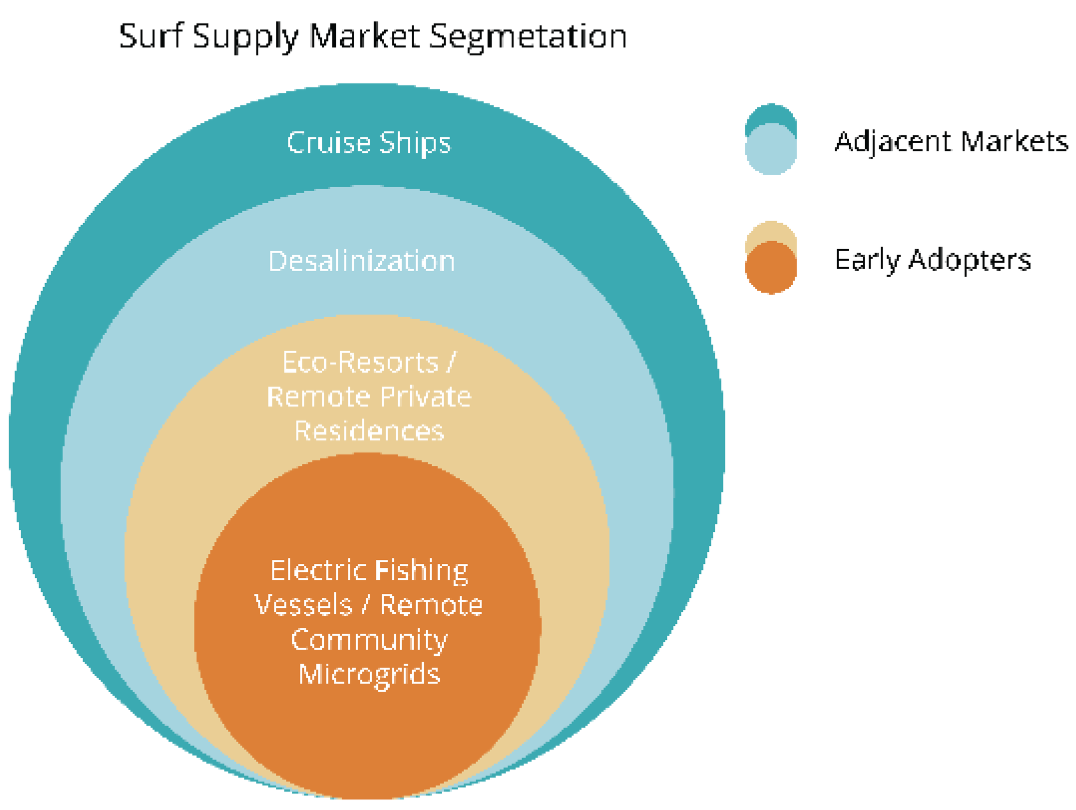
SURF SUPPLY ATOLLA: Winch-Based WEC

Objective

Design a wave energy converter device that can supply cost-effective power to coastal communities and electric marine vessels.

Market Opportunity



Remote Coastal Community Microgrids

Our primary and secondary research show that Surf Supply has a strong value proposition for microgrids in remote coastal locations with low wave heights and expensive or unreliable energy production options. In these locations, Surf Supply docks can become one of many energy sources that feed into a microgrid. Customers in these locations who may have a particular interest in Surf Supply's technology include eco-resorts, affluent individuals with off-the-grid coastal properties, and small communities. The technology can offer these customer groups an energy source that reduces expenses, increases their resilience to power supply issues, and aligns with sustainability values.

Electric Fishing Boats

A second potential early adopter segment is commercial fishermen operating electric boats. As mentioned above, the status quo of using diesel generators as a backup to electric batteries leaves much to be desired. Surf Supply could be deployed as a multi-dock network within a sheltered cove near fishing grounds, which is where fishermen often stay overnight.

