STEM WEC

1/C Anthony Sciulli, Holden Seybold,
Josean Colon Martinez, Kelli Giuliani, Melody Zhu,
Professor Andy Gish, LT Sarah Reilly, NAOE Department

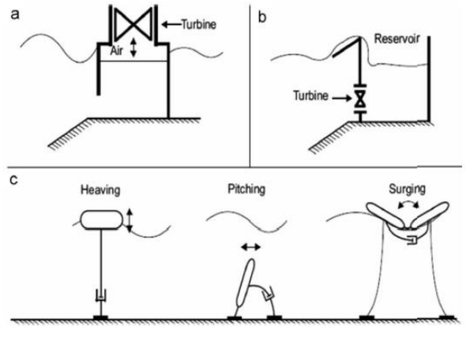
Abstract

Wave energy converters (WECs) currently have low energy output due to numerous steps the wave energy must go through to transform into electrical energy [1]. This project aims to create a working laboratory scale WEC demonstrator, in order to enhance awareness and generate interest in wave power as a renewable source of energy.

❖ **Unique Aspects of Design:**
- ➢ Triboelectric Nanogenerator (TENG).
- ➢ All electrical components dry, above waterline.

WEC Background

- ❖ Wave Activated Bodies (WABs), Overtopping Devices, Oscillating Water Columns.
- ❖ Chose WAB design due to relative simplicity and affordability.
- ❖ WABs outperformed alternatives in decision matrix.
- ❖ WABs also tend to have more effective Power Take Off (PTOs) to convert energy from wave to electrical.

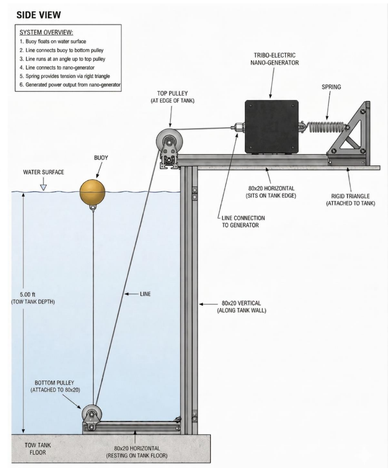


(a) OWC (b) Overtopping Device (c) WAB

Design Choices

- ❖ Spar Buoy
  - ➢ Cylindrical shape with added weight captured the wave action with limited lateral and transverse movement, while still achieving resonance.
- ❖ Mechanical Pulley System
  - ➢ Allows for the electrical components of the TENG to remain dry and out of the water.
- ❖ TENG
  - ➢ Uses copper (+) and PTFE tape (-), which are oppositely charged.
  - ➢ Efficient way of converting linear motion to electrical energy.

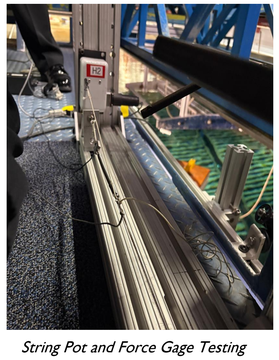
Final Design of TENG



AI Generated Schematic of Experimental Setup [4]

Lab Testing

- ❖ With a pre-determined wave height and period, displacement and force were measured using a string potentiometer and force gage.
- ❖ Used SolidWorks to design the TENG housing and sliding piece dimensions, determined by the displacement.
- ❖ Measured voltage output of the final fabricated TENG design.



String Pot and Force Gage Testing

Spar Buoy

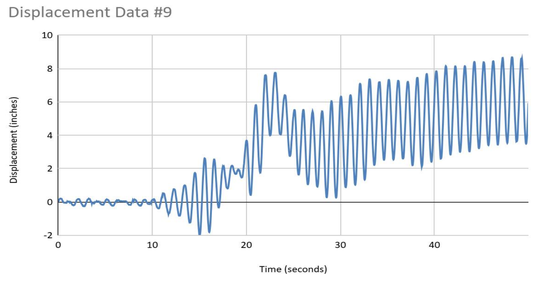
TENG

- ❖ **Tribo**: To rub.
- ❖ **Electric**: Surface charges.
- ❖ **Nano**: Nanometer scale to focus on the transfer of electrons.
- ❖ **Generator**: Converts linear motion to electricity.
- ❖ The TENG works by capturing the transfer of electrons between two oppositely charged surfaces when in contact with each other [3].

Machined and 3D Printed Inner TENG Piece

Experimental Results

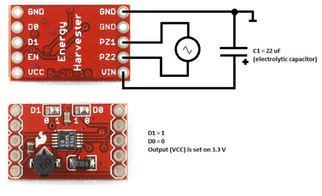
- ❖ Multiple experimental wave conditions used to determine optimal wave height and period.
  - ➢ 1 second period and 4 inch wave height
- ❖ Optimal displacement for TENG design is 5-6 inches. Our design is 7 inches to have extra length in case of over oscillation.
- ❖ Hand motion voltage test:
  - ➢ 0.25V per copper side (x4 copper sides)



Displacement of the Buoy Due to Wave Action (Period of 1 Second and 4 Inch Wave Height)

Circuitry

- ❖ AC current is induced through oscillating motion within the TENG housing.
- ❖ Using a full bridge rectifier within the energy harvester, the energy burst created by the waves and traveling through the TENG are converted from AC to DC Voltage.
- ❖ The energy bursts are stored with a 10μF capacitor.



SparkFun LTC3588 Energy Harvester Breakout Board (sparkfun.com)

Results

- ❖ Available wave power (H=4in, T=1s):
  - ➢ 3.01 Watts

$$P = \frac{\rho g^2 H^2 T D}{32\pi}$$

Maximum Power Available in a Wave

- ❖ Average voltage produced in TENG:
  - ➢ 0.25V x 4=1V

The TENG provides a low cost model to capture wave energy and maximize the output energy.

Future Work

- ❖ Conduct more research and testing on the circuitry output. Is a transformer able to be used, and what does actual storable energy look like?
- ❖ What materials are readily available and more structurally reliable than PTFE tape?
- ❖ Be able to optimize the TENG: length, force that produces the most voltage, total number of copper fingers on the TENG?
- ❖ The next steps for wave energy converters will be to continue to generate public interest by using this cheap, mobile demonstrator to take around the country and show to people what is possible.

References: