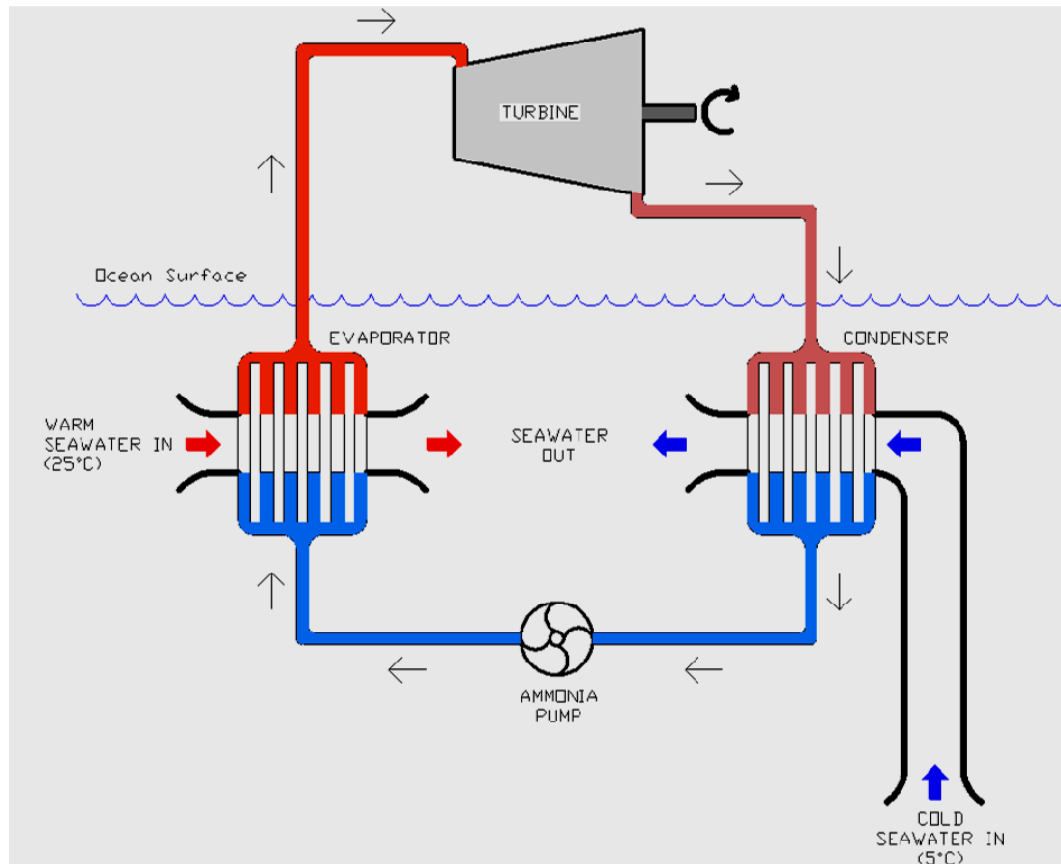


Design of OTEC Heat Exchanger Test Facility

Makai Ocean Engineering, Inc.

Joe Van Ryzin

Ocean Thermal Energy Conversion



Closed -cycle

1. Warm ocean surface seawater boils a refrigerant liquid at high pressure (130 psi).
2. Refrigerant vapor spins a turbine-generator, becomes low pressure (80 psi).
3. Cold deep ocean seawater condenses refrigerant to a liquid again.
4. Cycle continues -- similar to steam turbine but lower temperature.

OTEC Commercialization Strategy



Opportunity Qualification,
Staff/Team & Technology
Development

2007 – 2010

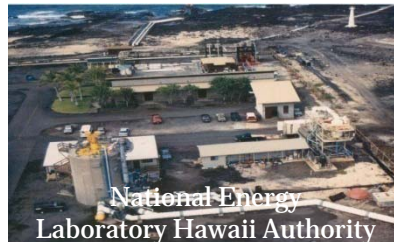
- Pursue funding opportunities
- Industry/Market Contacts
- Opportunity Development
- Technology to Reduce Cost

Key Tenets

- ✓ Focus on DoD opportunities with 10 MW Pilot Plant
- ✓ Seek DoD / DoE funding for Pilot Plant production
- ✓ Re-Package Pilot Plant design for 100+MW Production Plant

