Optimization Analysis Of Output Of Photovoltaic Types On The Effect Of Solar Temperature And Radiation

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Abstract — All Solar power plants (PLTS) work by absorbing solar light and converting it directly into electrical energy. This energy that comes from sunlight will not cause carbon emissions because it is an environmentally friendly energy that is free from pollution. Maximum solar panel operation at 25°C. So, the higher the temperature level of the solar panel, it will affect the power output obtained from the solar panel. In this study, a test was carried out to see the comparison of optamalization of the output of the photovoltaic type on the effect of temperature and solar radiation using 2 types of photovoltaic modules, namely monocrystalline and polycrystaline with different capacities of 40 Wp and 100 Wp. Based on the research results, it can be concluded that the highest voltage on July 1, 2021 is 37.7 Volt monocrystalline module with a temperature of 43º and 38.9 polycrystaline module with a temperature of 43.1º and solar radiation of 914.2 W/m². Then the highest current is 1.4 Ampere monocrystalline module and 0.86 Ampere polycrystaline module.

Keywords— solar power plant (PLTS), photovoltaic, monocrystalline, polycrystaline. temperature, radiation

INTRODUCTION

Energy derived from solar energy or what is called solar energy will not cause carbon emissions because it is environmentally friendly energy that is free from pollution. Solar power plants (PLTS) work by absorbing solar light andconverting it directly into electrical energy. The condition ofthe Indonesian state which is currently located on the equatorwhich has 2 hot and cold seasons brings advantages and disadvantages, the advantage is that the sun always shines throughout the year, it will get very large energy, but the average temperature value in the surrounding environment will higher, compared to other countries that have 4 seasons. Weather and climate conditions cannot be predicted, becauseit will cause several problems in the operation of the solar panels that will be used, because their instability greatly affects the current and voltage generated by photovoltaic cells. **So,** the specifications of each type of solar panel have different power results in converting the energy absorbed by the sun into electricity. The material of the arrangement of photovoltaic cells will not always be the same in every photovoltaic cell producing.

MATERIAL AND METHODS

A. Research Site

The location of the research to be carried out is at the Central Laboratory of Research and Assessment of New and Renewable Energy (P3EBT) Institute of Technology - PLN Jakarta, which is equipped with PLTS equipment. The time ofthe study was carried out on March 1 to April 16, 2021.

B. Research Flowchart

In this study, a flow chart is needed for an overview as follows:

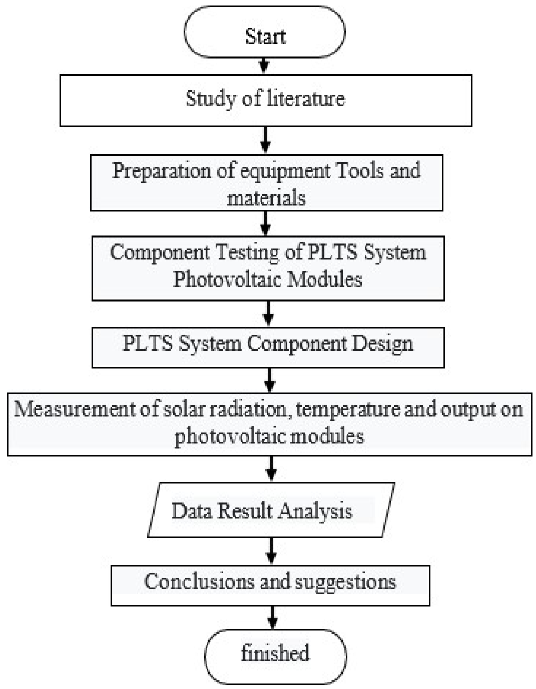

Figure 1. Research Flowchart

DATA ANALYSIS METHOD

A. Data Processing

Data processing will begin after all the required data has been collected to carry out research, data processing here is carried out by performing calculations including:

B. Calculation of Input Power on Solar Panels

Input power on solar panel is the maximum voltage multiplied by the maximum current in the photovoltaic module.

$$Pin = Vmp \ x \ Imp \tag{1}$$

where:

Pin = Input power due to solar irradiance (Watts)

Vmp = Maximum voltage on the photovoltaic module(Volts)

Imp = Maximum current in the photovoltaic module(Amperes)

C. Calculation of Output Power on Solar Panels

$$Pout = Vout \ x \ Iout \tag{2}$$

where:

Pout = Power generated by the solar cell (Watts) Vout = Voltage generated by the solar cell (Volts)

Iout= Current generated by the solar cell (Amperes

D. Calculation of Efficiency in Solar Panels

Solar panels also have efficiency, where efficiency is thepower parameter obtained from solar panels with solar irradiation that obtains input energy.

