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The Effect of Solar Panel Output Power Analysis with Reflector Angle Optimization and Addition of Heatsink-Fan Cooling System

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Abstract

The addition of reflectors to solar panels is used to increase the intensity of sunlight received by solar panels so that the electrical power generated by the panels increases. In adding reflectors to solar panels, they must consider various factors to be able to increase the power generated without having a negative effect on solar panels, one of which is providing a cooling system. Therefore, research is needed to increase the power generated by solar panels and cooling systems that are suitable for overcoming rising temperatures due to the addition of reflectors. The study was conducted by varying the glass mirror reflector, aluminum foil reflector, angle of the reflector, and heatsink-fan cooling system. The research method used in this study was to compare 2 solar panel models, namely: solar panels with the addition of glass mirror reflectors/aluminum foil and heatsink-fan cooling systems, and solar panel models without any addition. The results show that the solar panel model with the addition of a glass mirror reflector / aluminum foil can increase the output power according to the angle of the reflector, the highest increase reaching 16.70% in the 450-angled aluminum foil mirror reflector. The heatsink cooling system is considered to be useful for reducing the temperature of solar panels, but the decrease is relatively small below 5%.

Keywords: Solar panels, reflectors, heatsink-fan

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1. Introduction

1.1. Background

In the technological era we live in today, electrical energy is a very basic need for everyday life. Daily household needs average 640 kWh per month, covering everything from meeting basic needs or essential appliances such as lamps, refrigerators, and hingga rice cookers meet secondary needs or additional equipment such as TVs, irons, or fans.

Most modern technologies mostly use electricity. We need a power plant that can supply us with the electricity we need every day. Although the supply is limited (will run out), some factories in Indonesia are still largely fossil-based, which has a negative effect on the environment. As a result, a power plant with an unlimited supply of ecologically useful basic materials (Renewable) is required.

With two seasons and an average daily solar radiation of 4.5 kWh/m2/day, Indonesia, a tropical country, has a lot of solar energy potential (Aryza et al., 2017). In addition, Indonesia is in an ideal position for the use of solar energy due to its equatorial location and daily sun exposure of an average of 11 hours. With year-round availability, this great potential can certainly be used as a renewable energy source (alternative) to generate electricity without damaging the environment. Indonesia now has an installed capacity of 16.92 MW, and by 2025, the government wants to increase it to 6.3 GW.

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The inefficiency of energy collected from sunlight due to energy loss caused by solar panels and also limited storage so that it can be utilized at night is one of the difficulties in the use of solar power plants (PLTS). Not It is possible to completely absorb solar energy and convert it into electricity.

Solar panels are usually connected together in series to improve the efficiency of the electrical energy received from the photovoltaic output. However, under actual circumstances, the required count of photovoltaic cannot be ignored due to the high cost of construction, which requires considerable investment.

The study shows that by shifting the reflector to the east and west sides, reflector scanning technology finds the most maximum power point under certain circumstances. Using reflector scanning, previous research has included polycrystal type solar panels to increase output and electrical energy (Utomo et al., 2017).

With average yields of a 0.7533 A and 10.20 Watts, flat mirror reflector scanning technology improves the current and power output of solar panels compared to solar panels without them. This is because the voltage value is more stable. When comparing electrical energy and efficiency value generated by solar panel models with scanning reflectors and angle reflectors with solar panel models without inserting reflectors, panel models Solar with reflectors produces better results. Although research shows that the use of reflectors increases the temperature of solar panels, the average value of efficiency comparison is 6.362%, and the difference in electrical energy is 191012.62 Joules (Today, 2007).

Fast hot temperatures require a fast cooling system with a fan for high heat release. To reduce temperature rise, Widiantara et al., 2019 studied the use of water cooling as a temperature regulator for solar panels. According to research, the cooling effects on solar cells can function properly, but they are less profitable when viewed in terms of energy use efficiency.

According to the test findings, the ability of solar panels to generate 1 W less electricity in situations of lower light intensity, such as 600 W/m2, while still producing 4 W of power more in conditions of higher light intensity, 1000 W/m2, with cooling. The use of cooling systems on solar panels also proved ineffective as it consumed electricity to run the system before solar cells could be used to reach a surface temperature of 25°C.

Adding heatsink coolers to solar panels in a March 2019 study yielded results that improved solar panel performance when using reflectors. Compared to photovoltaic models with reflectors but lacking a cooling system, the research findings reveal that adding a cooling system to the photovoltaics placed by The reflector resulted in an average temperature drop from the solar panel of 18.26% and an average UT out increase of 10.14% (Pawawoi & Zulfahmi, 2019).

The addition of reflectors, followed by sunlight reflected in the direction of the solar panels with the help of reflectors, can intensify the amount of sunlight received by the panels, which can men Increase the amount of potential energy the sun can create. However, this increases the temperature of solar panels, which affects their ability to produce high output and lowers their maximum power output. Efforts to increase the output power of TOVOLTAIC FO by equipping solar panels with cooling systems.

2. Research Methodology

Testing of solar panels requires a strategic place to get the maximum solar intensity. This research will later be carried out at the ball field, Griya Alam Sentosa Housing, Cileungsi, Bogor Regency. This place was chosen because of the absence of barriers to sunlight entering such as tall buildings or shady trees.

Polycrystalline solar panels made by SUNASIA with dimensions of 100 x 67 x 3 cm will be used as experimental solar cells. It has a standard condition of 1000 W / m2. The characteristics and temperature of the modules are listed in table 1 at 25 degrees celsius.

A series of solar panels with mirror reflectors with *a heatsink-fan* cooling system are installed as shown in figure 1.

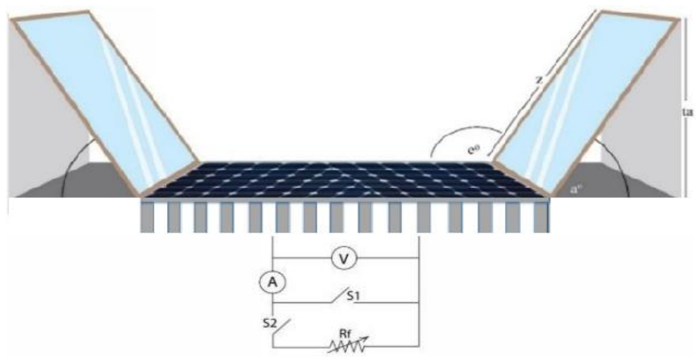

Figure 1. Solar panel circuit with mirror reflector and *heatsink-fan*
Source : (Pawawoi and Zulfahmi, 2019)

Table 1. Specification of *polycristaline* solar panel

Model	SP100-18P
Peak power (PMax)	100W
Cell efficiency	16.93%
Max power volt. (Vmp)	17.8V
Max power current (Imp)	5.62A
Open circuit volt. (Voc)	21.8A
Short circuit current (Isc)	6.05A
Power tolerance	±3%
Max. system voltage	1000V
Series fuse rating (A)	12
Number of bypass diode	2
Operating temperature	-4ºC to +85ºC
Maximum system voltage	1000V DC
Current temperature coefficient α (Isc)	0.03% / ºC
Voltage temperature coefficient β (Voc)	-0.32% / ºC
Power temperature coefficient γ (Pmax)	-0.42% / ºC

2.1. Solar Cell Variations by Using Angles

Assessing the influence of the output power generated by solar panels is the purpose of changing solar cells usingan angle. Three different types of angles, as given in table 3.2, will be used in this investigation.

