Nalu e Wai : A Wave-powered Desalination Concept

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Background

- Team participated in Waves to Water Prize compeition
  - Partnership with IIT Madras (India) and Uppsala University (Sweden)
  - Bottom-fixed Oscillating Wave Surge Converter (OWSC)
  - Reverse Osmosis (RO) PTO with Controls
  - Compact, easily shippable
  - Ease of deployment in disaster response scenarios
  - Excellent performance metrics in numerical space
    - Freshwater production
    - Total Dissolved Solids (TDS)
- *Ocean Engineering* journal paper*
  - Subsystems fine tuned
- Seeking funding to move to prototype development and testing
  - FOA 3097 (TA 4) proposal: Emphasis on RO PTO testing using raw seawater

* Suchithra, R., Das, T., Rajagopalan, K., Chaudhuri, A., Ulm, N., Paulraj, M., Samad, A., Cross, P. 2022. Numerical modeling and design of a small-scale wave-powered desalination system. *Ocean Engineering*, 256.

Why RO Desalination?

- Unique characteristics of wave energy resource
  - Large wave forcing/energy density
  - Typical wave periods well matched to pumping requirements
- Consider a 3mx3m* flap geometry in wind waves of H≈1m, T ≈ 6s
  - Wave force of 10 kN absorbed in a 2” hydraulic cylinder
  - Pressure in cylinder ≈ 50 bars [725 psi]
  - Seawater RO filtration requires ≈ 35 bars [500 psi]
  - Osmotic pressure easily achieved, demonstrating a unique property of wave energy

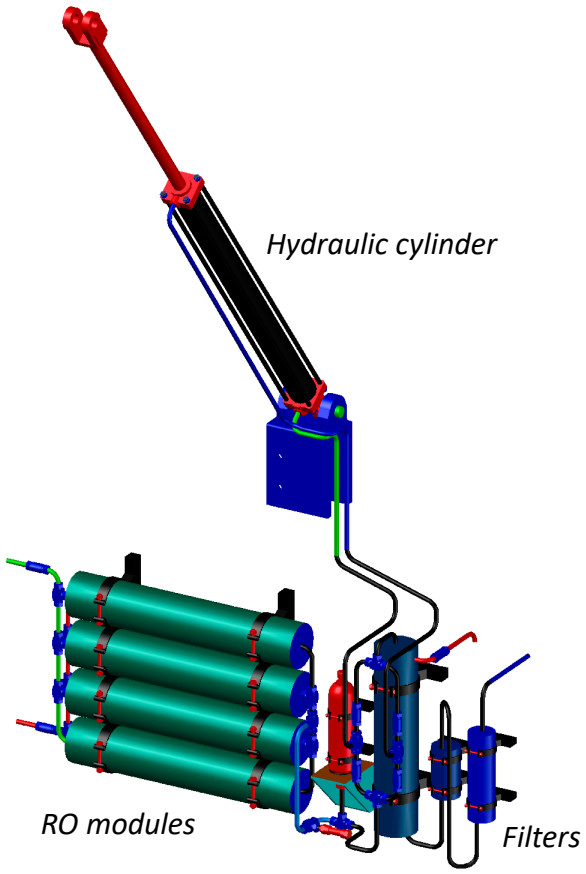
* Hydrodynamics of this scale of flap are well understood through DOE-funded HAWSEC project, with electric PTO being developed in that project.