$$\eta = \frac{\text{Voutput}}{\text{Vinput}} x\ 100\% \quad (3)$$

where:

Pout = Power generated by the solar cell (Watts)

Pin = Input power due to solar irradiance (Volts)

RESULT AND DISCUSSIONS

TEST COMPONENT SPECIFICATION DATA

A. Photovoltaic (PV) Module Specifications

When conducting the test, the PV module used was usingseveral models because in this test 4 PV modules and 2 different types of PV modules were used, namely monocrystaline and polycrystaline. The PV module is 100 WP monocrystaline model MY100S-12, polycrystaline 100 WP model MY100S-12, monocrystaline 20 WP model 20-921 andpolycrystaline 20 WP model SIP-20.

TABLE I. Monocrystaline Module Specification 100 Wp

Subject	Symbol	Score
Maximum Power	Pmax	100W
Voltage at Pmax	Vmp	18.1 V
Current at Pmax	Imp	5.54 A
Open-circuit voltage	Voc	22.2 V
Short-circuit current	Isc	6.00 A
Max System Voltage		700 V
Temperature range		-45° ~ +80°C
Dimension		1020 x 670 x 35mm

Note : power measured under standard test conditions : AM = 1.5 E= 1,000 W/M² Temp = 25° C

TABLE II. Polycrystaline Module Specification 100 Wp

Subject	Symbol	Score
Maximum Power	Pmax	100 W
Voltage at Pmax	Vmp	17,6 V
Current at Pmax	Imp	5,7 A
Open-circuit voltage	Voc	22 V
Short-circuit current	Isc	6,06 A
Max System Voltage		700 V
Temperature range		-45° ~ +80°C
Dimension		1020x670x30 mm

Note : power measured under standard test conditions: AM=1.5, E=1000 W/M²Temp = 25° C

TABLE III. MONOCRYSTALINE MODULE SPECIFICATION 20 WP

Subject	Symbol	Score
Maximum Power	Pmax	20 W
Open-circuit voltage	Voc	21.6 V
Short-circuit current	Isc	1.30 A
Max Power Voltage	Vpm	17.2 V
Max Power Current	Ipm	1.17 A
Max System Voltage		1000 V
Dimension		639 x 294 x 23 (mm)

TABLE IV. POLYCRYSTALINE MODULE SPECIFICATION 20 WP

Subject	Symbol	Score
Rated Power	Pmax	20 W
Open-circuit voltage	Voc	21.31 V
Short-circuit current	Isc	1.29 A
Max Power Voltage	Vpm	17.35 V
Max Power Current	Ipm	1.2 A
System Voltage		12V
Max System Voltage		715 V
Dimension		350 x 538 x 35 (mm)

A. Specifications of Solar Charge Controller (SCC)

SCC (Solar Charge Controller) functions to regulate the voltage and current for charging the battery with the PV module to make it more optimal. Choosing the right type anddesign of SCC is important to maintain PV mini-grid efficiency and battery life. SCC specifications are determinedbased on the configuration of the photovoltaic module array, the voltage system used, and the characteristics of the battery. Therefore, it is important to understand the SCC specificationsso as not to cause damage to the SCC components or the battery.

TABLE V. POLYCRYSTALINE MODULE SPECIFICATION 20 WP

Type	SC2430(B) - 20A
Rated charge current	20 A
Rated load current	20 A
Working Voltage	12/24V auto switch
Charging circuit voltage drop	< =0.26 V
Overvoltage protection	14.8V; x 2/24 V;
Working Temperature	-35ºC to +55ºC

A. Battery Specifications

The battery serves to store electrical energy that will be generated from the PV module. There is 1 type of battery to be tested, namely a VRLA battery with a capacity of 12 V 50Ah for VRLA. Batteries are usually defined by their nominalvoltage and capacity. The nominal voltage is basically the battery's midpoint voltage or the voltage measured when thebattery has a 50% charge state. While the capacity is the amount of current that the battery can provide for a certain time (Ah). The battery to be tested will be given electrical energy generated from the same PV module.

TABLE VI. VRLA BATTERY SPECIFICATIONS

Subject	Score
Nominal Voltage	12V
Nominal Capacity	50 Ah
Charge Current	Max 12.5 ; Recommend 5 A
Equalize Charge	13.8-14.1V
Float Charge	13.5-13.8 V
Self Discharge	3% per month at 25°C

SINGLE LINE DIAGRAM OF RESEARCH TESTING

In this study, we describe a single test in the PV mini-grid circuit that uses two different types of PV, Monocrystaline and Polycryatline and two types of batteries, namely VRLA.

