U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE

SETO CSP Program Summit 2019

# Hawaii Sunshot Desalination Program DE-EE0008403

## CSP Powered Renewable Desalination.

John Webley CEO Trevi Systems Inc

# Project Site

Desalination plant to be built at NELHA on Kona (big Island).
NELHA has existing seawater intake and outfall facilities.
The site has all the necessary permits to allow the construction of a full scale desalination plant.

# Solar Resource – Sopogy Array.

The NELHA site also has a micro-trough CSP array available with 2MW output.
1000 mirror field with 250°C mineral oil loop.
Site is fed with seawater and brine facilities.
Coupling heat exchanger to be installed between the CSP field and the desalination plant.

# Project Objectives

The project seeks to demonstrate a reduction of the levelized cost of water (LCOW) by 40% compared to current state-of-the-art.

Specifically, with key advances in the technology, Forward Osmosis will:

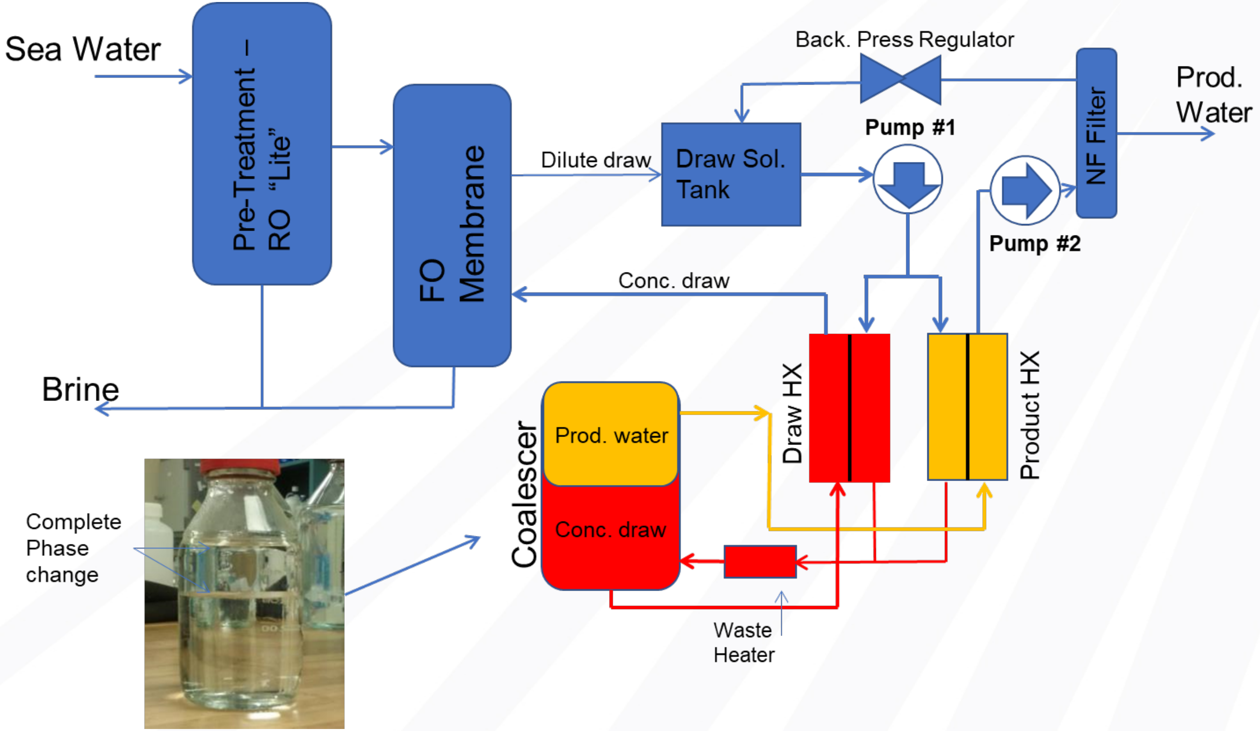
Lower the CAPEX for seawater desalination to $4.5M for 10,000 m3/day compared to $5.5M for RO; $7.3M for MED

Reduce energy cost to $0.10/m3, compared to $0.25/m3 for RO; $0.14/m3 for MED

Increase seawater recovery to 50-60%, compared to 40-48% for RO; 25-40% for MED)

Achieve a Levelized Cost of Water of $0.52/m3, compared to $0.79/m3 for RO; $0.92/m3 for MED

# Desalination Components to be installed.



# Existing Installs

Energy Consumption validated in 5 prior trial systems.

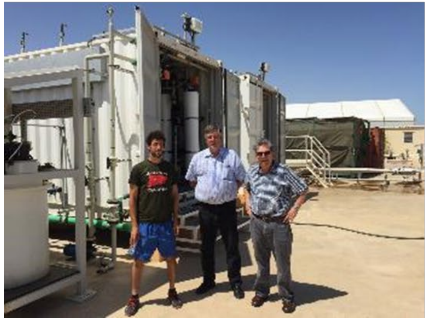
CAPEX has never been optimized although trial systems have been built using low cost components.

