Final Presentation

Active Solar Panels with Acoustic Energy Capture for Street Lights

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Abstract

- The focus of our project is to utilize sound and solar energy as the means to provide clean energy in an urban environment.
- This will be achieved through the implementation of attachable smart solar panels and passive speaker drivers that be affixed onto streetlights.
- Demonstrating an insightful solution and adaptability to the lack of energy production means in an urban environment.

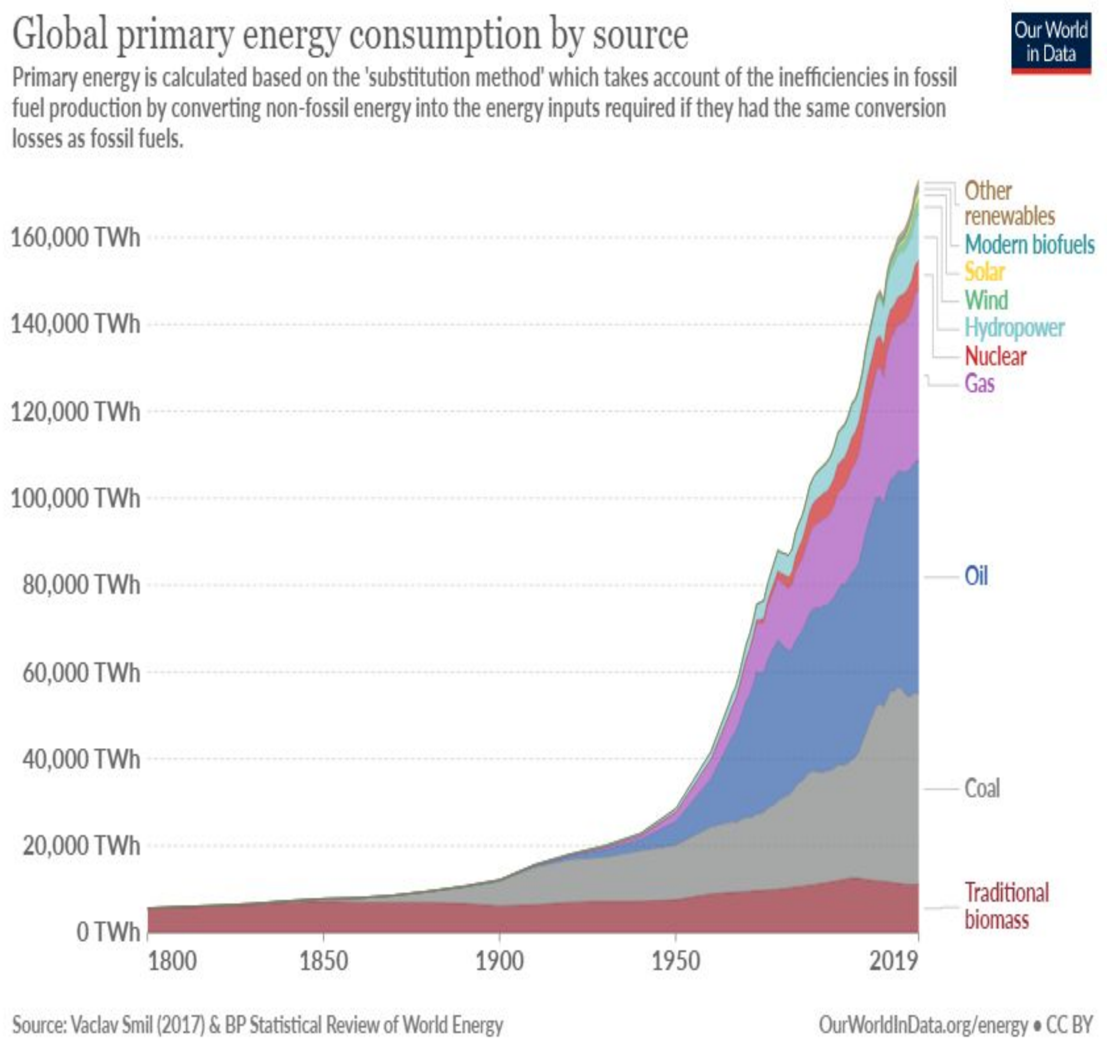
Introduction

- Energy consumption and production is a recurring topic that comes up every year. With the world population increasing at an exponential rate, the lack of energy supply and clean energy becomes a critical problem.

- As a reference, China is the country with the largest population in the world and with-it energy consumption has grown likewise.