Table 2. Solar cell variations

Addition of Heatsink-fan	Reflector 30^0 the panel
Addition of Heatsink-fan	Reflector 45^0 the panel
Addition of Heatsink-fan	Reflector 60^0 the panel

2.2. Reflector

Reflectors with aluminum foil and mirror glass are the choice to run this study with a thickness of 3cm. Dimensions of glass mirror reflector 100 x 50 cm, reflectance reflectance rr:0.85. The reflector will be placed on a special reflector holder of a mild steel frame that has a dual function that is useful as an angle adjuster and a place to put the solar cell with 30°.45°.60^{O} tilt angle for each test.

2.3. Heatsink-Fan

The heatsink-fan used in this study is a heatsink with square fins with 29 fins and made of aluminum with dimensions of 55 x 13 x 2 cm and with a fin thickness of 2.4 mm which will later be arranged the series on the back of the Surya panel and added a fan for quick heat release.

2.4. Solar Panel Frame

The function of the solar panel frame is designed to hold or become a mount of the solar panel and reflector to make it more stable and easier to retrieve data. When retrieving angular data from the reflector, it needs to be given a support to stabilize its position, so this frame is made.

2.5. Lux Meter

To measure the level of intensity of incoming light requires the right measuring instrument, and in this study a *lux meter* was chosen with the specifications described in table 3.3.

Table 3. Lux meter specifications

Material	ABS Plastic
Measuring range	0-200,000 Lux
Resolution	1 Lux
Accuracy	5% rdg 10 dtgs
Temperature range	-10~50 / 14-122
Sampling rate	1,5 times/sec
Measurement repeatability	2%
Operating temperature	0-50 (80%RH non-condesing)
Storage temperature	-10 – 50 (70%RH non-condesing)

2.6. Thermogun

Thermogun is the most suitable tool to be used in measuring temperature on solar panels. The thermogun used is describedn in table 4.

Table 4. Specifications of the *thermogun*

Temperature range	-50 ~ 380 (-58 ~ 716)
Accuracy	1.5% or 1.5
Repeatability	1% or 1
Distance spot ration	12:1

Emissivity	0.95 preset
Resolution	1.0
Response time	500ms
Wavelength	8-14m

2.7. Multimeter

A device for measuring the voltage and current of solar panels. The device has a calculator. Able to measure dc and ac (direct current) currents. (Table 5).

Table 5. Specifications of the multimeter

DCV, range	400m/4/40/400/600V, resolusi 0,1 mV
ACV, range	4/40/400/600V, resolusi 1 mV
DCA, range	40m/400mA, resolusi 0,01 mA
ACA, range	40/400mA, resolusi 0,01 mA
Resistance, range	400/4k/40K/400k/4M/40M ohm, resolusi 0,1 ohm
Capacitance, range	50n/500n/5/50/100F, resolusi 0,01nF
Frequency, range	5Hz – 100kHz

2.8. Protractor

This tool will later function to measure the degree on the reflector holder so that the angle of the reflector can have an angle of 30 0.45 0.60^0.

This research begins with the study of literature as the initial capital to know the theories related to the thesis material so that it can be used as a reference in the preparation of the thesis. This reference is taken from previous journals, *e-books*, *papers*, and previous skripsi which discuss renewable energy, solar panels, reflectors, heatsink-fan, characteristics of solar panels and its effect on the *output* power produced. *After* that, the Pre-Processing *stage is continued* to run research so that it can run smoothly. Preparation is in the form of procurement of research equipment, inspection of measuring instruments, making designs and assembling frames as stands from solar panels and reflectors to be used with dimensions of 1 x 0.5 x 0.3 m (figure 2).

This angle regulator is made to be a holder for the reflector to remain stable in position and another function is to vary the angle of the reflector to be passed n to the solar panel with variations 30 0.45^0, and 60^0.

After the frame design is made next the back of the solar panel will be installed *heatsink-fan* as a passive cooling system and the installation is carried out on the back of the solar panel, fin direction pada heatsink-fan installed thus has the intention of expanding the heat transfer area on the solar panel then making it easier for air flow through the heatsink-fan and given *thermal paste* to increase heat conductivity between the two parts.

The positioning of the test equipment will later the reflector will face the east and west. When all the components are ready, assembly will be carried out to perfect *the design* and ready for experimentation (figure 3).

Figure 2. Frame design and angle adjuster
(Source : Personal Documents)

Figure 3. Research-ready solar panels(source: Personal Documents)

Furthermore, manual data collection will be carried out at the processing step. The collected data will then be converted into documents for the advancement of this research. Data retrieval is carried out in parallel for solar panel models with the addition of reflectors and heatsink fans and solar panel models without the addition of reflectors and heatsink fans. Later, the two models will be contrasted. Specifically the current data retrieval is carried out by taking the Isc value (short circuit current) from the solar panel and for voltage data retrieval is carried out by taking the Voc value (Open circuit voltage) of the solar panel, the collection of panel temperature data is carried out using a *thermogun* and highlighted towards the center of the solar panel with a distance approximately 10 cm from the solar panel and for taking temperature data the *heatsink-fan* will use a *thermogun* and be highlighted towards the center of the solar panel.

The *post-processing* stage will be carried out, if it has successfully obtained the desired data. At this stage, the appearance of the results that have been achieved will be carried out. Results can be tables, graphs and explanations. From these results, it will be the basis for analysis.

Analisa result is the stage where an analysis of the results obtained in the previous process will be carried out to answer the formulation of the problem in the study.

3. Results and Discussion

The data retrieval results shown in the table are the average of data retrieval per 5 minutes. The results of data collection are taken from the first 2 solar panel models with the addition of reflectors and *heatsink-fan* cooling systems, then the second model is the solar panel model without the addition of reflectors and *heatsink-fan* cooling systems. Data retrieval was carried out on November 12, 2022, by retrieving data from 2 panel models and getting the results displayed in table 6.

Table 6. Data Retrieval with 30^0 Mirror Reflector and *Heatsink-fan*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	25842.78	20.87	1.95	100.00	32.55	32.07	28.36
11:00	41676.94	20.84	3.07	100.00	36.58	34.06	30.29
12:0pm 0	31672.78	20.73	2.86	100.00	37.40	34.12	30.20
13:00	22208.61	20.50	2.09	100.00	35.59	30.28	27.41
2:0pm 0	24530.28	20.70	2.17	100.00	35.74	31.74	29.48
15:00	24239.44	20.49	2.10	100.00	58.03	32.29	29.011

Table 7. Data Capture without 30^0 Mirror Reflector and *Heatsink-fan*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	25842.78	20.46	1.60	100.00	32.55	34.32	
11:00	41676.94	20.46	2.55	100.00	36.58	36.53	
12:0pm 0	31672.78	20.51	2.42	100.00	37.40	38.44	
13:00	22208.61	20.37	1.67	100.00	35.59	33.15	
2:0pm 0	24530.28	20.28	1.74	100.00	35.74	33.98	
3:0pm 0	24239.44	20.44	1.80	100.00	58.03	33.89	

Data retrieval is performed simultaneously getting the results shown in table 6 will be compared with table 7. From the results of data collection, what will be analyzed is the output power and temperature of 2 solar panel models.

Data Retrieval with Mirror Reflector 45^0 and *Heatsink-fan* was carried out on November 13, 2022, by retrieving data from 2 panel models and getting the results displayed in table 8.

Table 8. Data Retrieval with 45^0 Mirror Reflector and *Fan-Heatsink*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	53032.78	21.08	2.85	100.00	33.08	36.11	31.72
11:00	138495.28	20.69	4.31	100.00	39.11	41.47	40.63
12:0pm 0	72765.28	20.45	3.63	100.00	39.43	47.32	42.00
13:00	89104.44	20.24	4.21	100.00	42.06	51.30	47.00
14:00	61862.78	20.06	2.62	100.00	40.24	40.60	36.07
15:00	27473.50	20.40	1.59	100.00	34.74	30.30	27.42

Table 9. Data Capture without Mirror Reflector 45^0 and *Heatsink-fan*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	53032.78	20.50	2.13	100.00	32.57	36.17	
11:00	138495.28	20.32	3.83	100.00	38.24	42.82	
12:0pm 0	72765.28	20.09	3.22	100.00	32.57	48.07	
13:00	89104.44	19.80	3.97	100.00	41.83	54.38	
2:0pm 0	61862.78	19.86	2.30	100.00	40.57	43.35	
15:00	27473.50	20.52	1.13	100.00	33.35	34.01	

Data retrieval is carried out simultaneously getting the results displayed in table 8 will be compared with table 9, from the results of data retrieval, what will be analyzed is the output power and temperature of 2 models of solar panels.