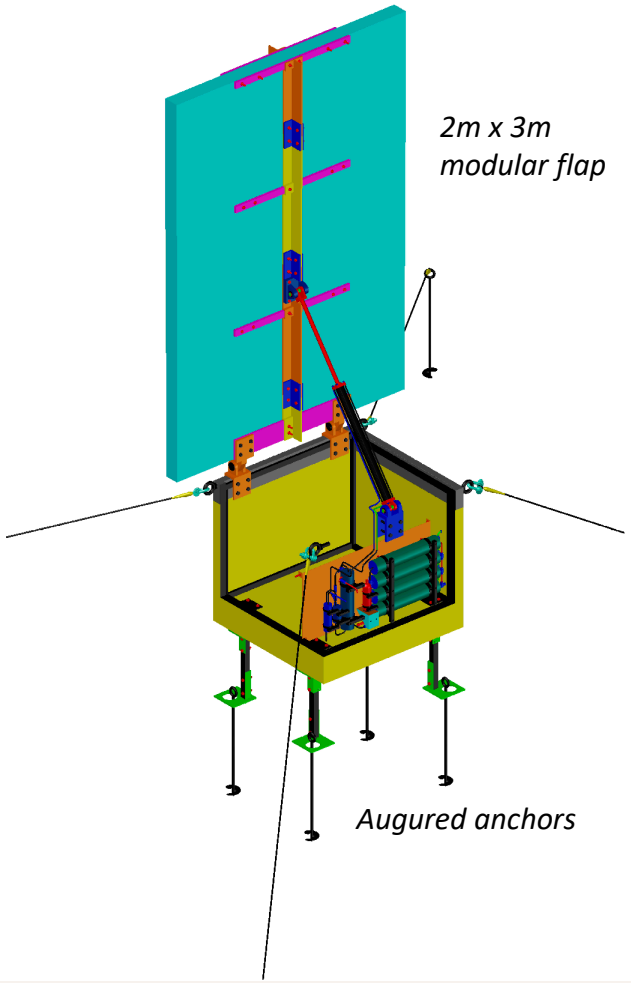
Powering Desalination from Marine Energy

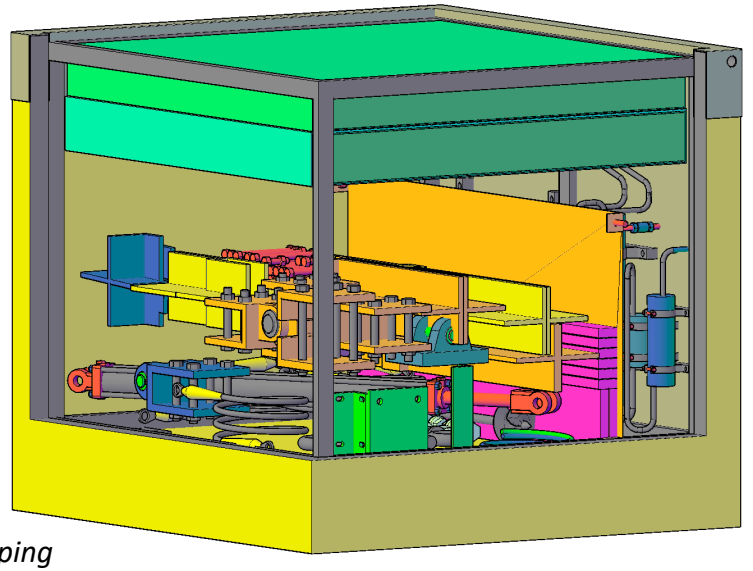
An emphasis of the Hawaii Marine Energy Center (HMEC)

- Fresh water availability in disaster scenarios (Maui wild fires)
- Synergy with HMEC's focus on Pacific Islands
  - Saltwater inundation of fresh water aquifers -> Climate refugees
- Collaboration with UH sister units such as Kewalo Marine Laboratory (KML)
  - PTO testing (no additional permits for saltwater handling)
  - Established connections with Pacific Island communities – Faculty, Students

Nalu e Wai: Subsystems (from W2W)

