Methods to Improve the Efficiency of Solar Panels

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Problem

- The methods used for Electricity generation are the leading causes of industrial air pollution in the U.S.
- In United States, 63 percent of electricity comes from burning fossil fuels, mostly coal and natural gas.
- This also creates greenhouse gases such as CO2, Methane and nitrous oxide.
- Climate change, greenhouse gasses, and CO_2 emissions have a major impact on our planet
- These factors affect humans and other species and pollute the air, land and water

Image from www.google.com

Clean Energy Sources

Windmills – Wind Energy

Solar Panels – Solar Energy

Images from www.google.com

Hydroelectric Dams – Hydroelectricity

- Renewable energy sources can be used to produce electricity with fewer environmental impacts
- Only 17% electricity comes from renewable energy sources
- There are many types of clean energy sources

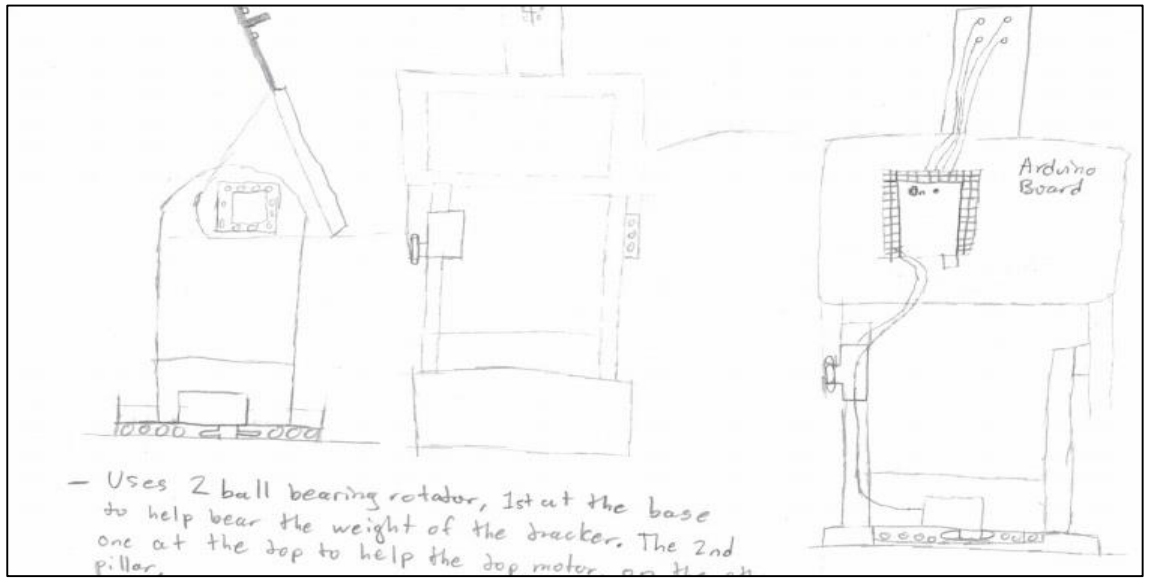
Solar Panels

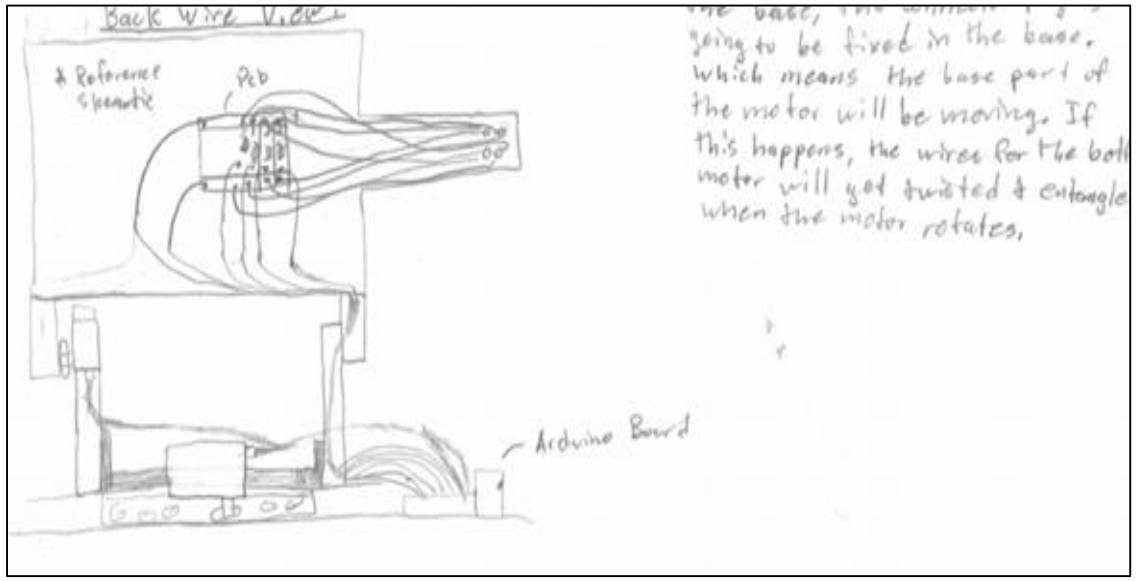
- Solar energy is one of the most sustainable, easily available clean energy sources.
- Only 1.8% of the US's energy was generated from Solar Power
- The amount of energy generated by solar panels is not consistent and depends on various factors such as temperature, location, shade, and availability of sunlight.
- Most Solar Panels are Static Panels

