Lux, then the area is not suitable for the use of solar energy. Because the data in Figure 5 shows an average figure of 90,000 Lux, it is very potential energy that can be utilized to be used as a source of solar power at Waru Tua's pier [24].

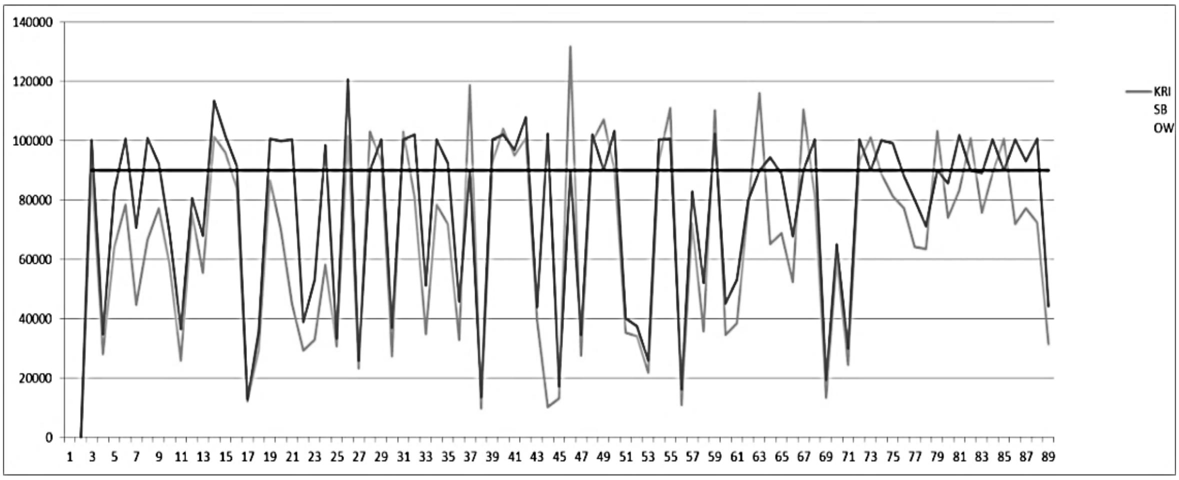

Figure 5. Light intensity measurement results

3.2. Solar power plan simulation using MATLAB

The following is a series of designs of solar power plant design Simulation with MATLAB application as follows in Figure 6. The series in Figure 6 is a series of solar power plants design simulation using the MATLAB application. In the application, the researcher uses the Simulink feature [25]. The solar power plants design simulation work system is the installation of solar cells that are installed totaling 64 solar cells. Then in the circuit, there are several main components namely the current sensor and voltage sensor whose function is to detect the current and voltage generated from the installed solar cell [26]. After that, the current will pass through a resistor whose function as a regulator in limiting the amount of current flowing in the circuit, and then the resistor is connected with a converter that serves to change the AC into DC [27]. In the circuit system, there is an Electrical Reference whose function is to protect against leakage or overloading. Electricity will flow directly to the ground, then enter the Solver Configuration whose function is to set the tolerance on Simulink [28]. Table 1 is a set of solar cell simulations used in the trial as follows.