Lower Fouling propensity validated.

Masdar 2 container 50m3/day Pilot (Outside Dubai)

FO membranes, Pre-treatment and Heat recovery HX

CEO J Webley, CSO G Carmignani and Field Te.ch at Masdar



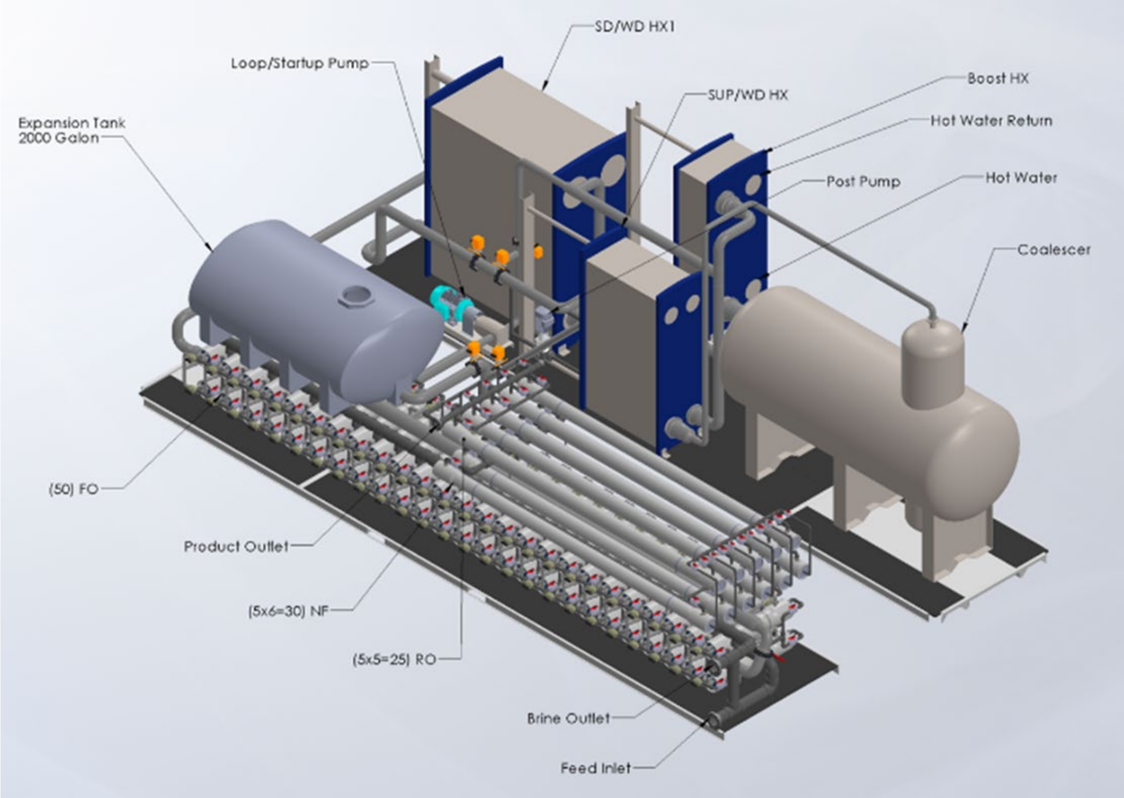
Biological Fouling at Masdar Trial

Coalescer and loop pump[

# 500m3/day (132,000gpd) CAD

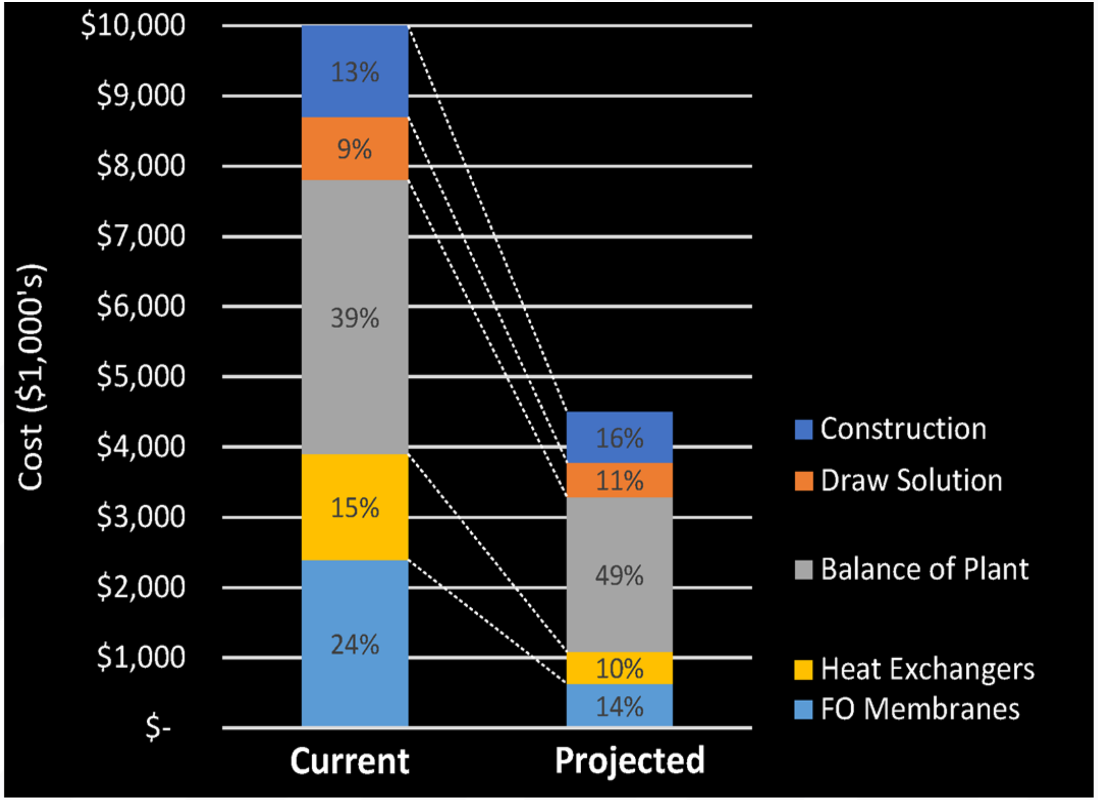
Design for 500m3/day in 2 40ft shipping containers.

