

Research Question

Questions:

How can solar energy be harnessed **efficiently** and **effectively** **without** the use of electricity for motors and other electrical components?

What is the **effective increase** in energy harnessed by such a solar tracker system compared to a fixed solar panel system?

Problem: Solar tracking solutions have increasingly grown in terms of its popularity and overall usage. However, given that solar tracking traditionally depends on electrical components, it is not always a cost-effective solution for developing nations. Hence, efficient solar tracking without the use of electricity is essential for the viability of this solution to harness electricity.

Hypothesis

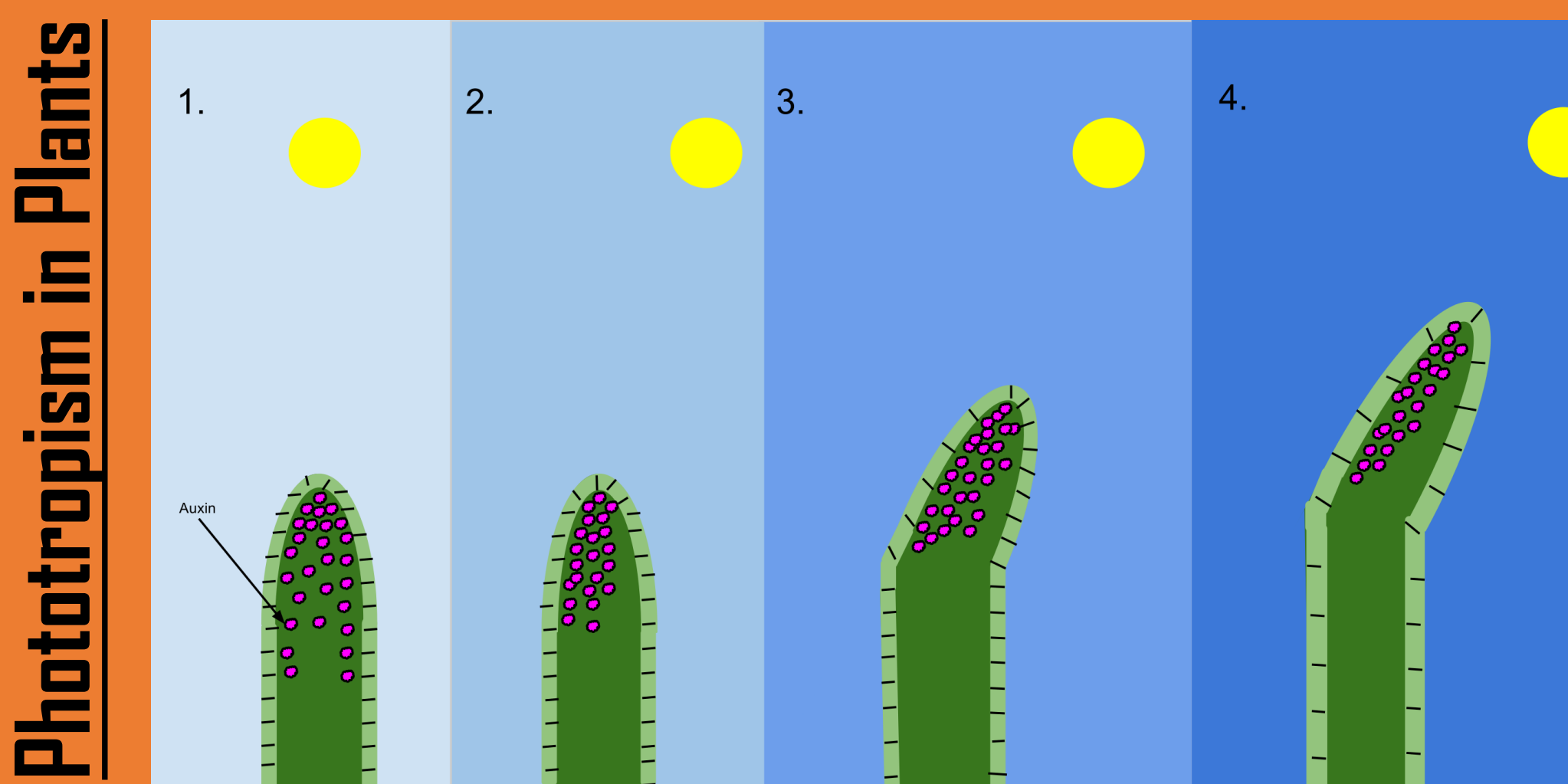
Solar energy can be harnessed efficiently and effectively without the use of electricity by using a **nature** inspired **phototropic** solar tracker system.

The amount of increase in the energy harnessed using a phototropic solar tracker is estimated to be about **50%**. The horizontal sweep angle of the sun is nearly 180° and that the effective light reception angle of a fixed-axis system is nearly 90° which implies that it does not harness energy half of the time. Given that the phototropic solar tracker continuously tracks light, it is expected that it will yield at least 50% increase in energy.

