Marine Energy Harvesting Buoy for Ocean Observation

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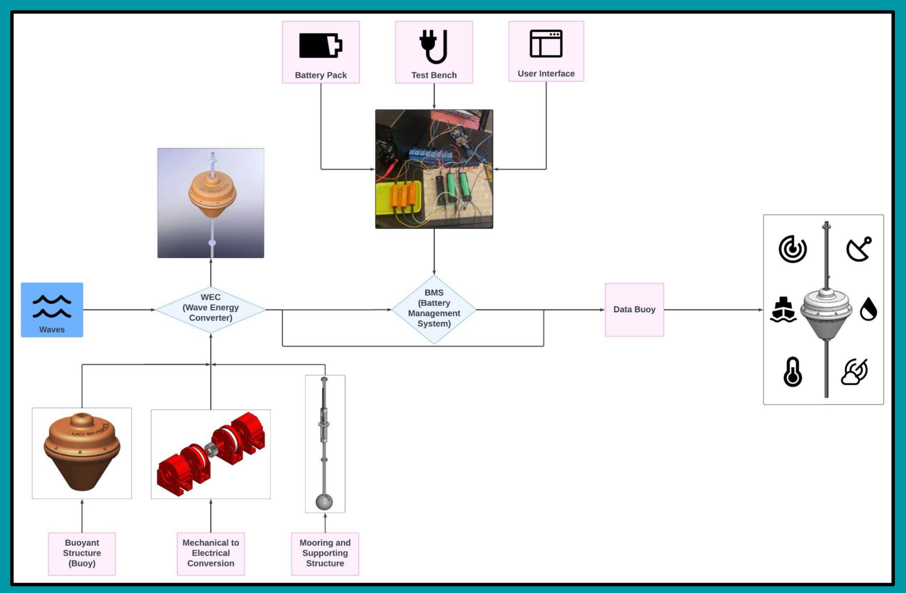
Project Motivation

UCR's Marine Energy Harvesting (MEH) project: Uniting ME, EE, and business students to create an efficient wave energy device and explore market opportunities.



Our Wave Energy Converter (WEC) aims to produce and store power for low-power ocean sensors and observation.

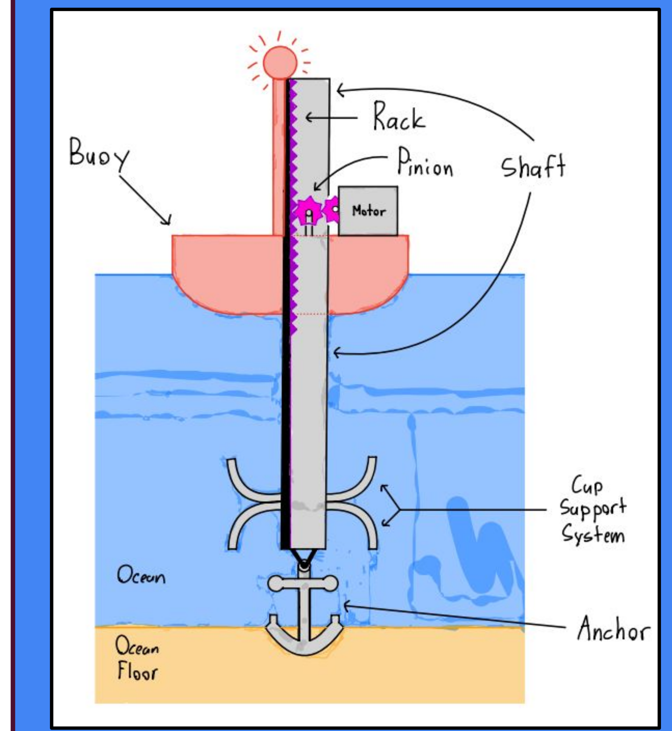
Proposed Solution

Design

- Wave Energy Converter (WEC)
- Converts Vertical Wave Motion to electricity to charge batteries with Battery Management System (BMS)
- Uses direct drive rack and pinion mechanism
- BMS charges batteries by smartly distributing power

