Team Sixteen sponsored by the U.S. Department of Energy

Wave Powered Reverse Osmosis

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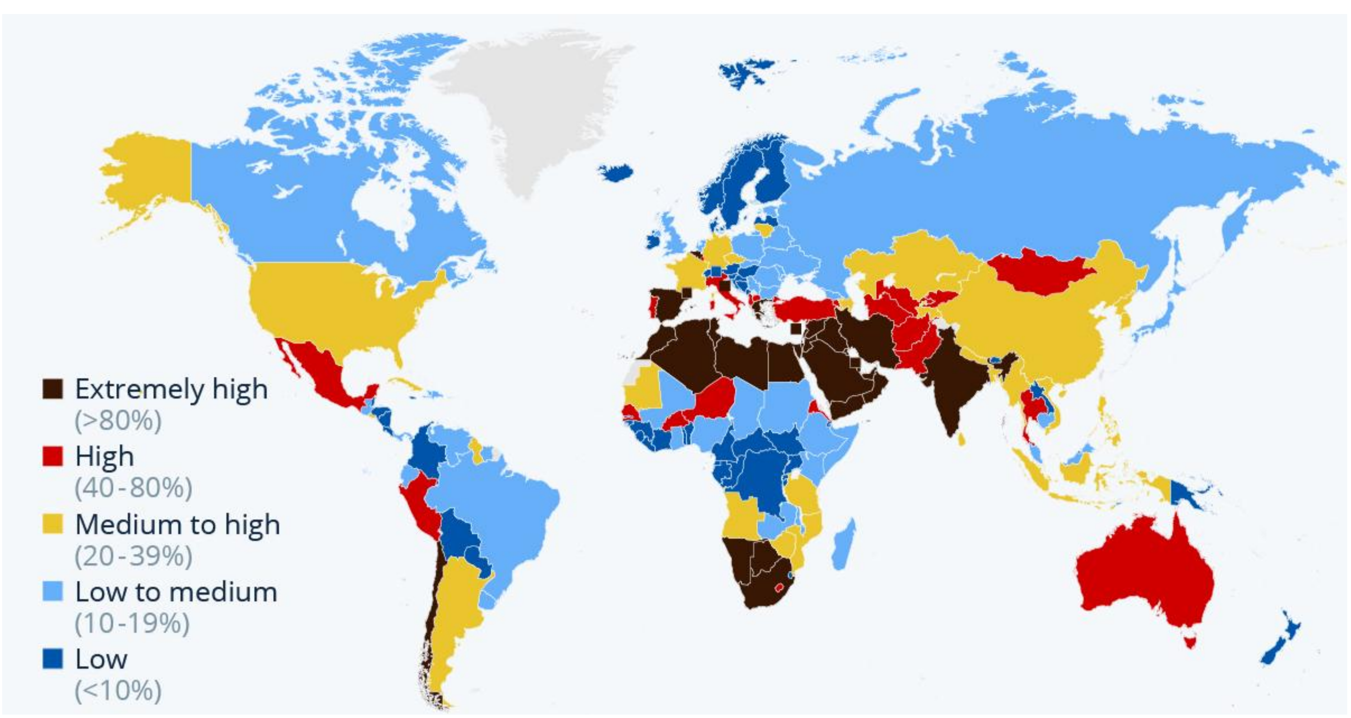
OBJECTIVE

The goal of this project was to develop a novel wave energy powered device using the process of pulse flow reverse osmosis to desalinate seawater in Puerto Rico to provide fresh drinking water. Working in tandem with an ME senior design team we worked to develop a wave energy convertor to provide water and pressure to a two-pass pulse flow reverse osmosis system.

Other contributors on this project include Dr. Warsinger, grad student Jarrod Robins, and PHD candidate Ali Beni. In addition to these contributors we also worked with an ME senior design team comprised of: Nikitha Sam, Lily Waterman, Nishtha Singh, Trysta Chiang, Ryan San Juan, and Diya Banerjee. This team focused on creating the wave energy convertor that supplied the water and pressure to the RO system.



CUSTOMER PROBLEM AND BACKGROUND

Coastal communities, particularly in regions like Puerto Rico, frequently face recovery challenges following natural disasters such as hurricanes, earthquakes, floodings, or other events. These disasters often result in extensive damage to essential infrastructure, one of which is the severely impacted access to clean drinking water. Looking back at past hurricanes that have impacted Puerto Rico highlights the vulnerabilities in local freshwater supply, and distribution. With current emergency responses typically relying on bottled water, which is highly costly and logistically challenging.

