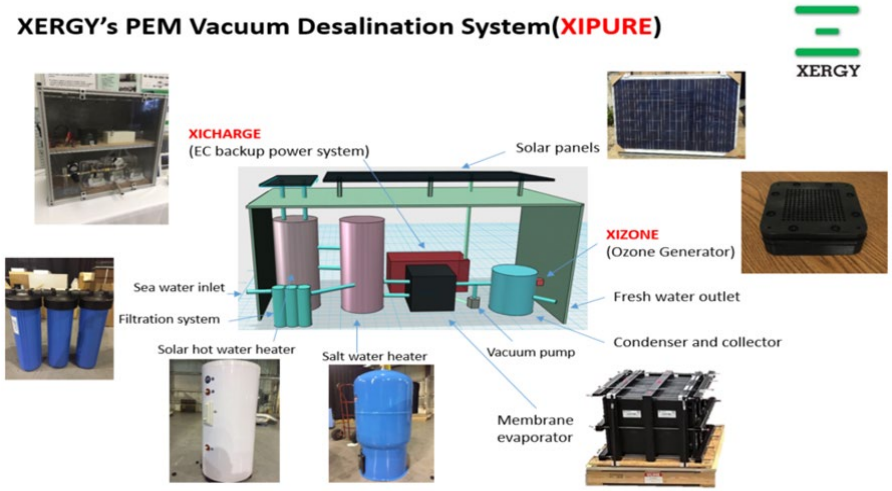
PEM BASED VACUUM DESALINATION SYSTEM

DE-SC0015923

Xergy Inc.

July 31, 2017 – July 30, 2019



Mark Stutman, Xergy Inc.
Harish Opadrishta, Xergy Inc.

U.S. DOE Advanced Manufacturing Office
Program Review Meeting
Washington, D.C.
June 11-12, 2019

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Overview

Project Title: PEM BASED VACUUM DESALINATION SYSTEM

Timeline:

Project Start Date: 07/01/2017

Budget Period End Date: 07/31/2019

Project End Date: 07/31/2019

Project Budget and Costs:

Budget	DOE Share	Cost Share	Total	Cost Share %
Overall Budget	$936591.68	$0	$936591.68	0%
Approved Budget (BP-1&2)	$936591.68	$0	$936591.68	0%
Costs as of 5/15/19	$928163.95	$0	$928163.95	0%

Objective:

To develop a solar powered, independent sea water desalination system for installation at a US Navy remote island, capable of producing 50 gallons per day of potable water.

Project Team and Roles:

- Mark Stutman,
  VP Operations
  Xergy, Inc
- Harish Opadrishta
  Product Manager, Pervaporation
  Xergy, Inc
- Abhishek Bandlore
  Engineer, Pervaporation
  Xergy, Inc

Barriers and Challenges:

Proof of Operations

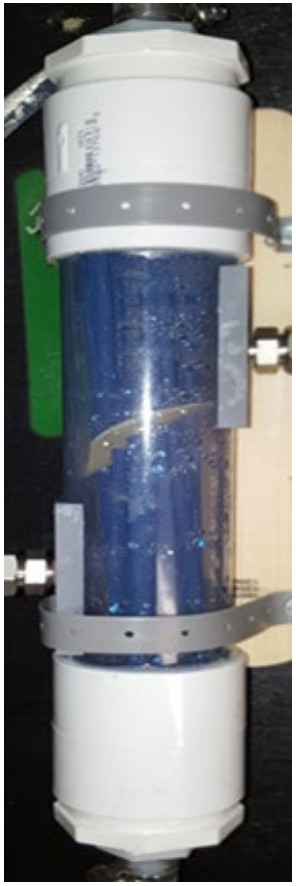
Durability Tests

Capital & Operating Costs

AMO MYPP Connection: Dr. Bob Gemmer

Project Objective(s)

- **To develop: "The most energy efficient, modular and scalable solar-powered membrane desalination system based on Ionic Membranes, that can effectively desalinate the widest range of seawater and waste streams to WHO accepted salinity levels"**