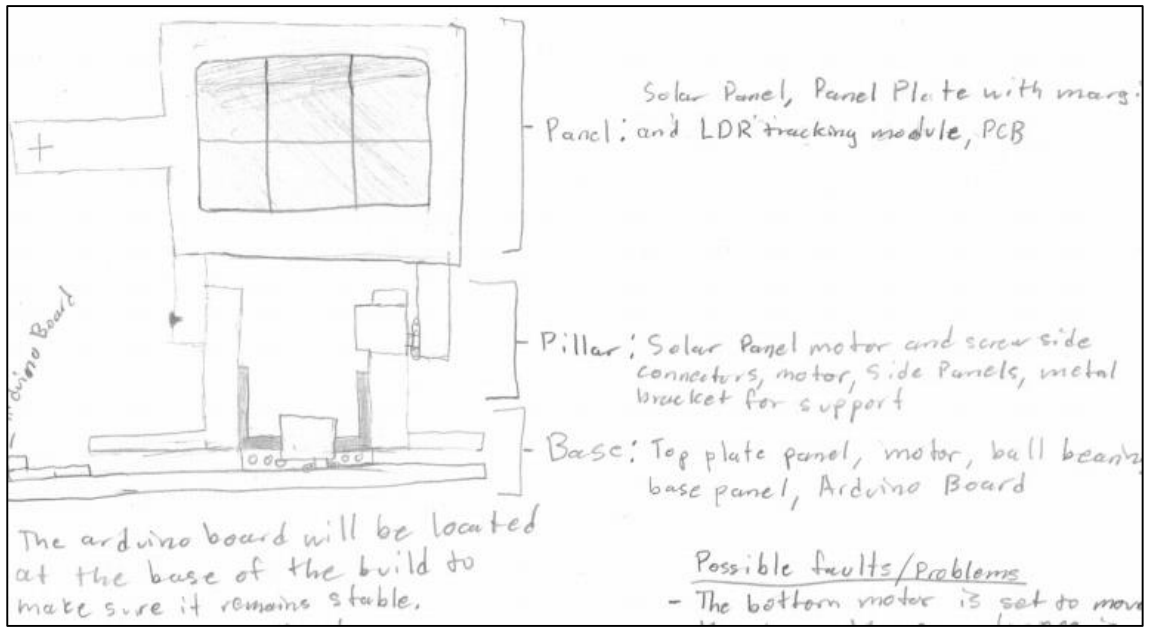
Image from www.google.com

The main goal of this project is to create multiple models and designs to enhance the power generated by a solar panel

Design Process



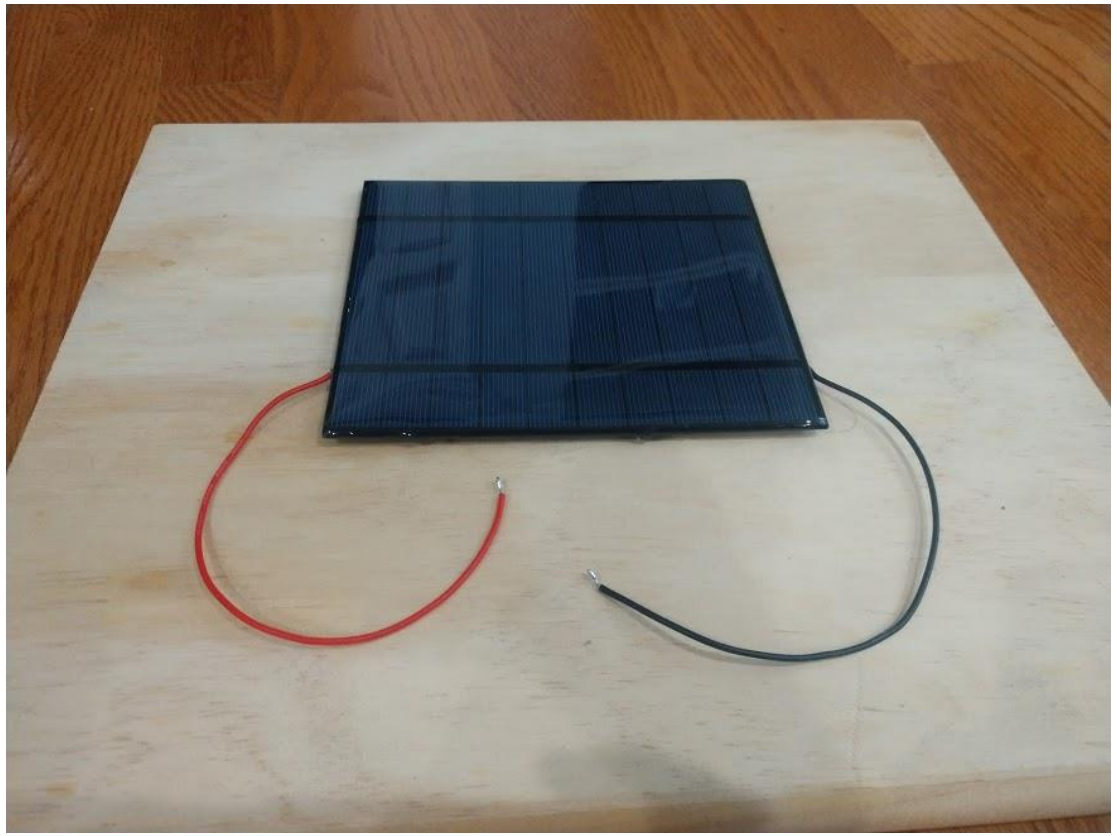




- Multiple designs were created until a final design was made
- These designs were used for brainstorming new ideas/possibilities, and solve issues with each design.

Static Solar Panel

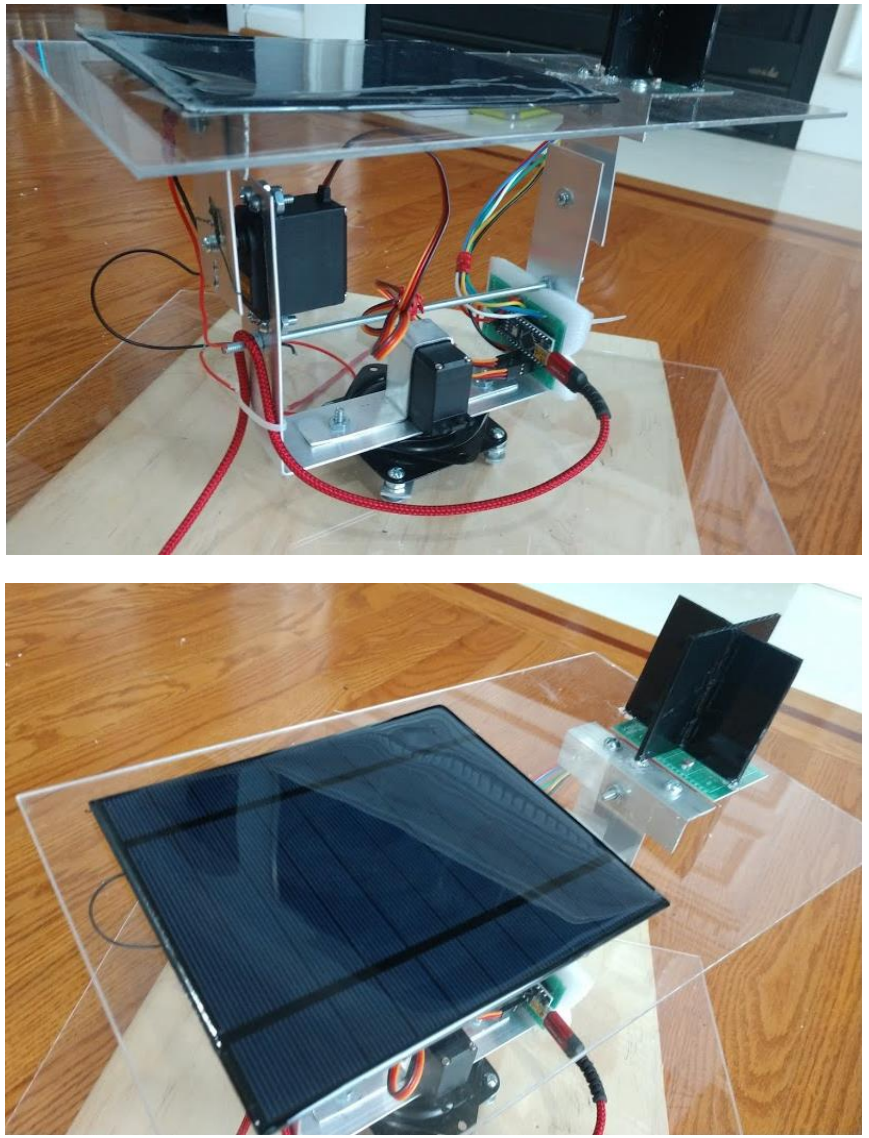
- Static solar Panel Model remains flat at a fixed position
- Acts as the control because currently many large scale solar panels are static
- Made with a Solar Panel and two wires soldered onto the terminals