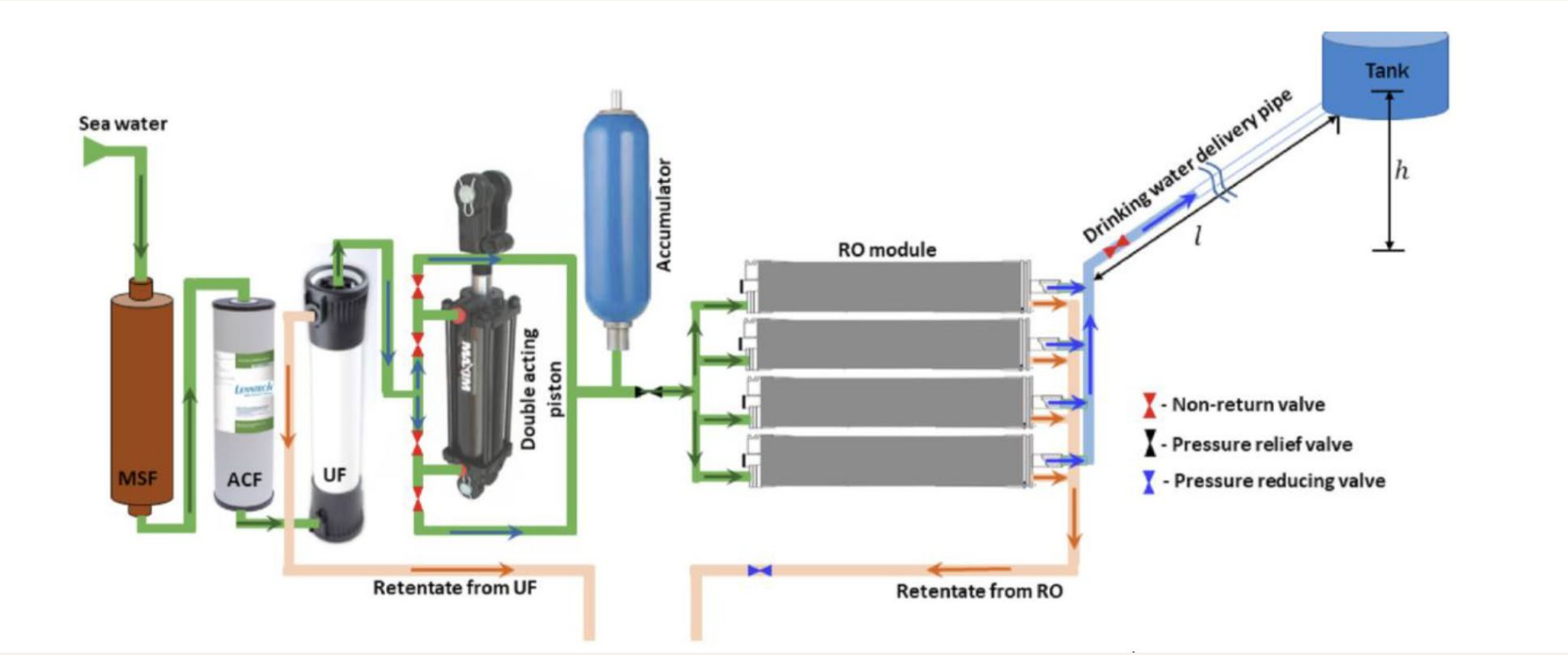






Shipping crate/flap base

RO PTO



- COTS
- Intake filters – Lenntech & Inge Dizzer
  - Multi-media sand filter
  - Activated carbon filter
  - Ultra filter
- Hydraulic Cylinder – 2” diameter
- Accumulator
- RO modules - Lenntech

RO PTO Performance Metrics

- WEC-Sim/Simscape simulations

Sea state	Significant wave height [m]	Energy period [sec]	Wave power (kW/m)	Avg intake rates [L/hr]	Avg desalinated water production [L/hr]	Avg desalinated water salinity [mg/L]
W1	0.5	6	0.7	66.7	35.3	420
W2	0.5	10	1.2	29.5	12.2	450
W3	1.0	6	2.9	99.7	60.1	380
W4	1.5	7	7.7	139.8	95.4	360
W5	2.0	7	13.7	147.1	105.3	348
W6	3.0	7	30.9	185.4	107.6	330

Coupled Hydrodynamics and RO PTO model in WEC-Sim (all subsystems modeled)

Proposed RO PTO Bench testing

Raw seawater ingestion (at KML)