3.1. Data Retrieval with 60^0 Mirror Reflector and Heatsink-fan.

Data retrieval was carried out on November 14, 2022, by taking data from 2 panel models and getting the results displayed in table 10.

Table 10. Data Retrieval with 60^0 Mirror Reflector and *Heatsink-fan*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	32566.11	20.82	2.38	100.00	34.56	34.44	30.68
11:00	52114.34	20.50	3.30	100.00	39.75	42.94	35.28
12:00	34277.03	20.44	2.46	100.00	40.19	34.39	30.30
13:00	23082.78	20.41	1.87	100.00	38.29	33.99	30.72
2:0pm 0	18749.19	20.10	1.52	100.00	36.28	30.93	28.05
15:00	30198.28	20.36	2.36	100.00	36.93	33.58	30.07

Table 11. Data Capture without 60^0 Mirror Reflector and *Heatsink-fan*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	32566.11	20.44	1.85	100.00	34.56	35.39	
11:00	52114.34	19.32	2.56	100.00	39.75	45.95	
12:0pm 0	34277.03	19.99	1.88	100.00	39.19	37.16	
13:00	23082.78	19.96	1.43	100.00	38.28	36.17	
2:0pm 0	18749.19	19.86	1.15	100.00	36.28	32.16	
15:00	30198.28	20.02	2.23	100.00	36.93	34.94	

Data retrieval is carried out simultaneously getting the results displayed in table 10 will be compared with table 11, from the results of data retrieval to be analyzed is the output power and temperature of 2 models of solar panels.

3.2. Data Capture with 30 ^{0} Aluminum Foil Reflector and Heatsink-fan

Data retrieval was carried out on November 15, 2022, by taking data from 2 panel models and getting the results displayed in table 12.

Table 12. Data Retrieval with 30^0 Mirror Reflector and *Heatsink-fan*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	44950.94	20.52	2.39	100.00	33.35	34.18	24.62
11:00	174876.00	20.74	4.45	100.00	39.63	46.29	35.57
12:0pm 0	95786.94	20.82	4.44	100.00	44.51	56.42	46.02
13:00	51434.44	20.18	3.13	100.00	43.66	51.31	43.28
2:0pm 0	22928.61	20.26	2.14	100.00	40.34	46.53	39.18
15:00	29955.28	20.56	2.40	100.00	38.01	42.56	34.47

Table 13. Data Capture without 30^0 Mirror Reflector and *Heatsink-fan*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	44950.94	20.29	1.83	100.00	33.35	36.82	
11:00	174876.00	20.54	4.05	100.00	39.63	47.28	
12:0pm 0	95786.94	20.49	4.03	100.00	44.51	58.87	
13:00	51434.44	19.91	2.84	100.00	43.66	55.53	
2:0pm 0	22928.61	20.09	1.82	100.00	40.34	49.65	
15:00	29955.28	20.39	2.14	100.00	37.91	45.64	

Data retrieval is carried out simultaneously getting the results displayed in table 12 will be compared with table 13, from the results of data retrieval to be analyzed is the output power and temperature of 2 models of solar panels.

3.3. Data Retrieval with 45 0 Aluminum Foil Reflector and Fan-Heatsink

Data collection was carried out on November 16, 2022, by taking data from 2 panel models and getting the results displayed in table 14.

Table 14. Data Capture with 45^0 Aluminum Foil Reflector and *nk-fan Heatsi*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	44736.28	20.79	2.66	100.00	37.43	39.47	32.18
11:00	97296.11	19.97	5.91	100.00	46.35	52.73	39.13
12:0pm 0	85393.28	19.51	4.46	100.00	45.99	56.64	46.34
13:00	59331.00	20.31	3.82	100.00	46.99	50.34	44.58
2:0pm 0	77131.11	20.38	3.81	100.00	45.28	48.43	42.82
15:00	90546.94	20.12	3.84	100.00	44.79	49.58	42.41

Table 15. Data Capture without 45 0 Aluminum Foil Reflector and *Fan-Heatsink*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	43625.17	20.43	2.17	100.00	37.43	40.92	
11:00	96185.00	19.68	3.58	100.00	46.35	53.65	
12:0pm 0	84292.17	18.62	3.37	100.00	46.10	59.49	
13:00	58220.00	19.43	2.61	100.00	46.99	52.94	
2:0pm 0	76020.00	19.63	2.98	100.00	45.28	53.47	
3:0pm 0	89435.83	19.86	3.46	100.00	44.80	55.33	

Data retrieval is carried out simultaneously getting the results displayed in table 14 will be compared with table 15, from the results of data retrieval to be analyzed is the output power and temperature of 2 models of solar panels.

3.4. Data Retrieval with 60 0 Aluminum Foil Reflector and Fan-Heatsink

Data collection was carried out on November 17, 2022, by taking data from 2 panel models and getting the results displayed in tabel 16.

Table 16. Data Capture with 60 0 Aluminum Foil Reflector and *Fan-Heatsink*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	129369.33	20.18	4.70	100.00	45.51	54.55	44.78
11:00	44107.92	19.22	2.11	100.00	41.54	40.96	37.31
12:0pm 0	9983.75	19.43	0.87	100.00	36.16	31.08	27.55
13:00	16162.92	19.80	1.49	100.00	36.34	35.02	26.78
2:0pm 0	12339.58	19.91	1.11	100.00	34.93	33.79	27.29
15:00	12224.33	19.90	1.19	100.00	34.35	33.78	28.39

Table 17. Data Capture without 60 0 Aluminum Foil Reflector and *Fan-Heatsink*

Measurement Time	Solar Radiation	Voltage	Current	Panel Capacity	Temperature		
Hour	lux	Volt	A	(WP)	Room	Panel	Heatsink-fan
10:00	129369.33	19.80	4.25	100.00	45.51	57.67	
11:00	44107.92	19.03	1.46	100.00	41.54	41.39	
12:0pm 0	9983.75	19.04	0.63	100.00	36.16	32.14	
13:00	16162.92	19.33	1.08	100.00	36.34	35.28	
2:0pm 0	12339.58	19.80	0.83	100.00	34.93	35.59	
15:00	12224.33	19.76	0.83	100.00	34.35	35.71	

Data retrieval is carried out simultaneously getting the results shown in table 16 will be compared with table 17, from the results of data retrieval to be dialedisis the output power and temperature of 2 models of solar panels.

3.5. Output Power Analysis

Data retrieval from solar panel output power takes short-circuit (Isc) and open circuit voltage (Voc) data after which it calculates the output power of the solar panel using equation (3) and the average output power use equation (8), and so on. The use of the beam graph is chosen with the intention of making it easier to display the analysis results, from this beam graph will later be displayedn the results of the analysis in the form of output power (W), increased power (W), and data retrieval time.

