https://cleanearth4kids.org/renewable-energy

Reflector Magic - Solarisation Optimization

Figure 1- Solar Energy & Earth

Project Aim

The aim of my project is to design a portable solar panel system that maximizes energy efficiency by utilizing rotating spherical shaped solar panels and aluminum foil as a reflector to direct sunlight onto solar panels. The effectiveness of my design will be tested by measuring battery charge levels when exposed to sunlight with and without aluminum foil reflectors.

Question

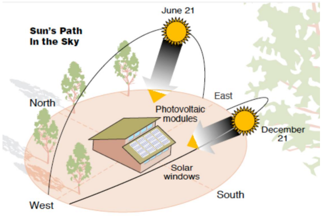
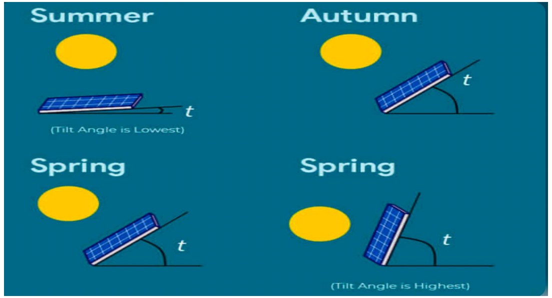
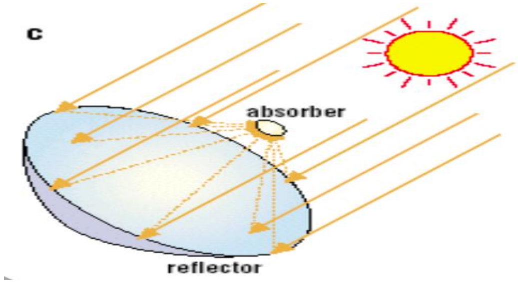
How using a rotating spherical design along with reflectors might improve solar panel performance by capturing sunlight more effectively?

Problem

1. Most solar panels absorb light from only one side, missing additional energy from other angles of sunlight.

2. Flat solar panels are fixed in place, making them unsuitable for when the angle of the sun changes.

3. Lack of Energy Storage - Without a built-in battery, energy is unavailable when the sun isn't shining.

Fixed positioning causes inefficiency as the sun's angle changes.	https://greenpassivesolar.com/passive-solar/scientific-principles/movement-of-the-sun/  Figure 2- Summer Winter Sun Path
The problem of fixed tilt panels is that they do not adjust dynamically to the sun's angle.	 Figure 3- Optimal Solar Angle jsusolutionsgroup.com
My solution utilizes a reflector to maximize solar absorption	 Figure 4- Sun Reflection reseachgate.net

Hypothesis

If a portable solar panel system is designed in a rotating spherical shape, along with strategically placed reflectors to reflect sunlight onto all surfaces, then the system will generate more electrical energy than traditional, single-sided solar panels because the reflectors will increase the amount of sunlight captured from various angles and throughout the day.

Method

The solar panels would be in a spherical shape that rotates, which would be more optimal since as the sun changes positions throughout the day, sunlight will continuously strike the sphere from all angles. To further enhance efficiency, my design incorporates reflective surfaces. The aluminum foil would reflect sunlight onto the bottom half of the sphere. This approach significantly improves solar energy capture compared to traditional designs. A flat solar panel is able to only capture the sunlight during the times when the sun is at its highest point. With my design, the solar panels is able to capture sunlight at all times of day with a higher efficiency rate. Changing the solar panel's shape from flat to sphere and incorporating reflectors will revolutionize the ways humans can harvest more sun energy in the hope of creating greater energy independence and a more sustainable future.

Method

Basic Concept
I designed a spherical solar panel that captures sunlight from all angles.

Incorporating Reflective Surfaces
I added aluminum foil to reflect sunlight onto the bottom half, maximizing sunlight absorption.

Comparing Flat vs. Spherical Panels
Flat solar panels capture sunlight at peak hours, while spherical panels with reflectors capture it all day.

Sunlight Capture in Different Positions
My design showcases how sunlight is captured at various times of the day from different angles.

Portable and Adjustable Design
My design is portable as it is mounted on wheels for easy repositioning and angle adjustments.

Background Research

The city of Calgary is promoting new energy sources and supporting the construction of green buildings. With an average of 2396 hours of sunlight every year, Calgary is an ideal city for using solar energy.

https://www.calgary.ca/content/www/en/home/environment/policies/solar-energy.html

Solar energy is one of the clean alternative energy resources; however, they are still considered inefficient because they do not maximize the amount of solar energy the panels can capture, also they do not have the capacity to support an entire city solely. My project will address these limitations, with rotating spherical shape solar panels, where reflectors are used to optimize sunlight reflection. Scientific research further supports the need for innovation in solar panel design. According to Rensselaer Polytechnic Institute, a silicon solar panel absorbs only 67.4% of the sunlight, which means roughly 33% of the sunlight is not harvested.https://www.sciencedaily.com/releases/2008/11/081103130924.htm

In addition, flat solar panels cannot absorb the same amount of solar energy throughout the day; most energy is observed during a narrow window when the sun is at its highest peak where the sun is at the right angle. Solar panels that are tilted or slightly curved are considered to be more energy efficient. Building on this idea, my design proposes a more efficient solution. https://energyeducation.ca/encyclopedia/Solar_panel_orientation

Background Research - Reflector

Reflection is when light bounces off an object. Aluminum is an excellent light reflector due to its shiny, metallic surface, which cause light photons to excite the electrons and re emit them, resulting in reflection.
With a certain alloy of aluminum, and using the proper polishing technique, an aluminum surface having the reflectivity as high as 89% has been produced.
https://www.brikbase.org/sites/default/files/ies_087.pdf

Aluminum foil reflectivity can be affected by many factors, such as purity, smoothness, and heat rays wavelength. The light reflectance will increase, if the purity, smoothness, and heat rays wavelength of the aluminum foil increases. In visible wavelength range of 0.38 - 0.76 m, the reflectivity is about 70% - 80 %, https://www.aluminum-foil.net/the-aluminum-foil-uses/

Background Research - Battery

Solar batteries contain two different materials, one material is for absorbing light energy, while the other one is for releasing it as electricity. Solar batteries can take anywhere from 12 to 24 hours to fully charge, depending on their location in relation to sun. Solar batteries are made up of rechargeable lithium ion cells. When exposed to sunlight, the solar panels supply direct current electricity that charges the battery. Solar batteries are designed to provide power 24 hours a day, so they can be used in remote locations and during emergencies where power is unavailable.

https://www.bluettipower.ca/blogs/knowledge-base/how-are-solar-batteries-different-from-rechargeable-batteries?srsltid=AfmBOoq_V7D1BZ0IQf_XwAXD_cw4Ms2TOvQ3iWCRnHtvpPJRCFUfsUwy

Variables

Manipulated Variable

1- Solar panel configuration shape.

