*Conference Paper SNMREC/CP-11-315*

November, 2011

# Marine Renewable Energy: HASE Challenges

**Howard P. Hanson**

**The 13th IEEE International**
**High Assurance Systems Engineering Symposium**
**Boca Raton, FL**
**(Invited Keynote Address)**

Southeast National Marine Renewable Energy Center
College of Engineering and Computer Science / Florida Atlantic University

# Marine Renewable Energy: HASE Challenges

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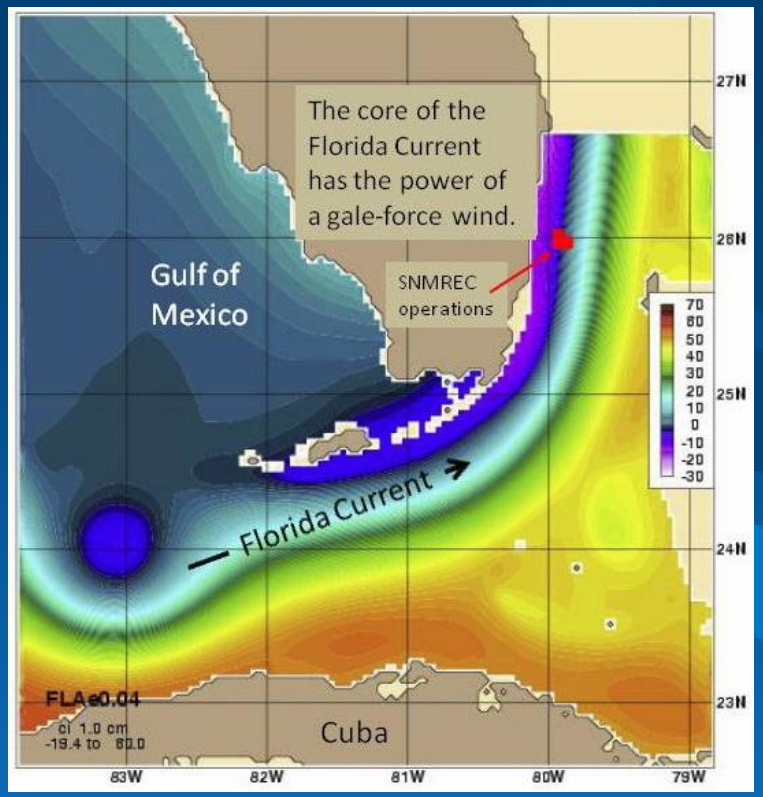
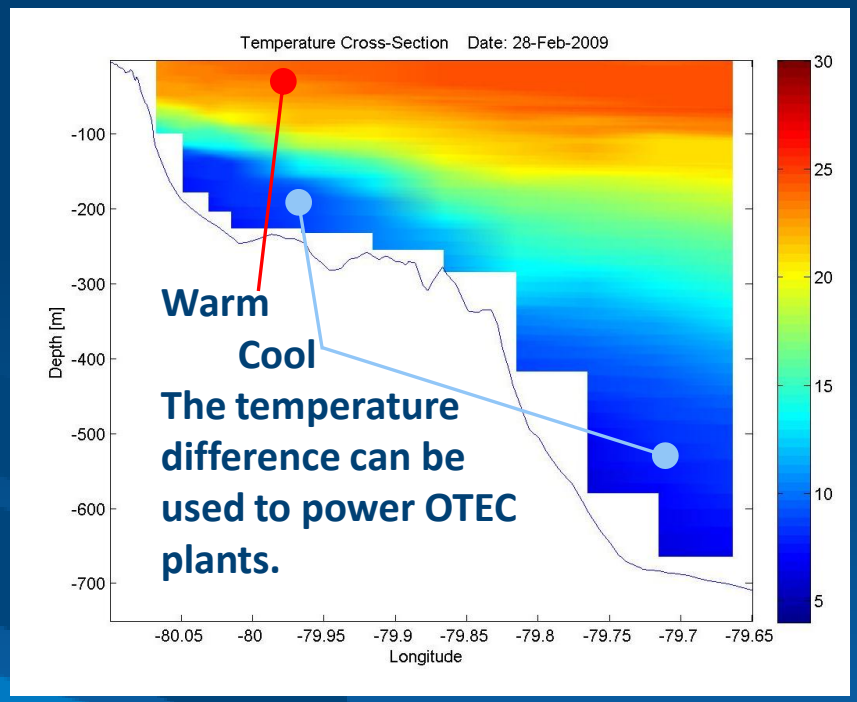
# MRE

- Finite fossil fuel resources plus their environmental impacts, combined with the inertia of large-scale energy production and distribution, make implementation of renewable energy urgent.
- Renewable energy resources are regional.
- Some coastal states have <u>marine</u> renewable energy resources:
  - Wave energy is strong on the west coast and in Hawai‘i;
  - Tidal energy depends on latitude and coastal configuration;
  - Ocean currents are strong in some locations;
  - Thermal resources for ocean thermal energy conversion (OTEC) exist in the subtropics and tropics.