“China’s per capita energy consumption has grown at an average annual rate of more than 4% since the launch of reform and opening in 1978”

(“World development indicators”, World Bank, 2019)

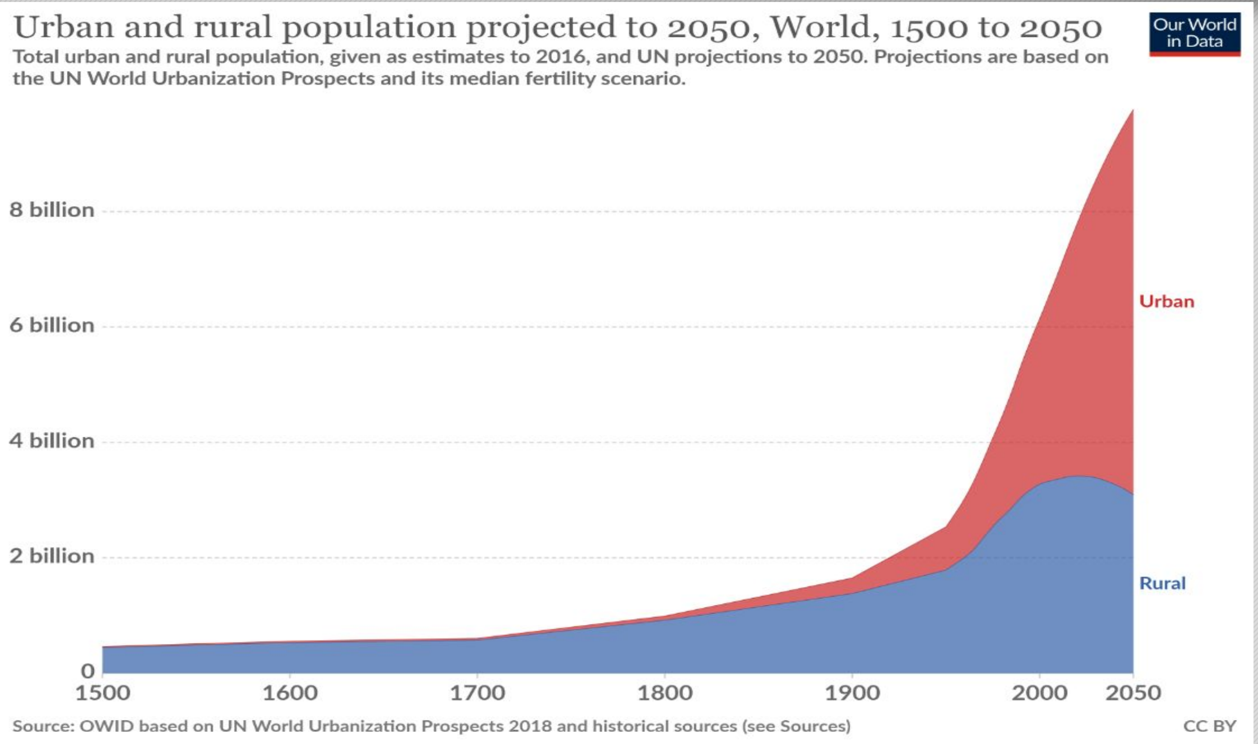


Consequently, as a result of an ever-increasing world population, social trends start to emerge as a result. One of the being urbanization.

“Urbanization is a worldwide phenomenon. The proportion of the world's population living in rural areas has fallen from two-thirds at the start of the 1960s to around 45% last year…Without exception, high-income economies have high levels of urbanization: urban living, rising energy use and rising incomes go together.”

(Urbanization and Rising Energy Consumption, John Kemp, 2019)

Continued urbanization will result in a drastic increase in per capita energy consumption in the near future



Project Goals:

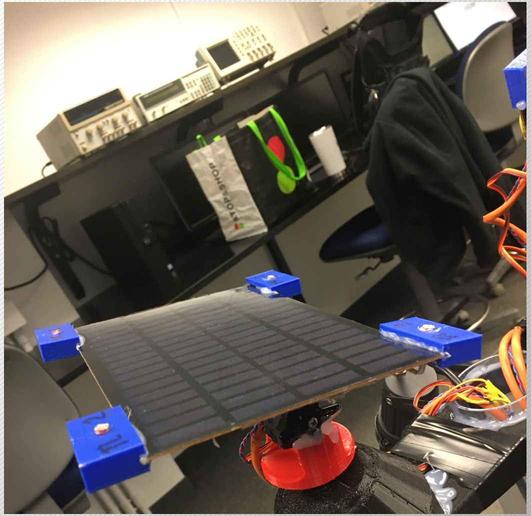
The focus of our project is to utilize sound and solar energy as the means to provide clean energy in an urban environment.