2- No reflector vs reflector

Controlled Variable

1- Materials & Equipments:: Type of solar panels used.

2- Environmental Conditions: Factors such as temperature, humidity, and light.

3- Testing Protocol: Duration of exposure during each test, same setup location.

Responding Variable

1- Energy output: The amount of energy generate, measured in volts.

2- Battery Performance: Charge rate or level of integrated solar battery.

Materials

- Solar panel buried lights, usually used for pathway lighting.
- Solar battery, rechargeable, included in the solar lights.
- Volt meter, to measure voltage and current output.
- Aluminum foil, acting as reflector.
- Styrofoam ball, to hold the solar panel
- Hollow half styrofoam ball, to hold the reflector
- Styrofoam stand, to hold the structure
- Glue and double sided tape.
- Scissors and cutters, to shape the reflectors and solar panels.
- Stopwatch to record time taken for battery charging.

Procedure 1

- Using the ruler, I drew hexagon on aluminum foil and folded it.
- Using scissors, I cut out 60 hexagons.
- I glued the aluminum foil cut out hexagons to the hollow half sphere styrofoam.
- I guled the base to the hollow half sphere.
- I disassembled the solar panels, removed the batteries and connected them to the voltmeter to measure their voltage.
- I cut out the solar panels' edges to make them fit on the the spherical styrofoam.
- I fixed the solar panels in the styrofoam sphere using pins.
- I glued the styrofoam sphere to the aluminum foil covered half sphere.

Procedure 2

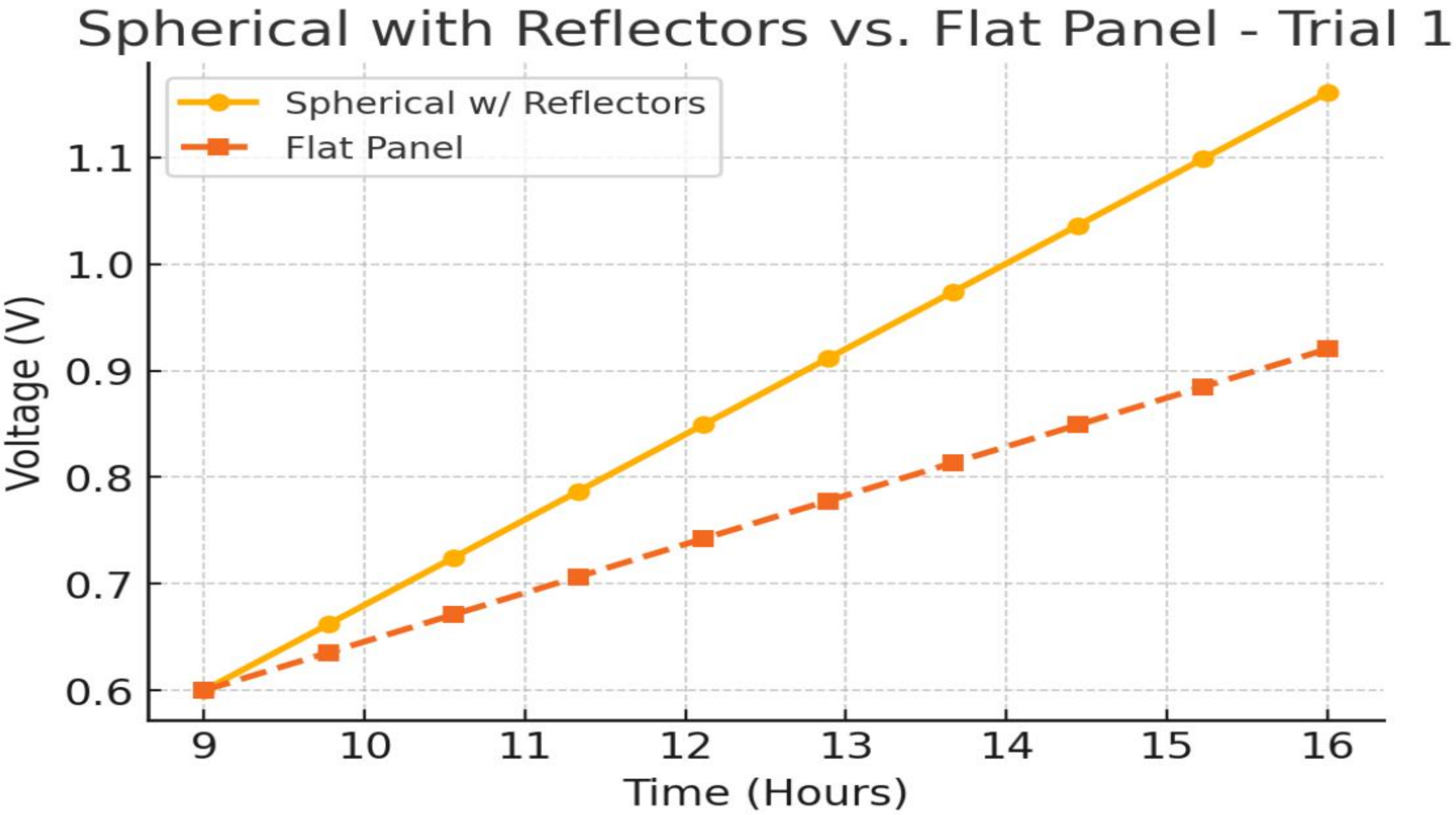
- For testing without reflectors, I placed solar panels in a direct sunlight.
- I removed the battery and connected the voltmeter to measure.
- I reinserted the battery and let it charge.
- I removed the battery and measured the voltage again.
- I logged the data in a table.
- For testing with reflectors, I placed the spherical solar panels in a direct sunlight.
- I removed the battery and connected the voltmeter to measure.
- I reinserted the battery and let it charge.
- I removed the battery and measured the voltage again.
- I logged the data then compared it to the baseline test.