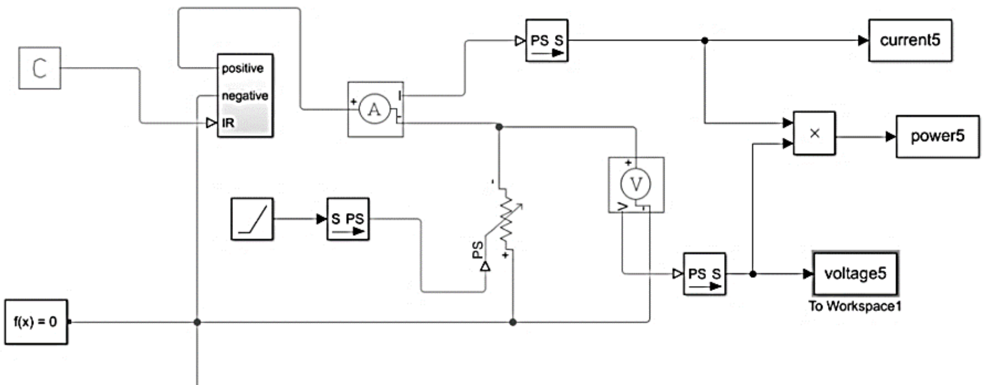

Figure 6. Solar power plant series

Table 1. Simulation of solar cells on Simulink

Variable Solar Cell	Irradiance (Lux)	Label
100WP	1038.85	current1, power1, voltage1
	794.74	current2, power2, voltage2
	641.48	current3, power3, voltage3
	507.97	current4, power4, voltage4
	260.463	current5, power5, voltage5
	78.131	current6, power6, voltage6
150WP	1038.85	current7, power7, voltage7
	794.74	current8, power8, voltage8
	641.48	current9, power9, voltage9
	507.97	current10, power10, voltage10
	260.463	current11, power11, voltage11
	78.131	current12, power12, voltage12
200WP	1038.85	current13, power13, voltage13
	794.74	current14, power14, voltage14
	641.48	current15, power15, voltage15
	507.97	current16, power16, voltage16
	260.463	current17, power17, voltage17
	78.131	current18, power18, voltage18
250WP	1038.85	current19, power19, voltage19
	794.74	current20, power20, voltage20
	641.48	current21, power21, voltage21
	507.97	current22, power22, voltage22
	260.463	current23, power23, voltage23
	78.131	current24, power24, voltage24

3.3. Solar cell circuit

The following series of solar cells used in the solar power plant design simulation is as follows in Figure 7. So, in Figure 7 is a series of solar cells totaling 64 solar cells. The series of solar cells are arranged in parallel with the dimensions of the pier in the location of Desa Waru Tua which has a length of 16 M and a width of 4 M, so with a large pier dimension so that 64 solar cells are very likely to be installed [29].

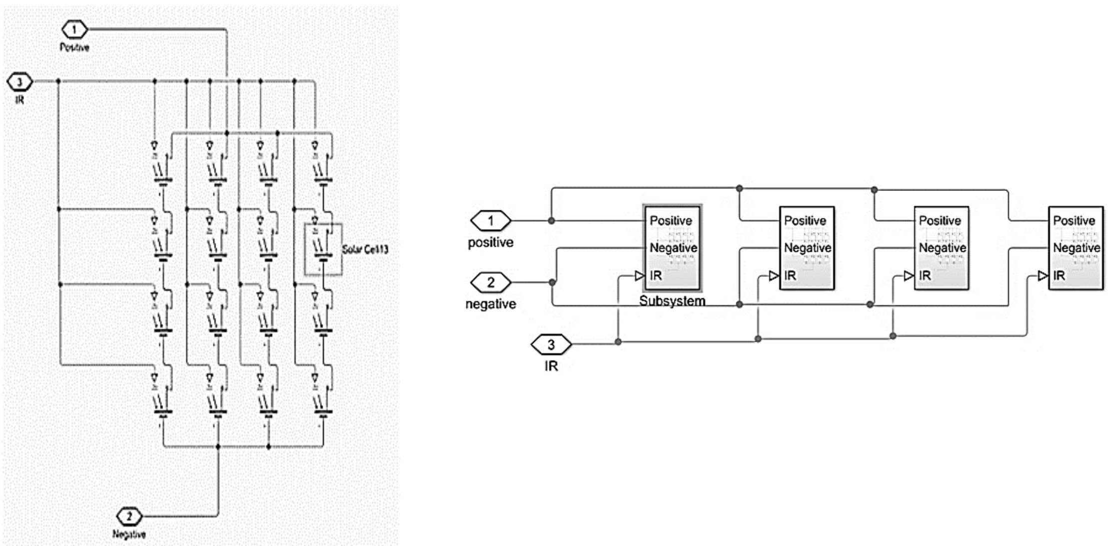

Figure 7. Solar cell circuit

3.4. Curve characteristic results

The following are the results of the curve characteristics in the design simulation of solar power plants at the Pier using the MATLAB application as follows:

– 100Wp voltage and power characteristics

Figure 8 is the result of a trial using a 100 Wp solar cell. The experiment was carried out six times, with different light intensity radiation from the largest to the smallest data. Maximal power generated from solar cells installed 6.4 kW, while the minimum power or the lowest to below 1 kW. Then the maximum voltage results up to 90 volts and the minimum voltage is approximately 70.5 volts. From Figure 9 is the result of the 100 Wp voltage-current characteristic curve. The resulting maximal current yields approximately 100 amperes and the minimum current is up to 8 amperes, tested with varying solar intensity radiation. Then the maximum voltage results are 90 volts and the minimum voltage results are approximately 70.5 volts.