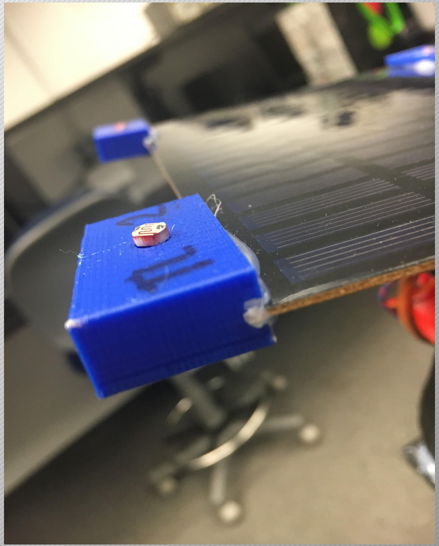
This will be achieved through the implementation of attachable smart solar panels and speaker drivers that will be affixed onto the base of the streetlights.

Initial 3D Model Prototypes

From the first versions of the 3D servo parts we had to make drastic changes to fit our needs as we started the prototype construction process. This included:

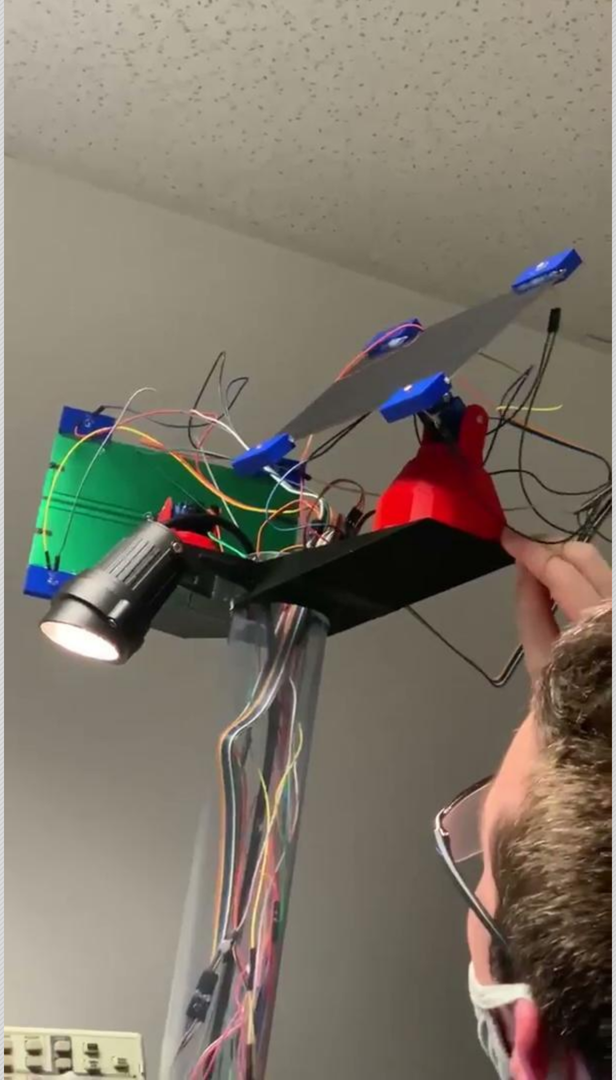
- Making the servo foundation thicker and robust to handle the weight of the other servo parts, the servo, and the solar panel.
- Making small adjustments to the servo arm allowing for the screws to fit in a easier manner.





Servo SG90 Failing Example

This video demonstrates the problems that we had with the SG90, in this case it was not handling the weight and it was not able to turn on its axis.



Initial Servo Problems

After further testing of our prototype we noticed that our initial servo of choice, the SG90, was not able to move the solar panel about its axis in a fluid manner.

We then decided to change the servo motor for the MG995 for they have a 20kg torque when compared to the SG90 with a 9g torque.