Background

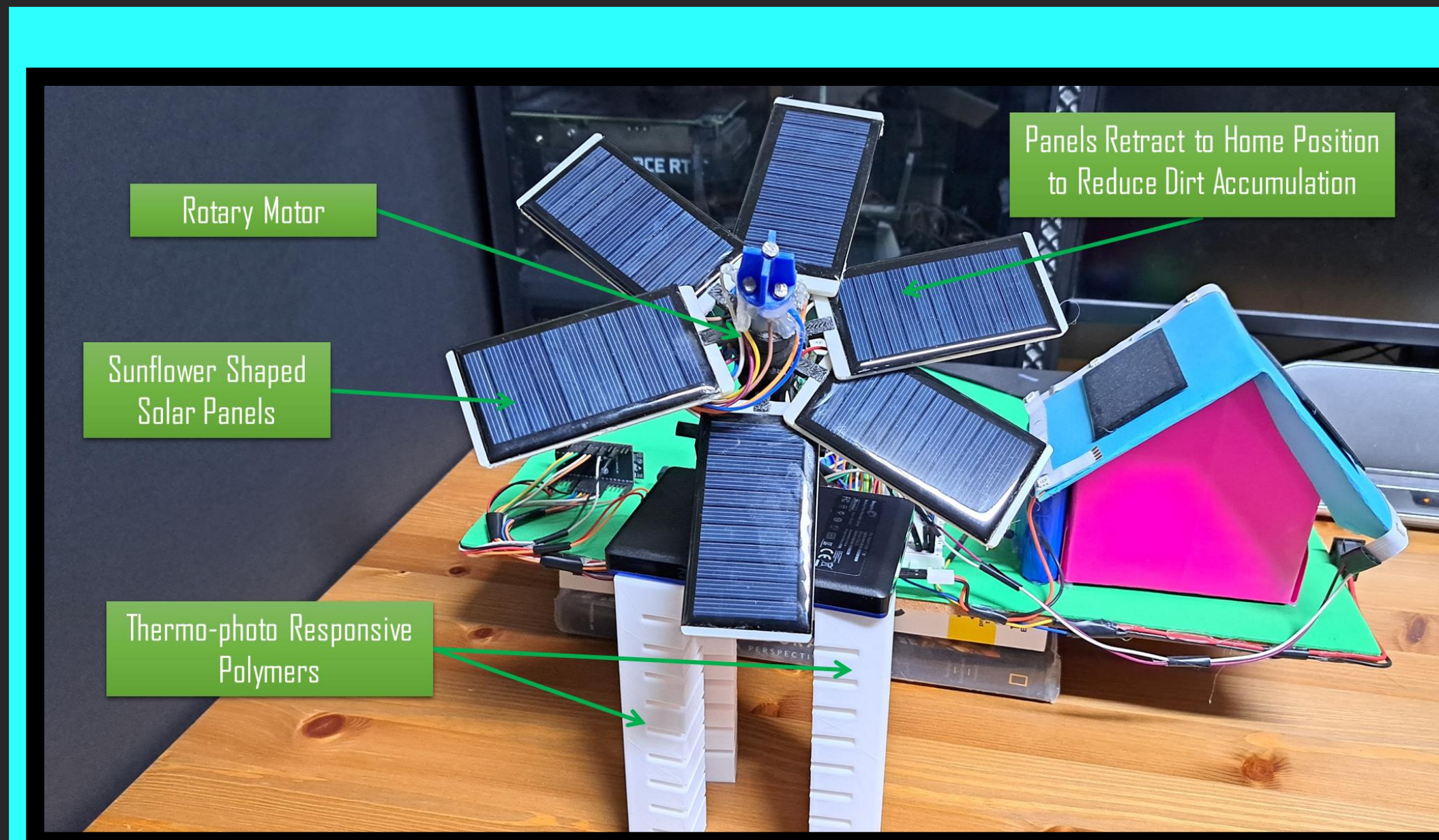
Phototropism is a biological phenomenon that occurs when a plant follows the movement of the sun during the day. Phototropic movement in response to light is stimulated by the concentration of hormones such as **auxins**. They allow the plant to autonomously and instantaneously detect and track incident light in 3D space **without** auxiliary power supply.

Thermo-photoresponsive polymers are polymers that exhibit drastic changes in their physical properties with temperature and light. For instance, *poly(N-isopropylacrylamide)* (PNIPAAm) copolymerized with *polyacrylamide* (PAM) and *gold nanoparticles* (AuNPs) exhibits stimulus-responsive behavior and rapidly changes equilibrium state in response to external stimuli such as light. Therefore, such artificial stimulus-responsive materials can be integrated to offer a nature inspired approach to solar tracking without the use of any electrical source to power tracking.