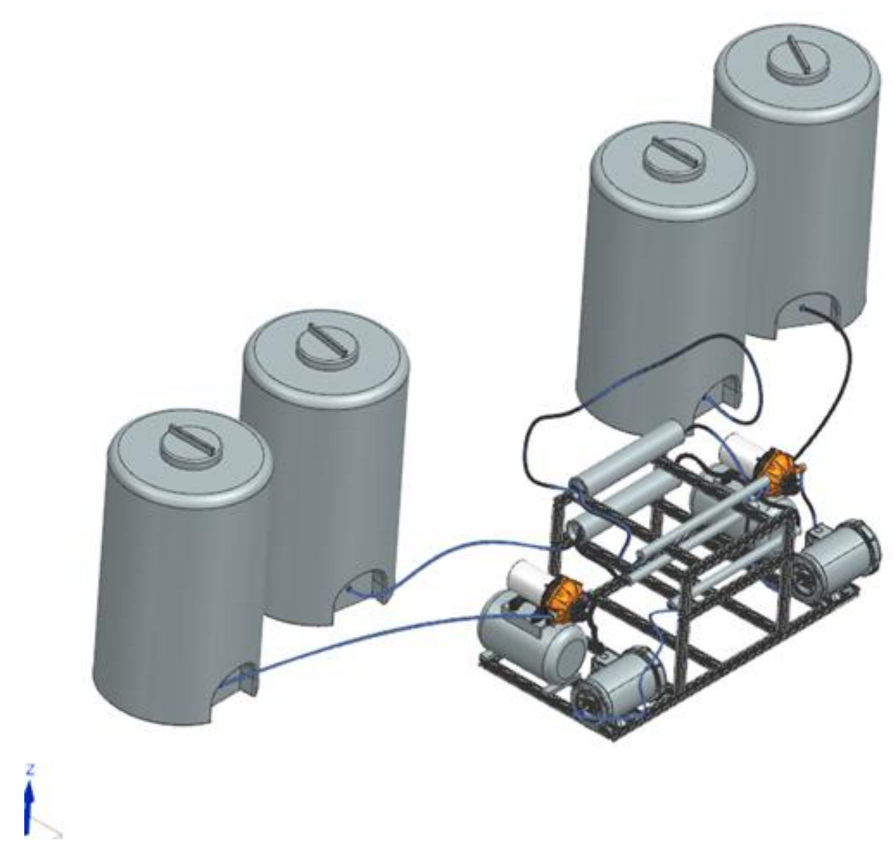
Despite the abundance of seawater available in coastal regions, the lack of affordable reliable and scalable technology limits its use in immediate disaster relief. Existing desalination solutions commonly require significant energy input, frequent maintenance, costly startup cost, and not designed to scale for rapid deployment. Therefore there is a need for an innovative, low cost, and easily deployable solution to convert abundant seawater into clean drinkable water to significantly improve disaster resilience and recovery in coastal communities.