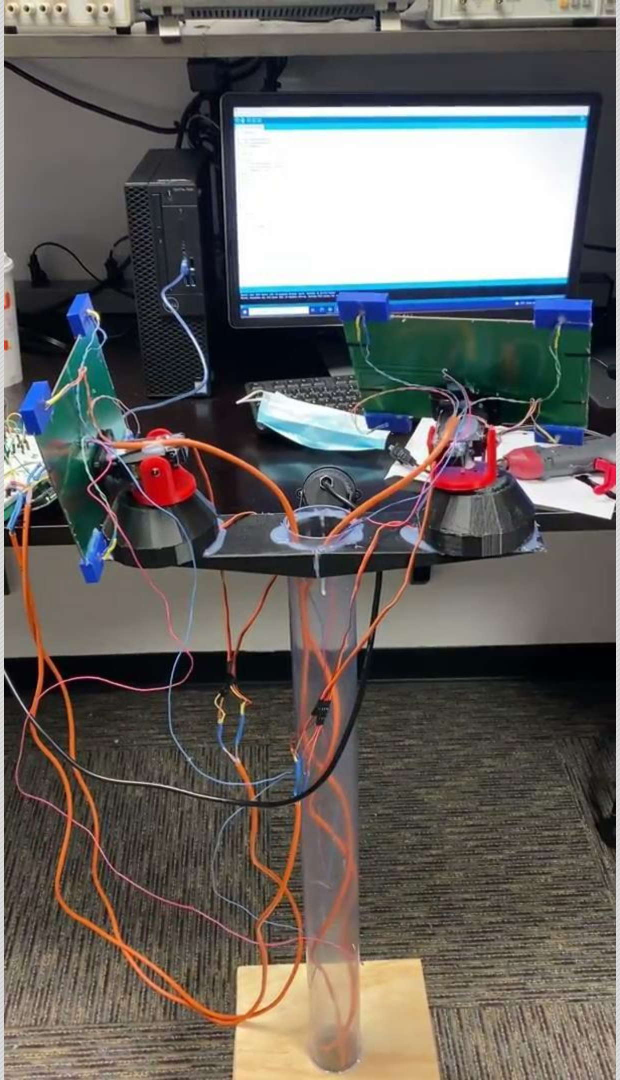
3D Servo Parts Revised

After choosing to exchange the servo with the MG995, we had to modify all servo parts except for the solar panel base support.

The following picture shows all the parts currently being used.