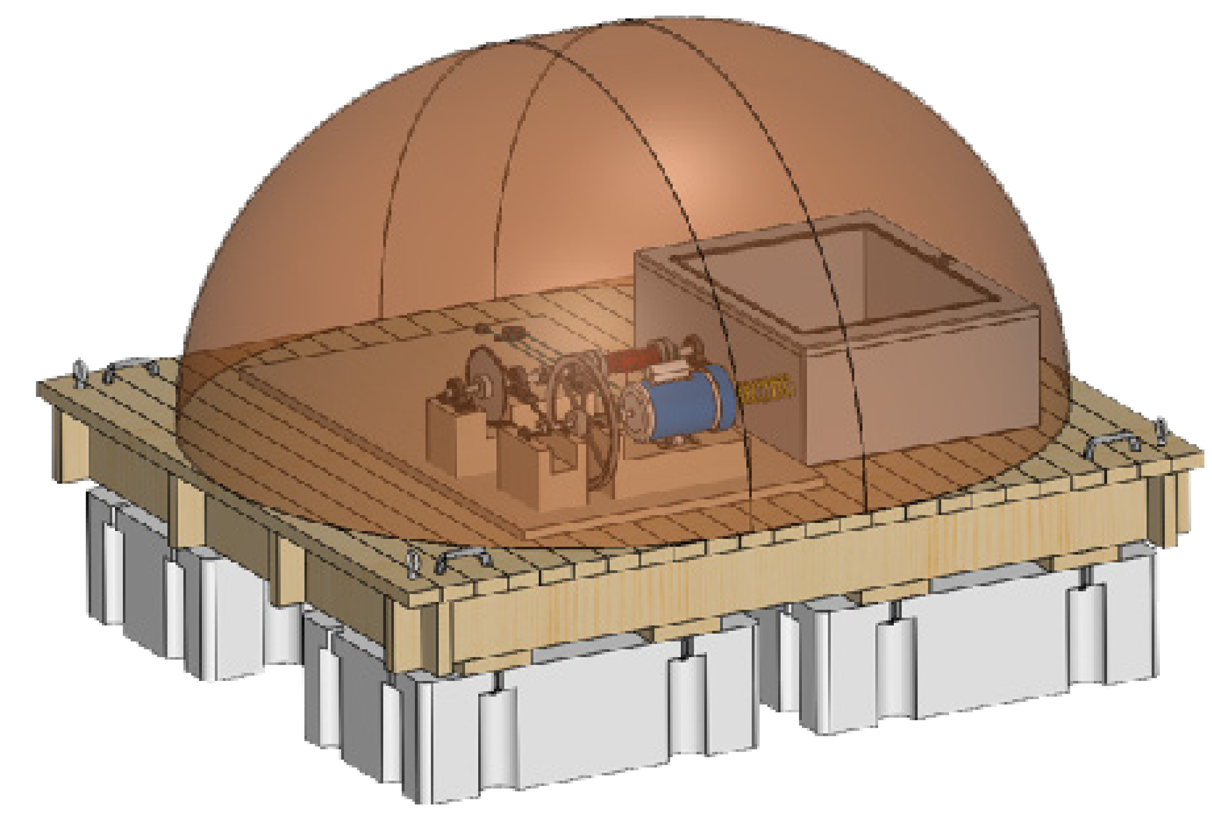
Financial Analysis

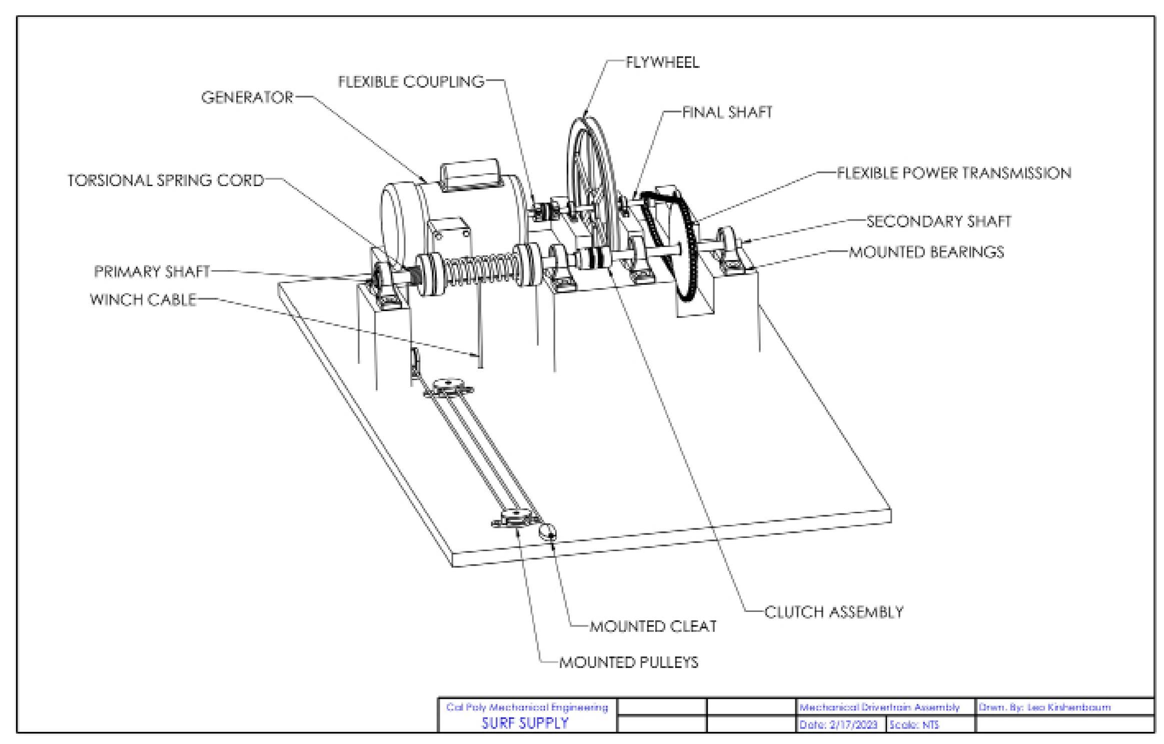
Based on an assumed capacity factor of 50%, 10 year device lifespan, 1 kW device output, $10,000 total capital costs, and a $3,300 NPV of operating expenses, our Generation 1 ATOLLA device is projected to produce 4,380 kWh of energy annually. This translates to a levelized cost of electricity (LCOE) of 0.30 $/kWh. With electricity as high as $1/kWh in remote Alaskan communities [1] our device can offer a cost-effective solution.

Levelized Cost of Electricity	
Total Capital Expenses	$10,000
Operating Expenses	$3,300
Annual Energy Production	4,380 kWh
LCOE	$0.30/kWh