CONCEPTS AND EXPERIMENTATION

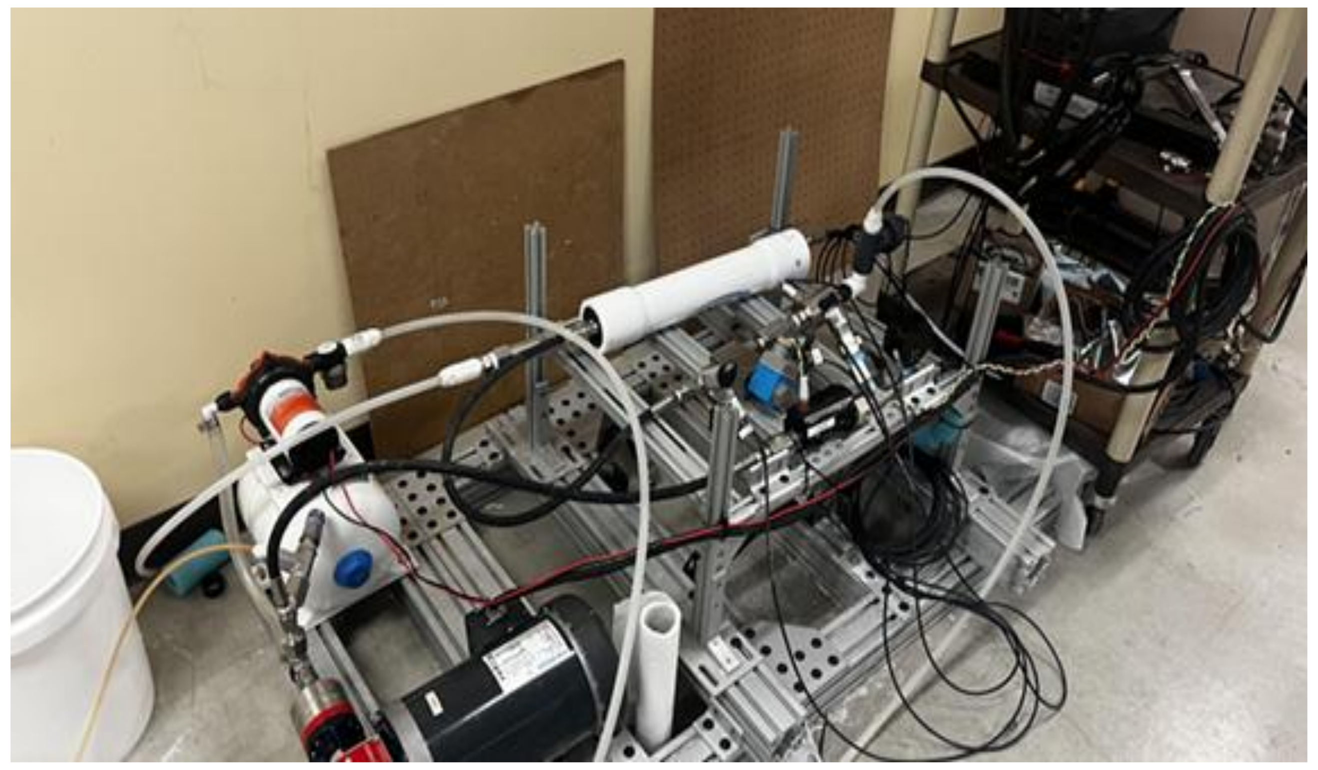
The project aimed to create an innovative and sustainable solution for generating clean drinking water from seawater in disaster hit coastal regions, particularly in Puerto Rico. The system will be powered. By a Wave Energy Converter (WEC), which harnesses energy from ocean waves to power pistons to provide the pressure necessary to cycle seawater through the two sages of the pulse flow reverse osmosis (PFRO) system. This design eliminated the need for traditional energy sources, making the system capable to be deployed in remote, disaster stricken areas where additional power infrastructure may not be available.

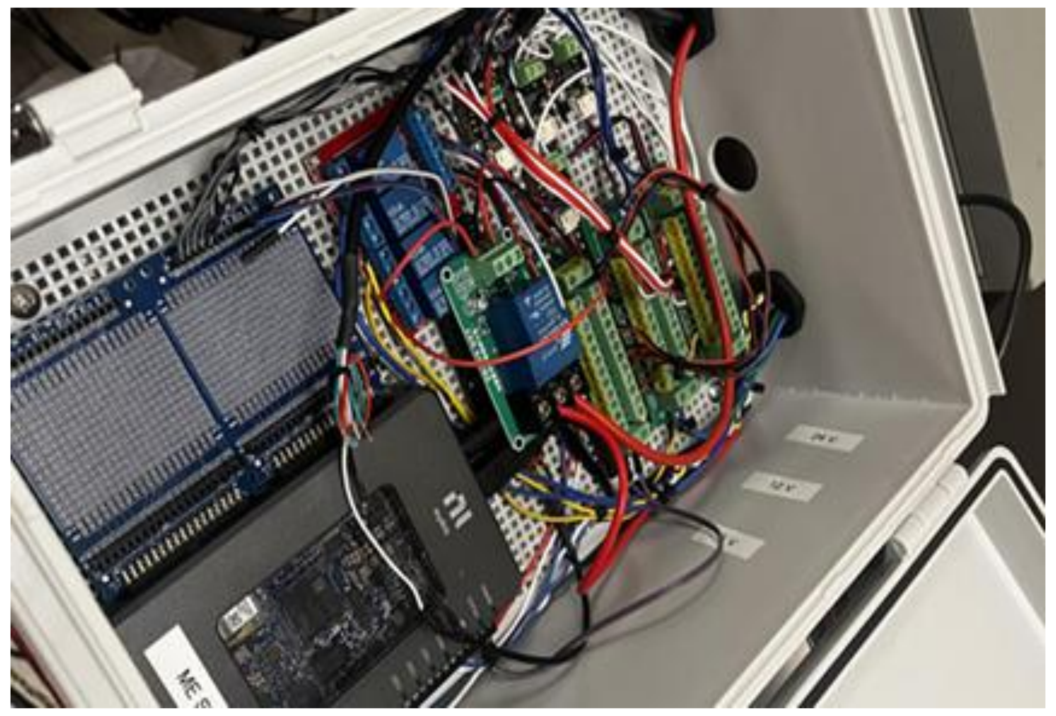
In the first stage, sea water is pressurized by the pistons and passes through the RO membrane to remove more than 80% of the salts and impurities. The second stage further reduces the salinity, ensuring that the output water meets drinking standards. The pulse flow system powered by the WEC allows for efficient energy generation and ability to maintain constant pressure through the system.