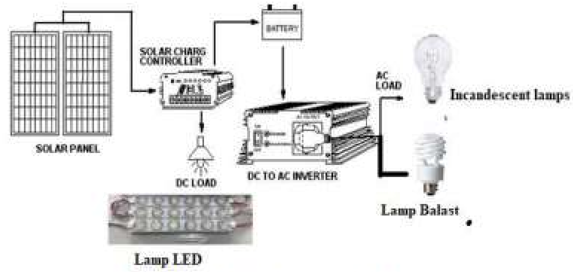

Figure 2. Single Line Diagram

A. Testing and Data Collection 21 June 2021 on 40 WpMonocrystaline and Polycrystaline Modules

TABLE VII. CALCULATION OF TEST DATA ON JUNE 21 ON PV 40 WP MONOCRYSTALINE

Hour	PV 40 Wp Mono		Pout	Vpm	Ipm	P Pin	Efficiency	Temp PV	Ambien Temp	Solar Radiation	Tilt PV	Weather Desc
	V	I	Watt	V	I	Watt	%	°C	°C	W/m²	40 Wp	
09.00	31,7	0,34	10,778	34,4	2,34	80,496	13,389	41,1	28,2	331,7	20	bright
10.00	34,3	0,23	7,889	34,4	2,34	80,496	9,800	48,4	30	812	20	bright
11.00	35,8	0,21	7,518	34,4	2,34	80,496	9,339	47,8	31,7	825	20	bright
12.00	13	0,18	2,34	34,4	2,34	80,496	2,906	29,8	27,9	77,5	20	overcast
13.00	12,8	0,17	2,176	34,4	2,34	80,496	2,703	26,7	27,3	52,4	20	rain
14.00	13,3	0,17	2,261	34,4	2,34	80,496	2,808	29,8	27,3	125,6	20	overcast
15.00	20,3	0,2	4,06	34,4	2,34	80,496	5,043	29,5	28,5	165,5	20	overcast

TABLE VIII. CALCULATION OF TEST DATA ON JUNE 21 ON PV 40 WP POLYCRYSTALINE

Hour	PV 40 Wp Mono		Pout	Vpm	Ipm	Pin	Efficiency	Temp PV	Ambien Temp	Solar Radiation	Tilt PV	Weather Desc
	V	I	Watt	V	I	Watt	%	°C	°C	W/m²	40 Wp	
09.00	31,7	0,34	10,778	34,4	2,34	80,496	13,389	41,1	28,2	331,7	20	bright
10.00	34,3	0,23	7,889	34,4	2,34	80,496	9,800	48,4	30	812	20	bright
11.00	35,8	0,21	7,518	34,4	2,34	80,496	9,339	47,8	31,7	825	20	bright
12.00	13	0,18	2,34	34,4	2,34	80,496	2,906	29,8	27,9	77,5	20	overcast
13.00	12,8	0,17	2,176	34,4	2,34	80,496	2,703	26,7	27,3	52,4	20	rain
14.00	13,3	0,17	2,261	34,4	2,34	80,496	2,808	29,8	27,3	125,6	20	overcast
15.00	20,3	0,2	4,06	34,4	2,34	80,496	5,043	29,5	28,5	165,5	20	overcast

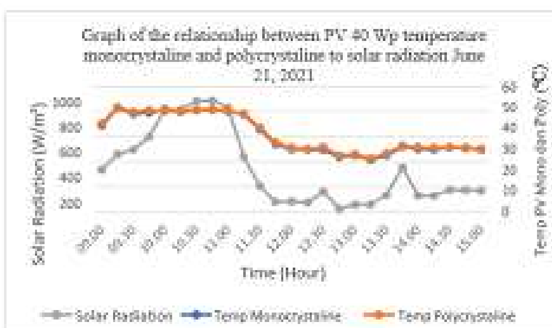

Figure 3. Graph 21 June 2021 Effect of solar radiation on temperature at 40 Wp monocrystaline and polycrystalline PV

For the highest PV voltage value produced at 11.00 with aslope angle of 20º, the value of the voltage is 35.8 Volts, andthe current is 0.21 Ampere with a temperature of 47.8 C on monocrystalline PV, and for the value of the polycrystalline PV voltage is 14.4 Volts and the current is 14.4 Volts. 0.3 Ampere with a temperature of 48.2 C and solar radiation of825 W/m².