Static Solar Panel Model
(Flat SP)

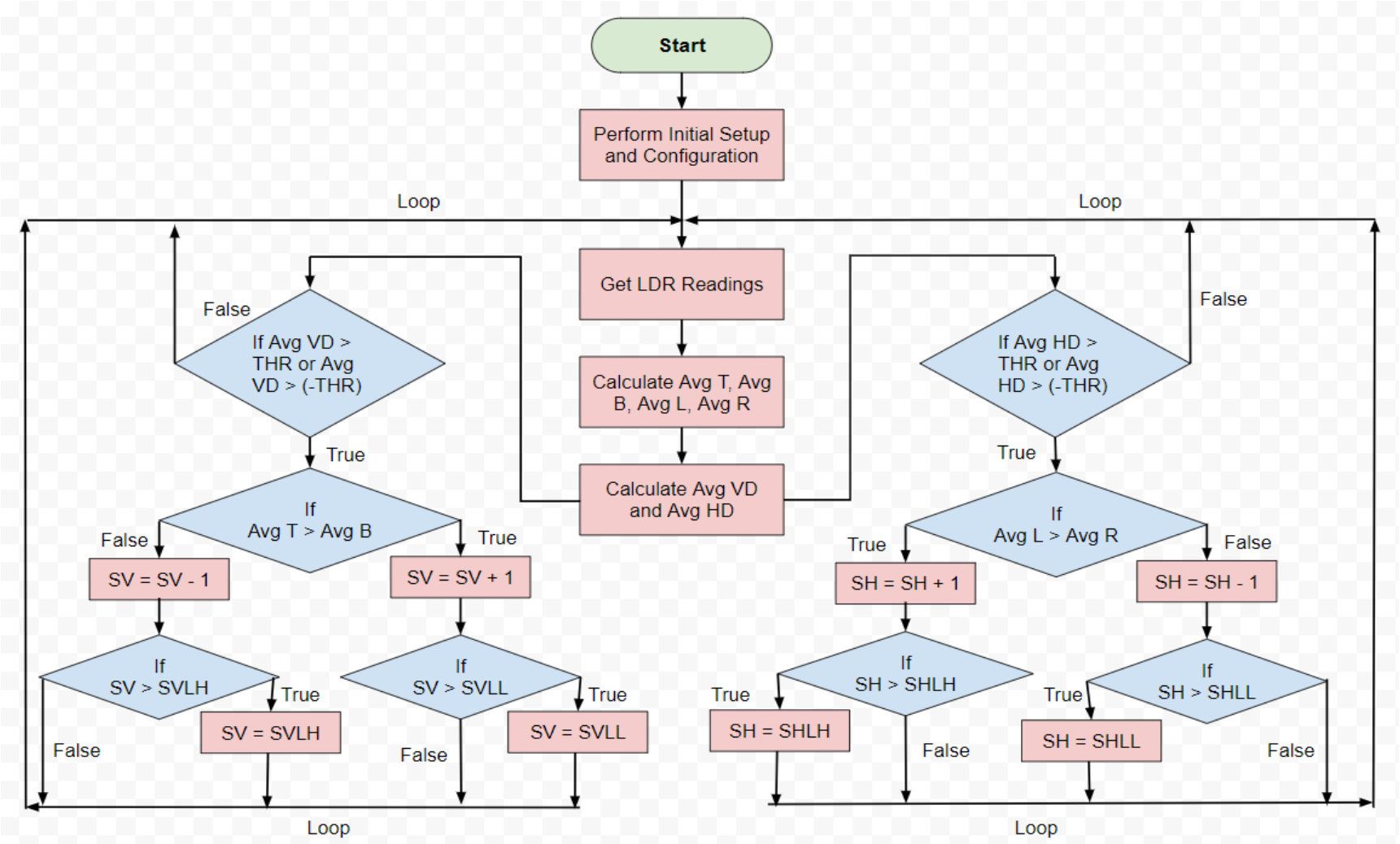
Tracking Solar Panel

- Tracking Model is dynamic and can track the moving light source
- Made with a Solar Panel, an Arduino Nano Microcontroller, LDRs(Light-Dependant-Resistor), Motors, Acrylic sheets, PCBs, and wires
- Works by the LDRs response to the light, signaling Arduino the direction of light and moving the motors accordingly
- More difficult to design and construct because it has more electronic components and multiple designs were created to brainstorm the best solution



Tracking Solar Panel Model
(Tracker SP)