Large Scale Testing,
Major System Trades,
Prelim. Design and Cost

2008 – 2010



10 MW DoD/Hawaii Pilot Plant
(Risk Reduction, Market Entry Size)

2008 – 2014



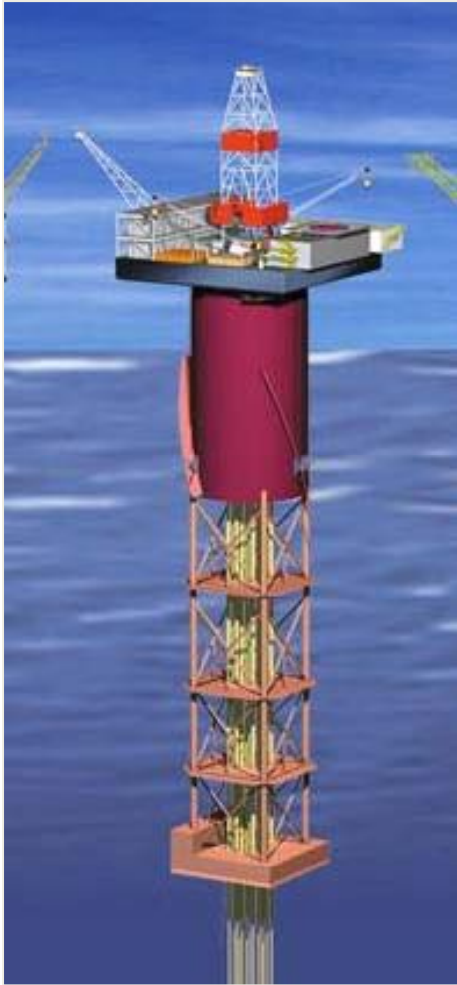
1st 100+ MW Production Plant



Hawaii is:

- ~90% reliant on petroleum for energy
- Mandating 20% energy from renewables by 2020
- DoE “showcase” for renewable energy (Clean Energy Initiative)
- Home to numerous DoD bases interested in distributed renewable energy

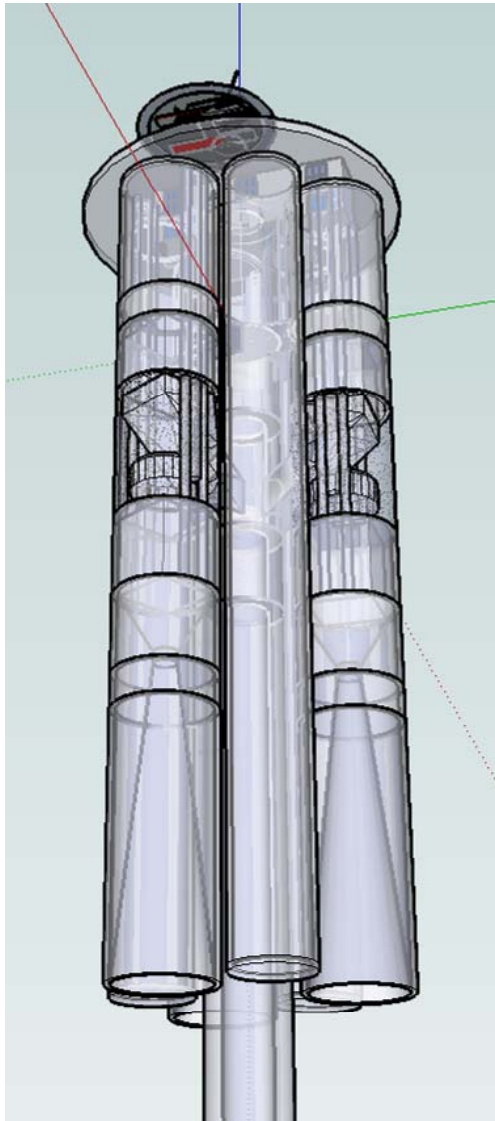
OTEC Technology



- Leverage DOE OTEC investment
 - DOE, 80's: OTEC ready for commercialization
- Technology boost from Offshore Industry
 - Platforms, moorings, dynamic analysis, standards
- Technology Issues:
 - Marine AI heat exchanger
 - Cold Water Pipe (9.5M dia for 100MW)
 - Dynamic cable to shore
 - Environmental Impact / Complex modeling multiple plants
- Financing is the primary challenge



Why HX are important...



