INFOKUM
Volume 13, Number 06, 2025, DOI 10.58471/infokum.v13i06
ESSN 2722-4635 (Online)
https://infor.seaninstitute.org/index.php/infokum

Comparative Analysis of Solar Power Plants Using Direct Sunlight and Glass Reflected Light

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Article Info	ABSTRACT
Keywords: Reflector, Solar Panel, Glass, Sunlight	Indonesia has the potential for new and renewable energy (EBT), including solar energy as a source of power generation. Energy efficiency can be defined as the ratio between the electrical power generated and the input power received. Low efficiency impacts the electrical power output of solar modules. This underlies the use of Solar Power Plants (PLTS) as a new and renewable electrical energy source to replace fossil fuels that have limited quantities and pollute the environment. Solar cells as PLTS units have the constraint of insufficient output power and are highly dependent on natural conditions. One method of optimizing solar cells is by using sunlight-reflecting glass (reflectors). Sunlight is a renewable energy source that can be utilized as a new power generator. However, in the process, certain additions are required to the solar cell module to optimize the output voltage produced. Efforts to optimize electrical output in solar modules by maximizing the intensity of light falling on the surface of the solar module by using direct sunlight. The results obtained are in the form of a comparison.
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INTRODUCTION

Electrical energy has become a primary need for society and this need will continue in the future, this is due to the use of increasingly modern household appliances that require electrical energy sources. The need for such a large amount of electrical energy is not comparable to the availability of power generation energy sources, especially those derived from conventional energy sources. Conventional electrical energy sources come from fossil fuels whose supplies are decreasing day by day and require a long period of time to regenerate their energy. The use of fossil fuels is the largest source of pollution that has an impact on global warming. Based on these conditions, human creativity is needed to find environmentally friendly renewable energy sources that can support the supply of electrical energy sustainably. One natural energy that can be utilized as electrical energy is sunlight or solar energy by building solar power plants or hereinafter referred to as Solar Power Plants (PLTS).

In the current era, Solar Power Plants (PLTS) are very commonly used both in big cities and in rural areas as a primary or backup energy provider. However, in this study, a 200WP Solar Power Plant (PLTS) system will be analyzed which will be tested using additional reflectors in the form of mirror glass. The Solar Power Plant (PLTS) data that will be analyzed can later be used for learning or research purposes by students of the Panca Budi Development University Medan or can be developed later into further projects. The purpose of this study is to determine the difference in input power values using reflectors and without reflectors. Knowing the comparison of input voltage and current values on PLTS using reflectors and without using reflectors.

Basetheory

Renewable energy is a source of energy found in nature (water, sun, air, and earth) that can be directly and freely utilized in relatively large quantities to produce ready-to-use energy such as electricity. New and renewable energy plays a crucial role in meeting energy needs. This is because the long-term use of conventional fuels for power generation will deplete the dwindling resources of oil, gas, and coal and can also cause environmental pollution.

Solar Cell (Solar Panel)

Solar Cell or also called cell*photovoltaic*will be increasingly in demand because it can be used for various relevant needs and in various places such as offices, factories, housing, and others. The formula for electrical power is as follows:

P (Watt) = V (Volt) x I (A).. (1)

Installation of Solar Power Plants (PLTS) requires planning regarding power requirements.

Solar Power Plant (PLTS)

Solar Power Plants (PLTS) are power plants that utilize sunlight through solar panels (*photovoltaic*) to convert solar photon radiation into electrical energy. Solar Power Plants (PLTS) are a renewable energy source, where sunlight is an inexhaustible source of energy, in addition PLTS is an environmentally friendly power plant because there are no rotating parts, does not produce noise, and does not emit exhaust gases or waste. Solar Cell Modules (photovoltaics) are the main components used to convert solar energy into DC electrical energy. These photovoltaic cells can be arranged in series to increase the output voltage, parallel to increase the output current or a combination of both, namely series-parallel.