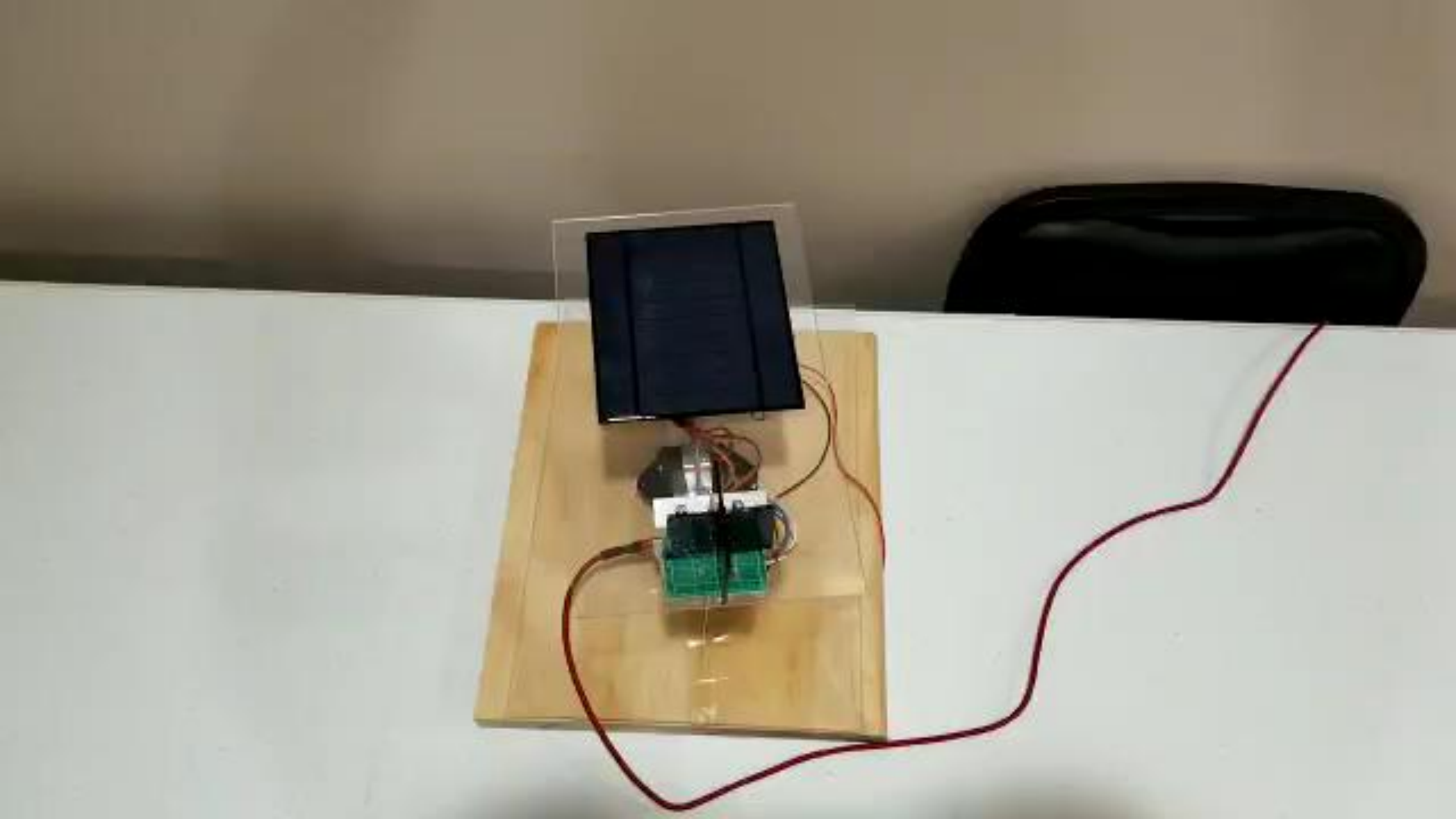
Tracking Solar Panel Flowchart Diagram



Variables and Terms:

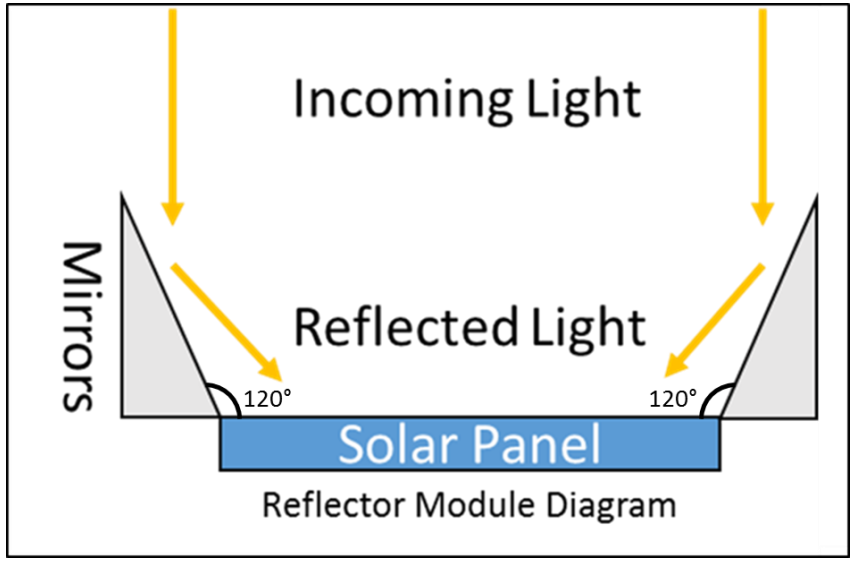
Avg - Average
T - Top
B - Bottom
L – Left
R - Right
THR - Threshold
VD - Vertical Direction
HD - Horizontal Direction
SV - Servo Vertical
SH - Servo Horizontal
SVLH – Servo Vertical Limit High
SVLL – Servo Vertical Limit Low
SHLH – Servo Horizontal Limit High
SHLH – Servo Horizontal Limit High

- The Continuous Inputs into the system are the data collected from the four LDRs
  - The Outputs from the system are the individual motor movements