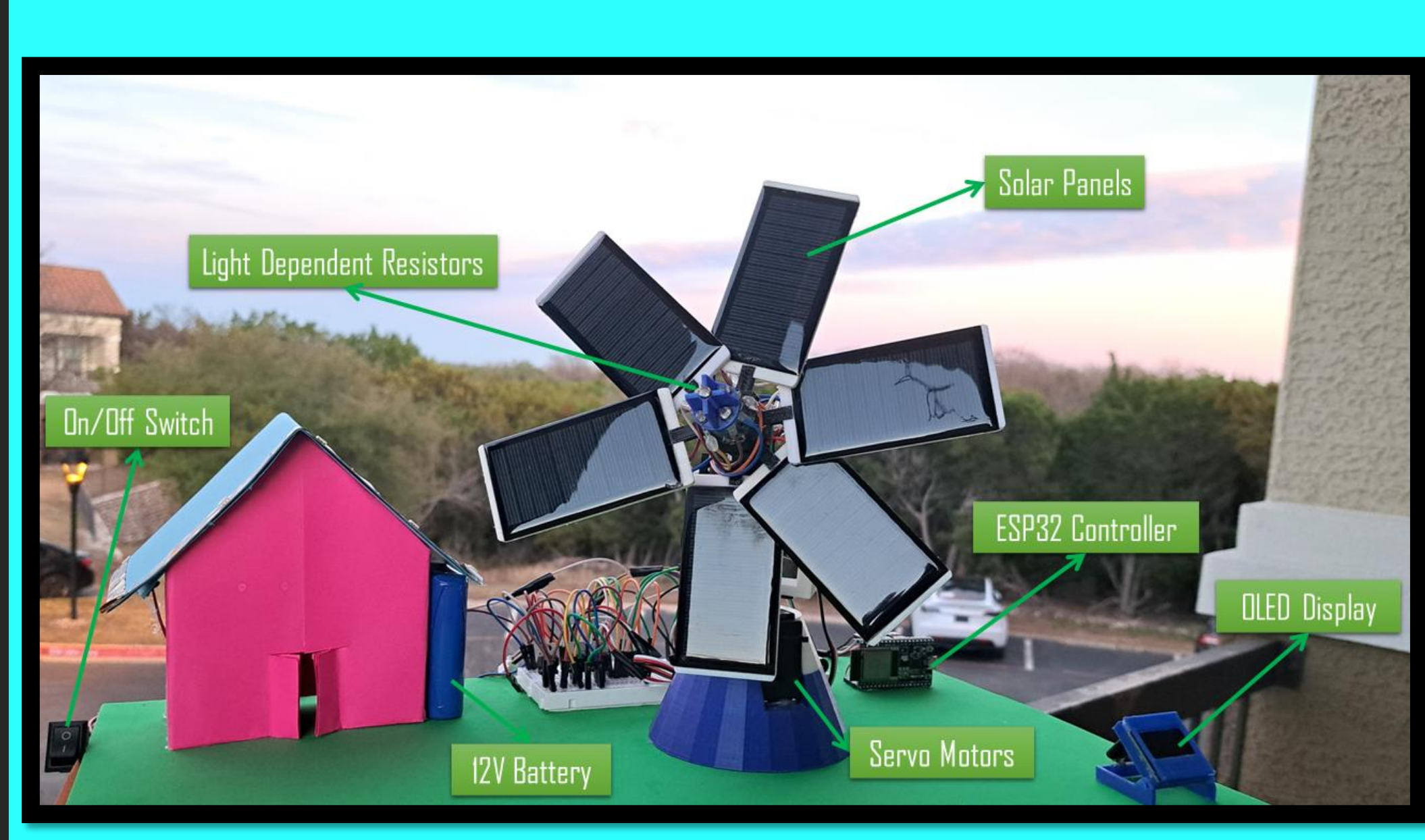


EcoTrack: Nature Inspired Phototropic Solar Tracking For Developing And Developed Nations