Picture 1. Solar Cell

Solar Charge Controller (SCC)

Solar Charger Controller (SCC) or also called Battery charging control is an electronic device that functions to regulate the current entering the battery from the solar panel module so that battery charging runs optimally, without undercharging or overcharging. To obtain the maximum output power level from the Solar Panel module, a system algorithm is needed that functions to maximize the work of the Solar Panel module to reach its optimal working point. In general, the Solar Charger Controller (SCC) has six pins, where each pin has its own function or path, which can be seen in the image below:

Picture 2. *Solar Charge Control (SCC)*

Battery

Picture 3. Battery

Batteries play a role as a medium for storing electrical energy from several alternative energies and to supply electric current when the system is working, therefore the use of batteries is very important to provide a reliable and sustainable energy supply for a relatively long time. Batteries consist of two types, namely primary and secondary batteries. In this study, secondary batteries are used, consisting of lead-acid battery types, namely FLA (Flooded Lead Acid) and VRLA (Valve Regulated Lead Acid) batteries and lithium battery types, namely LifePO4 (Lithium Iron Phosphate) batteries, where these three types of batteries are widely applied as a medium for storing electrical energy from several new and renewable energies.

Mirror

Mirror glassA flat mirror functions as a light reflector because it has a flat surface and is coated with a highly reflective metal layer (usually silver or aluminum). Light that hits a flat mirror will be reflected back regularly, following the law of reflection which states that the angle of incidence is equal to the angle of reflection. This reflection produces an image that is the same size, virtual (not real), and upright, just like the image we see when looking in a mirror.

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Picture 4. Mirror Glass

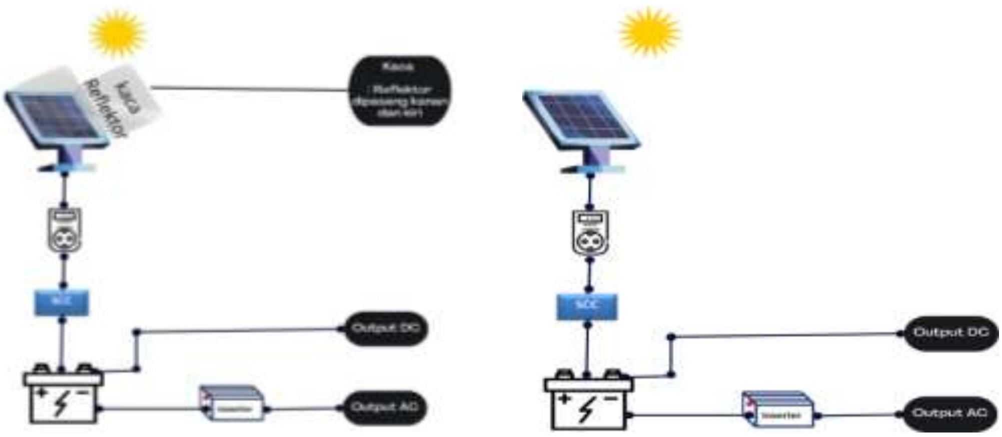
Watt Meter

Picture 5. *Watt Meter*

WattmeterBasically, it is a combination of two measuring instruments, namely an Ammeter and a Voltmeter. Therefore, a Wattmeter consists of a current coil (fixed coil) and a voltage coil (rotating coil), so that the installation is also the same, namely the current coil is installed in series with the load and the voltage coil is installed in parallel with the voltage source.

Solar Power Plant Design

The design of a solar power plant is very simple, requiring only a few components required in a solar power plant circuit. The following is a solar power plant design diagram:



(A) (B)

Picture 6 Block Diagram of Solar Panel (A) Circuit Using Reflector (B) Circuit Without Reflector

The solar panel block diagram above shows a design explaining how to design a solar power system circuit with a reflector. A photovoltaic solar power system operates based on the absorption of solar energy generated by the solar cells themselves.

RESEARCH METHODS

In this study, data collection was conducted using direct measurement methods. The data collected included voltage, current, power, and air temperature. The data were obtained by conducting direct measurements three times daily for seven days.

Time and place of research

The location of this research was carried out at the Electrical Laboratory of Panca Budi Development University Medan, Jl. Jend. Gatot Subroto Km. 4.5 Sei Sikambing 20122 Medan City, The time of data collection (research) took place in April.