Characteristics

- Easy on or off shore deployment
- Simple mechanism for easy maintenance



Visualization of WEC Design Concept

CAD model of WEC design

Scale Model Testing

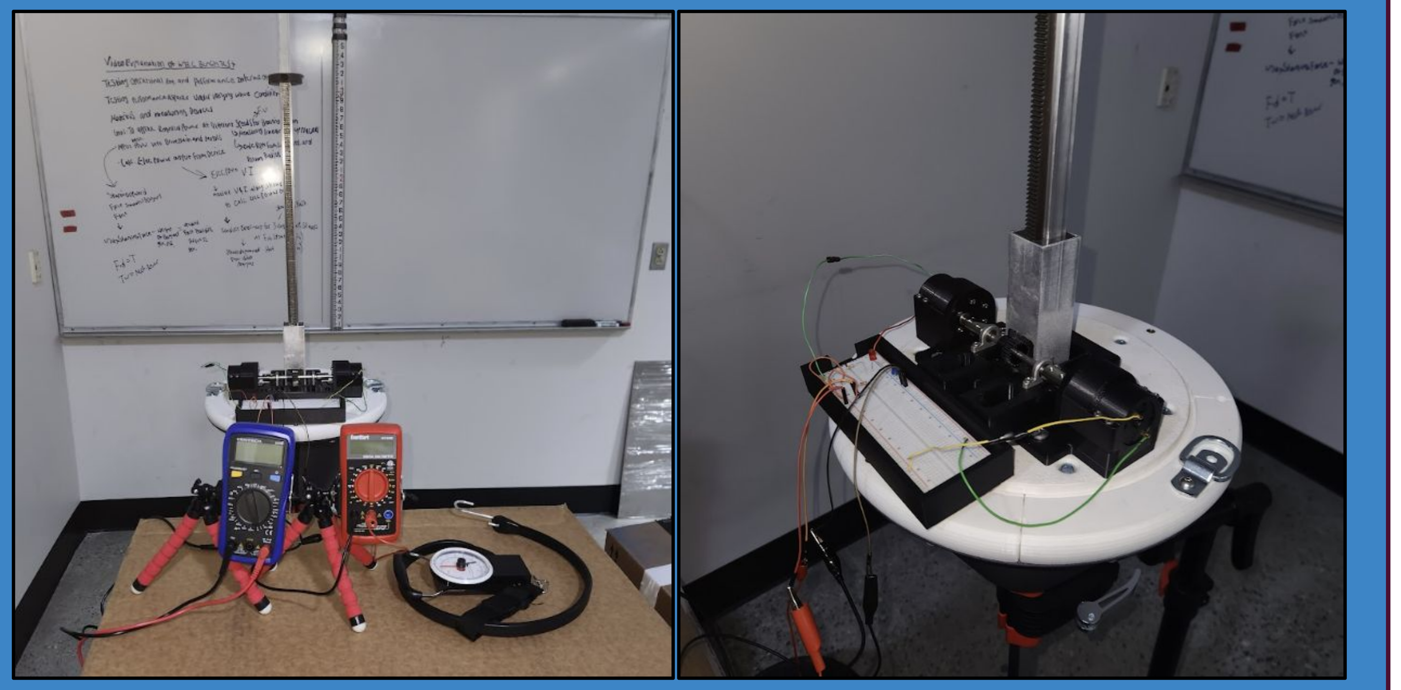
Tested Performance Characteristics of our 1:5 scale model of our design solution

Scaled assembled prototype of WEC (left), Scaled prototype of drivetrain Assembly (right)