Table 18. Average Power of Each Variation

	R. Mirror 30	R. Mirror 45	R. Mirror 60	R. Al foil 30	R. Al foil 45	R. Al foil 60
With the addition of	46.69 W	63.05 W	44.93 W	62.29 W	79.55 W	35.55 W
No additions	37.69 W	53.12 W	34.44 W	54.13 W	56.79 W	27.32 W

3.6. Reflector Mirror glass 30º

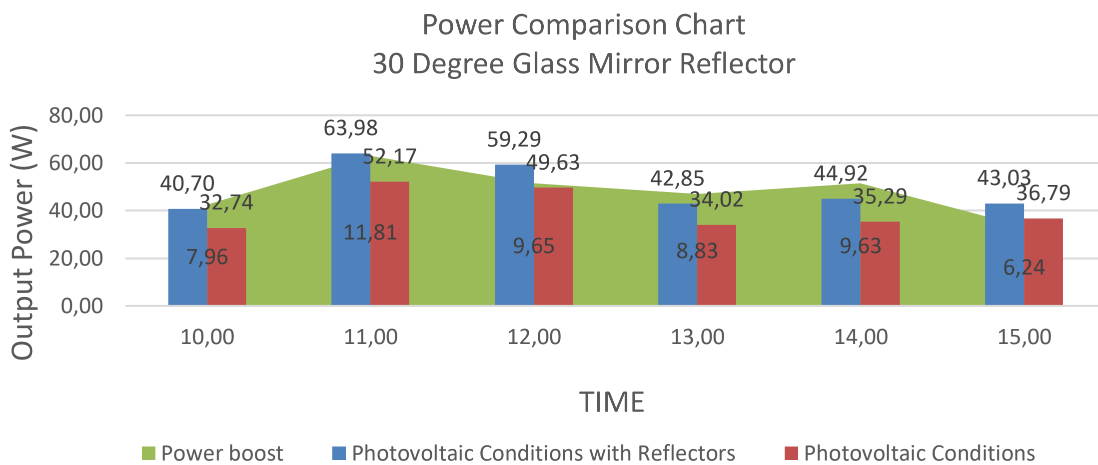

Figure 4. *Output* Power Comparison Chart with the Addition of a 30-Degree Glass Mirror Reflector and *Heatsink-fan*

The results of the data collection analysis in tables 6 and 7 conducted on November 12, 2022 concluded that the ability of solar panels to produce more power is significantly affected by the amount of sunlight they receive. In the test of solar panels with the addition of a 30 º angled glass mirror reflector, there was a 10.67% greater increase in power when compared to solar panels that were not given any additions. The average power of solar panels using reflectors is 46.69 Watts and the average power of solar panels without the addition of reflectors is 37.69 Watts. Weather conditions at the time of data collection tend to be sunny cloudy.

3.7. Glass Mirror Reflector 45º

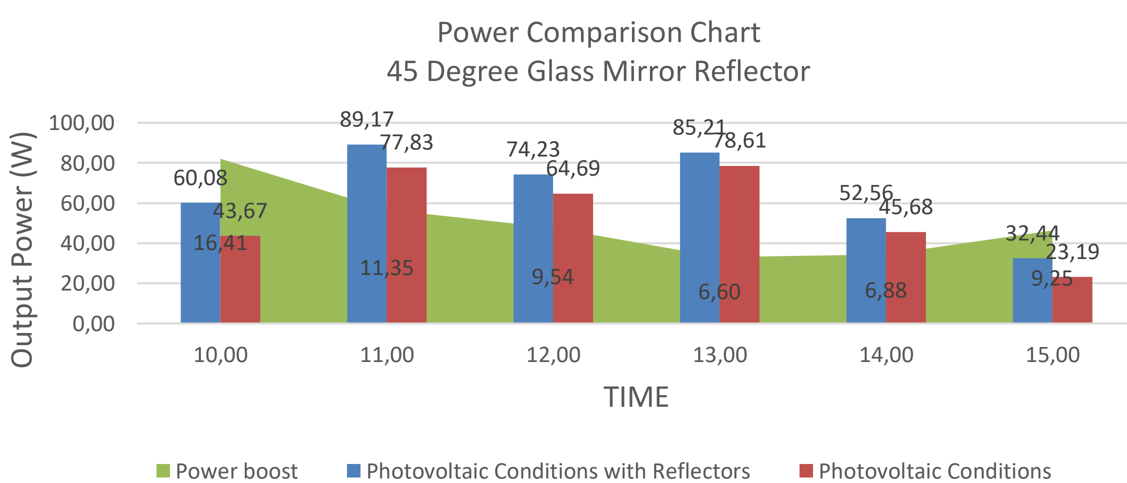

Figure 5. *Output* Power Comparison Chart with the Addition of a 45 Degree Glass Mirror Reflector and *Heatsink-fan*

The results of the analysis of data collection in tables 8 and 9 conducted on November 13, 2022 concluded that the ability of solar panels to produce more power was significantly affected by the amount of sunlight they receive. Solar panels with the addition of 45 º angled glass mirror reflectors experienced an 8.55% increase in power when compared to solar panels that were not added anything. The average power of solar panels using reflectors is 63.05 Watts and the average power of solar panels without the addition of reflectors is 53.12 Watts. The weather conditions at the time of data collection were very sunny and in the last hour of testing the weather turned cloudy and then drizzled.

3.8. 60º Glass Mirror Reflector

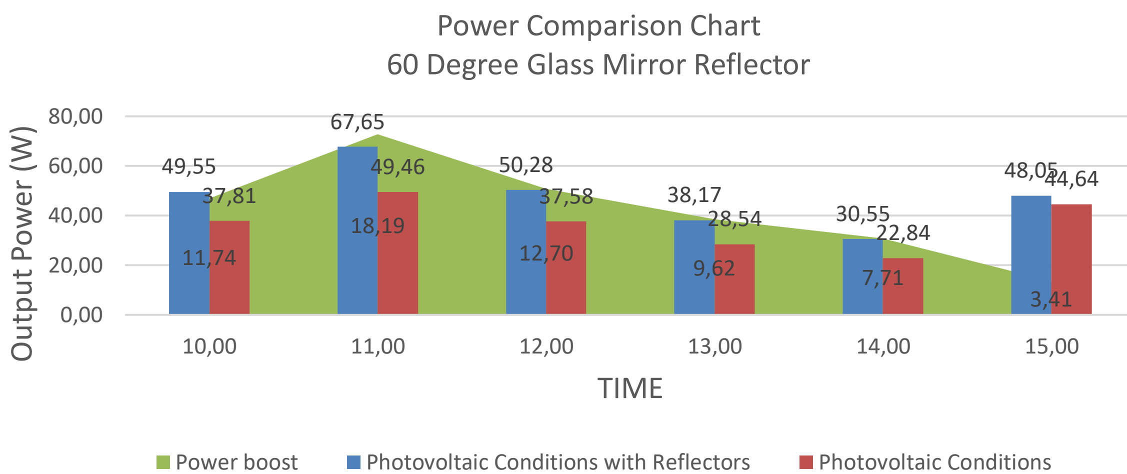

Figure 6. *Output* Power Comparison Chart with the Addition of a 60 Degree Glass Mirror Reflector and *Heatsink-fan*

The results of the data collection analysis in tables 10 and 11conducted on November 14, 2022 concluded that the ability of solar panels to produce more power was significantly influenced by by the amount of sunlight they receive. In the solar panel test with the addition of a 60º angled glass mirror reflector, it experienced a power increase of 13.23% when compared to solar panels that were not given an addition anything. The average power of solar panels using reflectors is 44.93 Watts and the average power of solar panels without the addition of reflectors is 34.44 Watts. Weather conditions at the time of data collection tend to be sunny cloudy.