Data Analysis

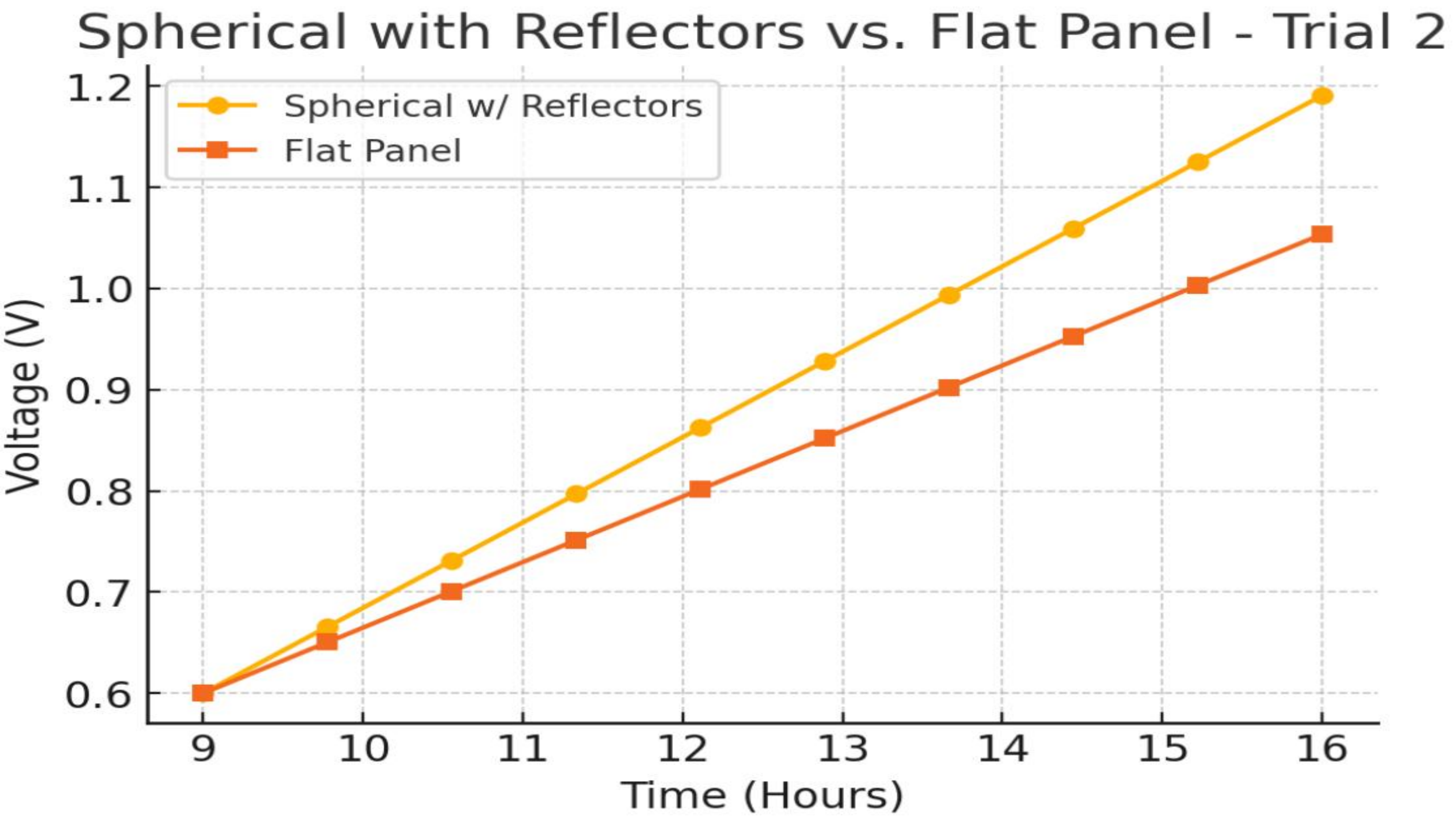
- <u>Spherical with Reflectors vs Flat Panel:</u> The three trials show that the spherical with reflectors consistently produced higher voltage, so my design optimized light collection and absorption throughout the day. The spherical with reflectors produced a range of 15% to 28% more voltage than the flat panel.
- <u>Spherical without Reflectors vs Spherical with Reflectors:</u> Even though the voltage gap is smaller in this test since the spherical design improved energy absorption; however, adding reflectors to the design resulted in 9.1% to 9.5 % higher voltage than the spherical without reflectors.
- <u>Spherical without Reflectors vs Flat Panel:</u> Even without reflectors, the spherical design outperformed the flat panel in energy absorption by producing 5% to 16.7% more voltage than the flat panel.

