Harnessing the Power of the Ocean: A Portable, Efficient, and Coastal Wave Energy Converter

Isabel Sperandio[1], Robert Cormia[2]
[1]Gunn High School, [2]Foothill College

INTRODUCTION

One of the main problems in the world today is the lack of clean energy. Most ways we obtain our energy are either extremely harmful to the environment, or very inefficient. Also, hurricanes, fires, and other natural disasters have left people homeless and without electricity. Hurricane Harvey caused more than 10,000 megawatts of forced outage (Lee).

There are a few main types of clean energy, such as solar and wind. These are all fairly well developed. However, there is a seemingly endless source of power that is not commonly used: ocean waves. Scientist predict that just the west coast of the US has around 250 TWh/year of energy, which could power 93,850 homes (BOEM).

ENGINEERING GOAL AND CRITERIA

To design a wave energy converter for people who suffered from natural disasters and/or do not have access to electricity that is:

Coastal - can be used without a boat

Efficient - converts the linear motion of waves into usable rotational motion

Portable - can be easily moved around

Usable - easily set up, installed & used without many instructions

Waterproof - protects the electronics

BUILDING PROCESS AND MATERIALS

1. CAD Model - Designed the prototype in solidworks CAD (computer aided design) to help determine dimensions and plan out each part.

2. Structural Chassis - Built the chassis using wood & screws. At first, it was unstable, so I added diagonals to increase rigidity. I painted 2 coats of polyurethane wood finish to protect it from ocean water.

3. Wheel and Axle - Drilled a hole for the axle in the wheel, using an interference fit, and in the chassis with a clearance fit. I added clay epoxy between wheel and axle to fix them together.

4. Water Angler - Used acrylic plastic sheet to direct water below the axle and used wood as a frame to hold it up.

5. Alternator - Generates electricity when spun forwards and backwards. Output: 3-phase AC. Used a Bridge Rectifier to convert to DC.

6. Axle - Alternator adapter - Used a block of wood with large hole for axle, with precise holes for bolts going into the alternator adapter. Used horizontal screws that went across the block and axle to fix it in place.

7. Alternator Support - Added alternator support, a thick metal plate with four holes for large bolts.

8. Alternator waterproofing - Used a rotary shaft seal to waterproof the rotating alternator. Glued it into metal plate. Sandwiched a waterproof box between the metal plate and alternator, and silicone caulk around washers, gaps, and holes in order to seal them.

9. Alternator frame - Attached wood that spanned across the chassis to posts, with large wood screws connecting to the metal plate. It was difficult to line up and had to be very strong.

10. Electrical Wiring - Soldered output wires to a long extension cord, attaching to the rectifier. Made a circuit with a volt sensor in parallel, an amp sensor in series, and resistor (car headlight).