3.9. 30 º Aluminum Foil Reflector

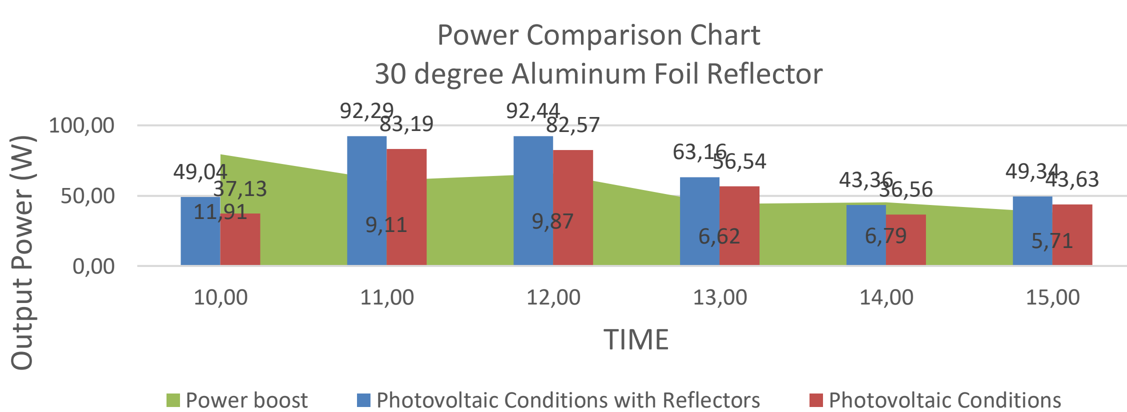

Figure 7. *Output* Power Comparison Chart with the Addition of a 30-Degree Aluminum Foil Reflector and *Heatsink-fan*

The results of the data collection analysis in tables 12 and 13 conducted on November 15, 2022 concluded that the ability of solar panels to produce more power is significantly affected by the amount of sunlight they receive. In the test solar panels with the addition of a 30° angular Aluminum Foil reflector, there was a 7.01% increase in power when compared to solar panels that were not added anything. The average power of solar panels using reflectors is 62.29 Watts and daya average of solar panels without the addition of reflectors is 54.13 Watts. The weather at the time of data collection was very sunny until 1 pm and began to be cloudy until 3 pm.

3.10. Aluminum Foil Reflector 45°

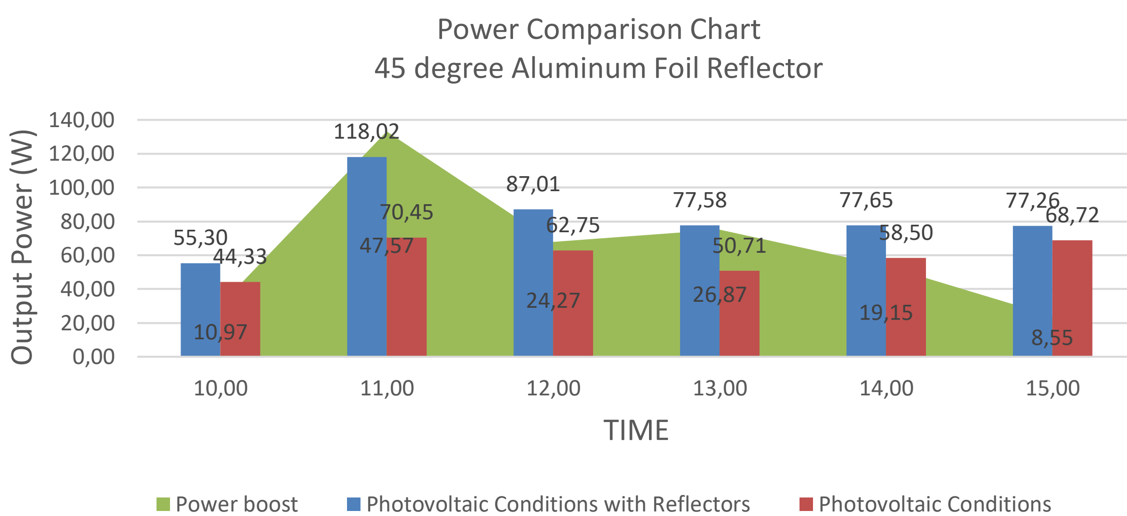

Figure 8. Graph Pcomparison of *Output Power* with the Addition of a 45-Degree Aluminum Foil Reflector and *Heatsink-fan*

The results of the data collection analysis in tables 14 and 15 conducted on November 16, 2022 concluded that the ability of solar panels to generate more power was significantly influenced by the amount of sunlight they receive. In the test of solar panels with the addition of a 45° angled Aluminum Foil reflector, there was a 16.70% increase in power when compared to the untreated solar p anel any additions. The average power of solar panels using reflectors is 79.55 Watts and the average power of solar panels without the addition of reflectors is 56.79 Watts. The weather at the time of data collection began to be cloudy in the first hour of testing and was so sunny that it tended to be sunny in the following hours.

3.11. Aluminum Foil Reflector 60°

The results of the data collection analysis in tables 16 and 17 conducted on November 17, 2022 concluded that the ability of solar panels to produce more power is significantly affected by the amount of sunlight they receive. In the solar panel test with the addition of a 60° angular Aluminum Foil reflector, it experienced a power increase of 13.09% when compared to solar panels that were not added anything. With the average power of a sury panel using a reflector is 35.55 Watts and the average power of a solar panel without the addition of a reflector is 27.32 Watts. The weather at data retrieval was very clear at the first hour of data retrieval, and in the following hours it was cloudy and drizzling which resulted in a decrease in output power.

3.12. Panel Surface Temperature Analysis

The use of the beam chart was chosen with the intention of making it easier to display the analysis results, from this beam graph will later be displayed the results of the analysis in the form of solar panel temperature (°C), difference in solar panel temperature (°C), and data retrieval time. Table 18 shows the average temperature of each variation.

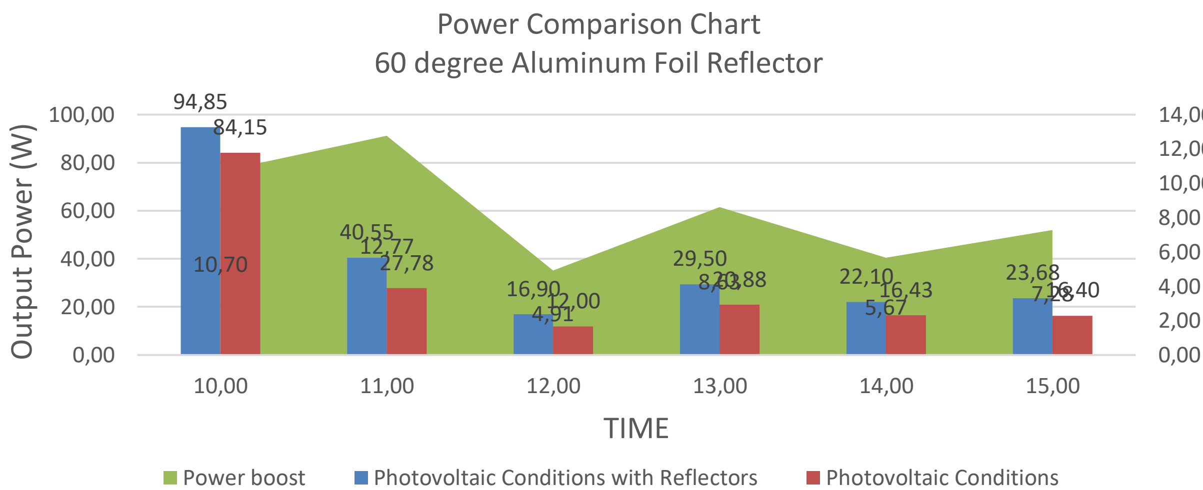

Figure 9. *Output* Power Comparison Chart with the Addition of a 60 Degree Aluminum Foil Reflector and *Heatsink-fan*