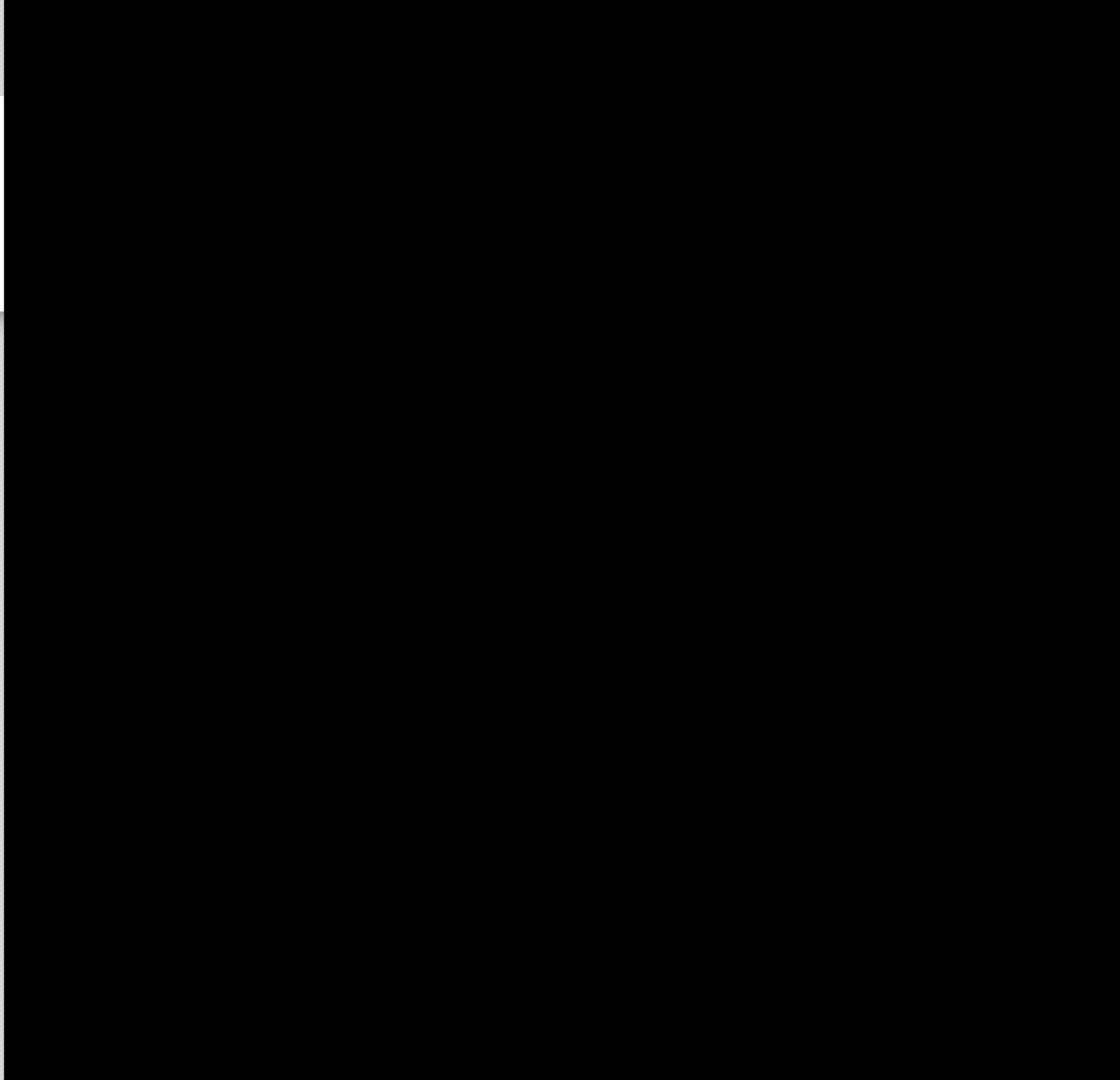
Servo Rotation with the New Servos

- This following video shows the rotation of the new servos along with 3D revised servo parts



Indoor Solar Tracking Testing

Here is a video for the testing of the solar panels indoors.



Outdoors Solar Tracking Testing

- Here is a video of the solar panels following the sun over a 10 hour interval ranging from 8:00 AM to 6:00 PM.

