Impact of Shading Area on PV System

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Abstract. This paper mainly studies the effect of shading area on the voltage, current and power of PV system. This study mainly conducted experiments and then collected data. Through the processing of the data, the trends of voltage, current and power of PV under different shading areas are analyzed. The main equipments for the experiment were a solar panel, a photovoltaic power generation circuit experiment box, and some cardboard and wires used for shielding. Let the photovoltaic panels run at the optimal operating point. Under the condition that the illumination conditions are basically unchanged, the voltage, current and power data of photovoltaic power generation under different shading areas are recorded by occluding different areas of the solar panel. The research results show that as the shading area continues to increase, the voltage and current of the PV system are continuously weakened. The power measured indirectly approaches zero as the voltage and current decrease. Therefore, shading area is one of the major factors affecting PV systems. The results of this study provide a theoretical basis for the installation environment of solar panels and the periodic cleaning of obstructions.

Key words: Shading Area; PV System; Curve; Current; Power.

1. Introduction
A PV system is a power generation system that converts solar energy into electrical energy, using a photovoltaic effect. Its main components are solar cells, batteries, controllers and inverters. A solar panel is a device that converts solar radiation directly or indirectly into electrical energy by photoelectric or photochemical effects by absorbing sunlight. Solar photovoltaic power generation process is simple, no mechanical rotating parts, no fuel consumption, no emissions of substances including greenhouse gases, no noise, no pollution, solar energy resources are widely distributed and inexhaustible. Photovoltaic power generation is one of the most sustainable development features (the most abundant resources and the cleanest power generation process) of renewable energy power generation technology. Nowadays, the main problem facing PV systems is how to make solar panels achieve long-term high-power output.

There are many factors affecting solar photovoltaic power generation, including the impact of the shading area studied in this paper. The most important method of this research is to collect data through experiments. Then process the data to get the final result. Through this research, when installing solar panels, the installation environment and the cleaning of the obstructions should be taken into consideration to achieve greater power output of photovoltaic power generation and maximize economic benefits.
2. Experiment
This experiment explores the effect of shading area on the volt-ampere characteristics of photovoltaic panels. The main experimental equipment includes a solar panel, a photovoltaic power generation circuit experiment box, and some cardboard and wires used for shielding.

The experiment is mainly divided into five parts. The first part is the study of experimental principles. The second part is to explore the volt-ampere characteristic curve of the panel under unshielded conditions. Our main purpose was to verify that the volt-ampere characteristic of the solar panels used in the experiments was consistent with the theoretical model. The third part is to explore the effect of the shading area on the voltage and current of the solar panel. The fourth part is to calculate the power of the solar panels under different shading areas through the data of the third part. Power is the most significant performance indicator of solar panels. Its influence on the shading area can best represent the impact of the shading area on the entire photovoltaic system. The last part is the experimental error analysis.

2.1. Experimental Principles
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Figure 1. Theoretical Volt-ampere Characteristic Curves of Photovoltaic Panels and Their Causes.

Under illumination, the P-N junction will produce a photovoltaic effect. When the incident light energy is greater than the forbidden band width of the conductor material, the photons are absorbed in a range of a certain depth of the surface, and the electron-hole pairs are excited in the space of the junction region and its vicinity. At this time, photogenerated electrons and holes in the space charge region are separated, and photogenerated carriers in the diffusion length range near the P-N junction are diffused into the space charge region. The electrons in the P region drift to the N region under the action of an electric field, and the holes in the N region drift to the P region, generating a photo-generated current. The photo-generated carriers drift and accumulate to form an electric field and a forward junction current opposite to the direction of the junction electric field. When the photo-generated current and the forward junction current are equal, the P-N junction establishes a stable potential difference, that is, the photo-generated voltage.

Figure 2. Experimental Circuit Diagram and Measurement Principle.
Connect solar PV modules, voltmeters, ammeters, and load resistors into a loop through the terminal block. After determining the load resistance “R” and measuring the current “I” flowing through the load and the voltage “V” on the load, you can get The volt-ampere characteristic of the photovoltaic module.