- The WEC prototype was tested under varying wave conditions manually moving the device at varying speeds and stroke lengths.
- Six tests were conducted, each labeled with the stroke position, time, velocity, RPM, mechanical power, voltage, current, electrical power, and efficiency.
- Test 1, Test 2, and Test 3 represent full strokes at slow, medium, and fast speeds respectively.
- Test 4, Test 5, and Test 6 represent half strokes at slow, medium, and fast speeds respectively.
- The tests aimed to simulate different wave heights and periods to evaluate the WEC's performance under various conditions.
- Average efficiency across all tests was calculated

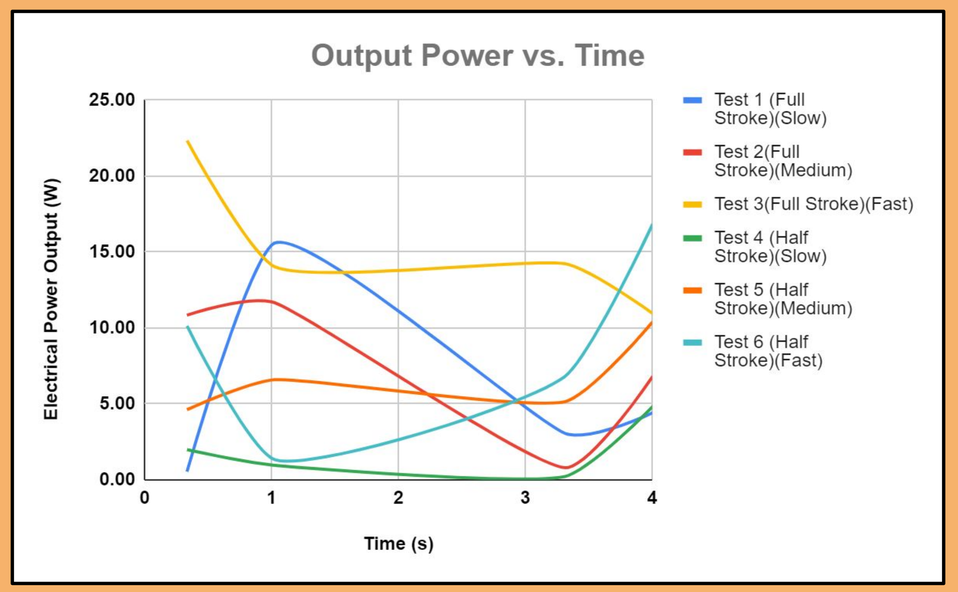
Explanation of Measurement and Data Recording:

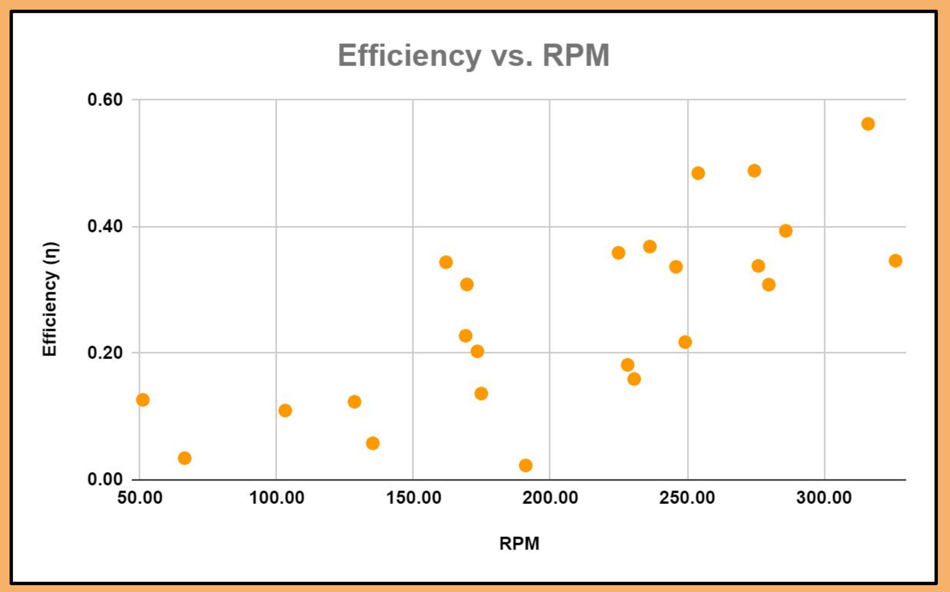
- Velocity of the device was tracked using Tracker software, analyzing video footage from cameras.
- Starting upward buoyant force was measured using attached anchors, tarp strap, and luggage scale, providing insight into initial power requirements.
- Electrical power output was recorded using multimeters connected to the circuit, measuring voltage and current.
- Data was synchronized at specific points along the stroke using video tracking software, enabling accurate analysis and comparison across different conditions.