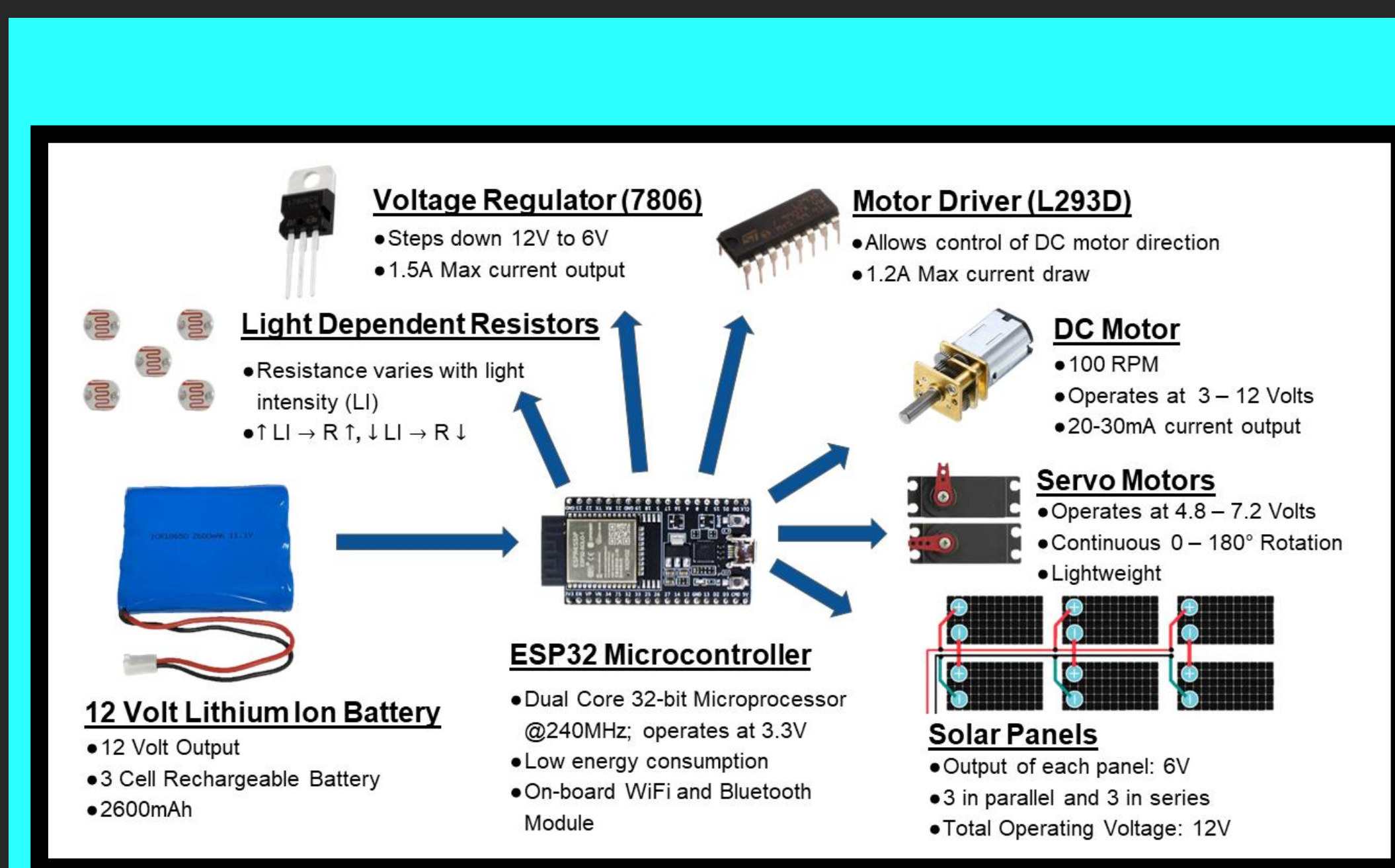
EcoTrack Solar Tracker



Traditional Tracker



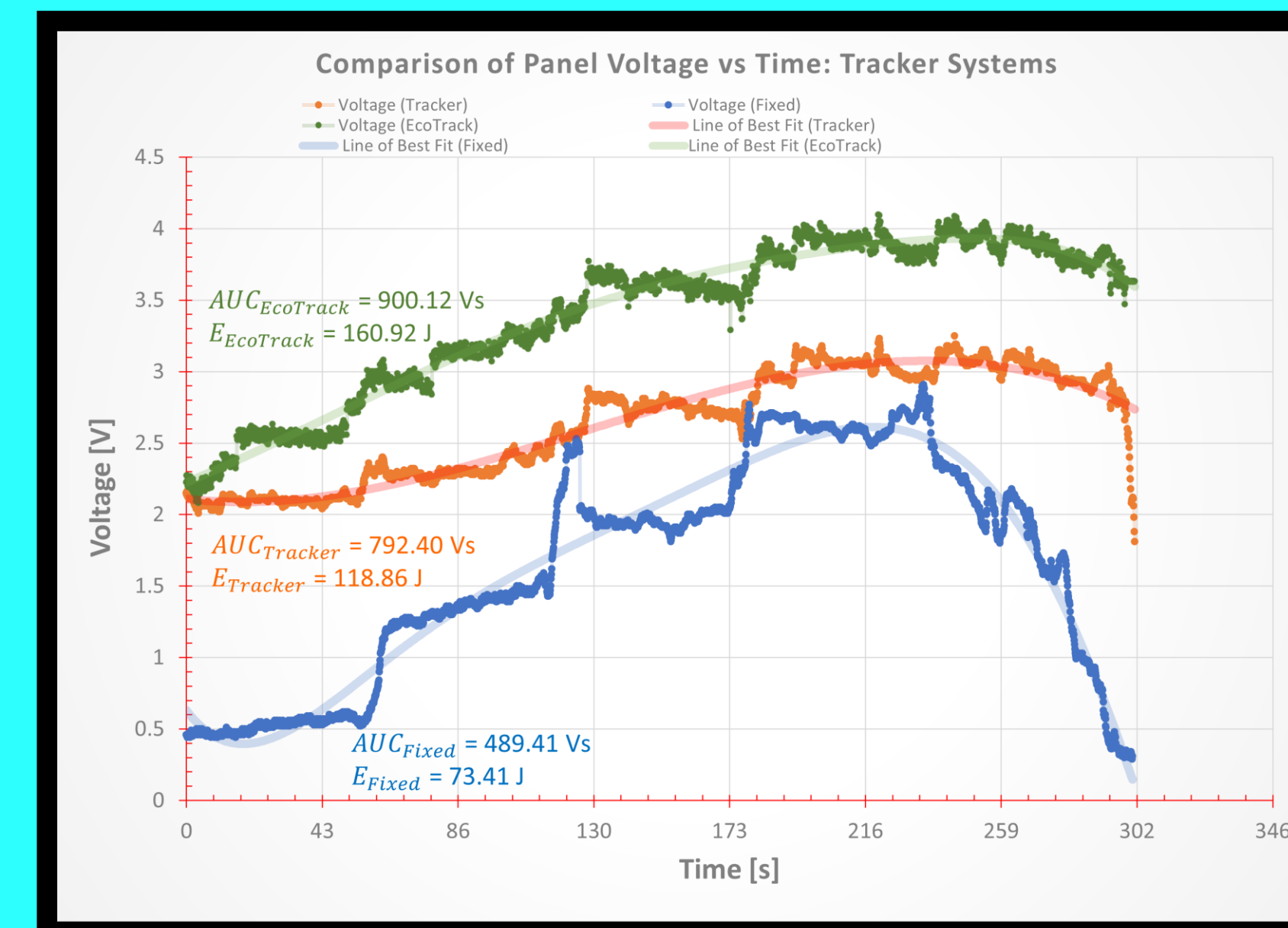
Electrical Schematic



Procedure

- Place the project board on a table and turn on the switch.
- Position a cell phone such that there is no line-of-sight to the panel system and that the distance between the cell phone and the panel system is about 0.5 m. This would be considered as the East position to mimic sunrise.
- Turn on the light on your phone and gradually move 1 step towards West at an interval of 1 minute for a total of 5 minutes. The elevation of the light should be gradually increased up to about 0.5 m at around 2.5 minutes and then decreased until the light is out of line-of-sight mimicking sunset. The light should now be turned off.
- The microcontroller data recording should now be saved.
- Conduct steps 1-4 for the fixed, dual-axis, and EcoTrack tracker (via simulation) systems and plot the recorded data for trials.