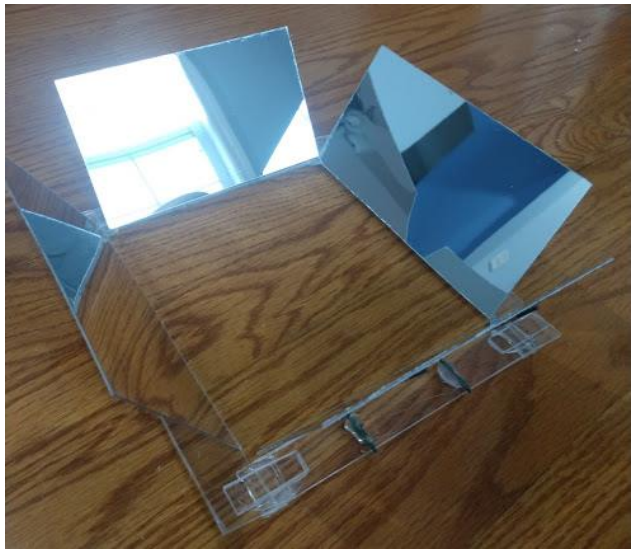


Reflector Module

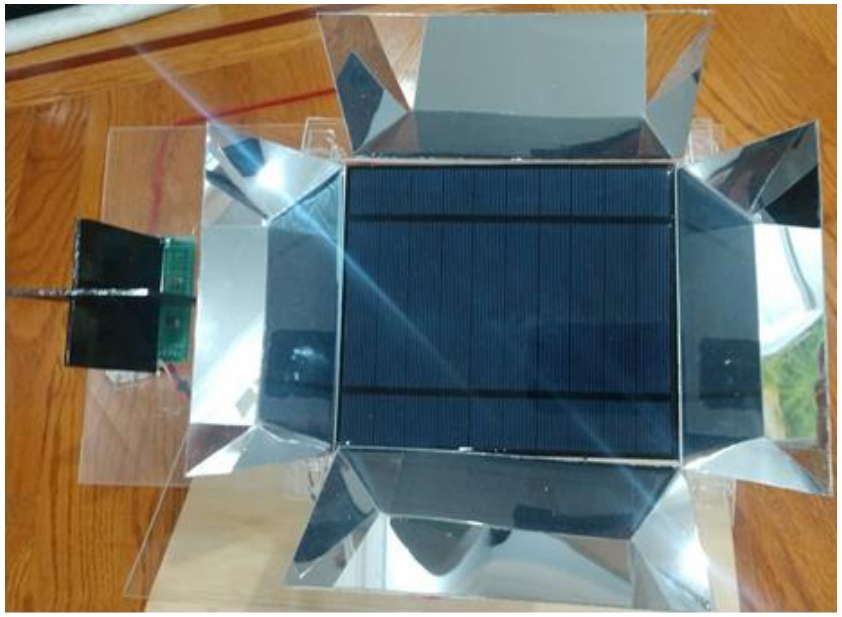
- Reflector Module is an “add-on” to the main models, and will rest on top of the solar panels
- Mirrors are set at a 120 degree angle from the solar panel to reflect more sunlight onto the solar panel from four directions
- Made with an Acrylic frame and four flexible, light-weight mirrors



Reflector Module Diagram


Reflector Module
(+ Ref)

Hypothesis

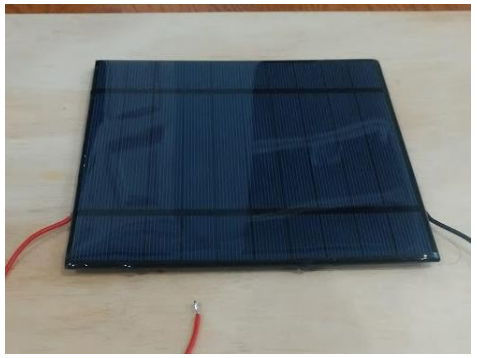


Tracking + Reflector Solar Panel Model

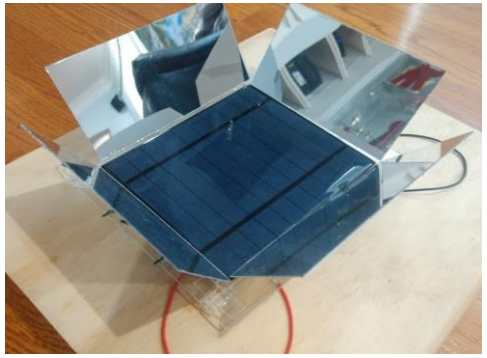
The hypothesis of my project is that the Tracking Solar Panel model with the Reflector module will generate more power than the other models.

Testing Materials and Methods

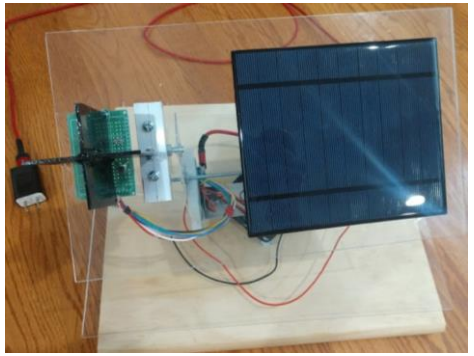
- Each Model
  - The Static Model
  - The Static Reflector Model
  - The Tracker Model
  - The Tracker Reflector Model
- A Tray to keep the models on
- A Multimeter to measure the voltage and current output
- Crocodile wires
- Pen and Paper to Record Results
- A Laptop for Programming



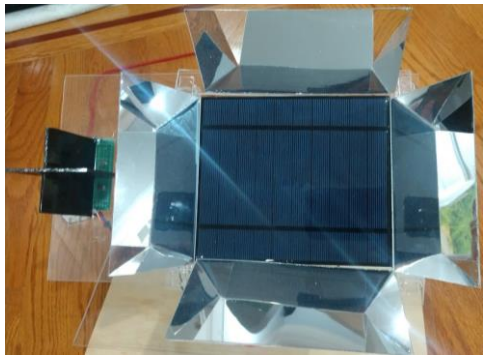
Static Solar Panel Model
(Flat SP)



Static + Reflector Solar Panel Model
(Flat SP + Ref)



Tracking Solar Panel Model
(Tracker SP)



Tracking + Reflector Solar Panel Model
(Tracker SP + Ref)

Arduino Nano

Tray

Multimeter

Pen and Paper

Laptop

Crocodile Wires

Average Voltage and Current Output Data Tables

Table 1: Voltage Readings Per Model

Time	Mode	Flat SP	Flat SP + Ref	Tracker SP	Tracker SP + Ref
9 AM	Voltage	5.81	5.59	6.00	6.11
11 AM	Voltage	5.99	5.83	6.22	6.29
1 PM	Voltage	6.05	5.99	6.19	6.35
3 PM	Voltage	6.06	5.92	6.26	6.37
5 PM	Voltage	5.56	5.39	5.76	5.87
Statistical Analysis	Mean	5.89	5.74	6.08	6.19
	Standard Deviation	0.17	0.20	0.17	0.17

All readings are in Volts (V)

(SP: Solar Panel, Ref: Reflector Module)

