BOEM Offshore Renewable Energy Workshop

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DOE - Offshore Wind and Marine Hydrokinetics (MHK) Overview

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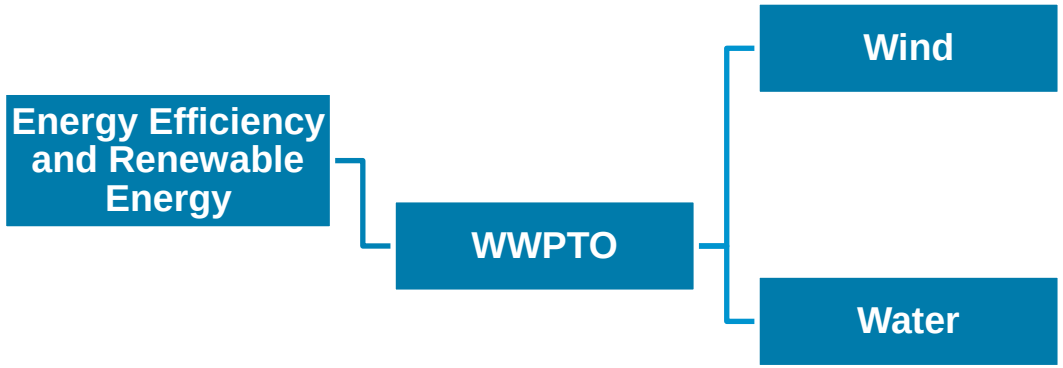
In Support of the US Department of Energy - Wind and Water Power Technologies Office

What is the Role of DOE and WWPTO?

Mission: To accelerate the deployment of wind and water power technologies through improved performance, lower costs, and reduced market barriers.

WWPTO Role

- **Inform** citizens and decision makers
- **Convene** leaders and **facilitate** national and international information exchange
- **Support** innovation partnerships to research, develop, demonstrate, and deploy unique technology solutions to address offshore wind and marine hydrokinetic challenges.



Global State of the Offshore Wind Industry

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State of the Industry

- 80 projects, 6,800MW installed (end of 2013) primarily in Europe
- Initial projects based on marinized land-based technologies
- Upwind, three blade rotor configuration with primarily geared generators
- High project and O&M costs contribute to high cost of energy and project risk

Global Leaders

- Most development in Europe so far – UK leading
- Japan is investing in floating technology development and demonstration
- China has over 5 GW approved, with 500 MW under construction

Yesterday

- Bottom fixed (monopiles)
- 2-4MW turbine with geared generator

Today

- Bottom fixed (jackets, monopiles)
- 4-6 MW turbine with direct drive generator

Tomorrow

- Floating foundations
- 6+ MW turbine with direct drive generator

U.S. Gross Offshore Wind Resource

Region	GW by Depth (m)		
	0 - 30	30 - 60	> 60
New England	100.2	136.2	250.4
Mid Atlantic	298.1	179.1	92.5
S. Atlantic Bight	134.1	48.8	7.7
California	4.4	10.5	573.0
Pacific Northwest	15.1	21.3	305.3
Great Lakes	176.7	106.4	459.4
Gulf of Mexico	340.3	120.1	133.3
Hawaii	2.3	5.5	629.6
Total	***1,071.2***	***628.0***	***2,451.1***

4,150 GW

National Offshore Wind Strategy

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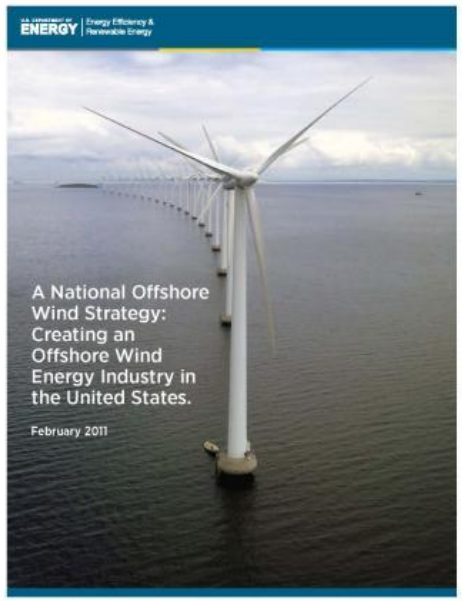
Two Critical Objectives