Experimental Results



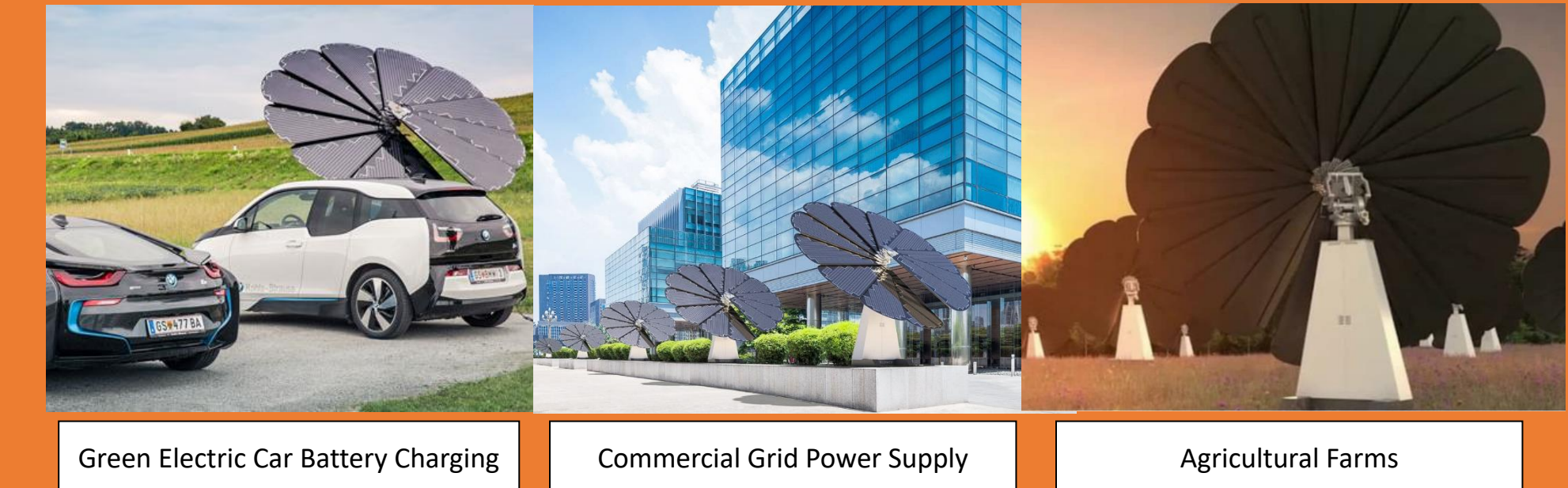
Analysis Of Results

The comparison plot shows the voltage vs time profile obtained from the fixed, dual-axis, and EcoTrack tracker systems. A line of best fit is generated to calculate the area under the curve (AUC) for all systems. Given that $E_{Harvested} = I \int_0^t V dt = I \times AUC$ and that the total current supplied by the panels is 0.15A, the energy harnessed by both systems can be obtained.

The energy lost due to added components for the dual-axis tracker must be considered. The total energy used by the microcontroller (0.040A), 2 servos (0.400A total), 1 DC motor (0.100A) is $E_{aux} = 3.3V \times 0.020A \times 300s + 6V \times 0.040A \times 50s + 12V \times 0.050A \times 2s = 33 J$. Thus, the net energy harnessed by the tracker is $118.86 J - 33 J = 85.86 J$. The EcoTrack system harnessed **87%** and **119%** more energy than the dual-axis and fixed trackers respectively given same exposure time to light.