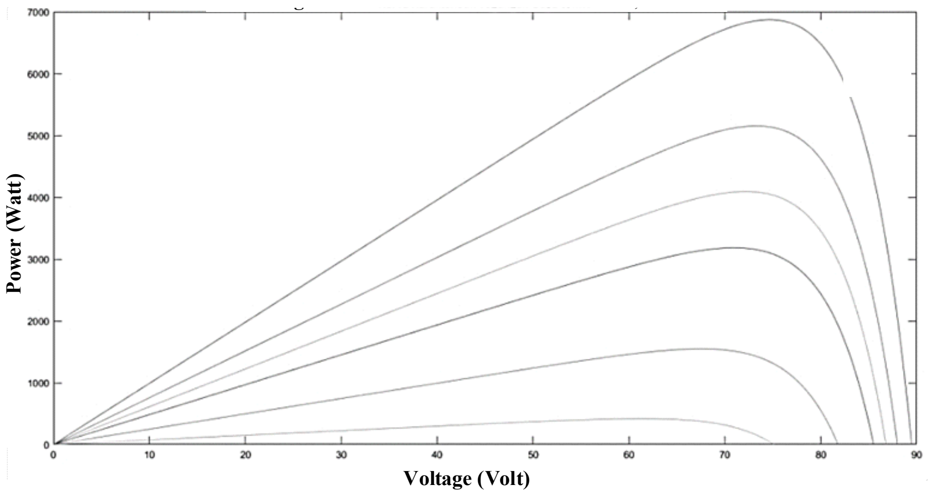

Figure 8. Voltage-power characteristic curve with 6.4 kW

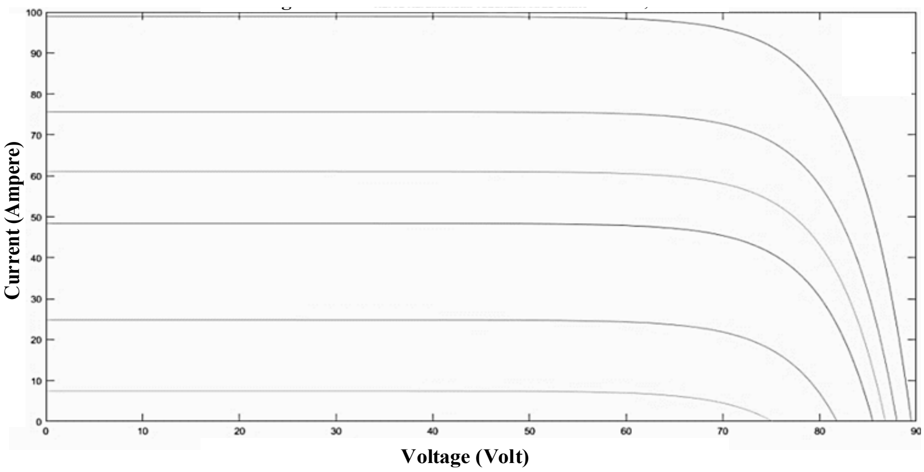

Figure 9. Voltage-current characteristics curve with 6.4 kW

– 150Wp voltage and power characteristics

The following are the results of the 9.6kW voltage-power characteristic curve in Figure 10, tested six times with radiation data of different light intensities from the highest to the lowest resulting in a maximal power of 9.6 kW and a minimum power of approximately 1 kW. While the maximum voltage generated is 90 volts and the minimum voltage is approximately 75 volts. Figure 11 is the result of the 9.6 kW voltage-current characteristic curve. They are tested six times with radiation data of different light intensities from the highest to the lowest, resulting in a maximum voltage of 90 volts and a minimum voltage of 70.5 volts. While the maximum current generated is 100 amperes and a minimum of 20 amperes.

