

Improvement of output voltage from shading interference on a solar cell using a reflector system

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Abstract

One of the factors that affect the performance of photovoltaic cells is shading. Shading can reduce the intensity of solar radiation on the cells. This study aims to design a system that can improve the voltage from shading disturbances to optimise the output voltage on the solar cell by using a reflector. The reflector is designed in a flat mirror measuring. There is expected to be an increase in the output voltage of the existing solar cell system. It proved that the more reflected light hits the surface of the solar panel with a certain angle and illuminates the shading area, the more significant the increase in output voltage, current and power, and vice versa.

Keywords:

*Output Voltage;
Reflector System;
Solar Cell;*

Article History:

Received: February 21, 2022

Revised: May 25, 2022

Accepted: July 14, 2022

Published: September 20, 2022

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INTRODUCTION

Efforts to find alternative energy sources as a substitute for fossil fuels are still being sought [1]. Several natural energy sources are available as alternative energy that is clean, non-polluting, safe, and with an unlimited supply, including solar energy. Solar energy is one of the abundant renewable energy sources for the future. This solar energy can be extracted by PV systems [2, 3, 4, 5]. Renewable energy is used as an alternative mode of power generation. Among the renewable energy options, solar energy is increasingly popular for its widely available and inexhaustible nature [6].

A solar cell is an alternative energy converter still being developed and implemented. However, if you look at the geographical conditions of Indonesia, located at the equator, the utilisation of solar energy through solar cells is very potential. Therefore, the empowerment of solar energy needs to be optimised in Indonesia. Furthermore, Indonesia is a tropical country that gets sun exposure all year round. This condition strongly supports the use of photovoltaic solar cells as a source of electrical energy [7].

Many factors determine the ideal output or optimum results in a photovoltaic module. However, the environment is one parameter that contributes directly to the photovoltaic performance. One factor that affects the amount of output power from solar panels is the intensity of solar radiation. In addition, the output power generated by solar panels also depends on the shading effect. The shading effect is the possibility of blocking the solar panel due to shading an object, resulting in reduced solar radiation that can be received by the cells in the solar panel. Shading can occur for different reasons, usually atmospheric

and surrounding conditions. Several types of shading are dust, shading due to tall buildings, tall communication towers, passing clouds, plants, birds, bird waste and not enough space between the strings of PV panels in the array [6][8].

Therefore, a method is needed to increase the output power of solar cells. One method that can be applied is a mirror reflecting sunlight (reflector) [9]. A study conducted in 2019 by Siahaan & Siswono [10] related to the method that has been done to get the maximum output of solar panels. One way to get the maximum output voltage is to add a reflector. Reflectors are beneficial and efficient for focused sun exposure on solar panels, but many reflectors do not work as well as they should with solar cells. While research in 2017 by Abubakar & Ali [11] states that shading, the intermittent nature of solar radiation and dust, reduces the total amount of radiation on PV panels, thereby reducing their efficiency. Flat mirrors are used to increase the incident radiation and minimise the above problem's effects. Likewise, the research results in the same year by Budiyanto & Fadliandi [12] showed that solar cells' current and output power increased by adding a mirror. Still, the open-circuit voltage and maximum power voltage decreased due to heat. By adding cooling, the open-circuit voltage and maximum power voltage are increased so that the output power is also increased.

This study uses a comparative experimental method to obtain research data in the form of voltage and current measurements on solar cells in the form of a tree and building shading that will cover part of the panels, which will cause a reduction in the output voltage. Efforts to reduce the influence of shading disturbances are carried out by designing a reflector system that utilises the basic properties of a plane mirror. Using a flat mirror is assumed to affect the optimisation of the voltage family of the solar system.

MATERIAL AND METHOD

Solar Cell System

The solar cell system consists of photovoltaic modules, solar charge controllers or grid inverters, inverter batteries, and other supporting components. There are several types of solar systems, both connected to the electricity network (on-grid) and solar systems that stand alone or are not connected to the electricity network (off-grid). The application of solar power plants is identical to photovoltaic technology, which converts sunlight into electrical energy through a photovoltaic process that produces electrical energy. The energy output is in the form of DC electricity, converted by the inverter into AC electricity.

In one model, the irradiation intensity is directly proportional to the current generated by the photovoltaic cell. Thus, the presence of shade will reduce the performance of the photovoltaic module [13]. The results of previous research in 2016 regarding shading conducted by Saidan [14] showed that the average level of efficiency degradation of solar modules exposed to dust was; 6.24%, 11.8% and 18.74% were calculated for exposure periods of one day, one week and one month. Another analysis of the output voltage decreasing on the solar cell is due to the position of the solar panels.