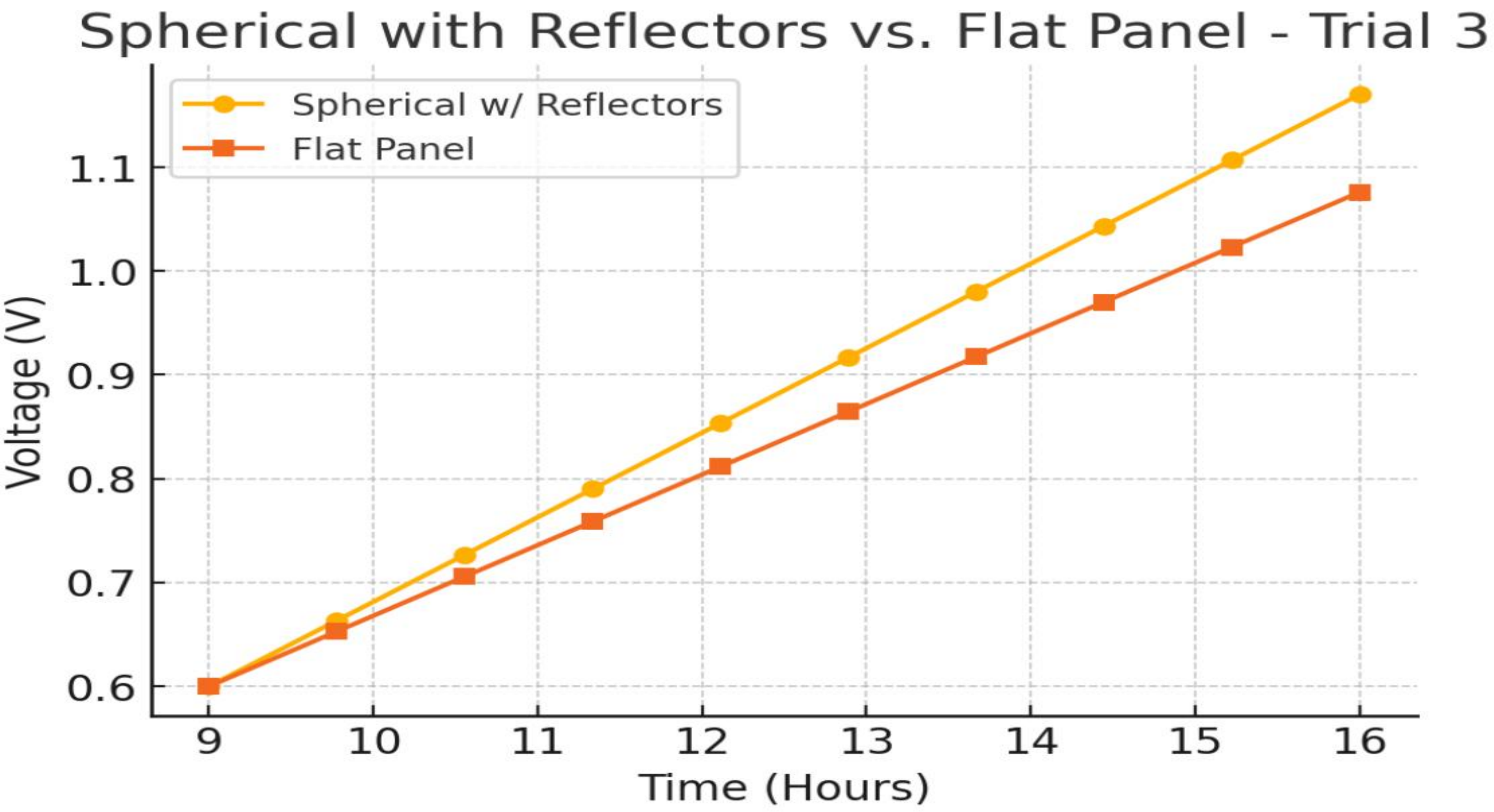
Data Analysis

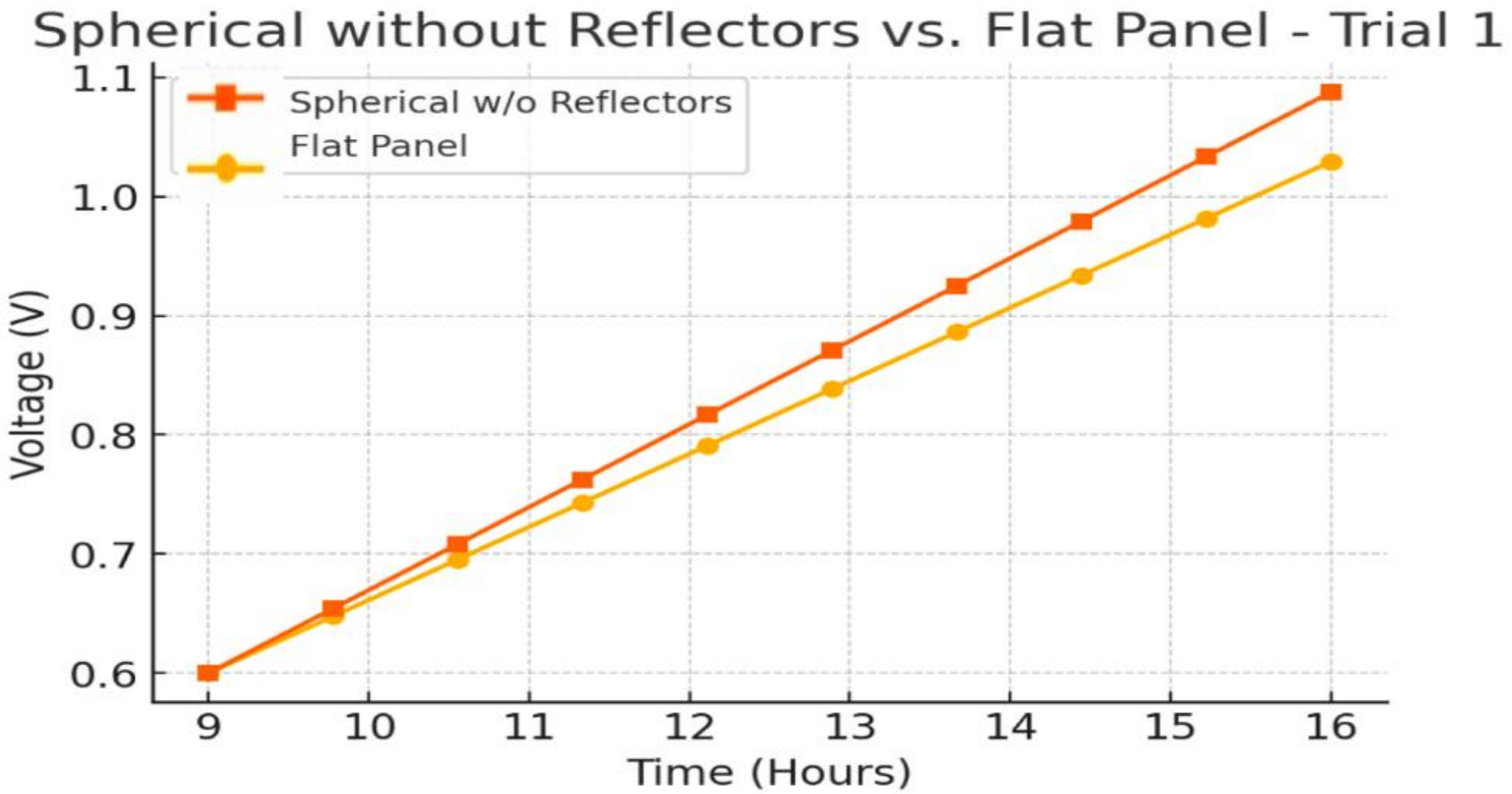
After three different tests with three trials for each test, my data shows that the the spherical with reflectors had the highest performance. The impact of the reflectors is equally important to switching the shape of the solar panels from flat to spherical, which means reflecting and redirecting sunlight is crucial in increasing solar efficiency.



Spherical with Reflectors vs. Flat Panel - Trial 1
Spherical w/ Reflectors
Flat Panel
Voltage (V)
1.1
1.0
0.9
0.8
0.7
0.6
9
10
11
12
13
14
15
16
Time (Hours)


Spherical with Reflectors vs. Flat Panel - Trial 2
Spherical w/ Reflectors
Flat Panel
Voltage (V)
1.2
1.1
1.0
0.9
0.8
0.7
0.6
9
10
11
12
13
14
15
16
Time (Hours)


Spherical with Reflectors vs. Flat Panel - Trial 3
Spherical w/ Reflectors
Flat Panel
Voltage (V)
1.1
1.0
0.9
0.8
0.7
0.6
9
10
11
12
13
14
15
16
Time (Hours)