# Florida's resources



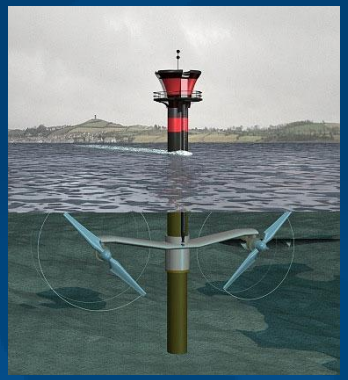

Hydrokinetic potential
≈200 GW total




Thermal potential
> 200GW total

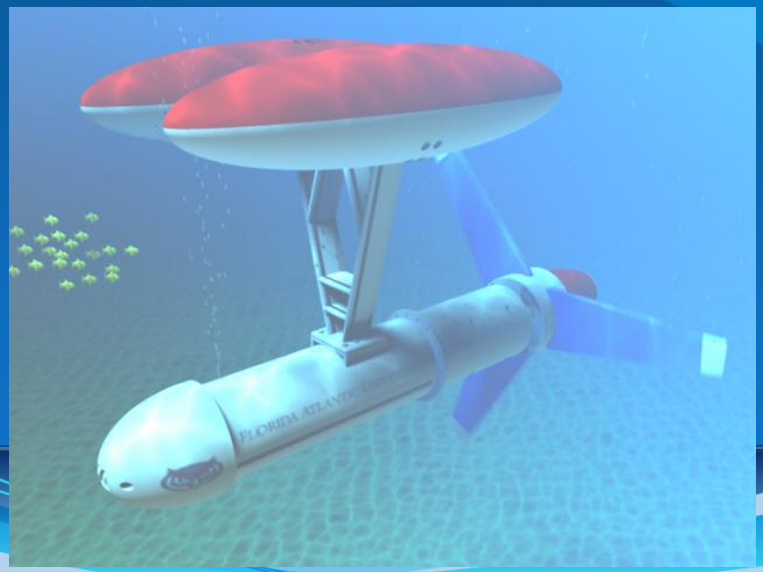
400 GW is more than <u>six Floridas</u> worth of power. Although not all of this potential can be realized, what can be will certainly help.