B. Testing and Data Collection 21 June 2021 on 100 WpMonocrystaline and Polycrystaline

TABLE IX. CALCULATION OF TEST DATA ON JUNE 21 ON PV 40 WP POLYCRYSTALINE

Hour	PV 100WP Mono		Pout	Vpm	Ipm	Pin	Efficiency	Temp PV	Ambien Temp	Solar Radiation	Tilt PV	Weather Desc
	V	I	Watt	V	I	Watt	%	°C	°C	W/m²	100 Wp	
09.00	16,2	1,4	22,68	18,1	5,54	100,274	22,618	38	28,2	331,7	20	bright
10.00	20,7	0,45	9,315	18,1	5,54	100,274	9,289	44,3	30	812	20	bright
11.00	21,5	0,29	6,235	18,1	5,54	100,274	6,217	47,4	31,7	825	20	bright
12.00	17,2	0,2	3,44	18,1	5,54	100,274	3,430	29,1	27,9	77,5	20	overcast
13.00	13,6	0,16	2,176	18,1	5,54	100,274	2,170	25,7	27,3	52,4	20	rain
14.00	18,6	0,23	4,278	18,1	5,54	100,274	4,266	29,5	27,3	125,6	20	overcast
15.00	20	0,24	4,8	18,1	5,54	100,274	4,786	28,5	28,5	165,5	20	overcast

TABLE X. CALCULATION OF TEST DATA ON JUNE 21 ON PV 100 WP POLYCRYSTALINE

Hour	PV 100 WP Poly		Pout	Vpm	Ipm	Pin	Efficiency	Temp PV	Ambien Temp	Solar Radiation	Tilt PV 100 Wp	Weather Desc
	V	I	Watt	V	I	Watt	%	°C	°C	W/m²		
09.00	15,6	0,86	13,416	17,6	5,7	100,32	13,373	40	28,2	331,7	20	bright
10.00	20,8	0,38	7,904	17,6	5,7	100,32	7,878	45,2	30	812	20	bright
11.00	21,6	0,52	11,232	17,6	5,7	100,32	11,196	47,9	31,7	825	20	bright
12.00	16,8	0,22	3,696	17,6	5,7	100,32	3,684	30,1	27,9	77,5	20	overcast
13.00	14,7	0,19	2,793	17,6	5,7	100,32	2,784	27,9	27,3	52,4	20	rain
14.00	18,6	0,15	2,79	17,6	5,7	100,32	2,781	30	27,3	125,6	20	overcast
15.00	19,5	0,14	2,73	17,6	5,7	100,32	2,721	28,6	28,5	165,5	20	overcast

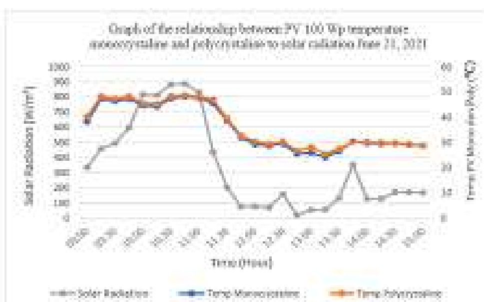

Figure 4. Graph 21 June 2021 Effect of solar radiation on temperature at 100 Wp monocrystaline and polycrystalline PV

For the highest value of PV voltage produced at 11.00 with a slope angle of 20º, the value of voltage is 21.5 Volts and current is 0.29 Ampere with a temperature of 47.4 C on monocrystalline PV, and for polycrystalline PV voltage values are 21.6 Volts and current 0.52 Ampere with a temperature of 47.9 C and 825 W/m² of solar radiation. Thenthe lowest voltage value at 13.00 is 14.7 Volts and the currentis 0.19 Ampere in monocrystaline PV with a temperature of 27.3 C. and for the polycrystalline PV voltage value of 14.7 Volts and current of 0.19 Ampere with a temperature of 25.7C and solar radiation of 52.4 W/m². When solar radiation increases, the temperature in the PV will also increase and theambient temperature will also increase.

CONCLUSION

From the results of research on optimizing the output of two types of photovoltaic modules which are influenced by temperature and solar radiation, it can be concluded that:

1. Of the two types of monocrystalline and polycrystalline PV modules, the best output and the best efficiency is monocrystalline PV around 15-20%. Based on the efficiency test, the best radiation is 825 W/m² with a voltage of 35.8 V and a current of 0.21 A monocrystalline 40 Wp and 21.5 V and a current of 0.29 at 100 Wp.
2. The best time to produce good output is duringthe day or when solar radiation reaches 1000 W/m² with sunny weather conditions. Based on the tests carried out at 882.7 W/m² radiation with a temperature of 47.4º C 100 Wp and 47.8ºC 40 Wp.
3. With the optimal angle of inclination whenconducting experiments, namely at an angle of20º C.

The suggestions that can be given by the author after testing are:

1. It is recommended to use monocrystaline module types, but they are more expensive, have better efficiency and produce good outputcompared to polycrystalline modules.
2. The selection of a PV module with a small or larger capacity will affect the output and the measurement tool must also be more sensitiveso that when taking measurements, the data obtained will be more accurate.

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