Spherical without Reflectors vs. Flat Panel - Trial 1
Spherical w/o Reflectors
Flat Panel
Voltage (V)
1.1
1.0
0.9
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0.6
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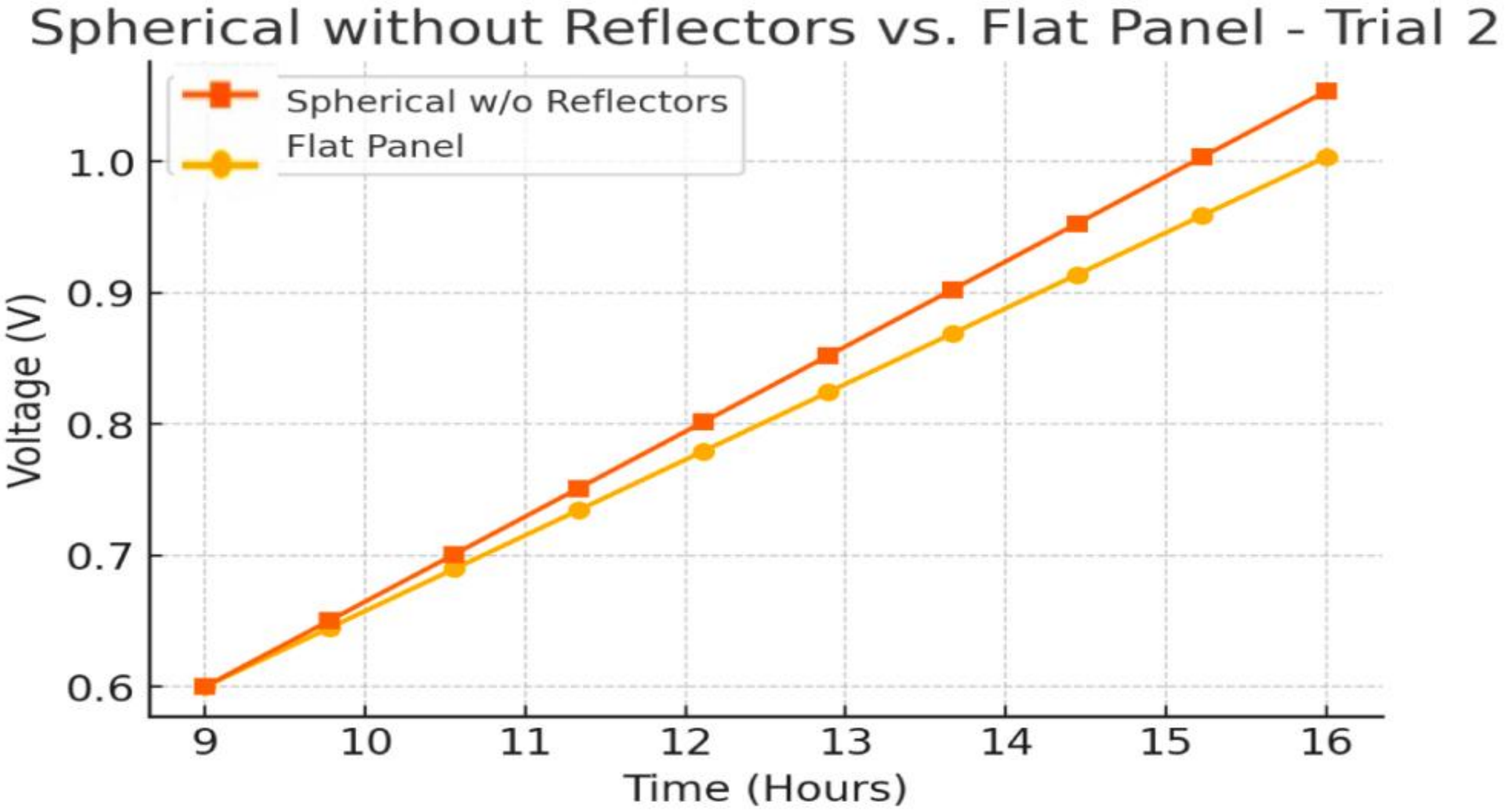
Time (Hours)


Spherical without Reflectors vs. Flat Panel - Trial 2
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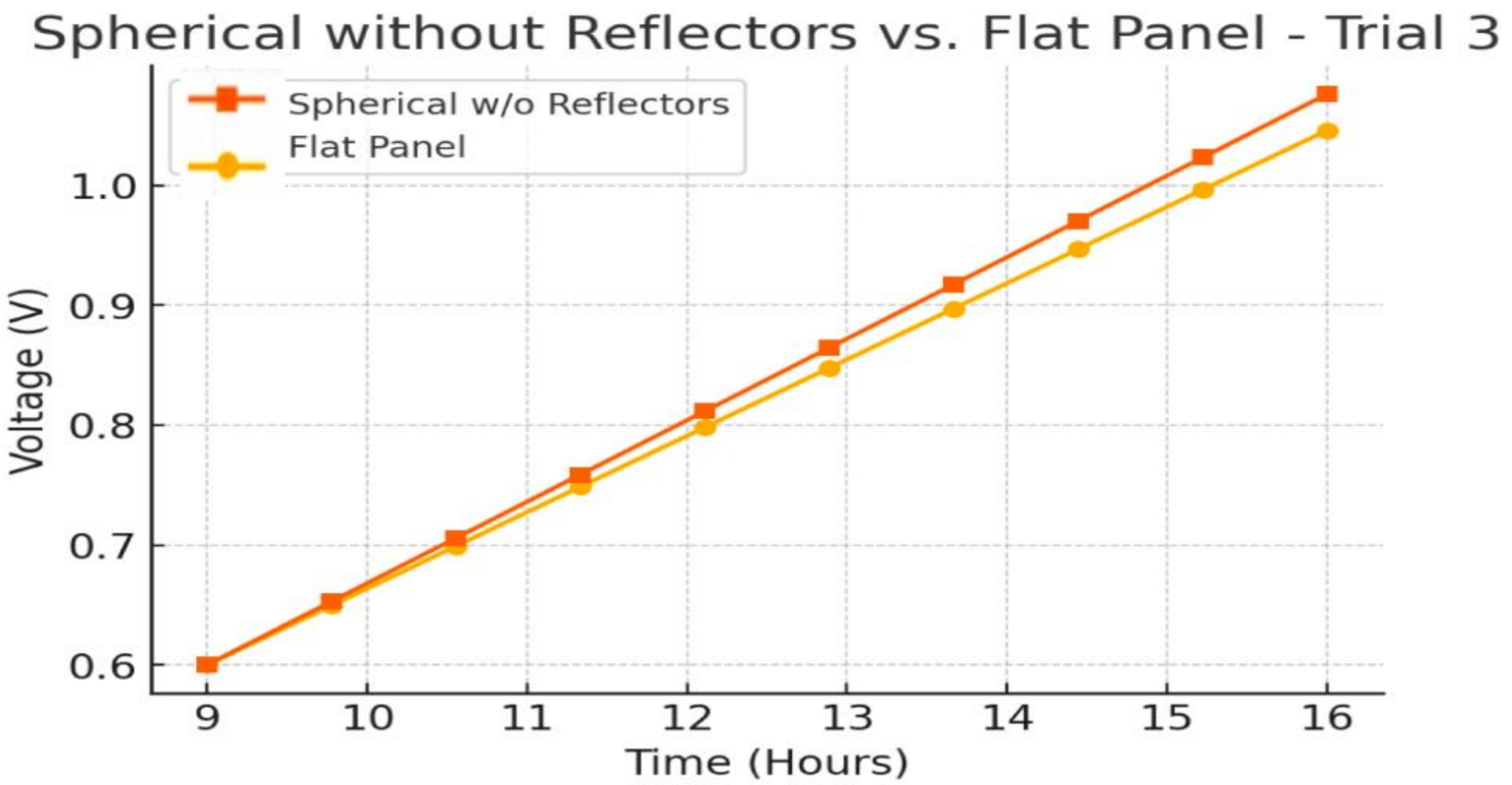
Time (Hours)