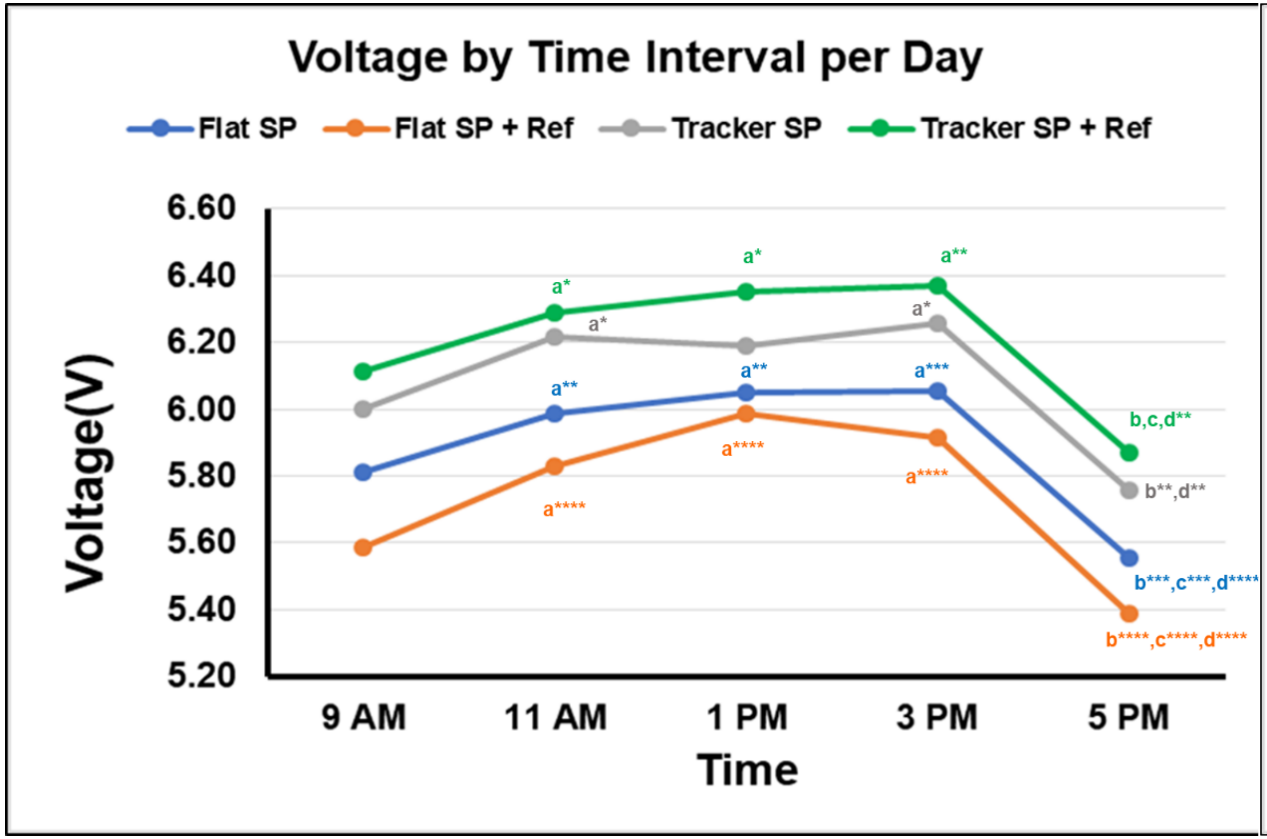
Table 2: Current Readings Per Model

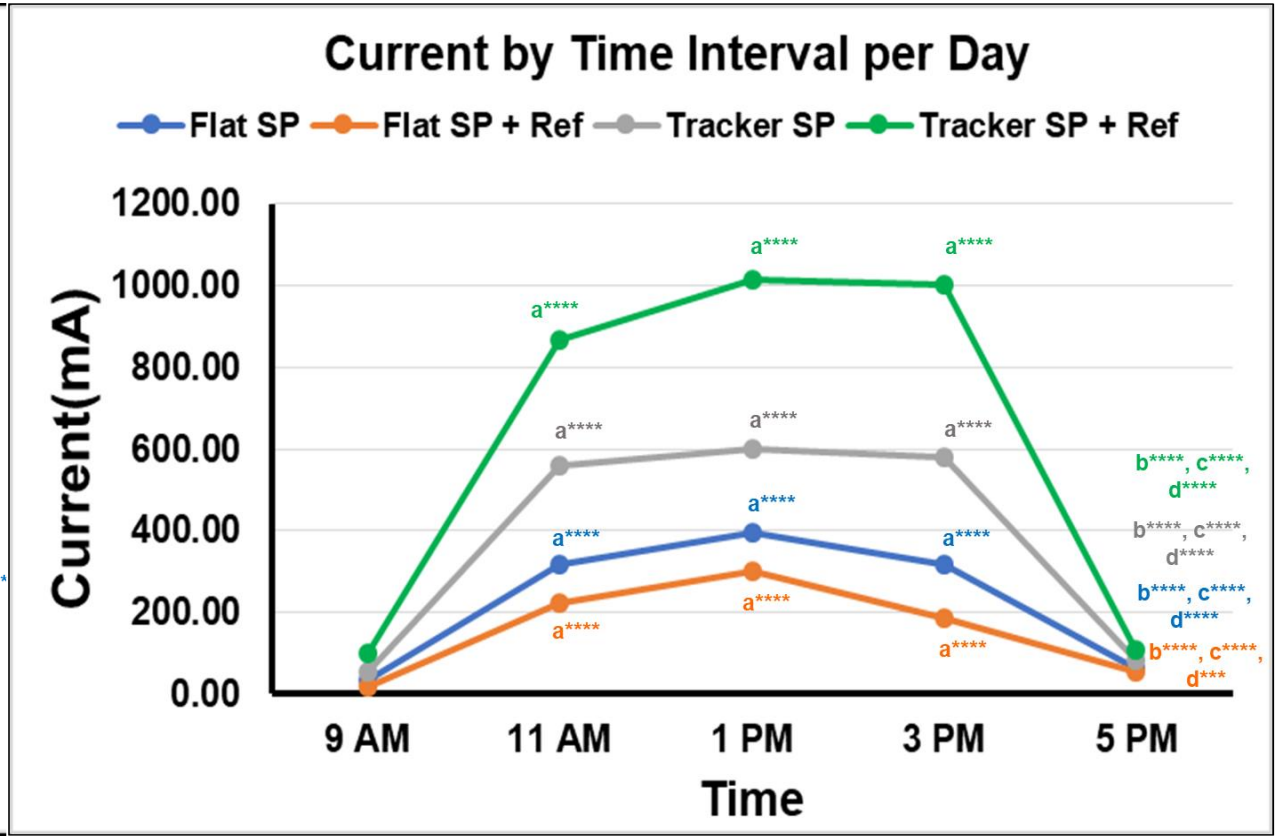
Time	Mode	Flat SP	Flat SP + Ref	Tracker SP	Tracker SP + Ref
9 AM	Current	35.58	16.85	56.43	100.82
11 AM	Current	318.33	225.00	560.00	865.00
1 PM	Current	396.67	301.67	600.00	1016.67
3 PM	Current	318.33	188.33	578.33	1001.67
5 PM	Current	62.83	53.82	82.62	109.07
Statistical Analysis	Mean	226.35	157.13	375.48	618.65
	Standard Deviation	134.82	97.32	228.46	385.93