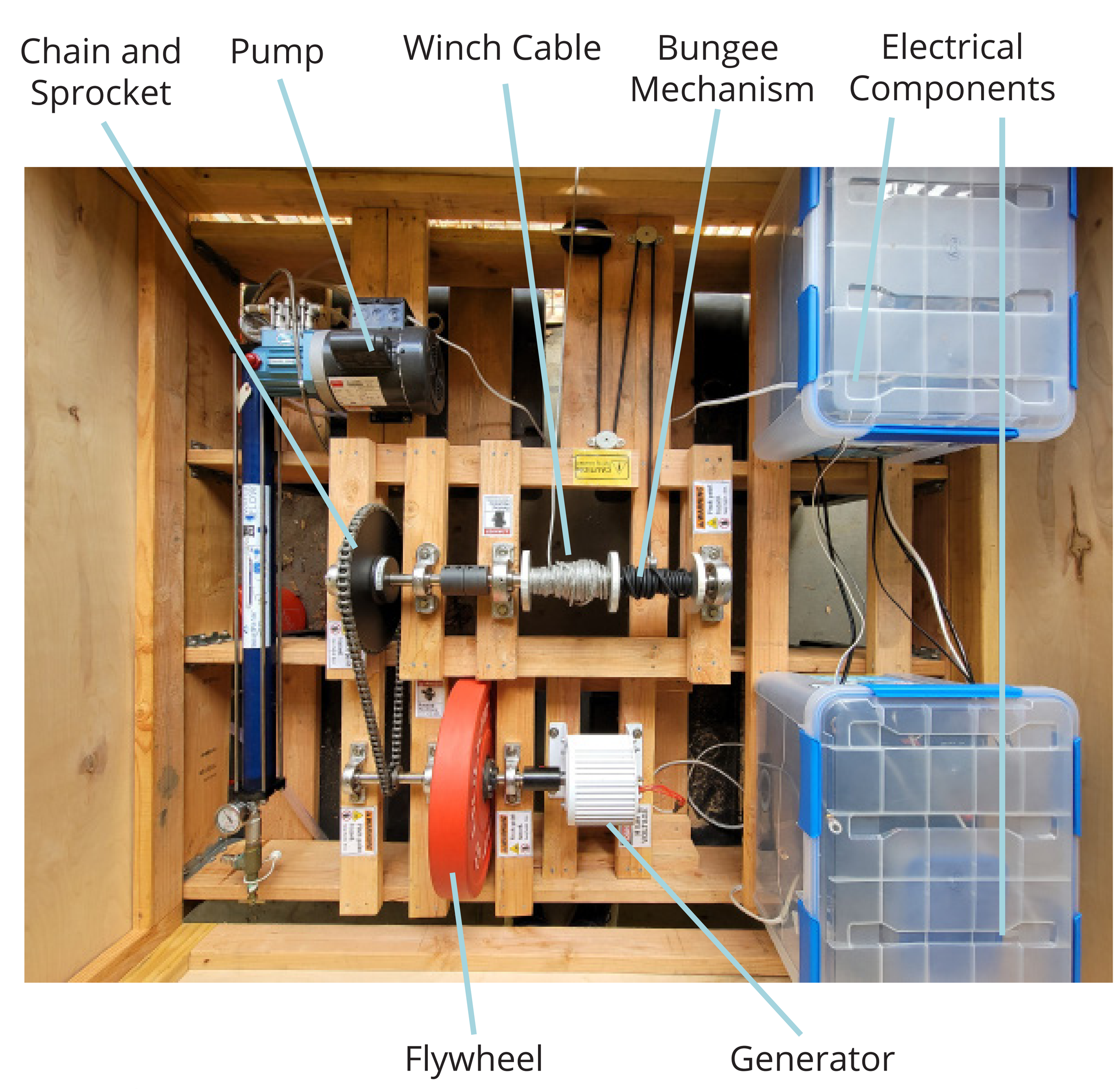
Design Concept

The ATOLLA WEC device is centered around a winch-based power take-off (PTO) system that converts the heave of waves into rotary motion and electricity. The PTO is housed on a surface float, which is anchored to the sea floor via a winch. The vertical heave of a swell unspools the winch, rotating a mechanical drivetrain coupled to an AC generator. This power is converted to DC and stored in onboard batteries. These batteries would supply power to remote microgrids or electric fishing vessels. Unique design features include the use of an elastic cord spring-return mechanism to respool the winch cable during the downfall of the wave and a flywheel to provide a smoother energy output, even in low sea states.





