Research and Design of High Maximum Power Output Solar Panel

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Abstract

Our aim with this project is to review, research, and design a highly efficient solar panel system that has bigger outcomes and power production than its predecessors. We will do this by studying the most power productive angles and materials and overall, most efficient design. This research will aim to measure the sun's irradiance on a different array of solar panels to be the most powerful and practical for general use. We will introduce a concept and result that will be used to design the next generation of solar panels. Our hope is to use this concept to start a fund to design better and more efficient panels to be used for various homes and buildings throughout our communities.

INTRODUCTION

- **Solar cell technology has been around for quite some time, and typically we understand that solar modules require sunlight to operate. But how does this actually work?**
- **Solar cells use sunlight to generate an electrical current. This happens when photons from the sun's rays hit the surface of the modules and knock electrons loose from the cell's layered n-type and p-type semiconductors. Many solar modules are made from semiconductors like silicon, that when hit by photons, generate charge that will pass through the entire panel and into the home of the user of the solar cell.**

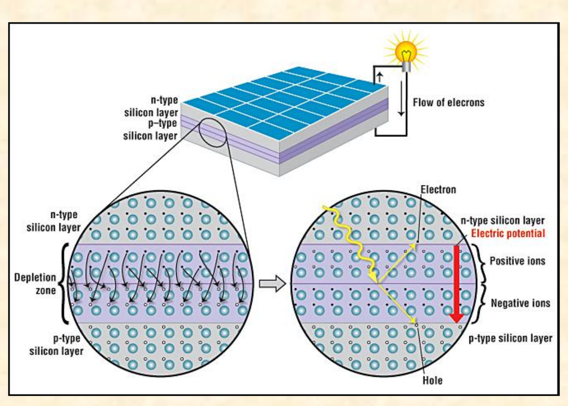

Fig.1: Breakdown of Solar cell.

- **Solar cells are divided into two categories: Monocrystalline and polycrystalline cells. Monocrystalline typically are made from single silicon crystals that form a cylindrical silicon ingot, which allow electrons to flow easier, making them the more efficient and the preferred cell. Polycrystalline cells are made from many silicon crystals melted together. This in turn allows less free movement from loose electrons throughout the cell.**

Fig.2:Monocrystalline silicon

Fig.3:Polycrystalline silicon

- **The questions I would like to ask about solar cells are: how do we know how different modules should be placed? What position allows for the maximum amount of sunlight to absorb for a given solar module? And how do different levels of shading affect these cells' energy production?**

Scientific Motivation

- **To understand the power production differences between two different cells, one large and one small, at different angles.**
- **To gain a better understanding of the effects of shading and temperature change has a solar module.**
- **To propose a more efficient design of solar modules to maximize energy output for the longest period of time.**
- **To observe the current and voltage for two different cells of the same type, but of a different size.**

References

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2. **Las, N. (2023). Production cycle of Solar Panels: An introduction. Retrieved from https://sinovoltaics.com/solar-basics/production-cycle-of-solar-panels-an-introduction/**
3. **Voss, N. (2022). What is the average solar panel output per day? (complete breakdown). Retrieved from https://infinity-renewables.com/what-is-the-average-solar-panel-output-per-day-complete-breakdown/**
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Procedure

- **Stand in a well-lit area under direct sunlight. Take readings for irradiance, temperature, electric potential, and current. Use a pyranometer, infrared thermometer, multimeter, and an amp clamp.**
- **Make sure to take these readings for 5 different positions for the solar module: ideal direction and ideal tilt, ideal direction and 90° tilt, horizontal, facing north and 90° tilt, and ideal direction and ideal tilt again except the module is warm.**
- **Repeat the same process for the larger solar module.**

Fig 5.:moving the cells to different angles

Shading

- **Next, keep the panel in the ideal direction and ideal tilt position. use sheets of thick paper or any opaque item to cover up segments of the panel for this part of the experiment.**
- **First cover up one cell of the panel and take measurements for irradiance, temperature, electric potential, and current.**
- **Take the same measurements on with one row shaded, and then one column shaded.**
- **For each position make sure to disconnect the any apparatus while the module is turned away from the sun.**
- **Repeat the process for the larger solar module.**