All readings are in Milliamperes (mA)

(SP: Solar Panel, Ref: Reflector Module)

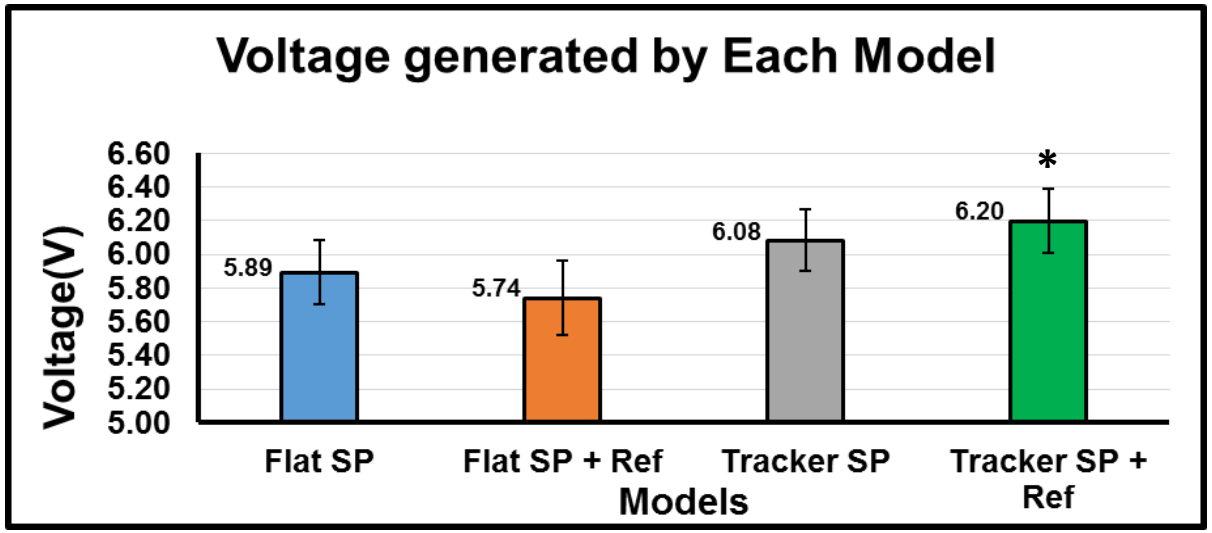
Voltage and Current Output from Solar Panel Models

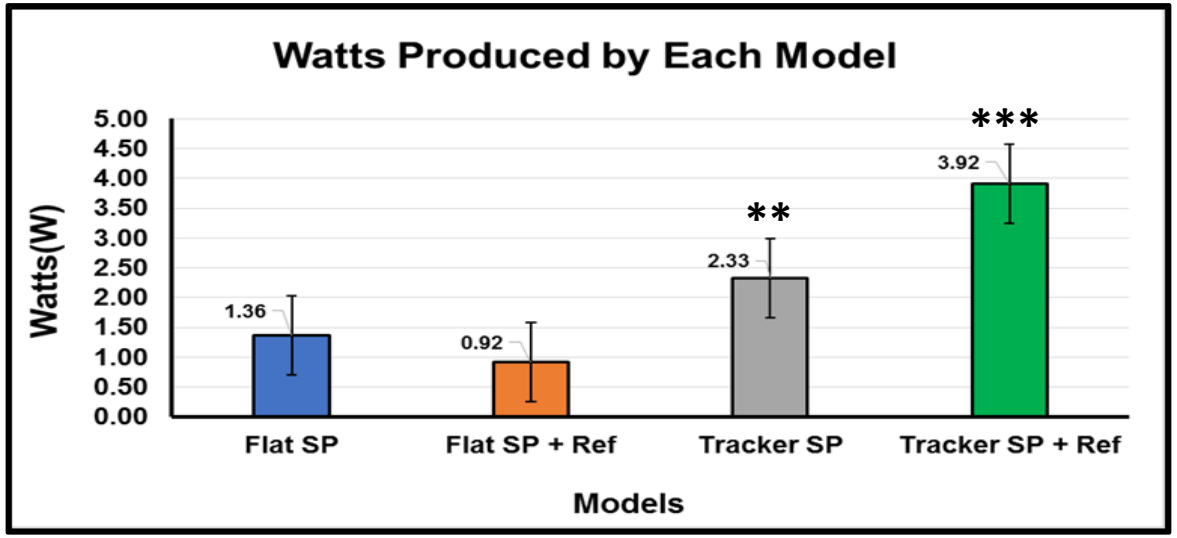


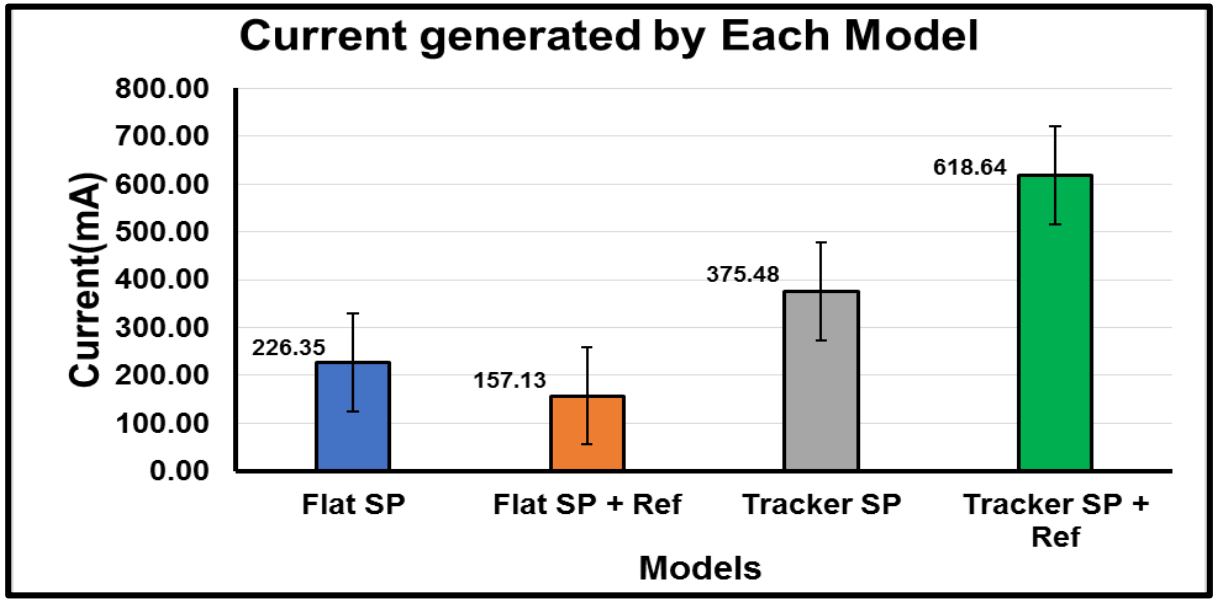


The data showed that the Tracker SP + Ref model generated more voltage and current compared to the other models at all the time points examined throughout the day.