– Power-voltage and voltage-current characteristics of 200 Wp

Results of a 12.8 kW voltage-power characteristic curve, the trial was carried out six times with radiation data of different light intensities from the highest and the lowest. The maximum power produced is 12.8 kW and minimum power is up to 1 kW. Then the maximum voltage generated is almost 140 volts and a minimum voltage of 120 volts which display in Figure 12. Figure 13 is the result of the voltage-current characteristics curve of 12.8 kW, then tested six times with different light intensity radiation data. The resulting current is maximal 120 kW and the minimum current is approximately 10 amperes. The resulting voltage is a maximum of 140 volts and the minimum voltage is up to 120 volts.

– Power and voltage voltage current characteristics of 250 Wp

Results of a 16-kW voltage-power characteristic curve, then tested six times with radiation data of different light intensities from the highest to the lowest. The maximum power produced is 15 kW and the minimum power is 1 kW. The resulting voltage is a maximum of 140 volts and the minimum voltage is 120 volts which display in Figure 14. Results of a 16-kW voltage-current characteristic curve, tested six times with different light intensity radiation data. Then the resulting current is maximal 120 amperes and the minimum current is up to 30 amperes. The resulting voltage is a maximum of 140 volts and the minimum voltage is 120 volts which display in Figure 15.

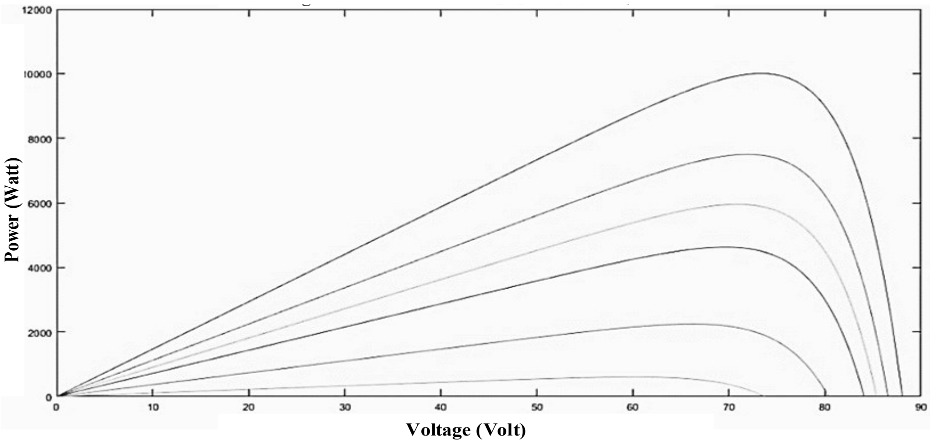

Figure 10. Voltage-power characteristics curve with 9.6 kW

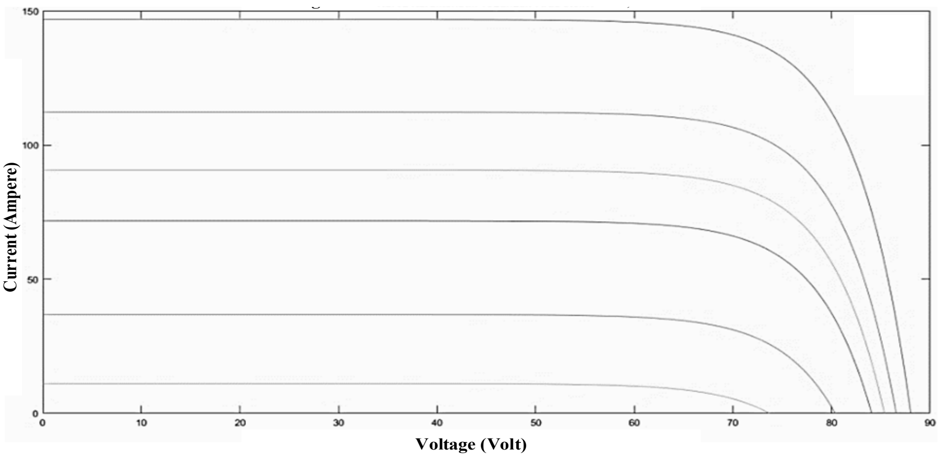

Figure 11. Voltage-current characteristic curve with 9.6 kW

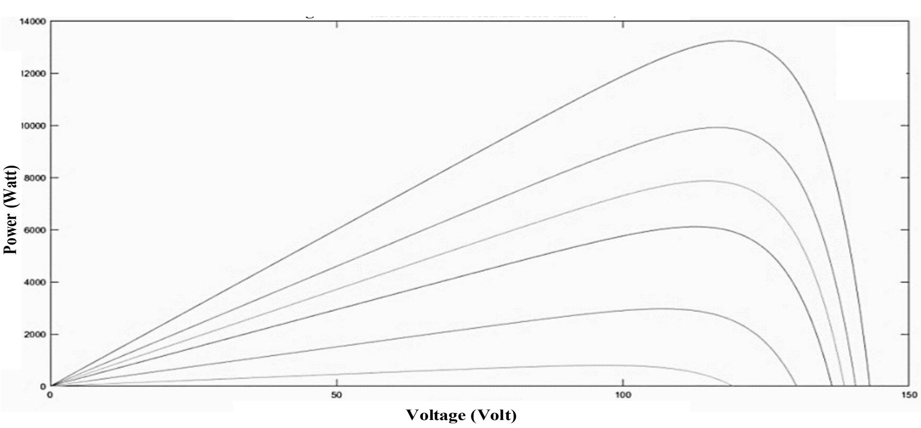

Figure 12. Voltage-power characteristic curve with 12.8 kW

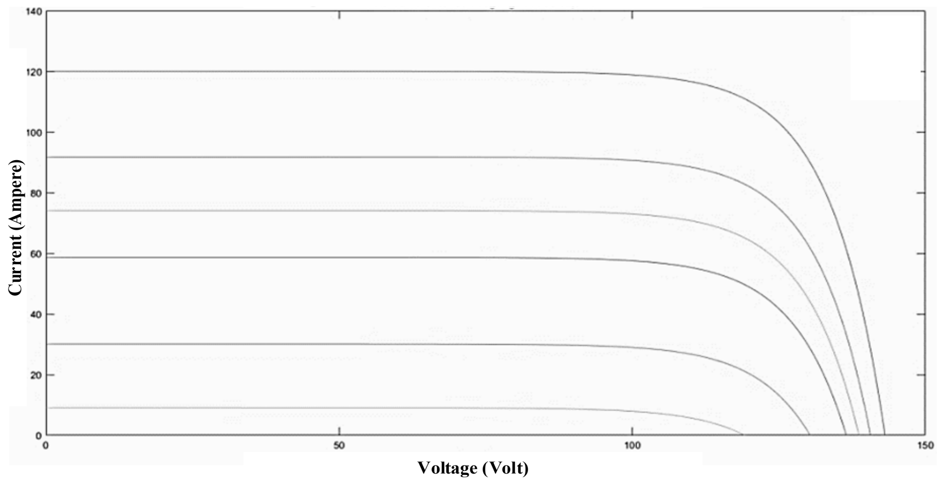

Figure 13. Voltage-current characteristic curve with 12.8 kW

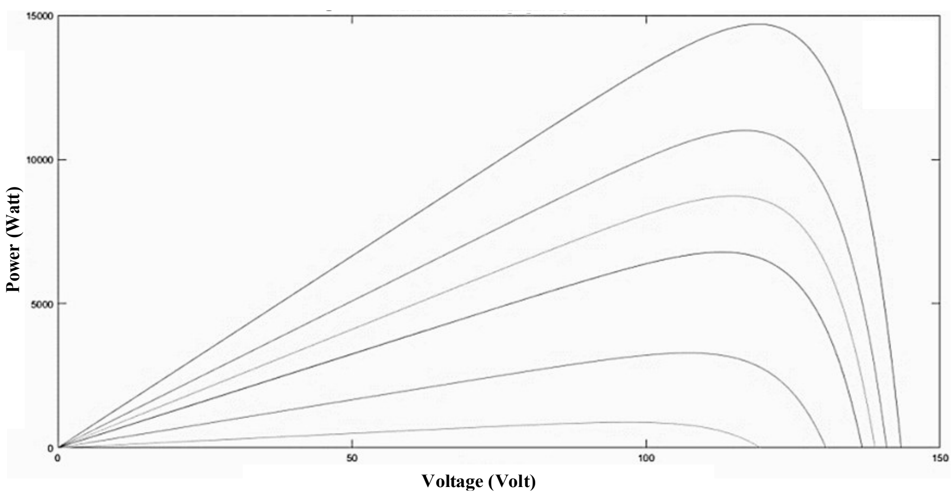

Figure 14. Voltage-power characteristic curve with 16 kW

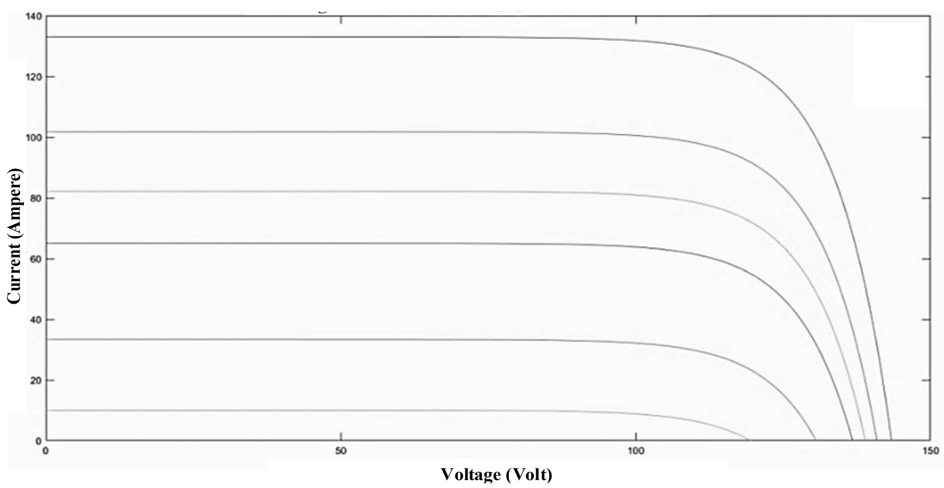

Figure 15. Current-voltage characteristic curve with 16 kW

4. CONCLUSION

From the analysis of the simulation results of solar power plants using Simulink on the MATLAB application, it can be concluded that solar power plant simulations that can be applied at Waru Tua pier using

64 solar cells installed in parallel, and simulations performed on MATLAB Simulink using four variations of solar cell power quantities, namely 100 Wp, 150 Wp, 200 Wp, and 250 Wp with each power produced as follows: 100 Wp = 6.4 kW, 150 Wp = 9.6 kW, 200 Wp = 12.8 kW, and 250 Wp = 16 kW. Based on these results, the capacity of 250 Wp solar cells can be used for public electricity needs as many as 17 housing units with an average power usage per house of ± 900 W. In the future socialization can be carried out to the community in the Waru Tua Pier related to the development of solar electricity and its benefits to meet the electricity needs in the area.

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Ain Sahara, I am born and raised in Balikpapan City on January 26, 1986. I am a lecturer in the oil and gas electronics instrumentation engineering faculty at STT Migas Balikpapan. The fields of science that they are involved in include digital engineering, and logic control programs. The current research that is in the field is related to renewable energy, namely the use of solar cells as alternative energy unified.

Riza Hadi Saputra is a lecturer in STT Migas Balikpapan which has focus in automation, energy management (especially about battery or battery management system), and anything connect with instrumentation. Concerning about solar power plant.

A. M. Miftahul Huda I am a lecturer at a private university in Balikpapan. The field of science that I enjoy is Physics. I am a physicist with major studies in geophysics and hazard mitigation. The research interests that I currently enjoy are research in the fields of Applied-Energy Physics and simulation, Computational Physics, and Seismology.