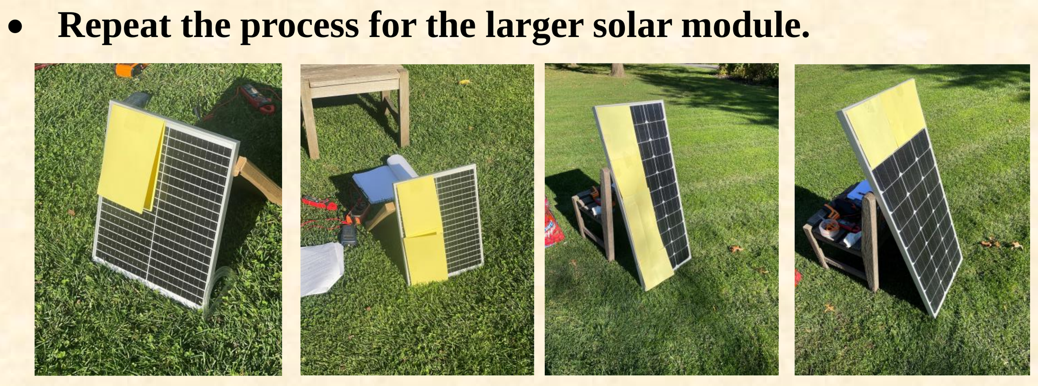


Fig.6: Shading the solar cells and comparing efficiencies.

Results

- **After measuring both cells in the sun as well as in the shade, it is apparent that when the both cells are shaded, they generate less power and when they are in direct sunlight their power output increases.**
- **The electric potentials of both cells seemed to hover around the same range when fully emersed in the sun and in the right position. The current seemed to be lower overall on the smaller panel than the large one.**
- **I concluded that the smaller cell was overall more efficient. The electric potential was overall higher than the large cell. And it maintained this through the rise in temperature and change in position.**

Fig.7: Small Module

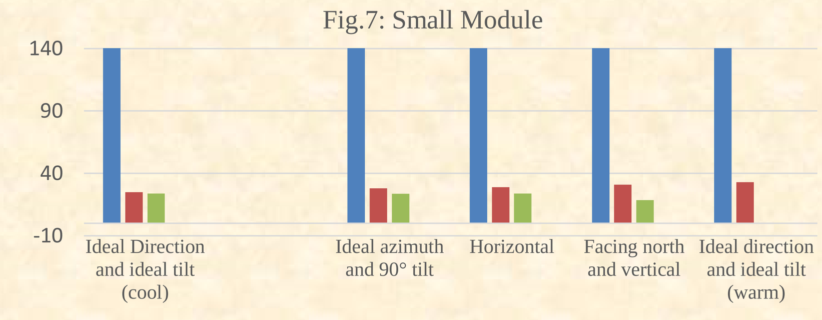


Fig.8: Large Module

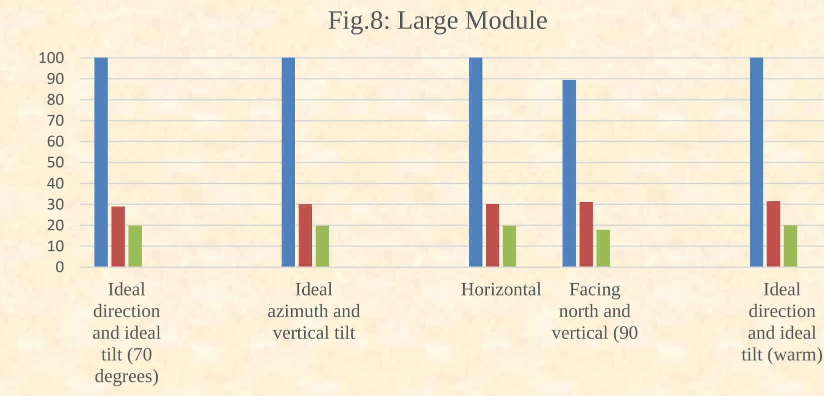


Fig. 9: Small module (shaded)