Build and Test



Testing

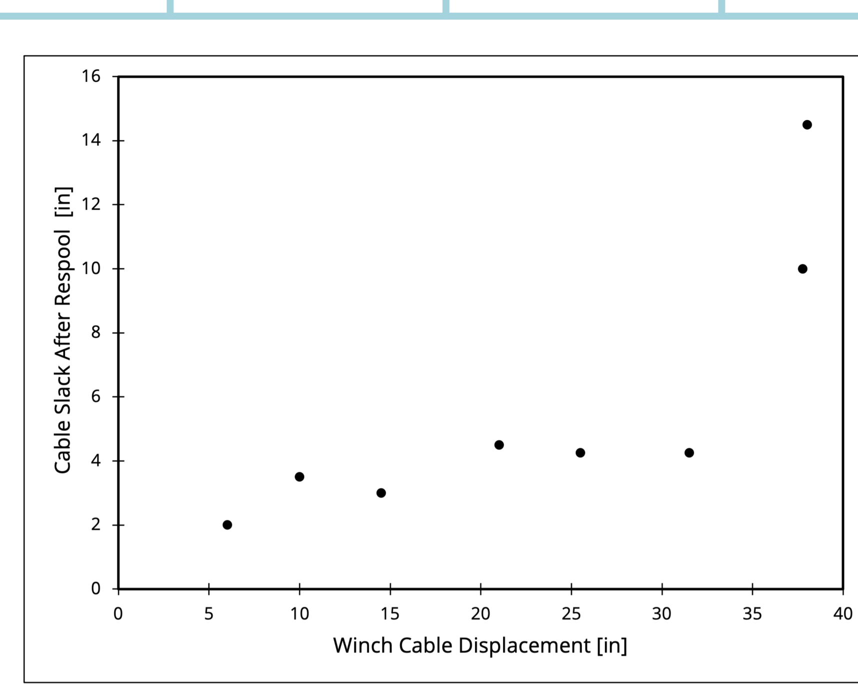
Methodology

- Simulate wave motion by displacing winch cable over a range of amplitudes and periods
- Measure RPM data via laser tachometer and power output via Arduino data acquisition system.

Performance Test Results

Amplitude [ft]	Average Period [s]	Maximum Speed [RPM]	Maximum Power [W]
3	11.7	157	99.6
5	12.1	181	116.6
7	10.5	156	86.5
9	7.8	175	115.3