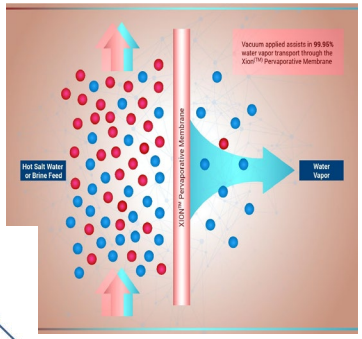
Tubular Membrane Contactor

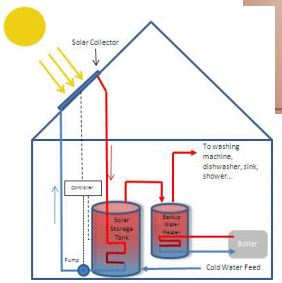
Key Challenges:

- Development of advanced membrane modules
- Operation & Durability of the membrane desalination unit

Technical Innovation

- Using "Pervaporation" i.e. dense (non-porous) Ionic Membranes, and low-grade heat to desalinate salt water.
  - Pervaporation: Permeation + Evaporation
    - Driving force – Chemical Potential
    - Lowest Fugacity for water transmission due to its hydrophilicity



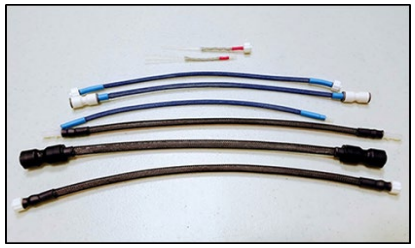


Pervaporation Schematic

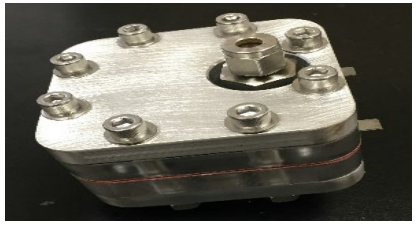
- Solar Thermal system provides low-grade heat
  - Pervaporation system requires 55 to 70 C operation
- Process Input parameters: salt-water concentration, temperature, & vacuum
  - Achieved 5 x flux rates of current state of art ionic membrane systems
  - Demonstrated capacity to efficiently handle Salt Streams > 3.5 to 10 % Salinity (well beyond RO Systems)
- Critical Process Output parameter: water purity
  - Obtained 99.9% removal of salts from 3.5% salt water. The TDS of the permeate obtained is 35 ppm which is an order of magnitude better than tap water.

Technical Approach

Key Scientific/technological aspects:



- Membrane module using novel ionic tubes
  - A Key Innovation is the use of these membranes in tubular form enables the construction of the lowest cost, highest performance, leak proof modules.
- Latent heat recovery unit used to simultaneously heat incoming feed water and condense product steam
- Integrate Electrochemical Ozone disinfection unit



Project risks / Go-No Go Points:

- ✓ Confirm system efficiency with latent heat recovery system
- ✓ Establish production method to produce ionic tubes
- ✓ Develop leak-proof, functional membrane module
- Operate unit to confirm system durability – in process

Additional Participant roles:

- Identified New Applications: Bechtel (Oil & Gas Production Water Purification), Norchem (Industrial Laundry and Waste Streams), Skeiron High Salinity (Brackish water) desalination

Results and Accomplishments

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- ✓ **Heat recovery module has been developed**
  - Operating efficiency of 83.32% demonstrated

- ✓ **Three generations of ionic tubes** developed.
  - The current generation of ionic tubes are leak proof, hold up to 85 psi pressure, and supported by monofilament braids.
  - Tube Sizes range from 0.05 – 0.5 inches

- ✓ **Five generations of modules** have been developed. Results obtained from the Gen 5 module below:

Feed Water Salinity(%)	Feed Water Temperature (C)	Feed Water Flow Rate (gpm)	Permeate Flux Rates (gfd)	Permeate Salinity (ppm)
3.5	70	1	3.05	37
3.5	80	1	3.377	39
3.5	80	2	3.648	32
3.5	70	2	3.127	33
3.5	70	1.5	3.122	38

Transition

- Exhibited Operating Unit at AWWA/AMTA meeting 2019

- Filed 1 Issued Patent, 4 patents in process

- Procured New Test Bed at Brackish Groundwater facility , DOI, Alamogordo, NM

- Obtained laundry waste streams from Norchem for Tests
  - Successful qualification of Norchem laundry waste effluent

  (TDS = 1500 – 2000 PPM). Permeate water obtained had a TDS of 35 ppm.

- Entered into agreements with Bechtel and Skeiron

- Ozone disinfection product launched as an independent product
  - Joint Development program for use in appliances

  (For Dish Washers, and Washing Machines)
  - Strategic Appliance Company Partners: Haier, Sub-Zero