2.2. Voltammetric Characteristics of Solar Panels without Shading
First of all, we did not block the area of the solar panels. By manually adjusting the voltage between the plates, the current and power of the solar panel are changed and data is recorded. Finally, the volt-ampere characteristic curve of the solar panel under the condition of no light blocking is obtained.

![Voltammetric characteristics of solar panels without shading](image)

**Figure 3.** Voltammetric characteristics of solar panels without shading.

As the voltage between the plates increases gradually, the process of current drop and power change can be divided into two phases. The first stage: During the process of increasing the voltage between the plates from 0V to 19V, the current decreases slowly with voltage, and the power increases linearly with the increase of voltage. The second stage: When the voltage between the plates is greater than 19V, the current decreases rapidly with the voltage, and the power decreases nonlinearly with the increase of the voltage. During the gradual increase of the voltage between the plates, the current gradually decreases with the voltage. When the voltage increases to 21V, the current decreases to zero. The power decreases with the voltage first, and the power reaches the maximum when the voltage is 19V, which is 4.15W. Compared with the theoretical curve, the linearity of the linear increase in power is better and the degree of credibility is higher. Therefore, it can be considered that the characteristic curve measured in this experiment basically conforms to the theoretical model. Then found the best working point of the photovoltaic power board, which is convenient for the follow-up experiment.

2.3. Influence of Shading Area on Voltage and Current of Solar Panels
In the case of constant illumination, let the photovoltaic system work at the optimal working point of the photovoltaic panel, and then continuously change the shading area of the solar panel and record the voltage and voltage values.
As the shading area continues to increase, the voltage between the solar panels gradually decreases. The voltage drop does not change linearly. When the shading area is less than 33%, the voltage drops rapidly with the increase of the shading area, and rapidly drops from 10.8V without shading to 1V. When the shading area increases from more than 33%, the voltage drops slowly. This means that to ensure the efficiency of the operation of the panel, the integrity of the panel must be ensured, and there must be no obstruction. Blocking a small portion can have a huge impact on panel operation.

As the shading area continues to increase, the current between the boards continues to decrease, and the experimental results of the voltage between the solar panels are the same. When the shading area is less than 33%, the current decreases rapidly with the increase of the shading area, and rapidly decreases from 0.2V to 0.02V. When the shading area is gradually increased from more than 33%, the current drops slowly.
2.4. Influence of Shading Area on The Power of Solar Panels
The corresponding power can be calculated from the voltage and current values under different shading areas.

![Power curve with shading area](image)

**Figure 6.** Power curve with shading area.

The power diagram is more intuitive and obvious than the voltage and current diagrams. When the shading area is less than 33%, the power drops rapidly from 2.12W to 0.21W as the shading area increases. When the shading area increases from 33%, the power drops slowly and both tend to zero, which is the meaning of the power map. The power of solar panels is an important consideration for photovoltaic power generation systems and directly reflects the benefits of photovoltaic power generation systems. In fact, voltage and current are direct measurement, power is indirect measurement, but the power diagram shows the effect is more intuitive and obvious, which is more conducive to our analysis of the problem.

2.5. Error Analysis
Due to the long duration of the experiment, there is a slight fluctuation in the light and temperature levels in the middle. It can also be seen from the data graph that the voltage, current and power drop processes are not smoothly reduced. It is also possible to indirectly derive the influence of illumination and temperature levels on the power generation of photovoltaic panels. However, the change of illumination and temperature relative to the change of the shading area during this experiment is still very small, which is not enough to affect the overall experimental results.

3. Conclusion
Whether it is from the voltage diagram, current diagram or power diagram, it can be directly observed that only blocking a small area will greatly arouse the power generation of the power generation board. Note If you want to ensure that the power board works at its best, try not to have a little occlusion.

As a sustainable power generation technology, photovoltaic power generation has been widely used in real life. But today's photovoltaic power generation technology is still less efficient at converting solar energy. Moreover, there are many factors affecting the power generation efficiency of photovoltaic power generation. The shading area discussed in this paper is one of the most important factors. After exploring the impact of the shading area on the power generation efficiency of photovoltaic power generation, we will have new considerations for the installation environment of the PV system and the cleaning of the obstructions. After integrating various influencing factors, the output of the PV system and the maximum economic benefit are realized.
Acknowledgments
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