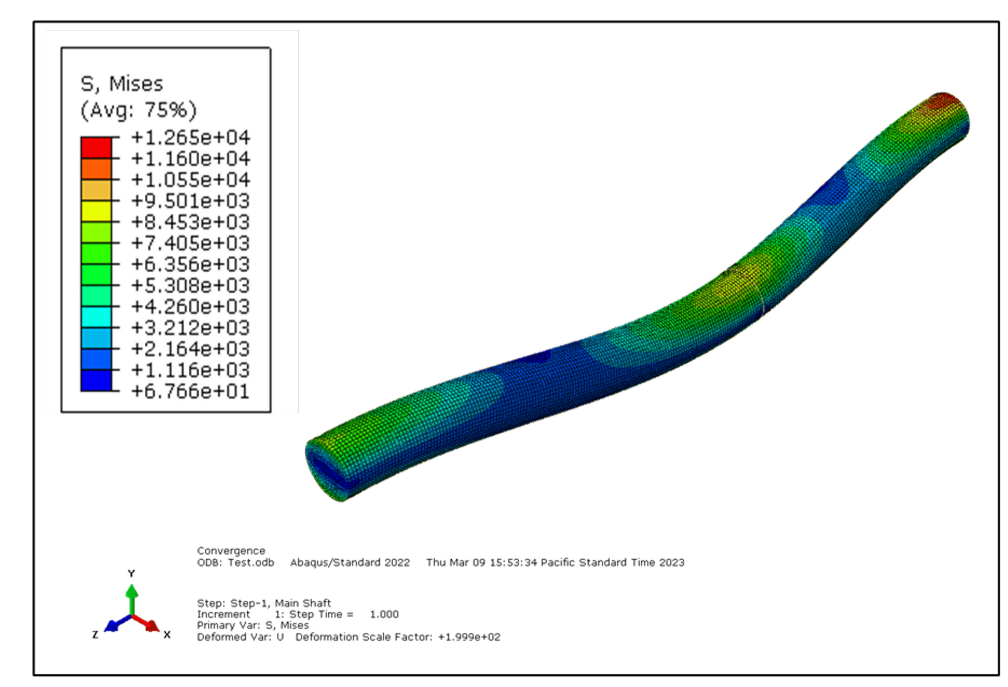
Performance Testing Results



Analysis

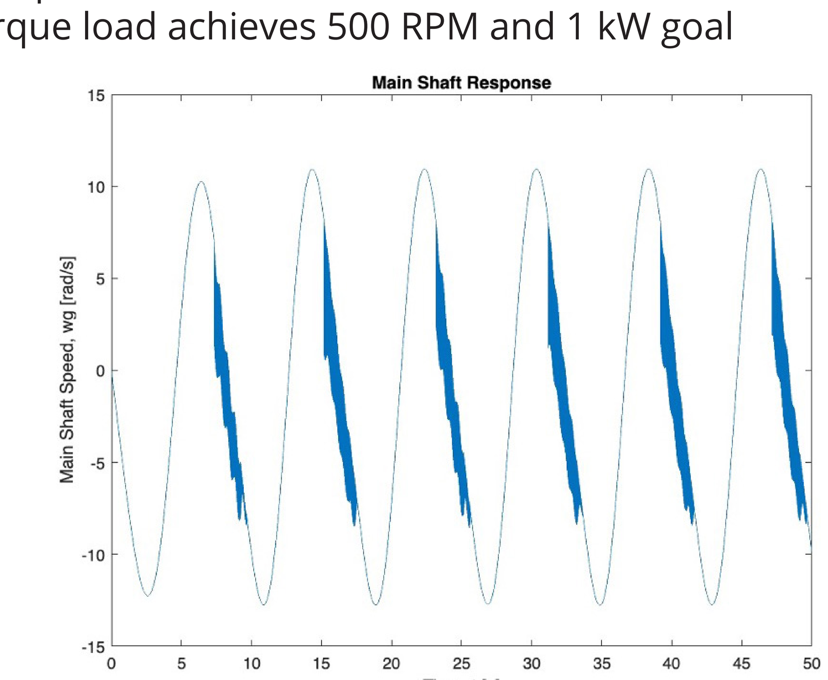
Stress Analysis

- Main Shaft had highest loads and drove design
- Critical Load Case: System Fully Submerged
  - -Cable Force = 2,995 lbf
  - -Safety Factor = 0.98
- Average Loading (NREL WEC Tool)
  - -Cable Force = 1,007 lbf
  - -Fatigue Safety Factor = 1.4



System Dynamics

- Developed MATLAB Simulink Driveline model from system normal tree
- Simulation Results:
  - Maximum Shaft Speed: 100 RPM
- 5:1 speed increaser transmission ratio with 20 Nm torque load achieves 500 RPM and 1 kW goal



Conclusions

- Successfully generated a maximum of 116.6 W
  - -Generator back EMF resulted in lower flywheel speed than predicted
  - -Ocean waves exert more force; we expect open water testing will yield results closer to expected values
- Torsional spring mechanism failed to fully recoil the winch and remove all slack in the cable
  - -Up to 4 inches of slack in cable at small displacements (<3 feet)
  - -Need lower friction cord to prevent bungee from binding on itself

Recommendations

- Redesign the torsional spring apparatus to allow for repeated, complete re-winding of the winch cable
- Prepare prototype for open-water testing to verify device performance at wide range of operating conditions
  - -Attach waterproof wire covers, place generator in IP66 rated enclosure, add full device cover
- Apply to TEAMER early to ensure sufficient time to test prior to MECC competition

Cal Poly's MECC project is an interdisciplinary team consisting of Mechanical and Electrical Engineering undergraduate and MBA graduate students.

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Faculty Advisors: Dr. Peter Schuster, Dr. Vladimir Prodanov, and Professor Barry Lieberman

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POWERING the BLUE ECONOMY Marine Energy Collegiate Competition U.S. DEPARTMENT OF ENERGY