Table 19. Average Temperatures of Each Variation

	R. Mirror 30	R. Mirror 45	R. Mirror 60	R. Al foil 30	R. Al foil 45	R. Al foil 60
With the addition of	31.32 ºC	40.09 ºC	33.98 ºC	45.1 ºC	48.42 ºC	37.09 ºC
No additions	33.98 ºC	42.02 ºC	35.85 ºC	47.85ºC	51.56 ºC	38.52ºC

3.13. 30º Glass Mirror Reflector and Heatsink-fan

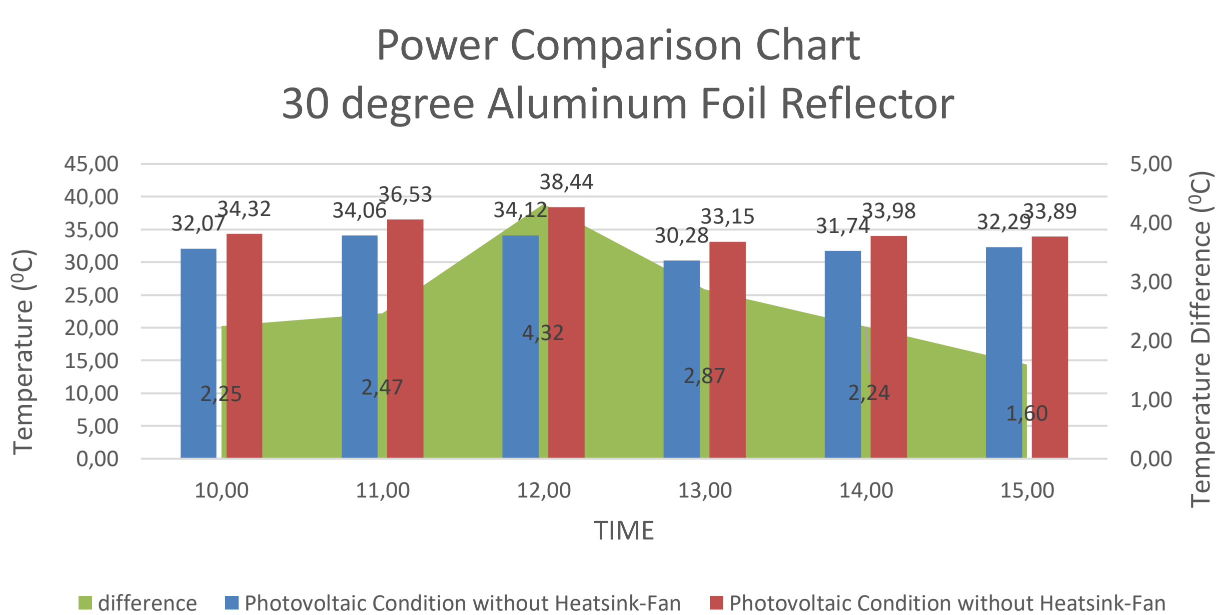

Figure 10. Temperature Comparison Chart with the Addition of a *Heatsink-fan* and a 30 Degree Mirror Reflector

The results of the data collection analysis in tables 6 and 7 conducted on November 12, 2022 concluded that in the solar panel test with the addition of a 30º angled glass mirror reflector and *heatsink-fan*, experienced a temperature drop of 4.07% when compared to solar panel models that were not given the addition of *heatsink-fan*. The average temperature of solar panels using reflectors and heatsink-fans is 31.32 ºC and the average temperature of solar panels without the addition of reflectors and *heatsink-fans* is 33.98 ºC. The amount of light exposed to solar panels determines how hot or cold they are. The temperature of solar panels with reflectors and heatsink fans is added lower, but the temperature difference is usually not too large.

3.14. 45º Glass Mirror Reflector and Heatsink-fan

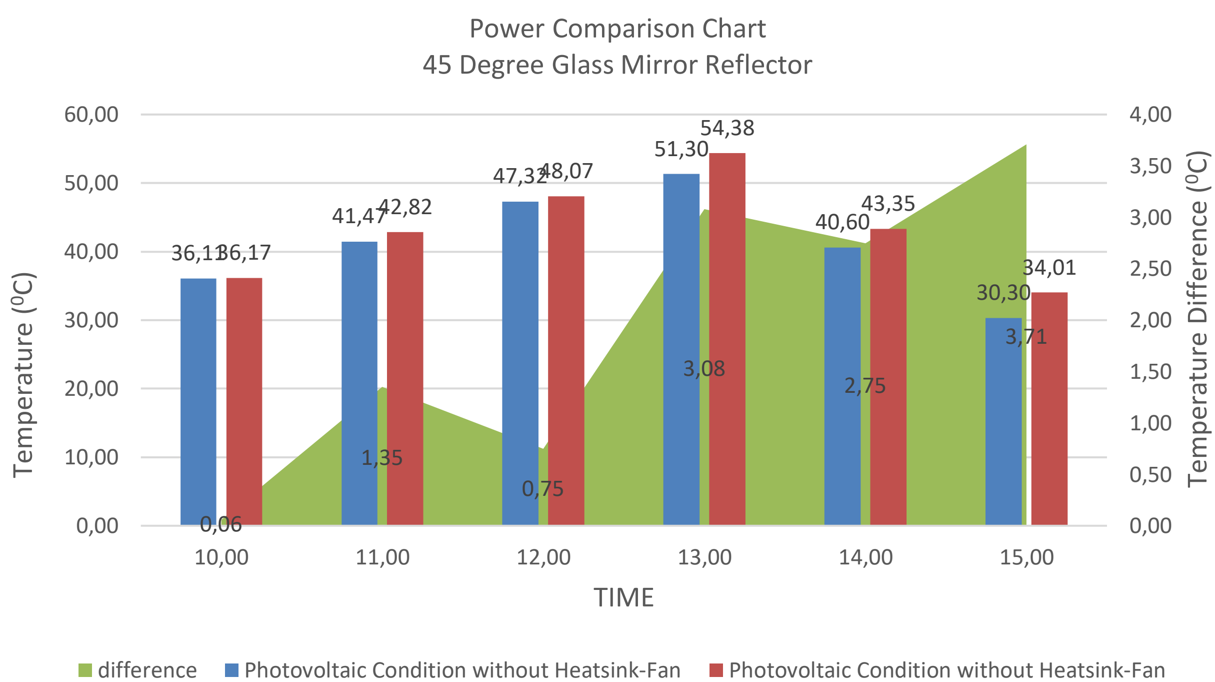

Figure 11. Temperature Comparison Chart with *Heatsink-fan* Enhancer and 45 Degree Mirror Reflector

The results of the data collection analysis in tables 8 and 9 conducted on November 13, 2022concluded that in testing solar panels with the addition of a 45º angled glass mirror reflector and *heatsink-fan*, experienced a temperature drop of 2.35% when compared to solar panel models that were not given the addition of *heatsink-fan*. The average temperature of solar panels using reflectors and heatsink-fans is 40.09 ºC and the average temperature of solar panels without the addition of reflectors and *heatsink-fans* is 42.02 ºC. The amount of light exposed to solar panels determines how hot or cold they are. The temperature of solar panels with reflectors and fan heatsinks is added lower, but the temperature difference is usually not too large.

3.15. 60º Glass Mirror Reflector and Heatsink-fan

The results of the data collection analysis in tables 10 and 11 conducted on November 14, 2022found that in testing solar panels with the addition of a 60º angled glass mirror reflector and *heatsink-fan*, experienced a temperature drop of 2.67% when compared to solar panel models that were not given the addition of *heatsink-fan*. The average temperature of solar panels using reflectors and heatsink-fans is 33.98 ºC and the average temperature of solar panels without the addition of reflectors and *heatsink-fans* is 35.85 ºC. The amount of light exposed to solar panels determines how hot or cold they are. The temperature of solar panels with reflectors and heatsink fans is added lower, but the temperature difference is usually not too large.