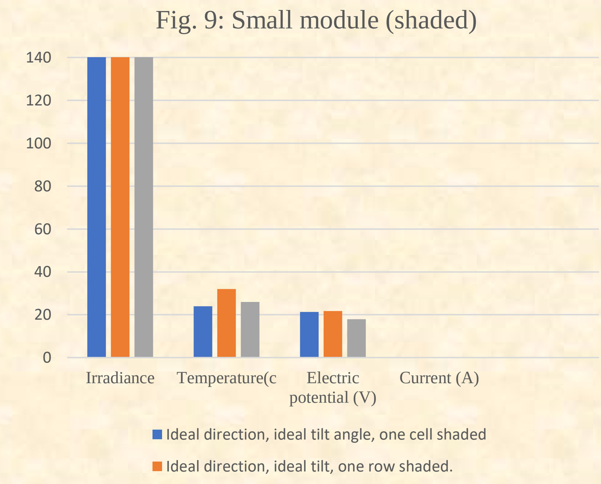
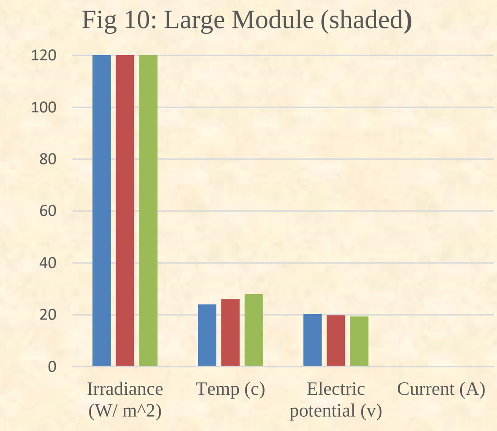


Fig 10: Large Module (shaded)



Final Comparisons

Fig 11:

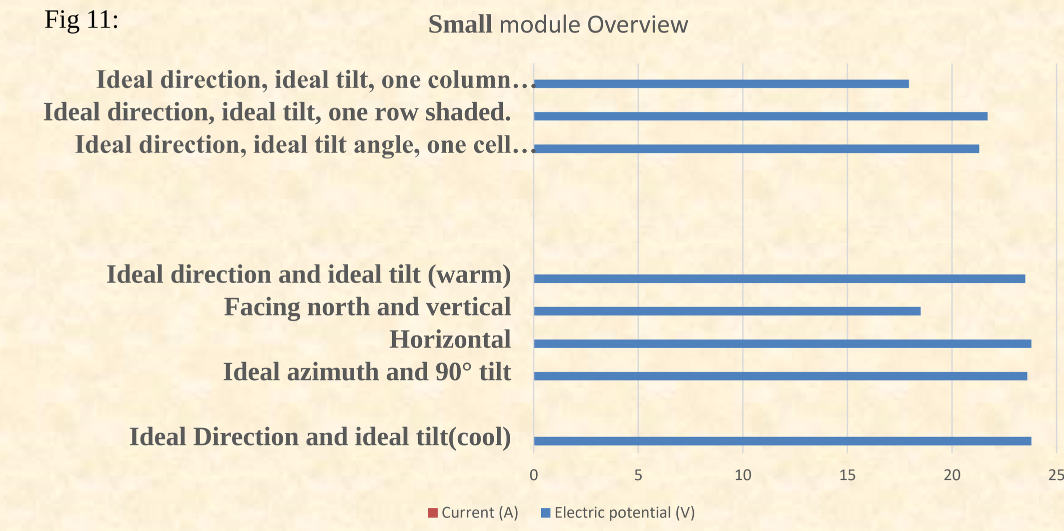
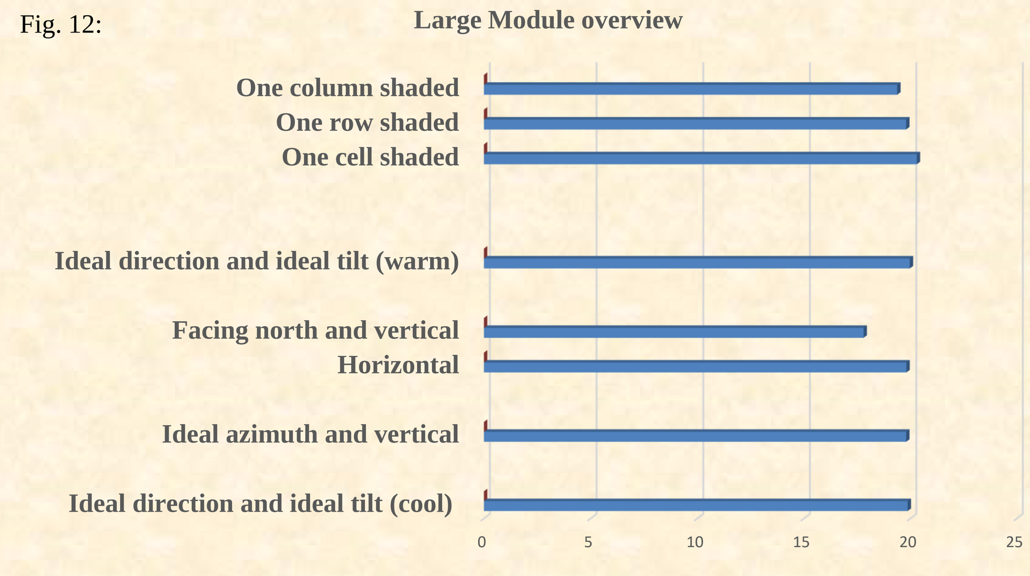


Fig. 12:



Ideal solar panel design

- **Based on my results, I found that the most ideal angle for the cell to be positioned at is anywhere between 70- 100 degrees.**
- **At this position , not only was the irradiance at its highest point, but the electric potential, and current increased as well.**
- **The other factor influencing power output was the Azimuth, or direction of the panel.**
- **The panel needed to have the sun toward its south side to receive the most complete immersion in light.**
- **To design a better panel system based off my results, I would suggest staggered system on an angle between 70-100 degrees.**

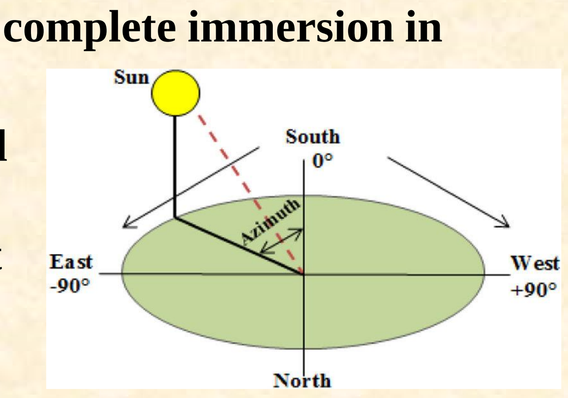


Fig.13: Azimuth angle diagram.

- **This would result in the most efficient output for a system of solar panels, no matter the size or surface area, maximizing the most amount of power to one's home.**

Summary & Observations

• From my results, I was able to conclude that even though shading on solar panels does cause a slight change, it is not enough to significantly effect the power output.

•The size of the cell does have a small effect, as the both modules gave similar readings, with the smaller of the two actually giving more efficient readings than the larger of the two. This could be because the smaller panel was more evenly hit by the sunlight, so it was able to have more loose electrons generating a power output.

•Finally, the most important factors that I found were the direction and angle. These need to be facing the source of light at 70—100 degrees for maximum efficiency.

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