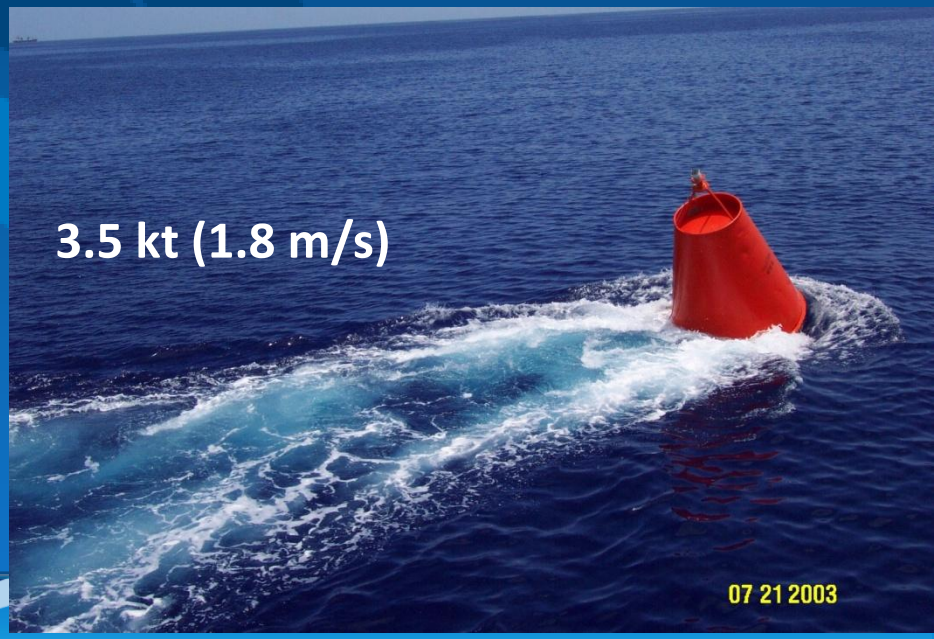
# Technologies - current



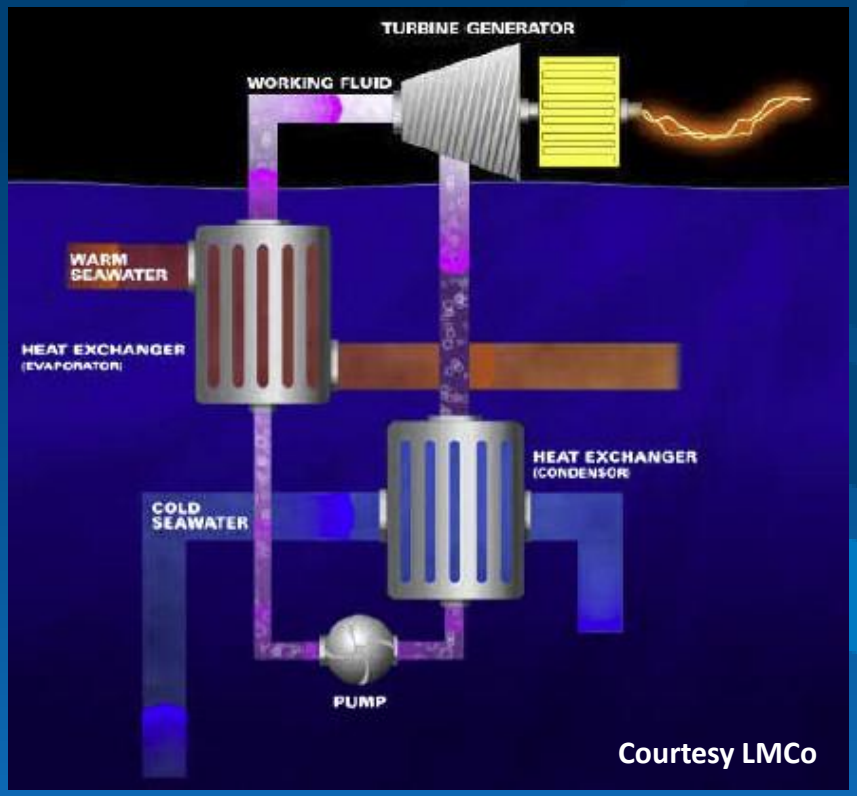
- The water is deep;
- The devices must "fly" in the current;
- Anchors must hold;
- And the current is deceptively strong.

Tidal systems are just underwater wind turbines. Current systems, however, offer greater challenges.





# Technologies - OTEC




OTEC uses a Rankine cycle, with ammonia as a working fluid.

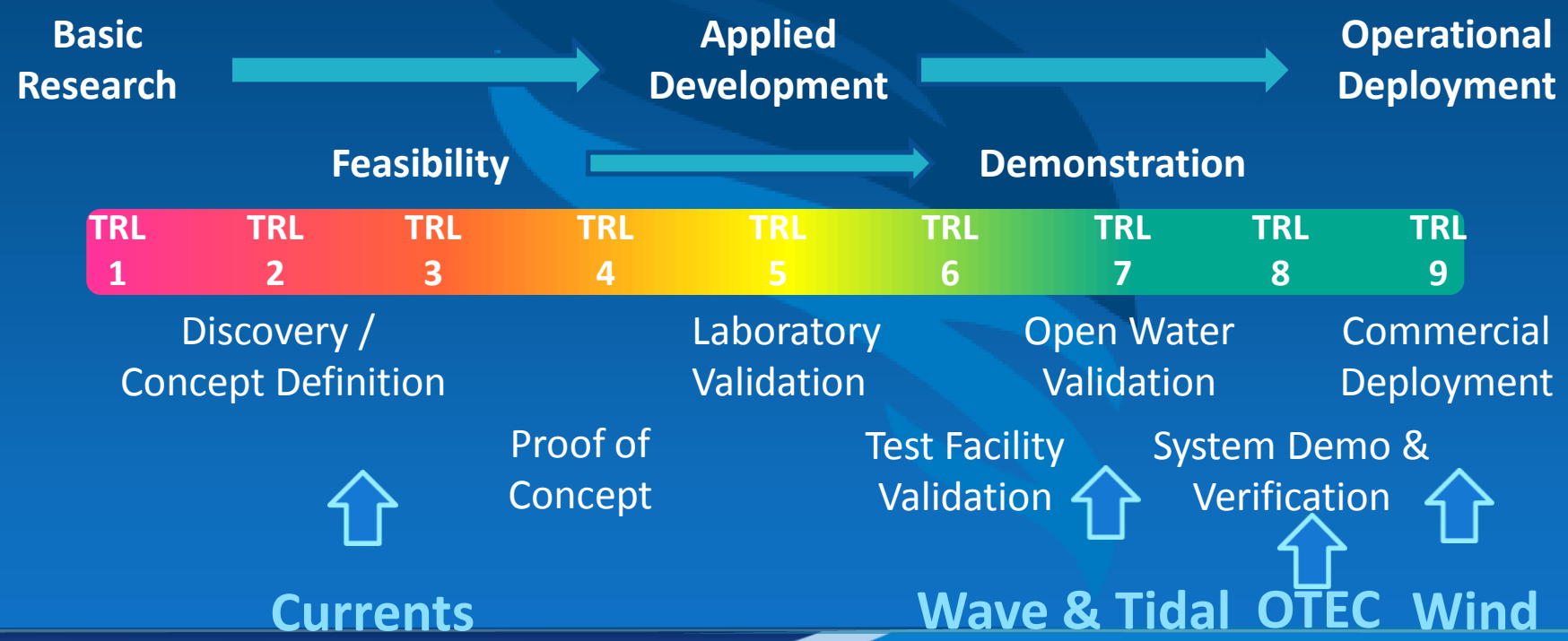

It requires technology on the scale of offshore oil platforms.