Membranes, Coalescer and Heat exchangers shown to scale.



# CAPEX Cost Reduction Goals.

- Cost of energy – Targets of $1kWh_e$ and $30kWh_t$ have been demonstrated at smaller scale and will improve with scale-up.
- Capital Cost – Target of reducing FO membrane and heat exchanger relative cost from 39% to 24%.
- Remaining Balance of Plant costs and construction costs are amenable to market based price reductions as they are mature (low tech) components.



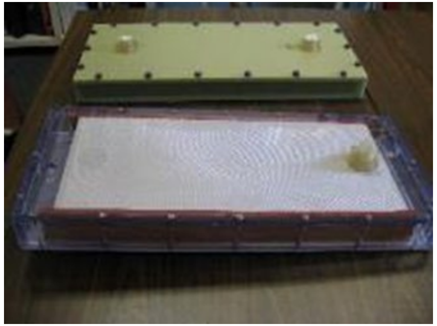
# Membrane Cost Reductions

- Two factors driving the cost of FO membranes are (1) Hollow fiber membrane element manufacturing costs and (2) pressure vessel costs.
    - There is no intrinsic reason that an FO membrane element should be more expensive than an RO element. Higher costs today are due to development costs still being amortized.
    - To drive costs down, a competitive landscape with several manufacturers is required.
- Trevi is in negotiation with three suppliers of Hollow fiber elements, two in Japan and one in the Europe, that have committed to producing the membranes. Trevi has entered a JDA with one supplier to accelerate the production. All three have given commitments that they can supply volume in the timeframe desired.
- As a back-up, if these three vendors do not meet the timeframes needed, Trevi is currently spinning its own membrane.

Pipe Housing

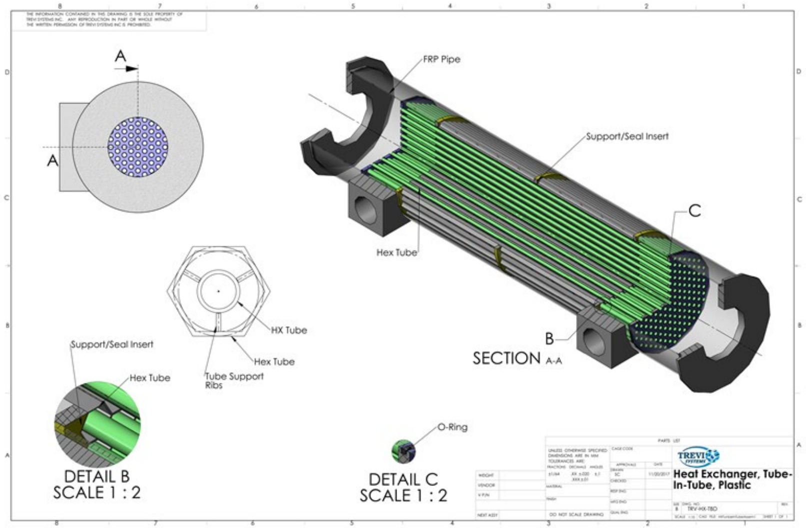
In-House membrane Development

# Plastic Heat Exchangers



In-House Flat Plate Hx

In-House Spiral HX




- The unique phase change characteristics of Trevi's draw solution requires a non-traditional heat exchanger design.
- This requires a tube-in-tube design, similar in performance to a plate and frame but optimized for the phase change induced viscosity changes, and is also different from a tube-in-shell, due to the tight pinch required (<2$^o$C).
- We believe the risk is low in scaling up the design as the structure is self supporting.

# Summary of Outcomes

- On-sun demonstration system at scale
- Hardware Innovations
  - Low pressure-drop polymeric heat exchangers
  - Commercially produced FO filters at viable cost-point
  - NF membranes capable of operating at higher temperatures
- System Optimization
- Advance technology from TRL 4 to 7