Photos of WEC power generation Test Setup

Prototype Testing Results





Performance Testing Analysis:

- Output Power vs. Time Graph: The graph depicts electrical power output across six trials, varying stroke length and wave speed. Full strokes consistently yield higher power, especially at faster wave speeds. Test 3 with a full stroke at a faster wave period proves most effective.
- Efficiency vs. RPM Scatter Plot: This plot shows a direct correlation between rotational speed and efficiency, indicating higher RPM leads to better power conversion. Identifying optimal RPM regions is crucial for maximizing efficiency.

Lessons Learned and Future Improvements:

- Despite generating usable power, the device's average efficiency of 26% suggests room for improvement. Higher RPM correlates with increased efficiency, suggesting a need to maintain optimal rotational speeds. Future enhancements could include integrating a flywheel mechanism to ensure continuous rotation at productive RPM levels and refining the device's design for maximum efficiency and performance.

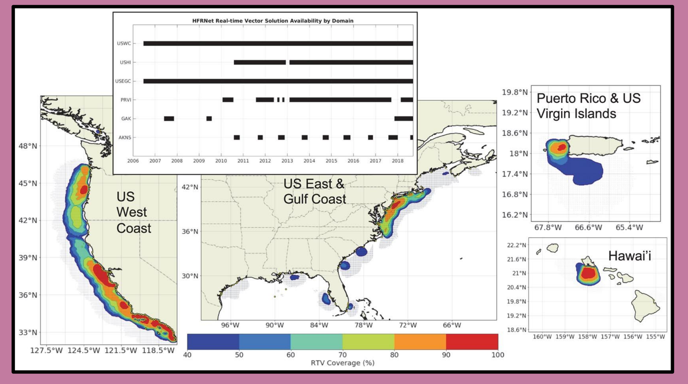
Cost Analysis

Component	Approximate Cost ($)
Stainless Steel (316)	$2750
Linear Low Density Polyethylene (LLDPE) Housings	$1100
AC Generators for Marine Environments	$2000
Battery Pack and Battery Management System	$550
Wave Tank Testing and Refabrication	$5000
Manufacturing Costs	$5000
Labor Expenses	$7200
Mooring Installation and Equipment Costs	$2060 - $31060
Total Estimated Cost	$23660 - $44160

Stakeholders

- **Investors:** SBIR Funding Boosts Ocean Motion Tech's Growth
- **Permitting Authority:** Coast Guard Regulates Private Aids to Navigation
- **Strategic Partnership (Private Entity):** CODAR Collaboration for Renewable Power
- **Strategic Partnership (Research Facility):** Scripps Institution of Oceanography Collaboration Enhances Data Collection
- **Risk Mitigation and Insurance:** Gallagher Provides Tailored Insurance Solutions
- **Maintenance and Deployment Partner:** Gravity Marine Services Optimizes Device Deployment

Deployment Areas



Our intention is to address the gaps in HF radar coverage depicted on this image along the Northern California and Southern Oregon coastlines.

Conclusions

- Scalable Models: Both the scaled and larger versions show market potential, indicating adaptability
- Design Optimization: Improved drivetrain and generator selection can boost efficiency
- Waterproofing Vital: Additional waterproofing measures are necessary for durability
- WEC-SIM Modeling: Future modeling will refine operational understanding for optimization

Acknowledgements

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