Relevance

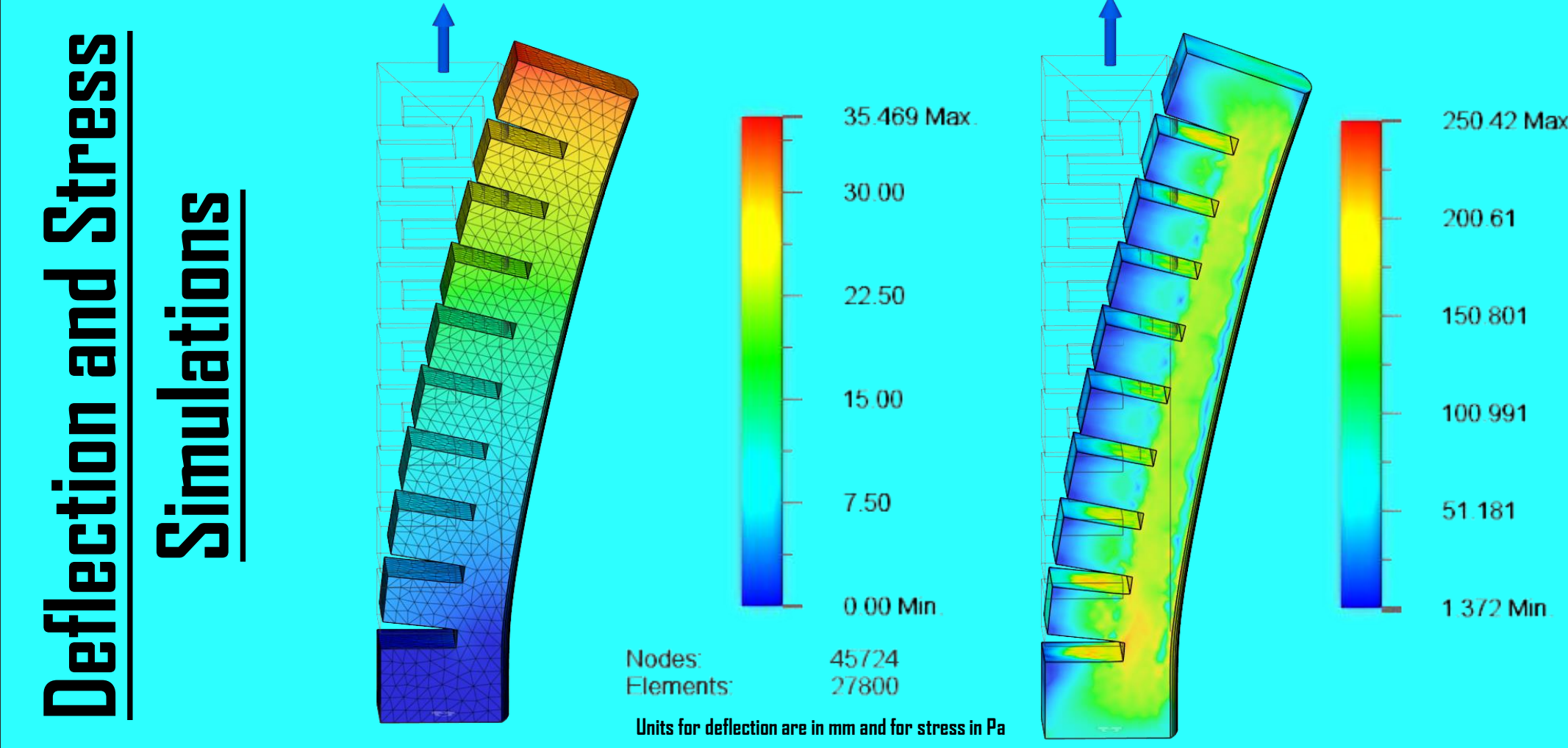
Given that phototropic solar tracking systems do not use electricity for tracking, it is viable to implement this system in developing nations where solar tracking is not an affordable option. Nature inspired solar trackers can be used as a higher energy output green source to power households and can also be used for industrial purposes.



Conclusion

Circling back to the two research questions posed for this project, the findings indicate that solar energy can be **efficiently** and **effectively** harnessed using the proposed nature inspired **phototropic** solar tracker. Additionally, the phototropic solar tracker does **not** require electricity for solar tracking. The effective increase in solar energy harnessed by this system is nearly **50%** compared to a fixed solar panel system.

Thus, the experimental results confirm the original hypothesis. The proposed solution offers a low-cost and low-maintenance solar tracking solution that can serve as a renewable and effective option for both developing and developed nations. This system, when scaled, is an ideal solution to applications ranging from electric vehicle charging, power grids, and farms.



References

Artificial phototropism for omnidirectional tracking and harvesting of light. *Nature nanotechnology*. (2019, November 4). Retrieved January 8, 2023, from <https://www.seas.ucla.edu/~pilon/Publications/NatureNano2019-OmnidirectionalTracking.pdf>

Thermo-responsive polymer. Thermo-Responsive Polymer - an overview | ScienceDirect Topics. (2023, December 10). <https://www.sciencedirect.com/topics/materials-science/thermo-responsive-polymer>

The smartflower solar panel can power your home or business. *Smartflower*. (2019, April 8). Retrieved January 8, 2023, from <https://smartflower.com/commercial/>