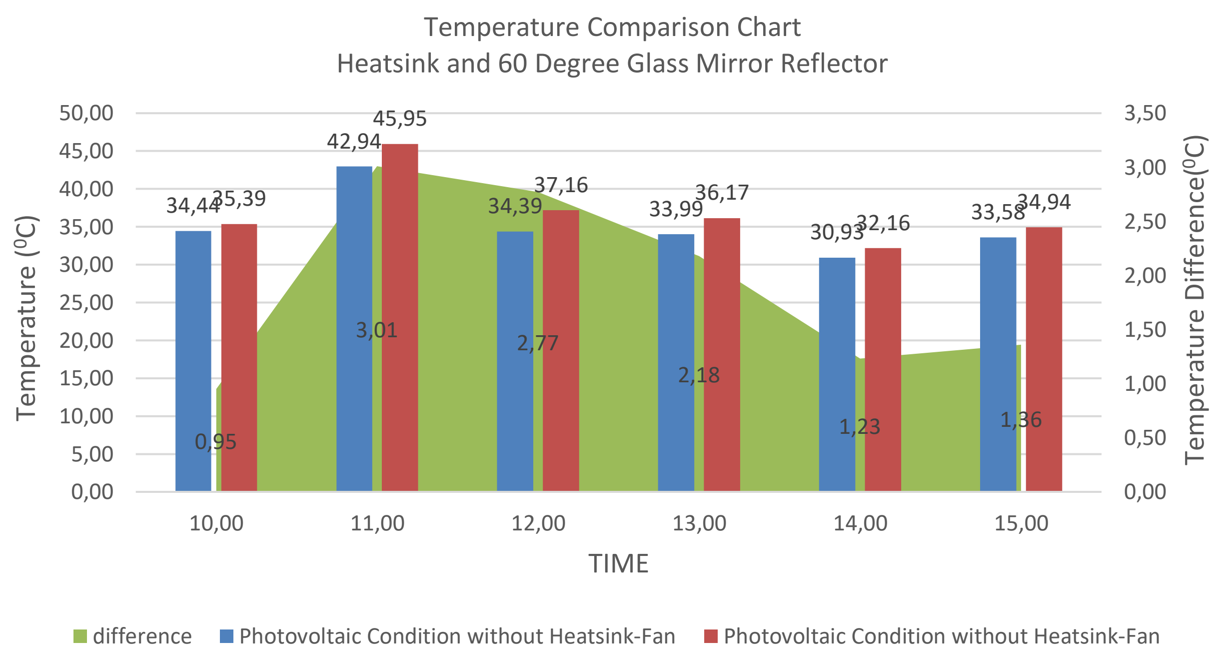

Figure 12. Temperature Comparison Chart with the Addition of a 60 Degree *Heatsink-fan* and Mirror Reflector

3.16. 30 º Aluminum Foil Reflector and Heatsink-fan

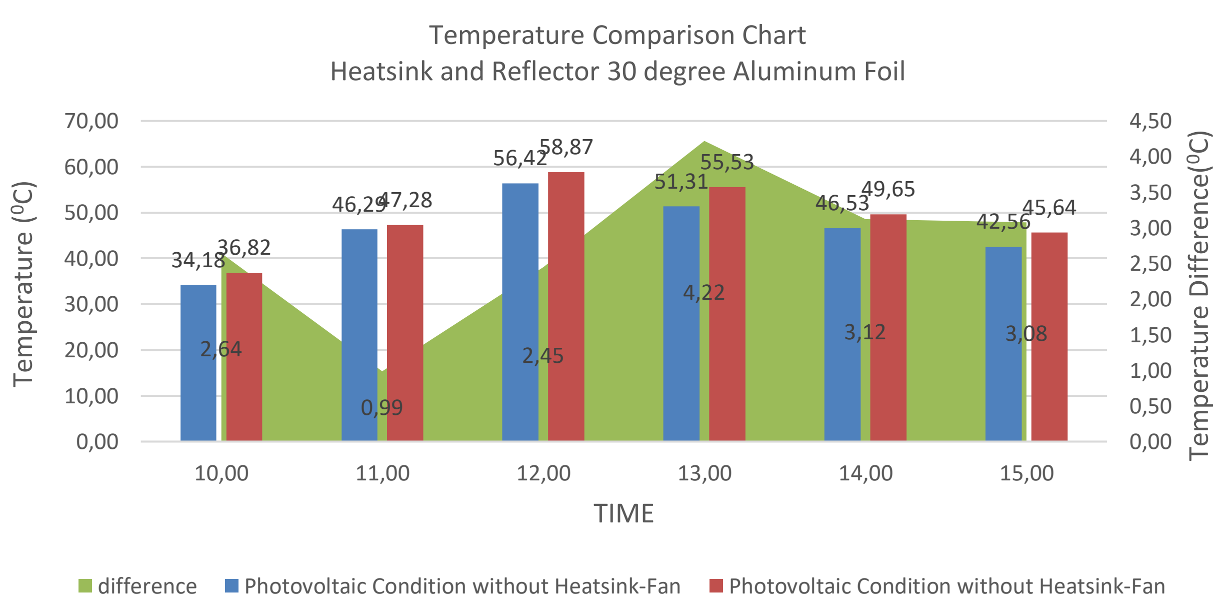

Figure 13. Temperature Comparison Chart with the Addition of a *Heatsink-fan* and a 30 Degree Aluminum Foil Reflector

The results of the data collection analysis in tables 12 and 13 conducted on November 15, 2022concluded that in testing solar panels with the addition of a 30° angular Aluminum Foil reflector and heatsink-fan, experienced a temperature drop of 2.96% when compared to a solar panel model that was not given a *heatsink-fan* addition. The average temperature of solar panels using reflectors and heatsink-fans is 45.1 ºC and the average temperature of solar panels without the addition of reflectors and *heatsink-fans* is 47.85 ºC. The amount of light exposed to solar panels determines how hot or cold they are. The temperature of solar panels with reflectors and heatsink fans is added lower, but the temperature difference is usually not too large.