By Makai's cost estimator
 Some costs up 40% past two yrs.
 (Costs in \$M Oct 2007)

Item	Qty	Confid	Unit	\$/unit	Cost	Confid	Cost
Center / side hulls	1	1.00	ea	\$364	364	0.75	6,467,096
Ht Exchangers	1	1.00	ea	\$311	311	0.75	19,568,386
OTEC Eqpt	1	1.00	ea	\$195	195	0.75	2,179,089
Installation	1	1.00	ea	\$185	185	0.75	1,092,988
CWP	1	1.00	ea	\$109	109	0.75	267,840
Topsides & Elex	1	1.00	ea	\$80	80	0.75	401,167
Mooring	1	1.00	ea	\$45	45	1.00	-
Design	1	1.00	ea	\$30	30	0.80	12,000,000
Total					\$1.3B		\$1,324,127,474
Possible Range with plus or minus tolerance applied							\$1,000,000,000

(Plausible savings to \$1.1B)

HTDV program pivotal

- \$150k for initial design of HX test facility
- That followed by nearly \$6.5m from ONR, NAVFAC, HNEI, Lockheed, NELHA

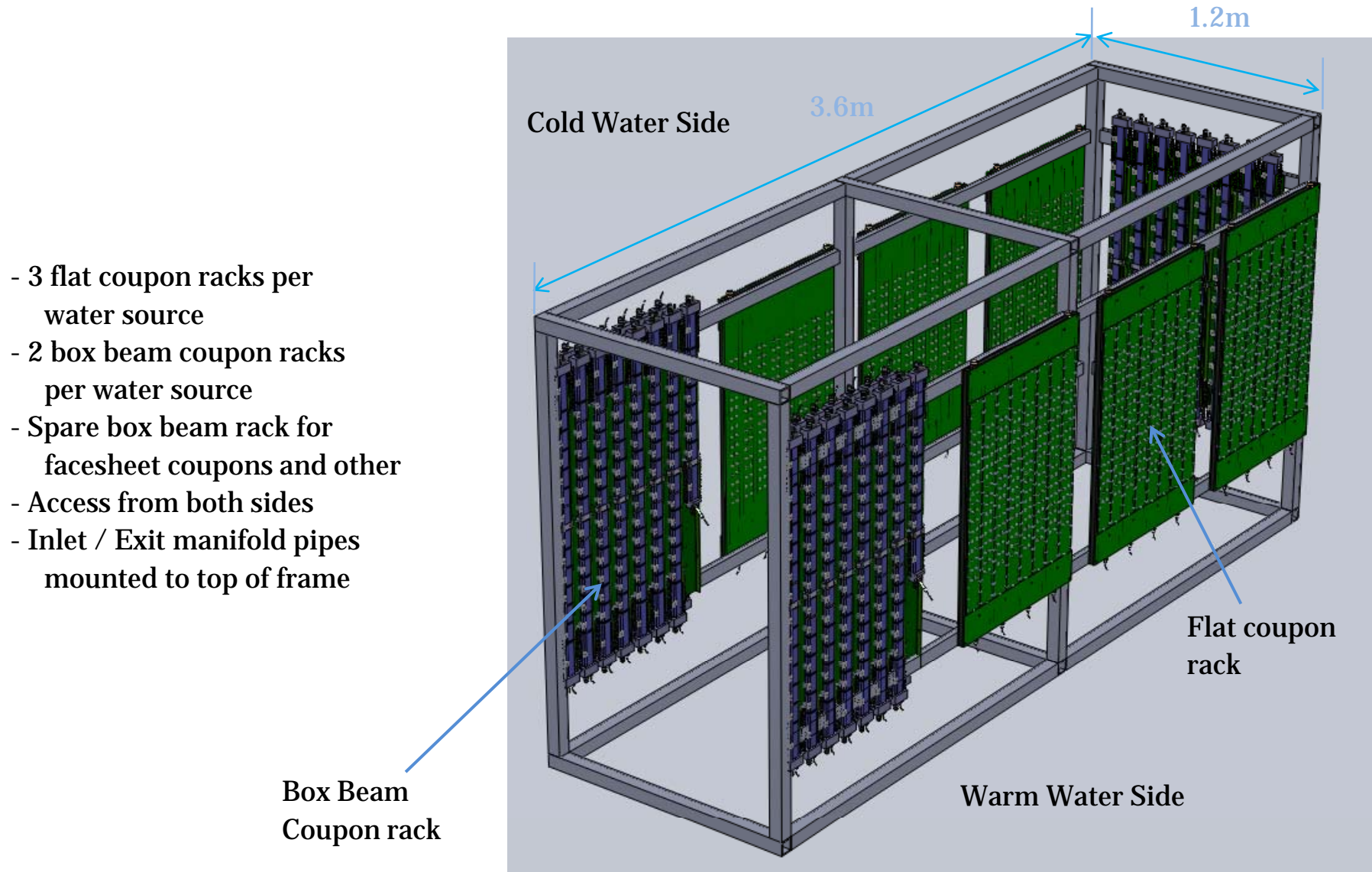
HX Test Objectives

- **Start w/small scale corrosion/biofoul tests**
 - Evaluate Differences 2200' vs 3000' DSW
- **Evaluate HX w/long term exposure to DSW**
- **Build Facility for Performance, Corrosion and Biofouling Tests**
- **Expand Facility to allow parallel unit tests**
- **Expand to allow full scale module performance tests.**