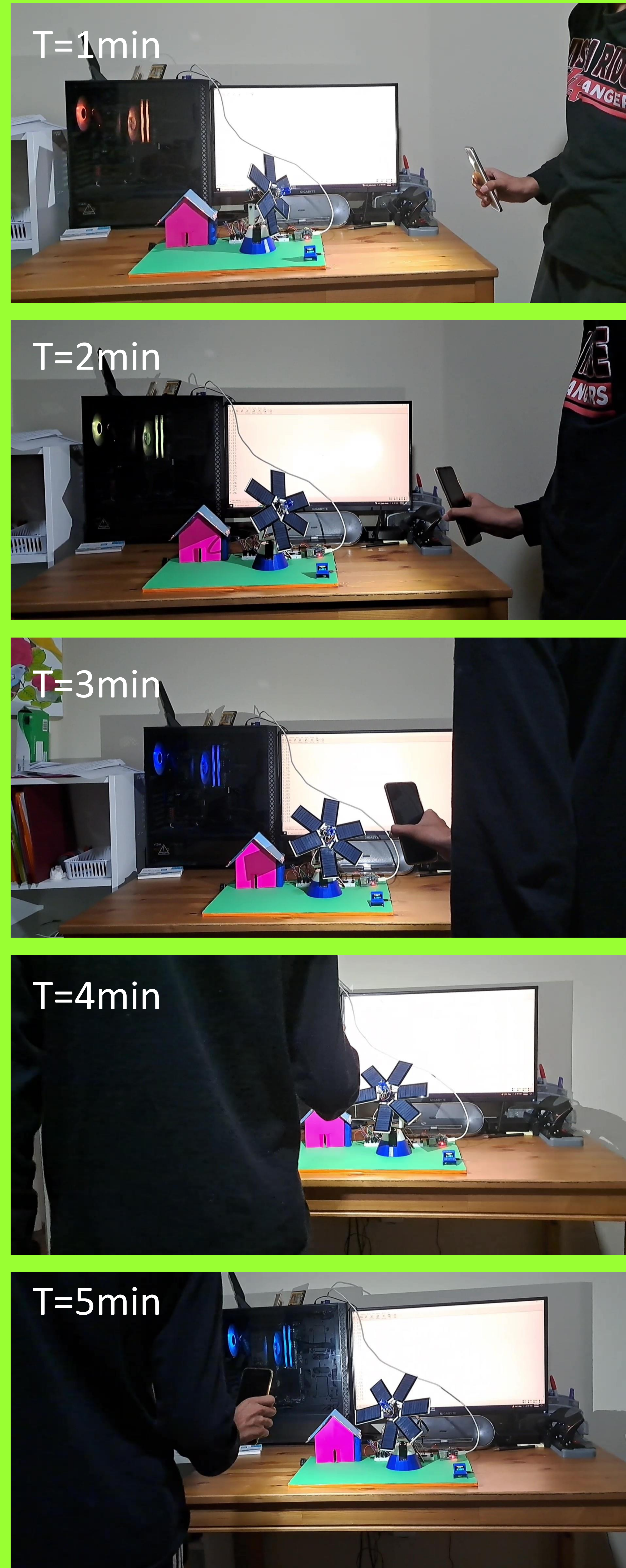
SunBOT: Solar cells that track the sun like a sunflower. *Electronics For You*. (2020, June 22). <https://www.electronicsforu.com/market-verticals/sunbot-solar-cells-track-sun-like-sunflower>

Supplementary Results

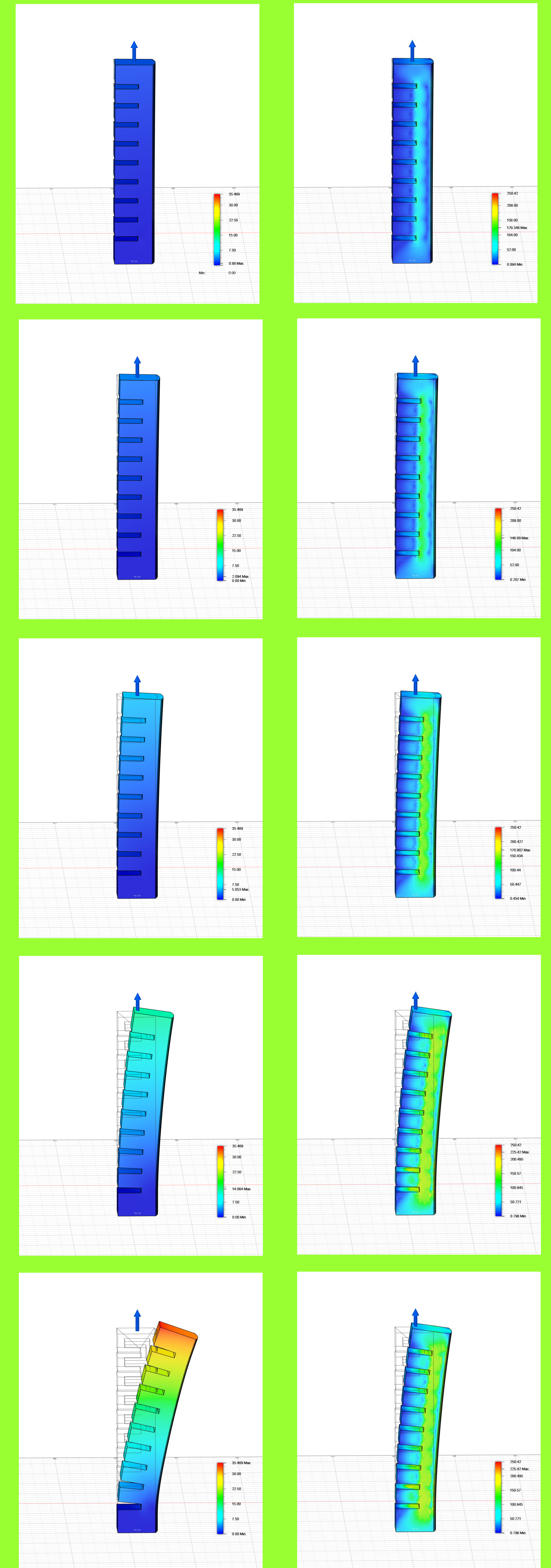
Experiment 1 – Fixed System



Experiment 2 – Dual-axis System



Deflection and Stress Simulation - EcoTrack



Approved Abstract and Form 7

Photography Acknowledgement

✓ Unless otherwise noted, all photos, tables and other graphics were created by the researcher.