The solar panel is permanently installed on the ground and surrounded by buildings and trees. The condition makes some parts of the solar panels covered with shading. The output power is significantly reduced as the percentage of shading increases. The Shade Impact Factor (SIF) is proportional to the panel area, so systems with large panels are more affected by the shading effect [15].

Reflector System

A mirror is a smooth surface reflecting all the light on it. A screen cannot capture virtual images, but images can be seen in a mirror formed by the extension of the reflected light behind the mirror. The basic Reflector Properties are shown in [Figure 1](#).

Method

This study uses a comparative experimental method to obtain research data in the form of voltage and current measurements on solar cells in the form of the tree and building shading that will cover part of the panels, which will cause a reduction in the output voltage.

The design concept in the research on power output comparison analysis on solar panels is to design a condition using a flat mirror as a reflector to reflect sunlight that hits it onto the surface of the solar panel covered in shading. Three different angles are used to see the most effective angle to increase the output value in the process. The research block diagram for data collection is as follows. The concept created is that a reflector will reflect the sun's rays in a flat mirror to reduce shading. For data collection, measurements of voltage, current and power of solar panels were carried out before and after using a reflector system with a reflector in the form of a flat mirror measuring 200 cm x 100 cm. [Figure 2](#) shows the block diagram system design.

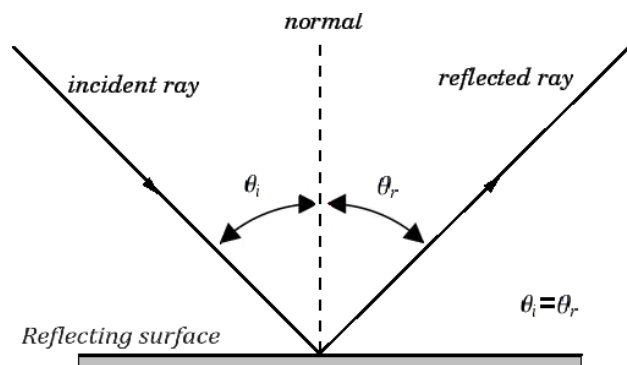


Figure 1. Reflector properties

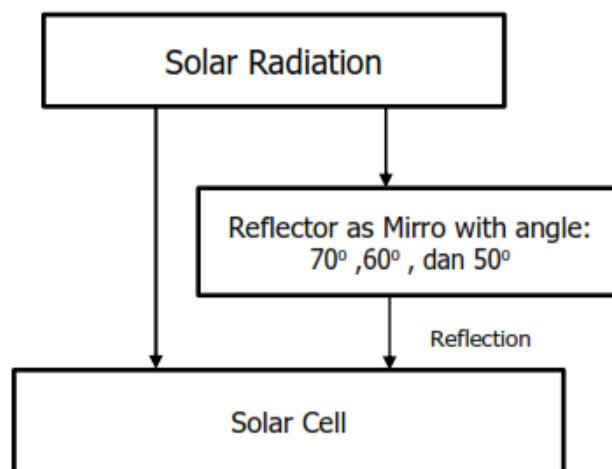


Figure 2. Block diagram system design

The research was carried out with the following stages:

- a. Data collection, measurement and initial observation of solar panels without reflectors. It aims to determine the system, specifications, and references to obtain other data to be used as data/comparison material before and after using the reflector.
- b. Installation of a flat mirror as a reflector system. The flat mirror used is 200 cm x 100 cm. In accordance with the properties of a plane mirror, the incident ray, regular line, and reflected ray lie in one plane; The angle of incidence is the same as the angle of reflection. Therefore, by using a plane mirror as a flat plane, the incident light will be reflected onto the surface of the solar panel, which is covered by shading.
- c. Measurement of reflector current and voltage with different sizes of flat mirrors and with reflector angles of 70° , 60° , and 50° . By applying the principle of a flat mirror, "the angle of incidence equals the angle of reflection", the use of different reflector angles aims to find the most effective angle used to reflect sunlight.
- d. Analysing the comparison of the results of the electrical power output of the reflector system with a predetermined angle to obtain maximum results. The most effective angle analysis was conducted after experiments using a reflector with a predetermined angle.
- e. Analysing the results of the electrical power output of the reflector system before using the reflector.

After getting the output measurement results before and after using the reflector, a comparative analysis of the most effective measurement results is carried out. Whether by using a reflector, there is an improvement in the output voltage.