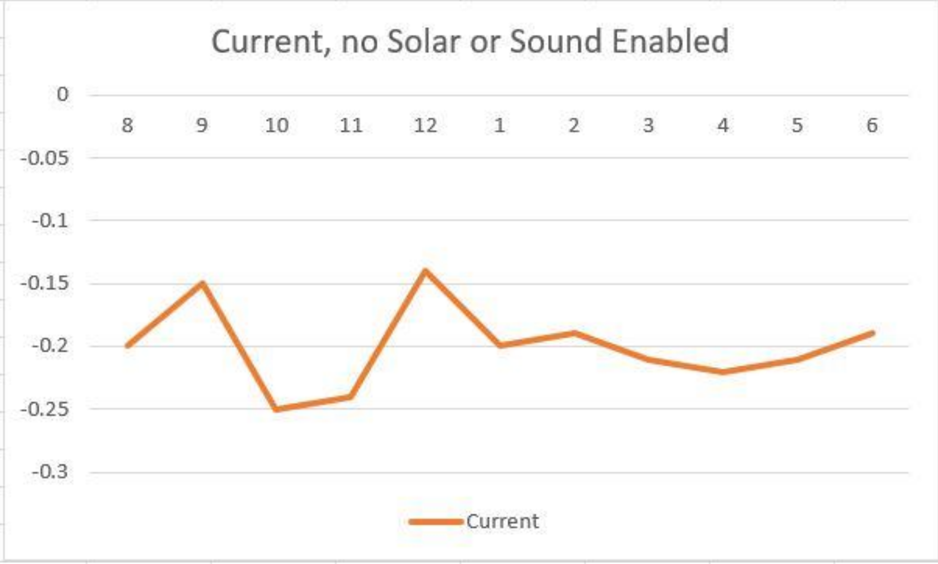
Initial Recorded Value Testing

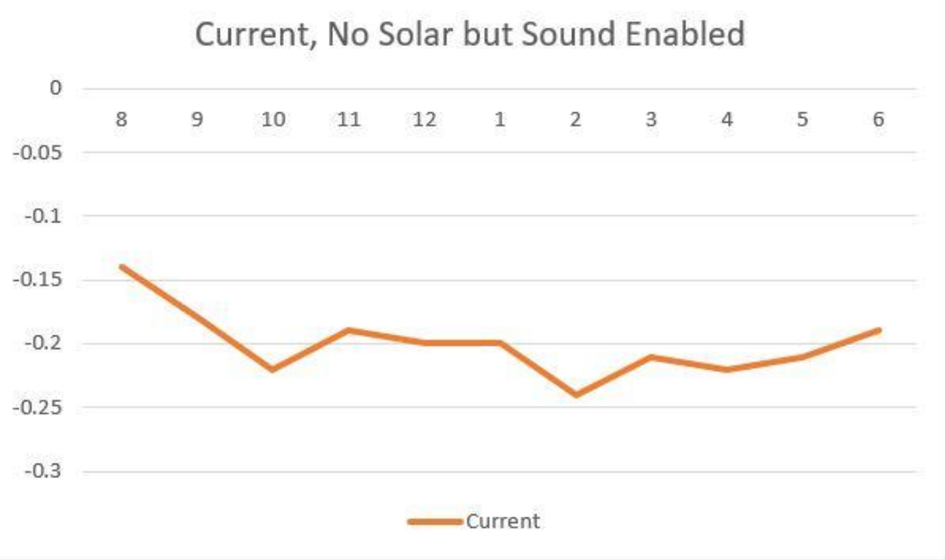
- When initially testing the solar panels we had very low wattage output that would not be able to charge the battery. Our initial calculations put the wattage at around 0.1W (100mw)
- Solar panels were rated at **2.5W** each for a total theoretical power of **5W.**
- After bringing the solar panels outside we were able to capture wattage values of 3W as expected.
- We limited the wattage of our LED with a 44 ohm resistor allowing it to only draw 1.935W. This allowed the solar panels to easily charge the system.

Test Setup

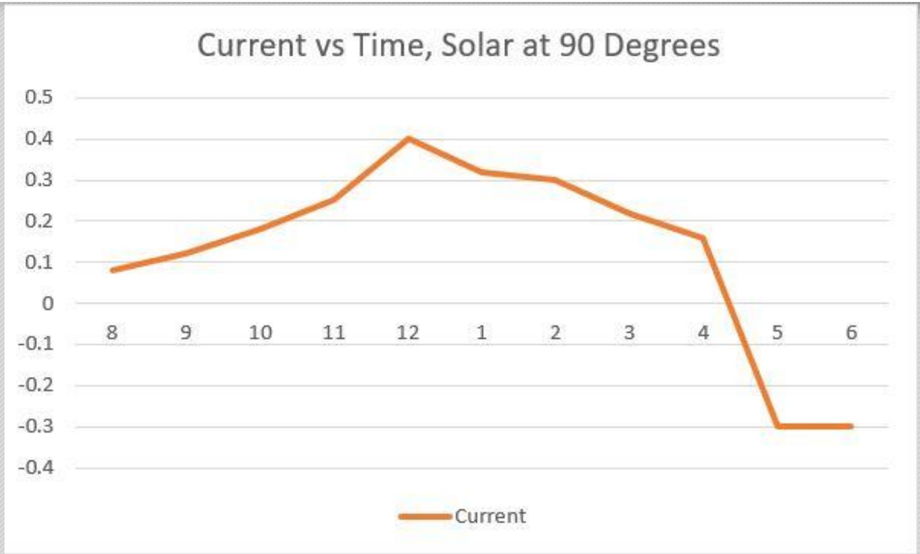
- Allowed project to track the sun throughout the day.
- We installed a multimeter to measure current from solar panels