For experimentation, key metrics were recorded, including flow rate, pressure at the input and output of each stage, as well as the salinity of the water produced. The reaffirmed the system's ability to produce drinkable water. A significant benefit of this design is its compact size and ability to quickly deploy for disaster relief.

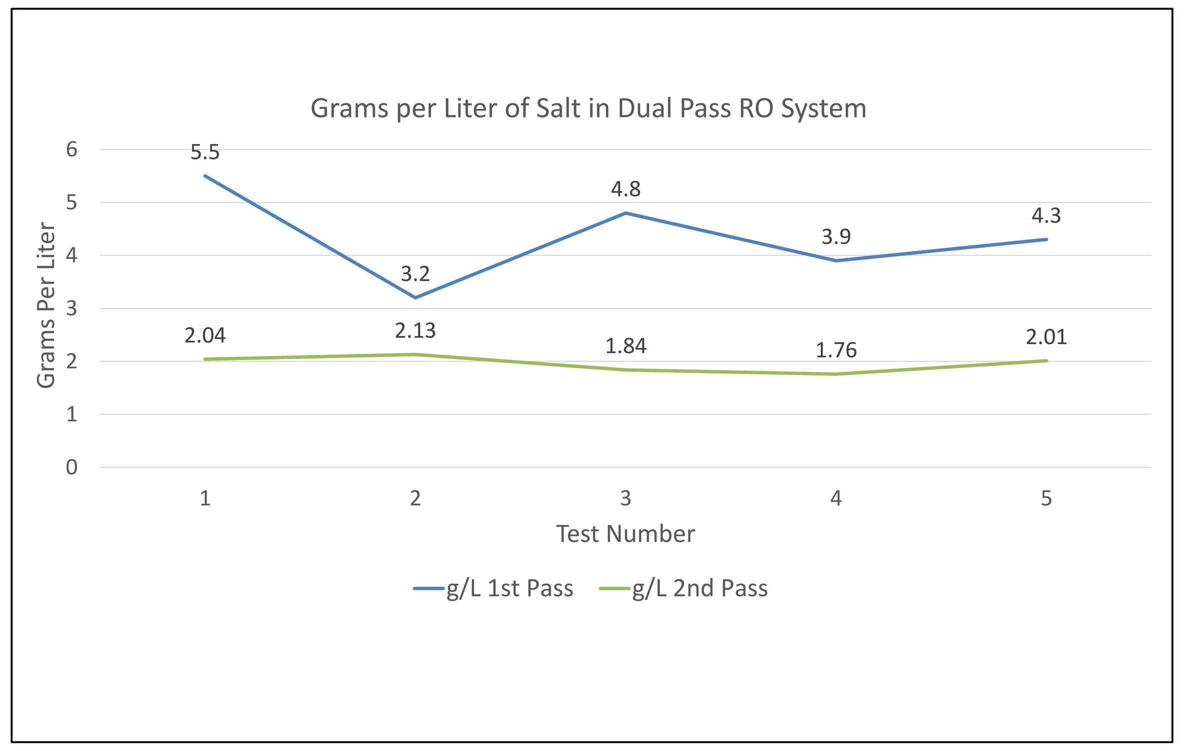


REQUIREMENTS AND FINAL DESIGN





TESTING RESULTS



CONCLUSION AND RECOMMENDATIONS

The two-stage pulse flow reverse osmosis system, driven by a Wave Energy Converter (WEC), effectively reduced seawater salinity from an initial concentration of approximately 36.5 g/L to significantly lower levels. Experimental data demonstrated substantial salt reduction, with salinity decreasing to between 3.2 and 5.5 g/L after the first pass, and further dropping to around 1.76 to 2.13 g/L after the second pass. This outcome confirms the system's effectiveness in producing potable water suitable for emergency relief in disaster-stricken coastal areas such as Puerto Rico, where traditional water infrastructure may fail.

For future improvement, recommendations include piston synchronization and wave-energy conversion efficiency to enhance water output consistency and further reduce salinity. Additionally, implementing a pre-treatment stage could protect membrane integrity and prolong the system's operational life without significant complexity. Given the compact design and quick deployment capability, it is advisable to proceed with larger-scale testing in diverse coastal conditions to assess performance reliability, ease of deployment, and long-term sustainability in real-world disaster recovery operations.