In both cases, an integrated systems approach is critical.

# Getting there

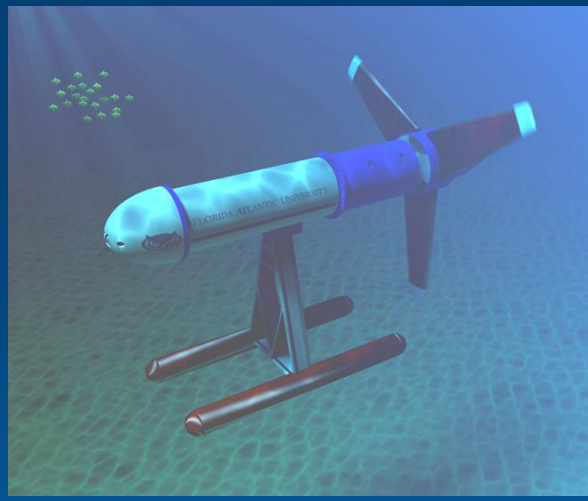
**Wind power is about 30 years ahead of MRE; wave and tidal power are about 10-15 years ahead of open-ocean current MRE. A useful framework for progress is the DoD/NASA/DOE approach of...**

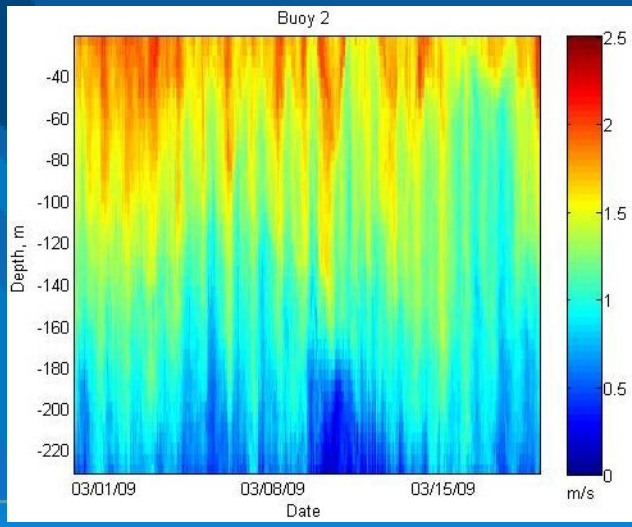
## Technology Readiness Levels



# Harnessing the Florida Current

- SNMREC is developing an at-sea test facility for commercial prototypes; scaled systems will come first, followed by full-size systems.
- Ultimately, individual devices in the 2.5 MW class will be networked in arrays; one or more 2,500 MW arrays seems quite feasible. (The economics are up in the air, though.)
- While the Florida Current is more steady than the wind, it does vary in space and time, on scales down to seconds and meters.





# Technology Challenges

- The individual devices need to operate autonomously and in synchrony.
- Autonomous operation must include system health monitoring and prognosis.
- Consequences of catastrophic failure are high; even minor failures will be quite problematic.
- Almost everything will be submerged – under salt water – more than 15 miles offshore.

# Environmental Challenges

- Endangered species (turtles) and marine mammals use the Straits of Florida as habitat and as migratory pathways – monitoring in concert with equipment health monitoring is required.
- Commercial and pleasure ship traffic is dense, and the U.S. Navy has training areas offshore.
- Underwater infrastructure—cabling, in particular—will need to traverse sensitive benthic habitats, including offshore reefs.
- Current variations require monitoring to predict effects on equipment.

# *Got HASE?*

High-assurance systems engineering is required for all of these challenges:

- Deployment systems need accuracy and fail-safe operation;
- Monitoring of equipment and environment must be reliable and well integrated;
- Operations and maintenance must be accident free (no spills) and safe.

MRE implementation may be seen as a *HASE Grand Challenge*

Initial attacks will be discussed in Session H (Friday morning)

# Path Forward

SNMREC testing infrastructure will include capabilities for

- Performance & health monitoring;
- Environmental monitoring;
- DAQ and real-time analysis.

But our work is very small-scale for a limited number of systems.

We look forward to working with the HASE community as MRE commercialization matures. Opportunities exist for the HASE community at the other National MRE Centers as well.