1) **Reducing the cost of energy** through technology development
2) **Reducing deployment timelines** and uncertainties



Developed jointly by DOE and DOI

World-Class Test Facilities	Removing Market Barriers	Next Generation Drivetrain R&D	Developing Innovative Technology	Demonstrate Next-Generation Designs
(ARRA Projects)	(Offshore FOA 1)	(Tech. Viability FOA)	(Offshore FOA 2)	(Offshore FOA 3)
Clemson 15 MW Dynamometer	Siting and Permitting	Aggressively Targets Key Cost Components	Computational Tools Turbine Design Marine Systems Engineering	Demonstration Project Partnerships with 50% Cost Share
Massachusetts Large Blade Test Facility (to 90m)	Infrastructure			
	Resource Planning			
COMPLETED	ONGOING	ONGOING	ONGOING	ONGOING
$70M	$16.5M	$7.5M	$26.5M	$168M

Realizing DOE Goals

- NREL and Clemson Dynamometer Facilities commissioned in 2013
- Large blade test facility in Massachusetts opened in 2011
- US market reports assessing:
  - Offshore wind vessels (Douglas-Westwood, 2013)
  - Ports report and tool (Garrad Hassan, 2014)
  - Manufacturing and supply chain (Navigant, 2013)
- Environmental studies in progress
  - Biodiversity Research Insititute – mid-Atlantic Baseline Surveys
  - Stantec – bat offshore habitat use
- Innovative technology development – floating and transitional depth system design work on-going

Offshore Wind Demonstration Projects: Original Selection

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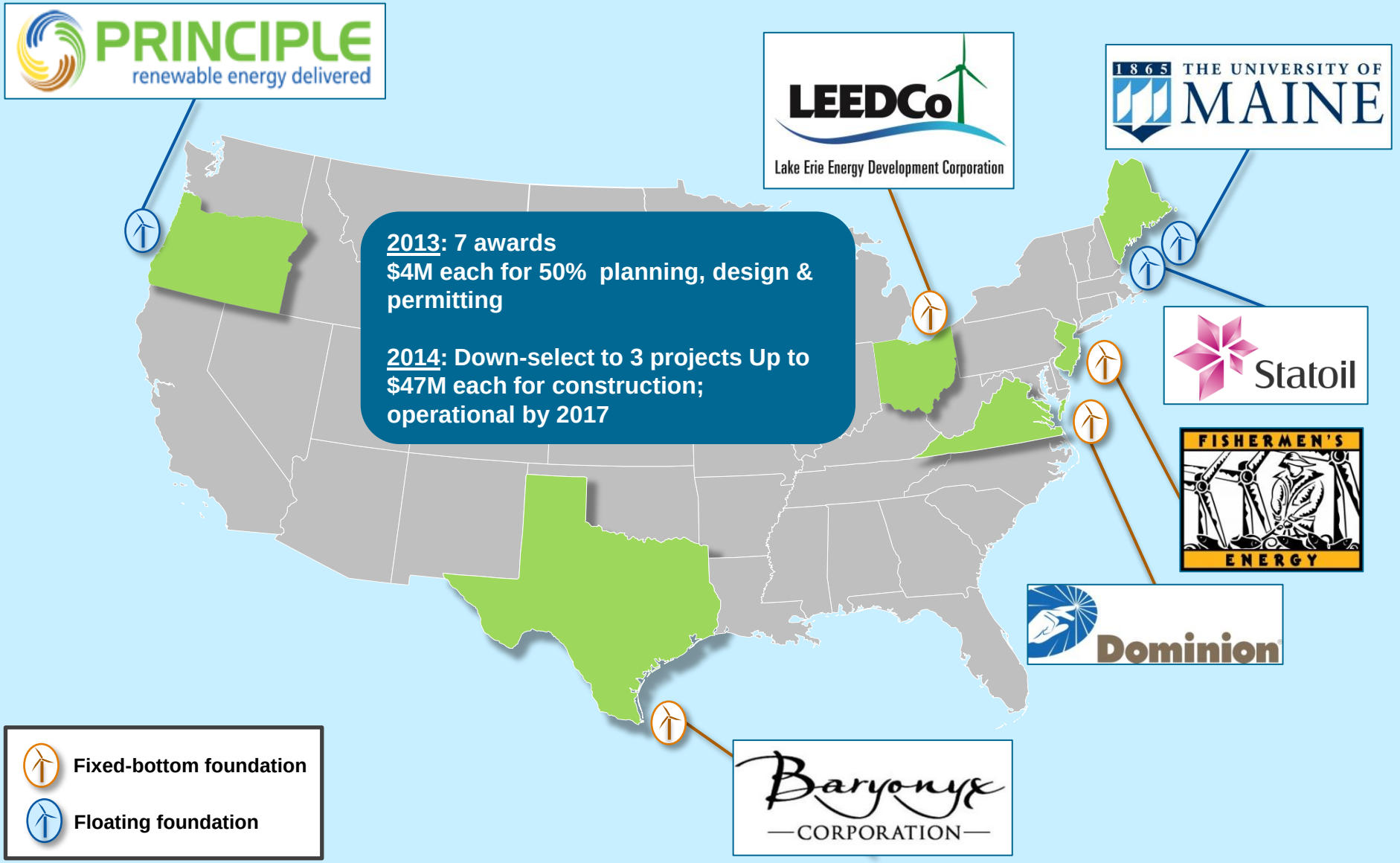