Table1 Tools, Materials and Specifications

Tool Name	Tool Specifications	Tool Capacity
Solar Cell	Maximum power (Pmax)	200 W
	Maximum current (Imp)	5.59 A
	Maximum voltage (Vmp)	35.8 V
	Short circuit voltage (Voc)	44 V
	Short circuit current (Isc)	6.08 A
Lifepo4 battery	Voltage	24 V
	Current	100 Ah
Inverter	Rated power	1500W
	Output waveform	Pure Sine Wave
	Output voltage	220V/230±5V
	Harmonic distortion	< 3% (Impedance load)
	Output frequency	50 Hz
	Standby current	<0.9A <0.4A
	Conversion efficiency	94%
	Rated voltage	12V 24V
SCC	System Voltage	24V/36V/48V (AUTO)
	Rated Current	60A
	Max PV Voltage	150V
	Max Power	(24V), 3120 (48V)
Glass Reflector	Size 50 cm x 40 cm	

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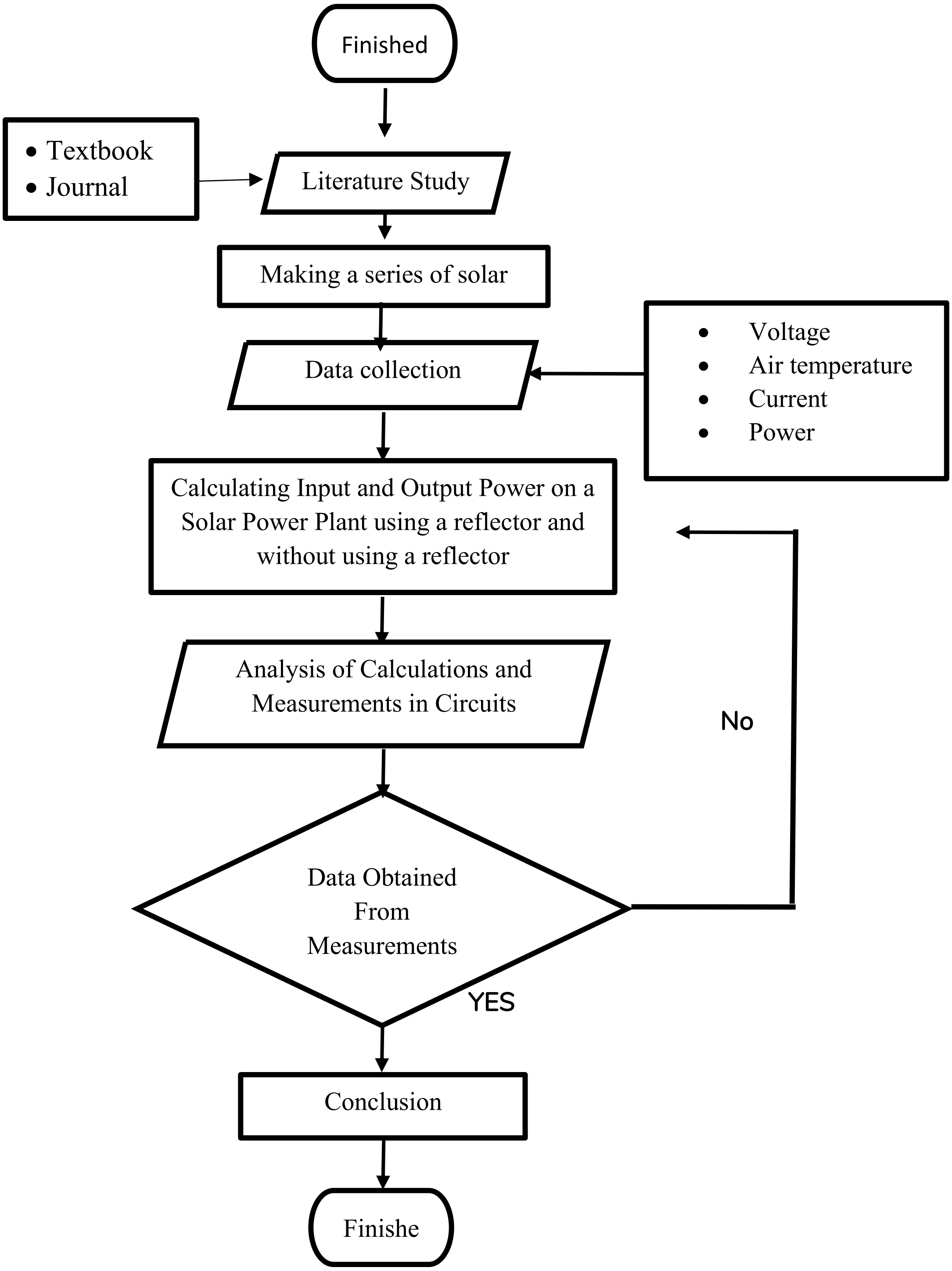

Figure 7. Research Flowchart

RESULTS

Current and voltage tests conducted on solar power plants using and without reflectors were conducted at the same time and using the same equipment to determine the power generated by the solar cells. Several factors influenced the results of this study, including weather conditions and solar panel temperature.