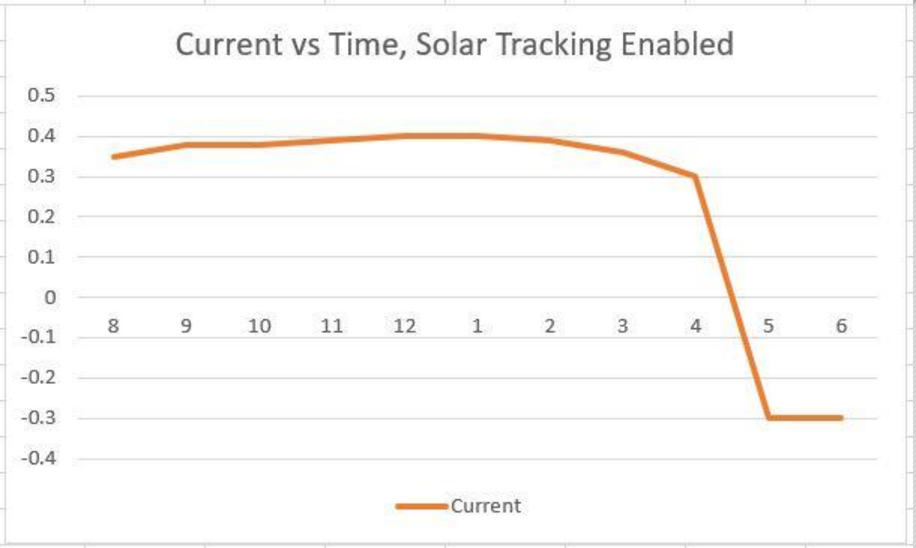
Sound Results



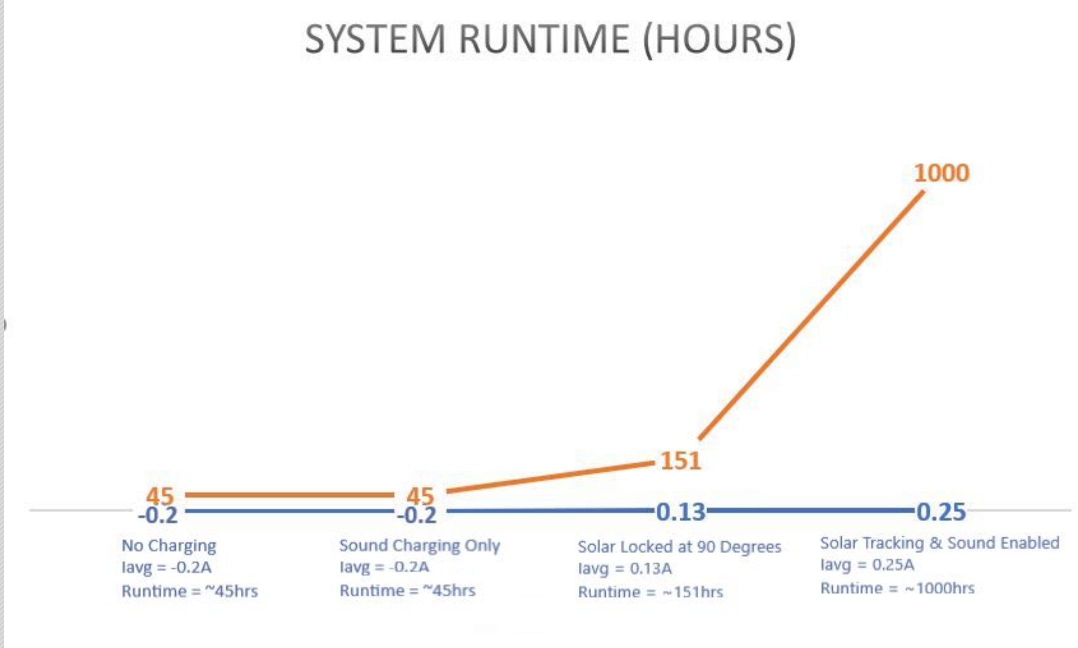


Solar Tracking Results





System Runtime Improvement with Solar Tracking



Initial Sound to Energy Testing

When we first tested the experimental concept in an ideal environment we proved that it could be viable:

- From testing a passive speaker driver in a closed environment taking a sin wave at a low frequency as the input we were **measuring an average of 500mv (0.3472mA).**