Spherical without Reflectors vs. Flat Panel - Trial 3
Spherical w/o Reflectors
Flat Panel
Voltage (V)
1.0
0.9
0.8
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0.6
9
10
11
12
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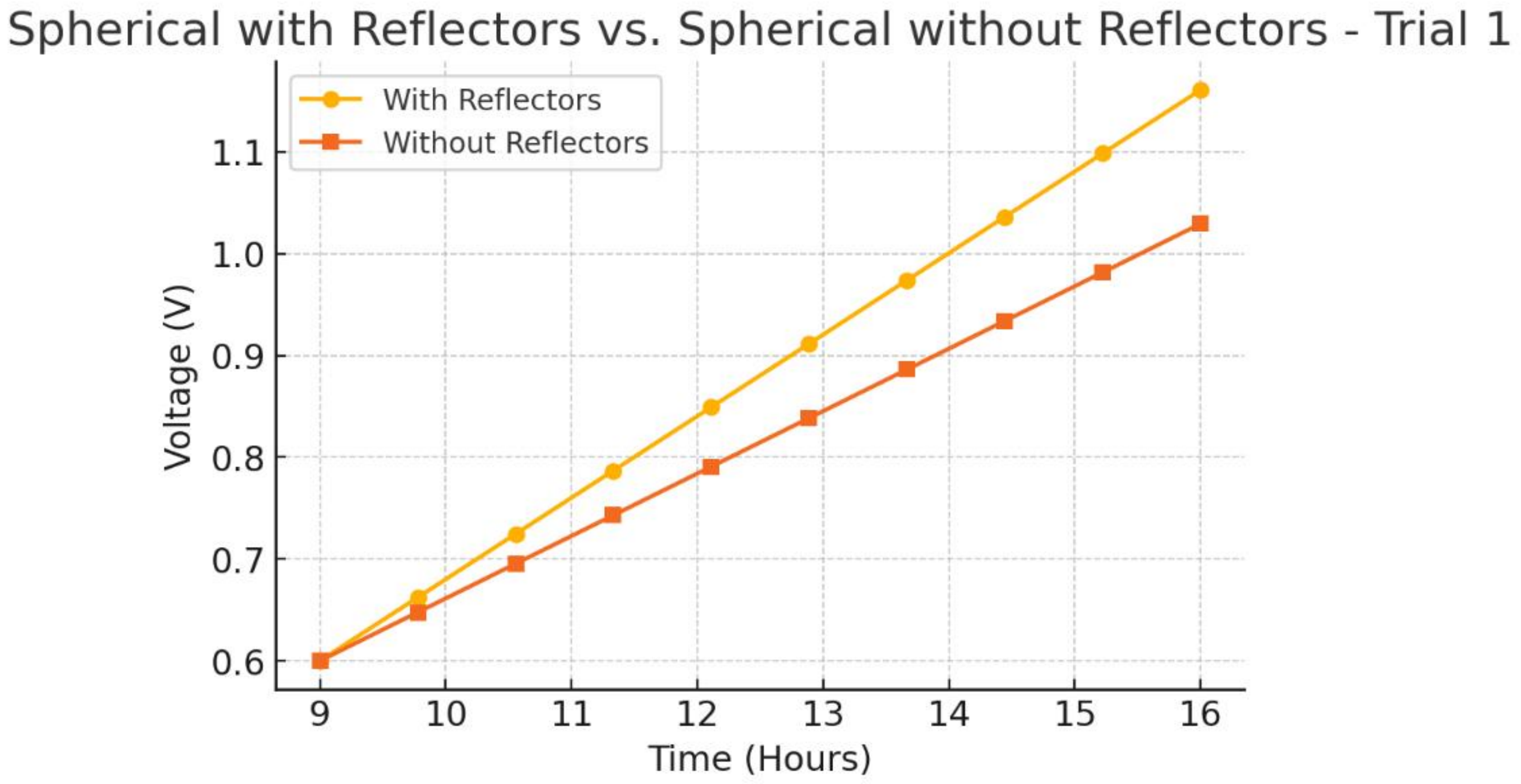
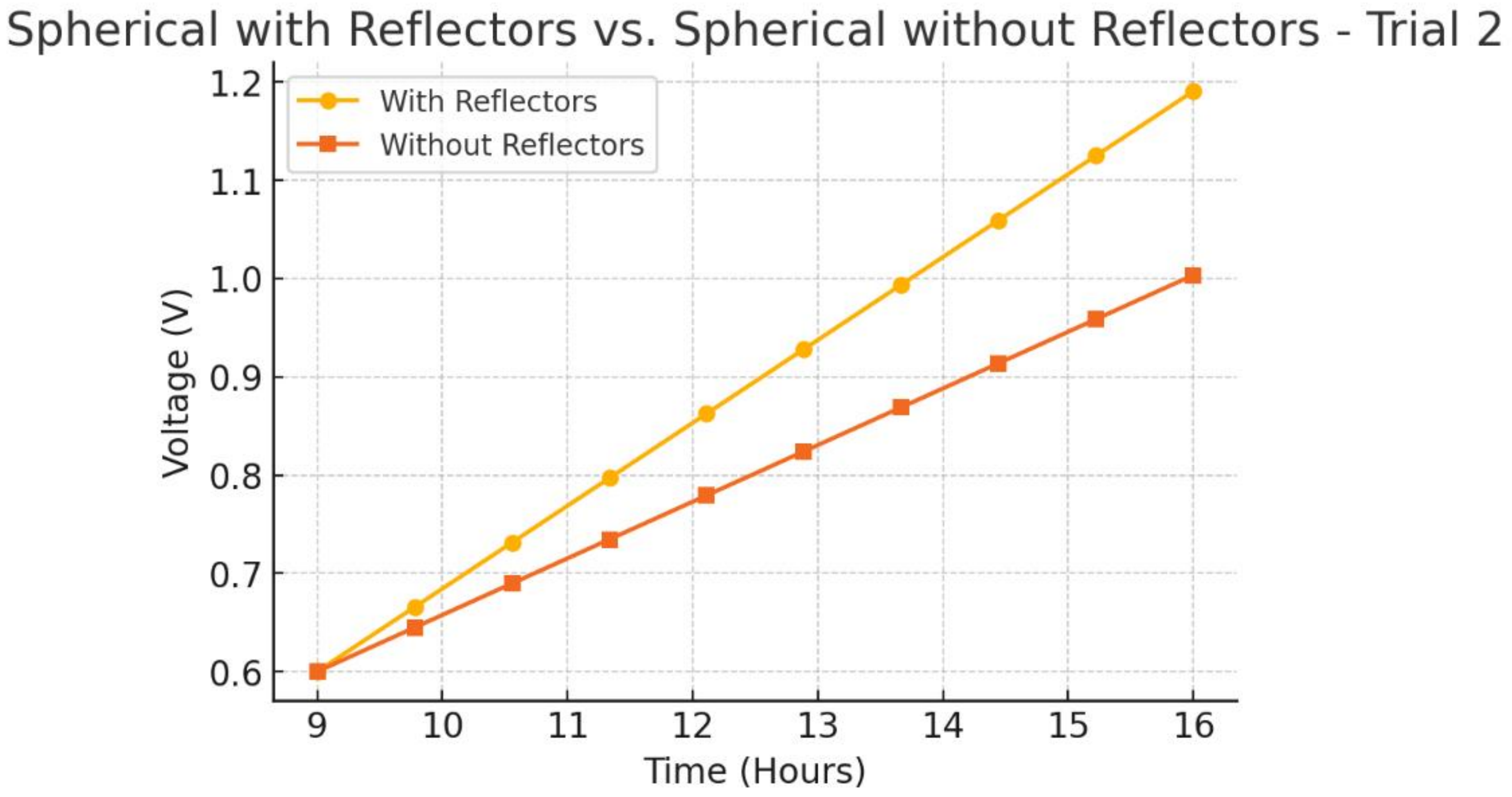
16
Time (Hours)