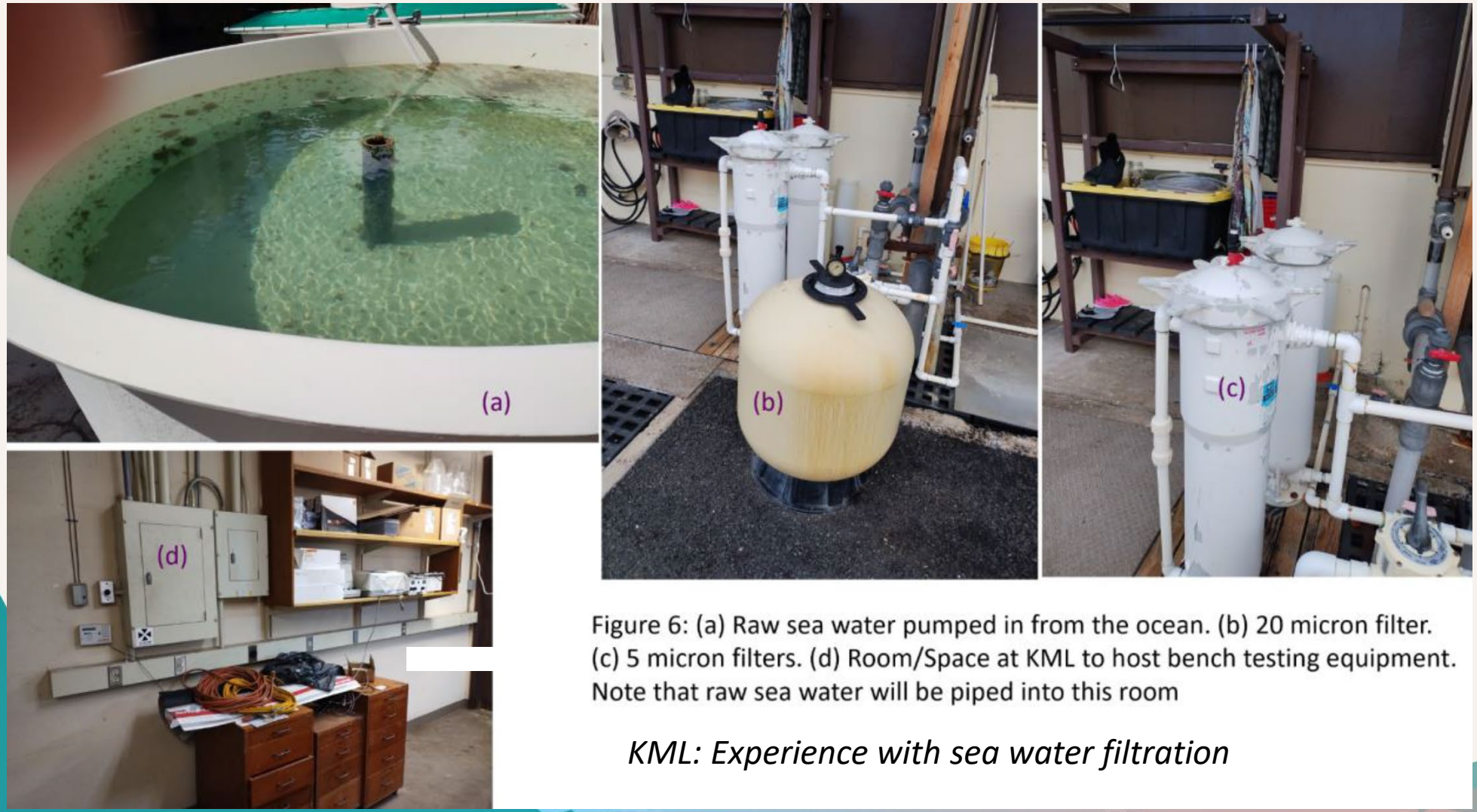


Figure 6: (a) Raw sea water pumped in from the ocean. (b) 20 micron filter. (c) 5 micron filters. (d) Room/Space at KML to host bench testing equipment. Note that raw sea water will be piped into this room

KML: Experience with sea water filtration

PTO Bench Testing Objectives

- RO Performance Metrics with (actual) sea water

desalinated water production (L/h)	desalinated water TDS (mg/L)	Saltwater production (L/h)	Saltwater TDS (mg/L)
29 to 185	330 to 450	17 to 77	82949 to 59575

(Can the above be achieved? LCOW?)

- Establish flushing mechanisms (Pre treatment & RO)
- How components (e.g. cylinder) withstand corrosive seawater ingestion
- Explore control strategies (Latching of PTO; Stiffness of flap)

Conclusions and Way Forward

- Wave-powered RO desalination shows promise
  - Particularly with fixed-flap approach
  - Foundation will be key, once PTO characteristics/performance are well known
- Priority is dissemination of results from future bench and field testing
  - Lessons learned
  - Benefit wave energy community
  - Journal publication and conference participation
- Complete system (Flap + RO PTO) deployment in Pacific Ocean region under future funds
  - Majuro?
  - American Samoa?
  - Guam, Yap, Pohnpei, …. ?