3.17. 45 º Aluminum Foil Reflector and Heatsink-fan

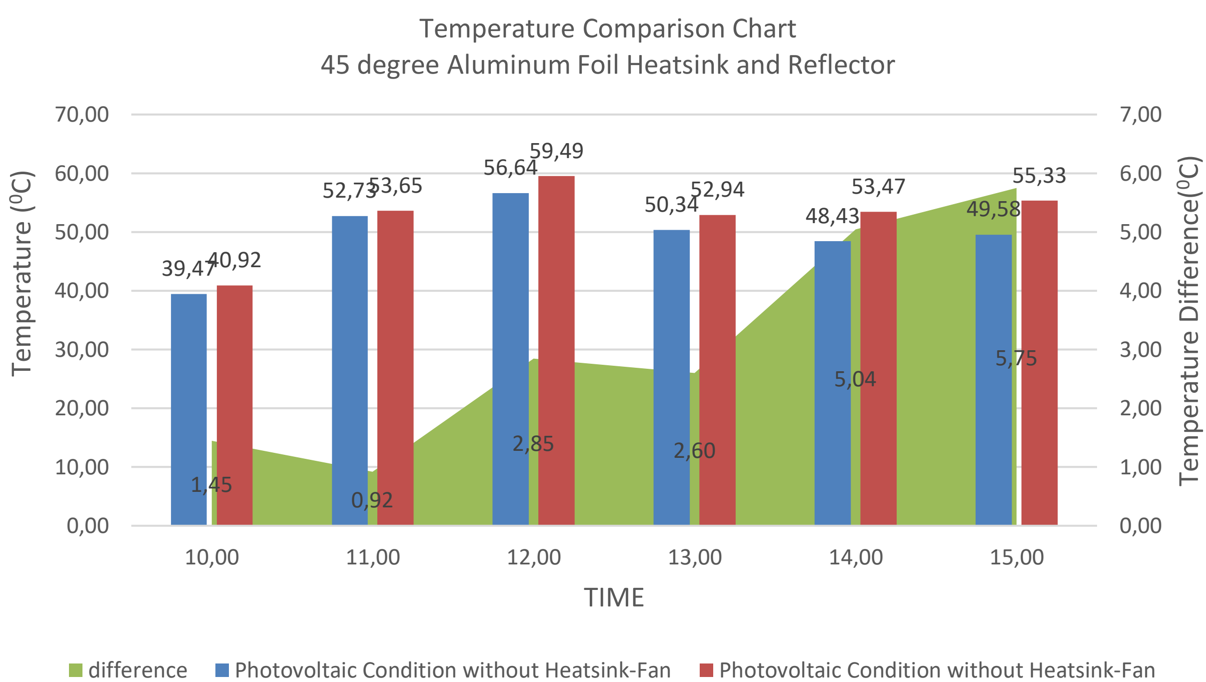

Figure 14. Temperature Comparison Chart with the Addition of a *Heatsink-fan* and a 45 Degree Aluminum Foil Reflector

The results of the data collection analysis in tables 14 and 15 conducted in FY November 16, 2022concluded that in the test of solar panels with the addition of a 45º angular Aluminum Foil reflector and heatsink-fan, experienced a temperature drop of 3.14% when compared to the unexplored solar panel model of *heatsink-fan*. The average temperature of solar panels using reflectors and heatsink-fans is 48.42 ºC and the average temperature of solar panels without the addition of reflectors and *heatsink-fans* is 51.56 ºC. The amount of light exposed to solar panels determines how hot or cold they are. The temperature of solar panels with reflectors and heatsink fans is added lower, but the temperature difference is usually not too large.

3.18. 60º Aluminum Reflector and Fan-Heatsink

In testing solar panel models with the addition of a 60º angle Aluminum Foil reflector and a heatsink fan, the temperature decreased by 1.89% compared to the solar panel model without the addition of a heatsink fan, according to analysis of data collection in tables 4.11 and 4.12 conducted on November 17, 2022. The average temperature of solar panels using reflectors and heatsink-fans is 37.09ºC and the average temperature of solar panels without the addition of reflectors and *heatsink-fans* is 38.52ºC. The amount of light exposed to solar panels determines how hot or cold they are. The temperature of solar panels with reflectors and heatsink fans plusthem is lower, but the temperature difference is usually not too big.

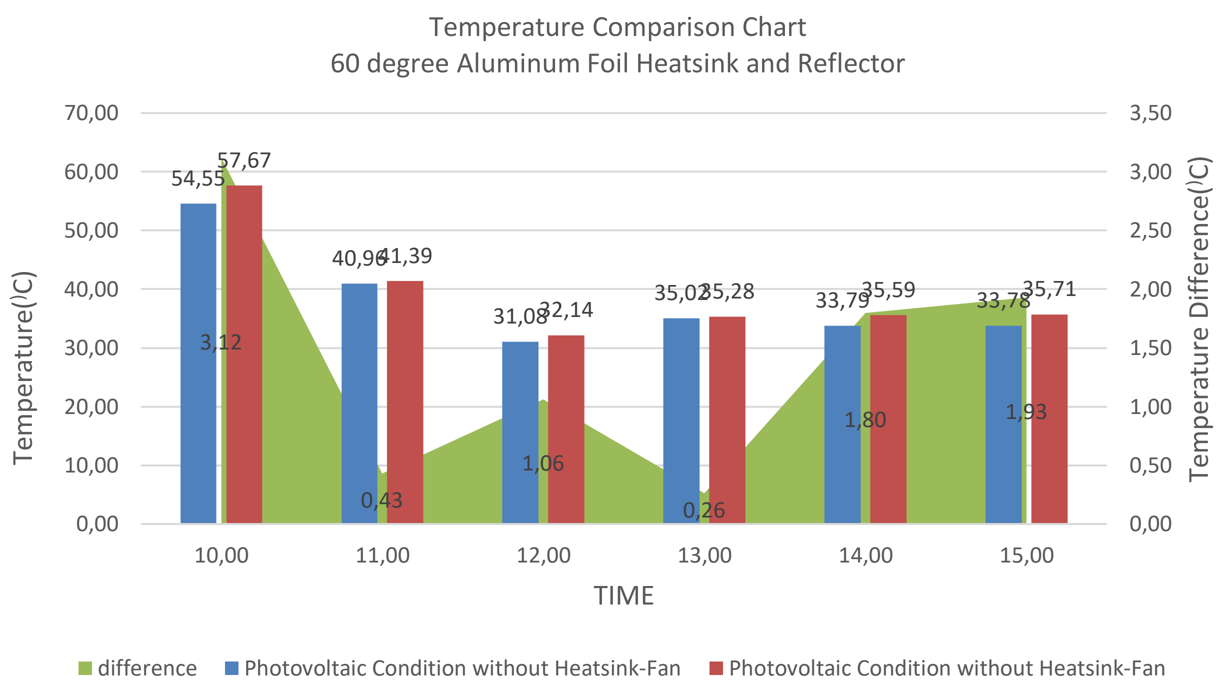

Figure 15. Temperature Comparison Chart with the Addition of a 60 Degree *Heatsink-fan* and Aluminum Foil Reflector

3.19. Effect of Temperature

When the amount of light received is too high, the current and voltage values decrease, which leads to an increase in the temperature of the solar panels. This has a significant impact on the output power generated by solar panels. The life of the solar panels will shorten or their performance will decrease over time if these conditions are continued without a good cooling system.

4. Discussion

According to the data and analysis presented above, solar panels with glass mirror reflectors and aluminum foil mirror reflectors added have more output power than solar panels without addition anything. We can draw the conclusion that the design of solar panels with reflectors is superior. This is because solar panels now have reflectors, which increases the amount of light that solar panels receive. However, the output power ratio is very low below 0.2 amperes in cloudy and rainy conditions.

The I-V curve for solar panel temperature shows that daya solar panel output is also significantly affected by its temperature. The amount of sunlight that solar panels receive has an impact on their temperature rise. If the solar panel reaches a temperature above 50°C, the voltage and current it can generate decreases.

According to the temperature conditions of solar panels with the addition of reflectors and heatsink fans, which undergo an increase in light intensity and output power, the use of a heatsink fan cooling system is considered to be quite functional . However, this panel model has a lower suhu value than solar panels that are not given any extras.

5. Conclusion

When compared to solar panels without the use of reflectors and heatsinks, the use of aluminum foil and glass mirror reflectors on solar panels is considered superior and good enough to increase the output power generated by solar panels. The average power for each variation is as follows: 62.29 Watts for 30-degree aluminum foil mirror reflector, 79.55 Watt for 45-degree aluminum foil mirror reflector, and 35.55 Watt for 60-degree aluminum foil mirror reflector. These values are obtained using glass mirror reflectors at angles of 30, 45, and 60 degrees. For each variation, the average surface temperature of solar panels with reflectors and heatsink fan cooling systems is as follows: for glass mirror reflectors at 30 degrees, for 45 degrees, for 60 degrees, for aluminum foil reflectors at 30 degrees, for 45 degrees, and for 60 degrees. If the surface temperature of the solar panel is too high, the current and voltage will decrease, which has a significant impact on the output power produced. The temperature of solar panels is estimated to be lowered by using a fan heatsink cooling system, but the reduction is estimated to be relatively small and does not exceed 5% when compared to solar panels without the addition of a fan heatsink.31,32°C40,09 °C33,98 °C45,1°C48,42 °C37,09 °C

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