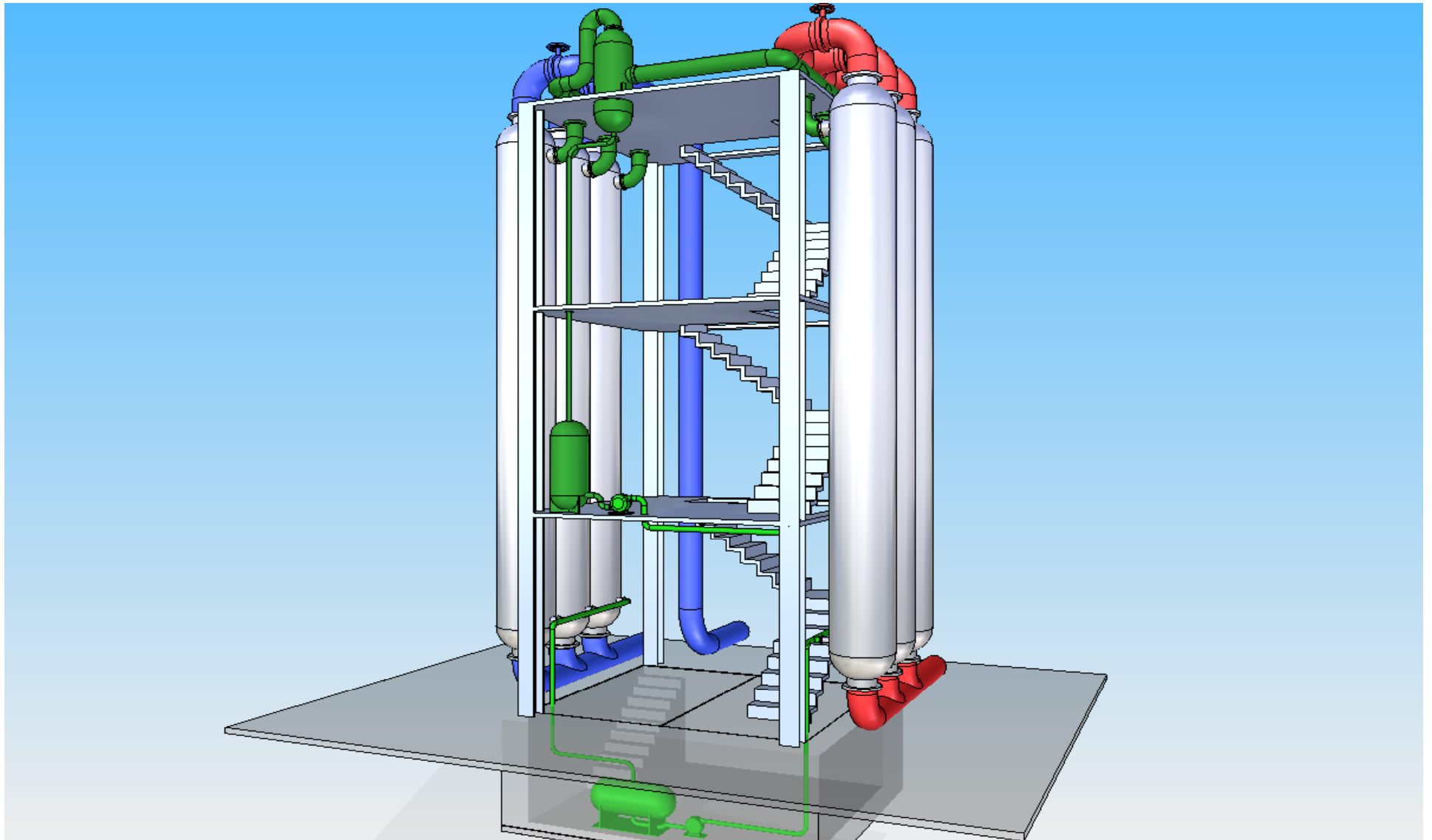
Natural Energy Lab of Hawaii



Corrosion Apparatus Coupon Racks



HX Test Facility



10 MW Semi-Sub Platform