CAD MODELS, PICTURES, AND DATA

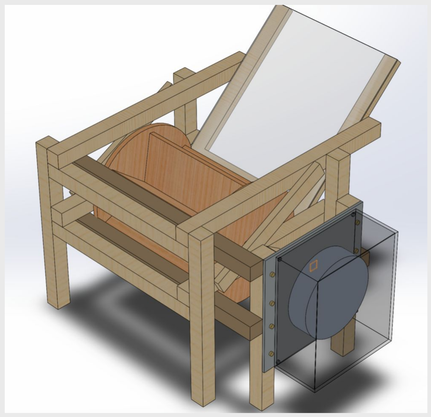

Fig. 1 - Isometric View CAD

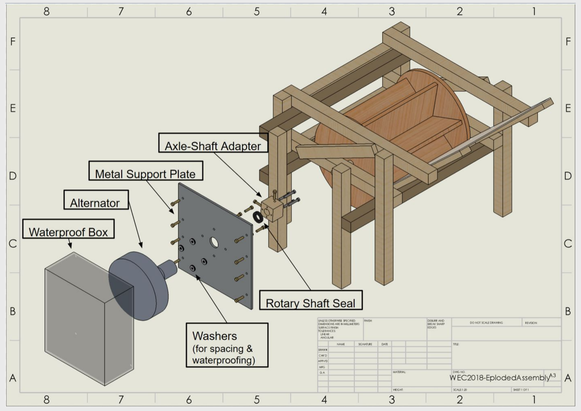

Fig. 2 - Waterproofing - labeled exploded view

Fig. 3 - setup for testing at Pescadero beach

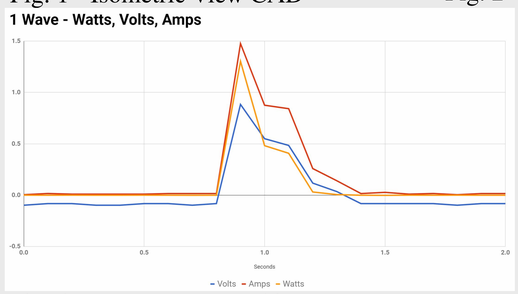

Fig. 4 - Energy generated in a wave

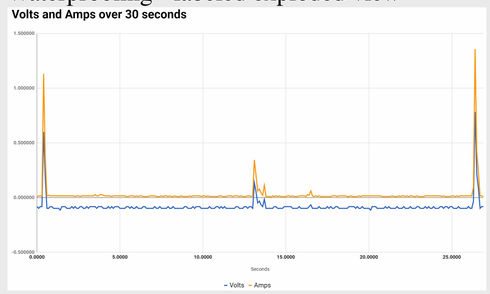

Fig. 5 - Energy generated over 30 seconds

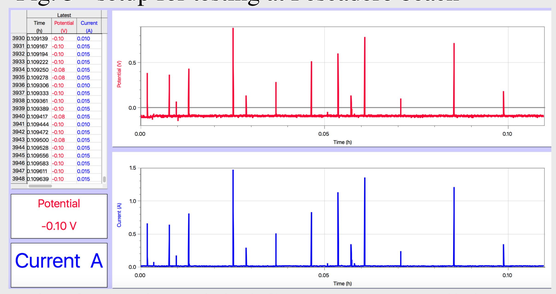

Fig. 6 - Analog-Digital Converter setup, all data

PRE-EXPERIMENTATION

- Before I did my final data collection, I did many pretests. The main ones are:
  - 1 - Half Moon Bay: testing interaction of waves and sand with objects
  - 2 - Dumbarton Bridge: testing concept with only chassis and wheel
  - 3 - Home: waterproofing test by dumping water on the prototype
  - 4 - Home: measuring devices test by building & troubleshooting the circuit

TESTING AND METHODOLOGIES

- I measured volts and amps, multiplying to watts.
- I went to Pescadero Beach when the tide was low (1 ft).
- I placed the prototype so that most waves were about 3/4 the height. It was connected to the electronics and measuring tools about 20 ft away.
- Cement blocks weighed down the frame. 4 minutes in, a huge wave pushed it over. The power cord kept it in place, and the water angler broke.
- I collected data for 6 minutes with 5 measurements per second, getting a total of 4,000 data points.

ACKNOWLEDGEMENTS / REFERENCES

Special thanks to Brad Booth, Robert Cormia, and Tarn Wilson for helping make this project possible.

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DATA ANALYSIS

- There are about 2-3 energy spikes every 30 seconds, each lasting about half a second, at an average of 0.8 watts.
- With medium waves, the wheel spun slower and generated little power.
- 1 in 3 waves generated energy.

CONCLUSIONS, IMPLICATIONS

- The device performed well for a first prototype, even though the energy output was not high.
- The experimentation gave me many insights about how to further improve it into a useful device.
- This could be useful for people affected by hurricanes in places such as Costa Rica and Florida to power lights, communication, medical devices, and water desalination.

NEXT STEPS

Ideal Prototype	Current Prototype
Stable anchoring - ropes & stakes	Cement blocks that can fall off
Strong and supported water angler	Flimsy plastic water angler that broke
Better waterproofing - take apart and fill holes with marine epoxy	Some water and sand leaks; the silicon caulk did not hold up
Stable metal structure with bolts and lock washers	Wood structure that can wiggle, with screws that can come loose
Gear ratios to increase rpm of alternator - pulleys or gears	1:1 ratio from wheel to alternator