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INFOKUM
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Table2. Current and Voltage Test Results Data on Solar Panels Using Reflectors

Day/Date	Weather Temperature	Review Time	Corner	V Solar Panel (Volt)	I Solar Panel (Ampere)	P Solar Panel (Watt)
Monday / April 14, 2025	31	11.00 13.00 15.00	90o	18.80 19.90 17.47	1.86 1.94 1.78	34.96 38.60 31.09
Tuesday / April 15, 2025	32	11.00 13.00 15.00	90o	18.55 19.60 17.80	1.83 1.90 1.79	33.94 37.24 31.86
Wednesday / April 16, 2025	32	11.00 13.00 15.00	90o	19.42 19.90 18.45	1.88 1.92 1.83	36.50 38.20 33.76
Thursday / April 17, 2025	32	11.00 13.00 15.00	90o	19.27 19.44 18.53	1.96 1.91 1.85	37.76 37.13 34.28
Friday / April 18, 2025	29	11.00 13.00 15.00	90o	17.84 17.80 17.14	1.81 1.77 1.72	32.29 31.50 29.48
Saturday / April 19, 2025	31	11.00 13.00 15.00	90o	18.51 18.37 17.91	1.91 1.83 1.77	35.35 33.61 31.70
Monday / April 21, 2025	31	11.00 13.00 15.00	90o	19.57 19.47 18.78	1.98 1.91 1.79	38.74 37.19 33.61

Table 2 shows data from a 7-day study of solar power plants using reflectors. Data were collected three times daily at 11:00, 1:00, and 3:00 PM. The data collected included air temperature, solar panel tilt, voltage, current, and power from the solar power plant. For example, on day 1 at 11.00 the author obtained data in the form of an air temperature of 320, the PLTS using a reflector produced a voltage of 18.80 V, a current of 1.86 A and a power of 34.96 W. Next, the data was calculated to find the average value of the data using the following method:

Average Current and Voltage Values in Solar Power Plants Using Reflectors

Average value of $V_{panel=}$ $= \frac{Vtotal}{21}$

$= \frac{392,52}{21}$

$V_{Average} = 18,69\ V$

Average value $I_{panel=}$ $= \frac{Itotal}{21}$

$= \frac{38,94}{21}$

$I_{Average} = 1,85\ A$

Average Power Value

$$P_{Average} = \frac{Ptotal}{21}$$

$$= \frac{728,79}{21}$$

$$P_{Average} = 34,56 \text{ watt}$$

Table3. Current and Voltage Test Results Data on Solar Panels Without Using a Reflector

Day/Date	Weather Temperature	Review Time	Corner	V Solar Panel (Volt)	I Solar Panel (Ampere)	P Solar Panel (Watt)
Monday / April 14, 2025	310C	11.00 13.00 15.00	90o	17.61 18.79 16.23	1.73 1.81 1.65	30.46 34.00 26.77
Tuesday / April 15, 2025	320C	11.00 13.00 15.00	90o	17.35 18.23 16.54	1.69 1.74 1.65	29.62 31.72 27.29
Wednesday / April 16, 2025	320C	11.00 13.00 15.00	90o	18.09 18.76 17.23	1.73 1.79 1.68	31.29 33.58 28.94
Thursday / April 17, 2025	320C	11.00 13.00 15.00	90o	18.15 18.23 17.11	1.80 1.77 1.72	32.67 31.91 29.42
Friday / April 18, 2025	290C	11.00 13.00 15.00	90o	16.59 16.44 16.02	1.67 1.65 1.55	27.70 27.12 24.83
Saturday / April 19, 2025	320C	11.00 13.00 15.00	90o	17.31 17.23 16.69	1.75 1.71 1.63	30.29 29.46 27.20
Monday / April 21, 2025	310C	11.00 13.00 15.00	90o	18.17 17.91 16.72	1.81 1.78 1.64	32.88 31.87 27.42

Table 3 shows data from a 7-day study of solar power plants using reflectors. Data were collected three times daily at 11:00, 1:00, and 3:00 PM. The data collected included air temperature, solar panel tilt, voltage, current, and power from the solar power plant. For example, on day 1 at 11.00 the author obtained data in the form of an air temperature of 310, the PLTS using a reflector produced a voltage of 17.61 V, a current of 1.73 A and a power of 30.46 W. Next, the data was calculated to find the average value of the data using the following method:

Average Current and Voltage Values at tT Reflector Solar Power Plant

Average value of $V_{panel=} = \frac{Vtotal}{21}$

$$= \frac{365,40}{21}$$

$$V_{Average} = 17,40 \text{ V}$$

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Average value $I_{panel=} = \frac{Itotal}{21}$

$= \frac{35{,}95}{21}$

$I_{Average} = 1{,}71\ A$

Average Power Value

$P_{Average} = \frac{Ptotal}{21}$

$= \frac{626{,}44}{21}$

$P_{Average} = 29{,}83\ Watt$

Research Data on Current and Voltage in Batteries

Table4. Research Data on Batteries Using and Without Reflectors

Time			Using a Reflector		Without using a reflector	
Day / Date	Weather Temperature	Review Time	V battery	I Battery	V battery	I Battery
Monday / April 14, 2025	310C	11.00 13.00 15.00	14.41 14.38 14.33	1.68 1.53 1.48	14.33 14.28 14.18	1.43 1.38 1.25
Tuesday / April 15, 2025	320C	11.00 13.00 15.00	14.53 14.48 14.38	1.78 1.73 1.64	14.38 14.35 14.28	1.48 1.46 1.38
Wednesday / April 16, 2025	320C	11.00 13.00 15.00	14.58 14.43 14.39	1.79 1.72 1.63	14.43 14.41 14.34	1.53 1.51 1.45
Thursday / April 17, 2025	320C	11.00 13.00 15.00	14.61 14.58 14.43	1.67 1.65 1.58	14.43 14.34 14.31	1.51 1.46 1.43
Friday / April 18, 2025	290C	11.00 13.00 15.00	11.00 13.00 15.00	14.28 14.23 14.13	1.64 1.48 1.43	14.23 14.21 14.18
Saturday / April 19, 2025	320C	11.00 13.00 15.00	14.42 14.36 14.25	1.64 1.62 1.58	14.38 14.28 14.23	1.44 1.42 1.38
Monday / April 21, 2025	310C	11.00 13.00 15.00	14.60 14.53 14.47	1.73 1.71 1.64	14.54 14.51 14.40	1.70 1.65 1.61

The table shows data from the results of battery research sourced from solar power plants using reflectors and without reflectors for 7 days, with data collection carried out three times each day at 11:00, 1:00, and 15:00. The data collected included air temperature, solar panel tilt, voltage, current, and battery power.

For example, on the 1st day at 13.00 the author obtained data in the form of an air temperature of 320, the battery sourced from the PLTS using a reflector produced a voltage of 14.38 V, a current of 1.53 A, while the battery sourced from the PLTS not using a reflector produced a voltage of 14.28 V and a voltage of 1.38 A. Next, the data was calculated to find the battery efficiency from the data using the following method:

Output and Input Power Difference Values Using a Reflector

1. Efficiency value on the first day at 11.00

$$\eta = \frac{output}{input} \text{ x } 100\%$$

$$\eta = \frac{24{,}2}{34{,}96} \text{ x } 100\%$$

$$\eta = 69{,}2$$

2. Efficiency value on the first day at 15.00

$$\eta = \frac{output}{input} \text{ x } 100\%$$

$$\eta = \frac{21{,}2}{31{,}09} \text{ x } 100\%$$

$$\eta = 68{,}2$$

Difference between Output and Input Power Without Using a Reflector

1. Efficiency value on the first day at 11.00

$$\eta = \frac{output}{input} \text{ x } 100\%$$

$$\eta = \frac{20{,}4}{30{,}46} \text{ x } 100\%$$

$$= 67{,}03$$

2. Efficiency value on the first day at 15.00

$$\eta = \frac{output}{input} \text{ x } 100\%$$

$$\eta = \frac{17{,}7}{26{,}77} \text{ x } 100\%$$

$$\eta = 66{,}07$$

CONCLUSION

Based on the discussion of the research results, several things can be concluded as follows. The average output power produced by the PLTS without using a reflector in 7 days of the experiment was 29.83 watts and using a reflector could reach 34.56 watts. This shows that the output power produced using a reflector is greater than without using a reflector. The difference in output power produced in this study is clearly visible in the data presented in the study. The data above shows a difference in power produced by solar power plants using and without reflectors of 4.73 watts.

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