Efficiency Comparisons between Solar Panel Models







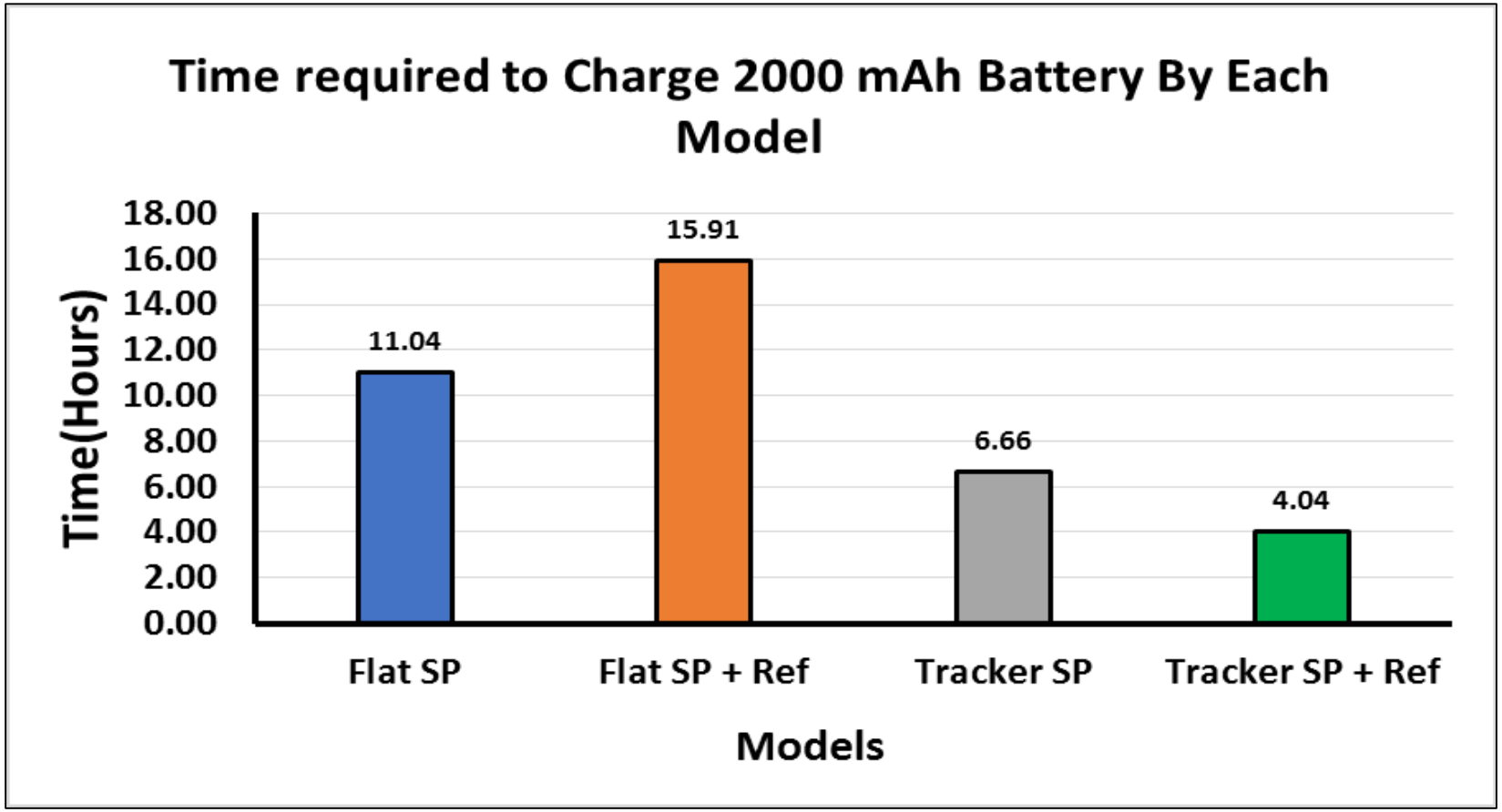
Efficiency Comparison to Static/Flat Model

% Change	Flat SP + Ref	Tracker SP	Tracker SP + Ref
Voltage	-2.54%	+3.22%	+5.26%
Current	-30.53%	+65.92%	+173.45%
Watts	-32.35%	+71.32%	+188.23%

Tracker SP model + Ref module is the most efficient Solar Panel Model

Rechargeable Battery Model Comparisons

- The Graph to the right is a practical representation of the data.
- It shows how long it would take for each model to charge one 2000 mAh rechargeable battery
- With this current, the Tracking Model + Reflector module can charge on an average, almost 3 batteries in 12 hours.



Calculation Formula at 80% Charging Efficiency: Hours to charge one battery = (2000mAh/Average Charging Current)/0.8

Conclusion

- **Overall, my hypothesis proved to be true, the Tracking Model with the Reflector module generated the maximum power output.** It generated the most amount of voltage and current output throughout all of the models.

- On an average, the Tracking Model with the Reflector module generated about 6.2 Volts and 600 mA per time interval shown by the Model Comparison graphs.

- The Tracker SP + Ref model required the least amount of time to fully charge a rechargeable battery than the other models.

Future Direction

- Currently, in this project, the Flat Solar Panel model is laying on the ground without any inclination. In order to generate more power, proper angle it needs to be identified and positioned to get more exposure to sun.

- In this project, a low power solar panel was used. If a large/heavy duty solar panel is used, along with the Tracking model + Reflector module, it would be interesting to know how much more power it could generate.

- Finding the optimum dimension and angle of the Reflector module's mirrors would generate even more power output for the Tracking model + Reflector module, hence improving efficiency.

- It would be interesting to see temperature's effect on the efficiency of these models.

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Thank You