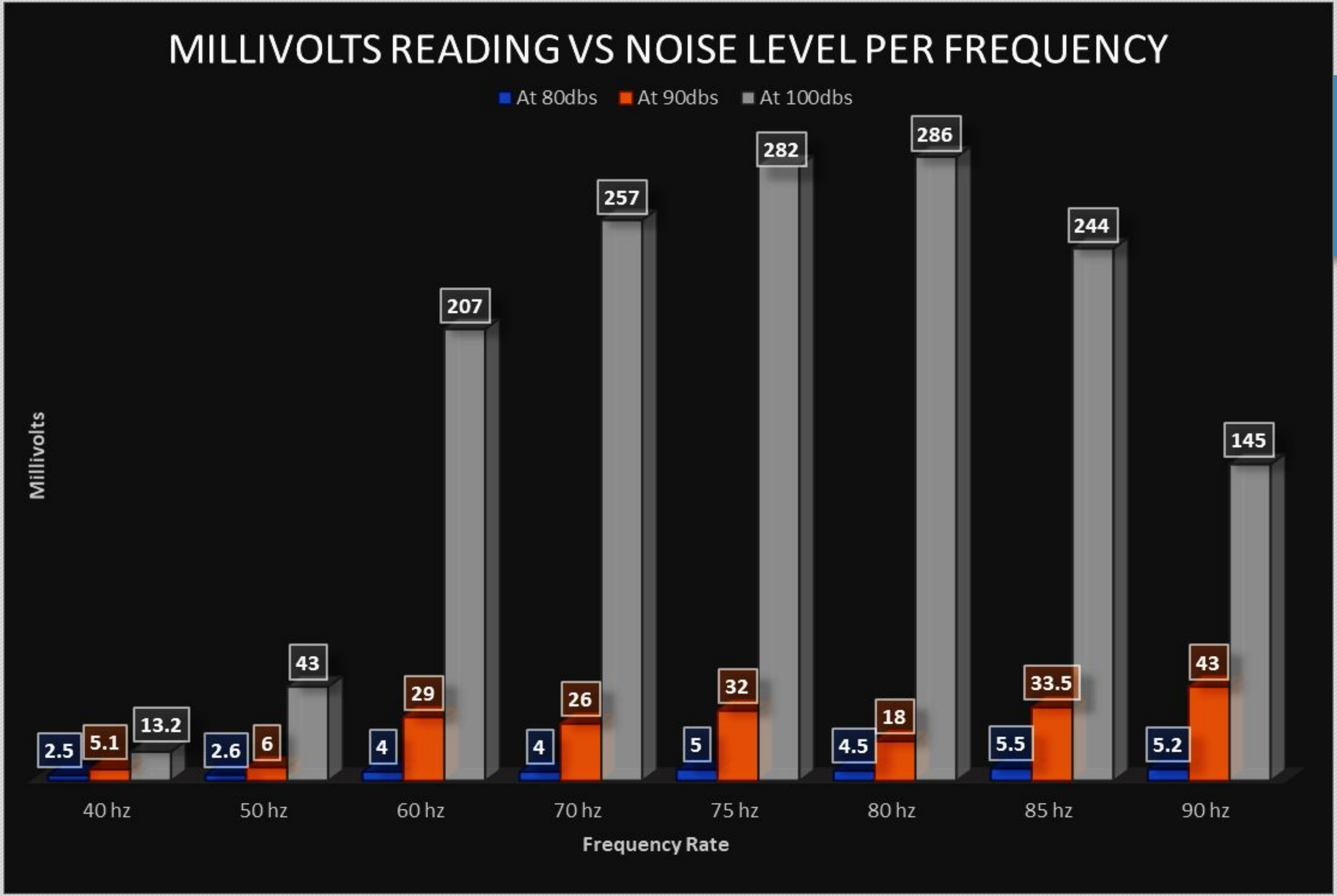
Then we continued testing utilizing traffic noise as input

Live Sound Testing

From our practical testing we saw that the values were within the range of **15-25mv (1.736uA!)**, way lower than the tested value of **500 mv (0.3472mA)**

We came to the conclusion that sound to energy output strongly relies on **two parameters:**

- **The proximity to the sound source, allowing for greater db levels to be transduced by the speaker**
- **Dependency to low-frequency noise.**


MILLIVOLTS READING VS NOISE LEVEL PER FREQUENCY
At 80dbs
At 90dbs
At 100dbs
Millivolts
2.5
5.1
13.2
2.6
6
43
4
29
207
4
26
257
5
32
282
4.5
18
286
5.5
33.5
244
5.2
43
145
40 hz
50 hz
60 hz
70 hz
75 hz
80 hz
85 hz
90 hz
Frequency Rate

Future Optimal Sound Applications

Through testing we were able to observe that voltage output relies on noise level and low-frequency noise.

One possible application optimizing the output could be placing at **train tunnels**, where it would produce greater noise level due to the **closed environment**

Challenges we Encountered

- Solar tracking algorithm from our simulations in EENG 489 did not work in the real world prototype in EENG 491.
- PCB Design from EENG 489 did not have resistor divider networks to protect the Arduino from 12V values.
- 3D Parts from EENG 489 used servos that were too small to move the solar panels. We had to reprint the parts for stronger servos.
- Piezoelectric elements from key papers did not perform as well as speaker driver.

Future plans and goals

- Research more efficient speaker drivers with increased budget.

- Research sound to energy conversion in louder environment such as airport or subway.

Conclusion

- Solar tracking method significantly improved system runtime. We found the runtime increased by 6.6x when compared to having static solar panels.
- Sound to energy conversion did not work as well as we were led to believe in key papers.
- Sound in normal environments was 75-80dB and made no improvement on system runtime.
- Possibly a louder environment such as a subway station or airport would yield better results.

Acknowledgments

- We would like to express our gratitude to Professor Ilyas who helped guide us throughout the entire project

- We would also give thanks to Professor Fanning who helped us with the 3D printing

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Questions?