Continuation/Research Progression Projects Form (7)

Required for projects that are a continuation/progression in the same field of study as a previous project. This form must be accompanied by the previous year's abstract and Research Plan/Project Summary.

Student's Name(s) Om Bhatt

To be completed by Student Researcher: List all components of the current project that make it new and different from previous research. The information must be on the form; use an additional form for previous year and earlier projects.

Components	Current Research Project	Previous Research Project: Year: 2023
1. Title	EcoTrack: A Low-Cost, Low-Maintenance, and Efficient Solution to Solar Power Production for Both Developing and Developed Nations Using Nature Inspired Phototropic Solar Tracking	Maximizing Solar Power Output Using A Dual-Axis Solar Tracker
2. Change in goal/purpose/objective	The primary change in the goal of this project is to present a solution that can be easily adopted in both developing and developed countries. The prior project lacked this versatility.	Electrical components required for tracking have been eliminated to yield a low-cost and low-maintenance solar tracking solution.
3. Changes in methodology	The implementation of thermoresponsive materials and corresponding utilization for tracking is the primary change in methodology.	Electrical components required for tracking have been eliminated to yield a low-cost and low-maintenance solar tracking solution.
4. Variable studied	Total energy harnessed by the tracker, E, in Joules.	Total energy harnessed by the tracker, E, in Joules.
5. Additional changes	Design and fabrication process.	N/A

Attached are:

Abstract and Research Plan/Project Summary, Year 2023

I hereby certify that the above information is correct and that the current year Abstract & Certification and project display board properly reflect work done only in the current year.

Om Bhatt  10/31/23
Student's Printed Name(s) Signature Date of Signature (mm/dd/yy)

Abstract: Greater Austin Regional Science and Engineering Fair

EcoTrack: A Low-Cost, Low-Maintenance, and Efficient Solution to Solar Power Production for Both Developing and Developed Nations Using Nature Inspired Phototropic Solar Tracking

Om Bhatt

Vista Ridge High School, Cedar Park, Texas, United States

Category

Choose only one

- Animal Sciences (ANIM)
- Behavioral & Social Science (BEHA)
- Biochemistry (BCHM)
- Biomed & Health Science/Biomedical Engineering (BMED)
- Cellular and Molecular Biology (CELL)
- Chemistry (CHEM)
- Earth and Environmental Sciences (EAEV)
- Embedded Systems (EBED)
- Energy: Sustainable Materials and Design (EGSD)
- Engineering Technology: Statics and Dynamics (ETSD)
- Environmental Engineering (ENEV)
- Materials Science (MATS)
- Mathematics (MATH)
- Microbiology (MCRO)
- Physics and Astronomy (PHYS)
- Plant Sciences (PLNT)
- Systems Software (SOFT)
- Translational Medical Sciences (aka Disease Studies) (TMED)

Solar tracking solutions have become increasingly popular and have been widely adopted. However, given that tracking traditionally depends on electrical components, it is a cost-ineffective and high-maintenance option for developing nations. Hence, efficient solar tracking without the use of electricity is essential for the viability of this technology. Thus, the two primary research questions for this project are: 1) How can solar energy be harnessed efficiently and effectively without the use of electricity? and 2) What is the effective increase in energy harnessed by such a solar tracker compared to traditional trackers? In this work, EcoTrack, a nature inspired phototropic solar tracker system that does not use electricity for tracking is proposed. Given that EcoTrack can track light at all times, it is expected that it will yield at least 50% increase in energy. A working prototype to confirm this hypothesis was developed and the experiments conducted involved the collection of voltage and current with respect to time while mimicking the daily movement of the sun. The experimental results demonstrate that the EcoTrack system harnessed 87% and 119% more energy than traditional dual-axis and fixed trackers respectively. Consequently, the proposed solution offers a superior alternative to traditional solar panel tracker systems. Moreover, it provides a low-cost and low-maintenance solution for developing nations. Such phototropic tracking systems have a significant practical relevance given that they offer a renewable and effective solution for commercial and personal use in applications such as farming, vehicle charging, and power grids.

- As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):
 - human participants
 - potentially hazardous biological agents
 - vertebrate animals
 - microorganisms
 - rDNA
 - tissue
- This abstract describes only procedures performed by me/us, reflects my/our own independent research, and represents one year's work only.
 - yes
 - no
- I/We worked or used equipment in a regulated research institution or industrial setting.
 - yes
 - no
- This project is a continuation of previous research.
 - yes
 - no
- My display board includes non-published photographs/visual depictions of humans (other than myself)
 - yes
 - no
- I/We hereby certify that the abstract and responses to the above statements are correct and properly reflect my/our own work.
 - yes
 - no

**GARSEF
APPROVAL**