Spherical with Reflectors vs. Spherical without Reflectors - Trial 1
With Reflectors
Without Reflectors
Voltage (V)
1.1
1.0
0.9
0.8
0.7
0.6
9
10
11
12
13
14
15
16
Time (Hours)


Spherical with Reflectors vs. Spherical without Reflectors - Trial 2
With Reflectors
Without Reflectors
Voltage (V)
1.2
1.1
1.0
0.9
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0.7
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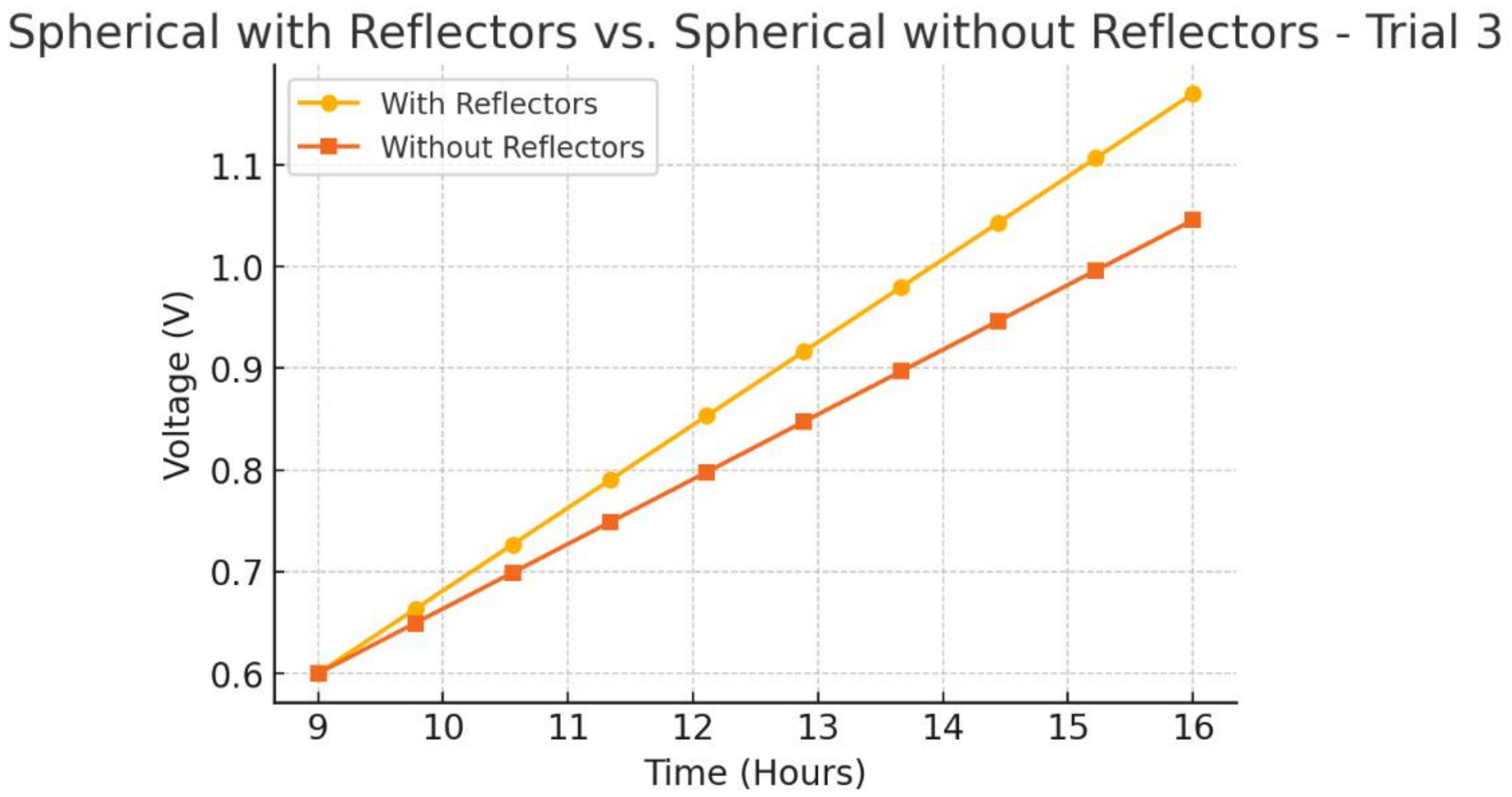
Time (Hours)


Spherical with Reflectors vs. Spherical without Reflectors - Trial 3
With Reflectors
Without Reflectors
Voltage (V)
1.1
1.0
0.9
0.8
0.7
0.6
9
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11
12
13
14
15
16
Time (Hours)

Conclusion

In this project, my scientific question was “ How using a rotating spherical design along with reflectors might improve solar panel performance by capturing sunlight more effectively? I asked this question because I realized that flat solar panels are still considered inefficient because they do not maximize the amount of solar energy captured, also they do not have the capacity to support an entire city solely. Recognizing the need for a more efficient approach, I came up with a revolutionary design, a rotating spherical shaped solar panels, I also incorporated sunlight reflectors to maximize energy efficiency, by increasing the amount of sunlight captured from various angles and throughout the day. The goal of my project is to investigate whether this unconventional method could offer a practical solution to the limitations of flat solar panels, and contribute to the development of more reliable and efficient solar energy harvest techniques. My hypothesis was “ If a portable solar panel system is designed in a rotating spherical shape, along with strategically placed reflectors to reflect sunlight onto all surfaces, then the system will generate more electrical energy than traditional, flat solar panels because the reflectors will increase the amount of sunlight captured from various angles and throughout the day.