RESULTS AND DISCUSSION

The solar panels at Serang, Banten, were installed in December 2018. At the beginning of the installation, the condition of the equipment was still new, so it was hoped that the results would be maximal. However, several obstacles arise, namely shading or shading that covers some parts of the solar panel. The condition, of course, affects the output or output of the solar panels. Therefore, a reflector is used to minimise the existing shading. The use of a reflector aims to increase the intensity of sunlight on the panel's surface due to the reflected light from the reflector falling on the surface of the solar panel. [Figure 3](#) shows the condition of the solar panels in the morning, which is covered with a bit of shading.



Figure 3. Shading Solar Panel Conditions
(a) In the morning and (b) In the afternoon (right)

Because the presence of a building causes the shading, a flat mirror is used to reflect sunlight to illuminate the part affected by the shading.

This data is then collected before using the reflector, whether there is a change or not. The test was carried out five days from July 17-21, 2021, with different weather conditions and sunlight intensity. The average results of current, voltage and output power measurements on solar panels before adding a reflector in the form of a flat mirror can be seen in Figure 4. Figure 4 shows that the measurements were carried out from 08.00 to 17.00 WIB by measuring the current, voltage and output power. The voltage and current are still low in the morning, especially at 08.00. Over time, the voltage and current increased and peaked at noon. After 12.00, the current and voltage went down even though they were still high until 15.00. Significant changes occurred between 10:00 to 15:00. Finally, at 17.00, the voltage and current reached their lowest point in the afternoon.

In the end, it is shown in Figure 5, the results of the use of reflectors in the existing solar cell system. The location of the reflector system is given different angles, namely 50° , 60° and 70° . It can be seen in the figure that there is an increase in the resulting voltage compared to without using a reflector system and using a reflector system. The resulting voltage increase significantly occurs in the reflector system, which has an angle of 70° . This proves that the reflection system can increase the intensity of sunlight collected in the solar cell system.

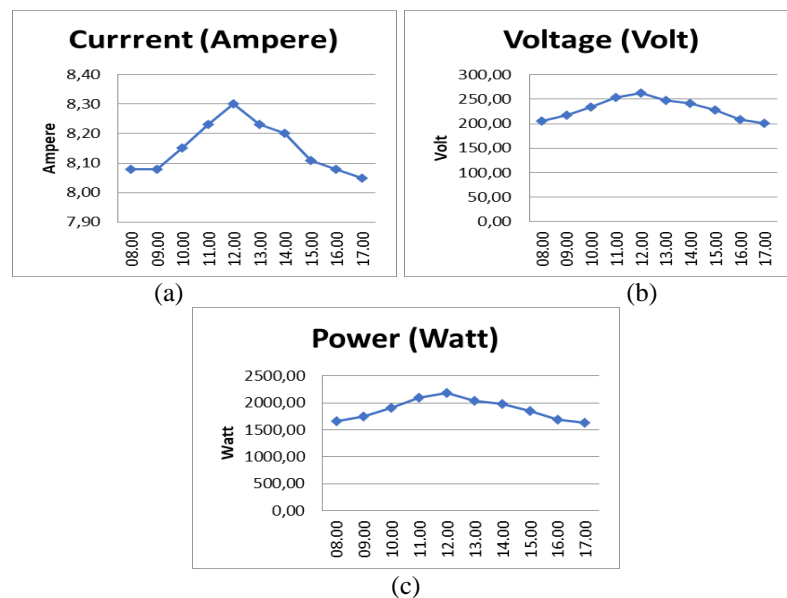


Figure 4. Graph of average measurement before using reflector system
(a) Voltage, (b) Current and (c) Power

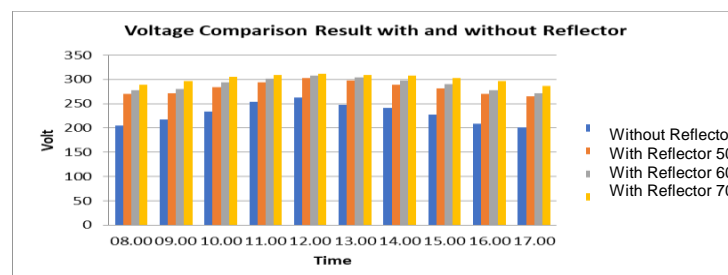


Figure 5. Voltage Comparison with and without Reflector with a different angle

Increasing the sun's power growths, the voltage generated by the solar cell system better than previous research [15].

CONCLUSION

A review of the solar power generation system has been submitted. The shading of some objects causes a voltage dropout problem. Efforts to reduce the influence of shading disturbances are carried out by designing a reflector system that utilises the basic properties of a plane mirror. The following research will try to implement a reflector system to reduce shading interference to produce an optimal voltage output. The output voltage comparison before and after using the reflector system is compared and analysed. The use of a reflector system with an angle of 70° has been shown to significantly increase voltage production.

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