Conclusion

To test my hypothesis, I built a prototype from everyday materials, then I ran three different tests with three trials each for more accurate results. All trials showed promising results for my design, where the spherical shaped solar panels in addition to reflection and rotation improved efficiency by a range of 25% to 27% from traditional flat solar panels.

My project demonstrates an innovative and cost effective method to improve solar panel efficiency. The experiment proves energy gains through real world testing of battery charge levels. My project will revolutionize the solar energy industry in both small portable designs as well as a larger scale for residential and solar power farms.

In conclusion, changing the solar panel's shape from flat to sphere and incorporating reflectors and rotation will revolutionize the ways humans can harvest more sun energy in the hope of creating greater energy independence and a more sustainable future.

Solarisation Optimization and The Environment

1. Renewable Energy Optimization: Solar power is already a clean energy source, but some efficiency limitations reduce its effectiveness. My project improves energy capture by redirecting more sunlight onto panels, increasing power output without requiring larger solar panels or continuous maintenance. This means more electricity generation from the same amount of sunlight, making solar energy more viable in areas with less direct sun exposure.

2. Reduction in Energy Waste: Without reflectors, a significant portion of sunlight misses the solar panels. Using reflectors reduce this loss by optimizing light redirection, which lead to more efficient energy use without extra resource consumption.

3. Potential for Reducing E-Waste: Many low efficiency solar panels get discarded due to poor performance. My project enhances panel performance, increasing their lifespan and delaying disposal. Also, there is less need for frequent battery replacements due to faster and more efficient charging.

Real Life application

1- Off-Grid Power Generation:

The large scale system of my project can be used in remote or rural areas where traditional grid power is unavailable, such as for cabins, rural homes, or remote research stations.

2- Disaster Relief and Emergency Response:

My project is ideal for quick deployment during natural disasters or emergencies to provide power to communication devices, medical equipment, or lighting in affected areas.

3- Recreational and Mobile Use:

The compact system is perfect for RVs, boats, and camping setups, providing a reliable source of power for charging devices and running small appliances while on the move.

4- Temporary Installations for Events and Construction Sites:

My project's lightweight and efficient design offers an ideal power solution for outdoor festivals or construction sites

Further Questions

- What considerations should be taken into account when scaling up spherical shaped solar panels for larger electricity generation applications? How can this technique be practically implemented on a commercial scale?
- What structural and mechanical challenges can be encountered when installing?
- What strategies should be implemented to avoid photovoltaic degradation rates that might be caused by any additional reflected light?
- How far in the future technology will evolve to design a spherical solar panels that can address material stress, heat, and wiring complexities introduced by the curved shape?

Sources of Errors

Inconsistent Sunlight Conditions

Voltmeter Accuracy and Connection Stability

Differences in Solar Panels Efficiency

Heat Build up on the Solar Panels

Battery Charge Level Variability

Environmental Factors such as wind and dust.

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- Figure 3 - Optimal Solar Angle. JSU Solutions Group, https://jsusolutionsgroup.com.

- Figure 4 - Sun Reflection. ResearchGate, https://www.researchgate.net.

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Acknowledgements

Zainab Solomon: Project mentor

Dr. Garcia

Mr. Ziemmer

Ali Shahbazi

Project Log

Date	***Summary of Activity Performed***	***Time Spent***
Sep 16, 2024	Brainstorming and finding the topic for my SF project: Reflector Magic - Solisation optimization	1hr
Sep 18, 2024	Background research about relevant technology or approach: I research through PubMed on solar panels efficiency Paper 1: "Beamline development for energy-efficient systems" Paper 2: "Battery less IoT sensors powered by ambient energy"	2hrs
Sep 20, 2024	Background research about different types of reflectors to determine the most ideal for my project.	2hrs
Sep 23, 2024	Background research about solar batteries to better understand how energy storage work.	2hrs
Sep 25, 2024	After my extensive research, I was ready to propose my hypothesis.	30 minutes

Project Log

Date	*Summary of Activity Performed*	*Time Spent*
Sep 28, 2024	I sketched the initial design for my project which helped me to develop the initial concept for the solar panels.	2hrs and 30 minutes
Oct 3, 2024	Variables: I figured out the independent variable, controlled variable, and the responding variable of my project	1hr
Oct 11, 2024	I started prototype planning, I gathered all the materials I needed to build my prototype.	2hrs
Oct 15 , 2024	Prior to assembling my prototype, I cut out all solar panels to fit on the styrofoam ball, cut out aluminum foils into hexagonal shapes, and painted all strophomes for esthetic purpose.	2hrs
Nov 1, 2024	I measured the voltage then drained all solar panels' battery from 1.2 to 0.6 v.	1hr

Project Log

Date	*Summary of Activity Performed*	*Time Spent*
Nov 15, 2024	I put all the component together and built my design.	2hrs
Dec 1, 2024	Trial one of test 1: Spherical with Reflectors vs Flat Panel	1hr
Dec 14, 2024	Trial two of test 1: Spherical with Reflectors vs Flat Panel	30 minutes
Dec 18, 2024	Trial three of test1: Spherical with Reflectors vs Flat Panel	2hrs
Dec 21, 2024	Trial one of test2: Spherical without Reflectors vs Flat Panel	2hrs
Dec 23, 2024	Trial two of test 2: Spherical without Reflectors vs Flat Panel	2hrs
Dec 28, 2024	Trial three of test 2: Spherical without Reflectors vs Flat Panel	2hrs
Jan 1, 2025	Trial one of test 3:Spherical with Reflectors vs Spherical without Reflectors	2hrs
Jan 4, 2025	Trial two of test 3: Spherical with Reflectors vs Spherical without Reflectors	2hrs
Jan 11, 2025	Trial three of test 3: Spherical with Reflectors vs Spherical without Reflectors	2hrs

Project Log

Date	*Summary of Activity Performed*	*Time Spent*
Jan 18, 2025	I analized my data in preparation for classifying them.	1hr
Jan 26, 2025	Data Analysis, I put all the data I gather from 9 trials into different charts to help me analyze it.	4hrs
Feb 1, 2025	Conclusion, I gather my findings and wrote the conclusion based on the analyzed data.	2hr and 20 minutes
Feb 9, 2025	Sources of Errors, I worked on identifying the sources of errors that can influence the outcome of my experiment.	2hrs
Feb 15, 2025	Real life application, how my project can be beneficial in real life.	1hr
Feb 22, 2025	Bibliography and final review: I put all the online resources I gather information from throughout the research and experiment of my project.	2hrs
Mar 4 to 8, 2025	I designed and prepared the trifold for science fair	4hrs
Mar 9-10, 2025	I practiced my presentation for the science fair.	4hrs