Why Offshore Wind Demos Now?

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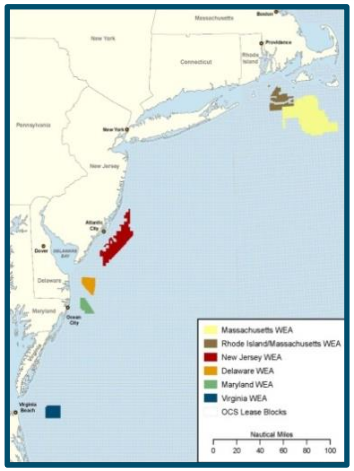
Development of the US offshore wind industry will not look like Europe

- Unique solutions needed for different wave and bottom conditions, hurricanes, and large deep water resource

Demo Projects will Reduce Barriers

- Cost of energy reduction
- Clarification of regulatory uncertainties
- Address questions about environmental impacts
- Supply chain will start to develop to support the industry



State of the US Industry

- No US offshore wind farms currently exist
- 3 GW are in advanced stages of development along East and Gulf Coasts

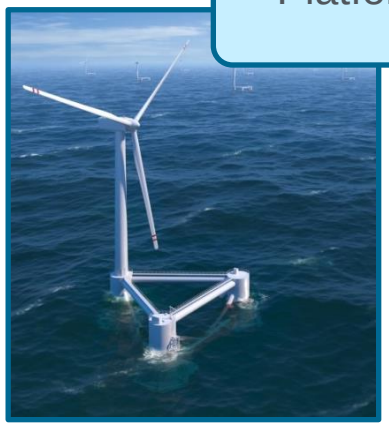
DOE is in a unique position to jump start the offshore wind industry in the U.S. through targeted investments.

Offshore Wind Demonstration Projects Goals

Drive down the cost of offshore wind with demonstration project innovations

Advanced Materials

Floating Platforms



Demonstrating Innovations

Large Direct Drive Turbines

Improved Manufacturing

Leading-Edge Foundations

Offshore Wind Demonstration Projects Goals

- Create a pathway and advance the regulatory frameworks vital to implementing offshore wind in the U.S.
- Collect environmental data before, during and after construction to inform future siting and approval processes
- Address public concerns associated with the concept of offshore wind

Offshore Wind Demonstration Projects: Down-Selected Projects

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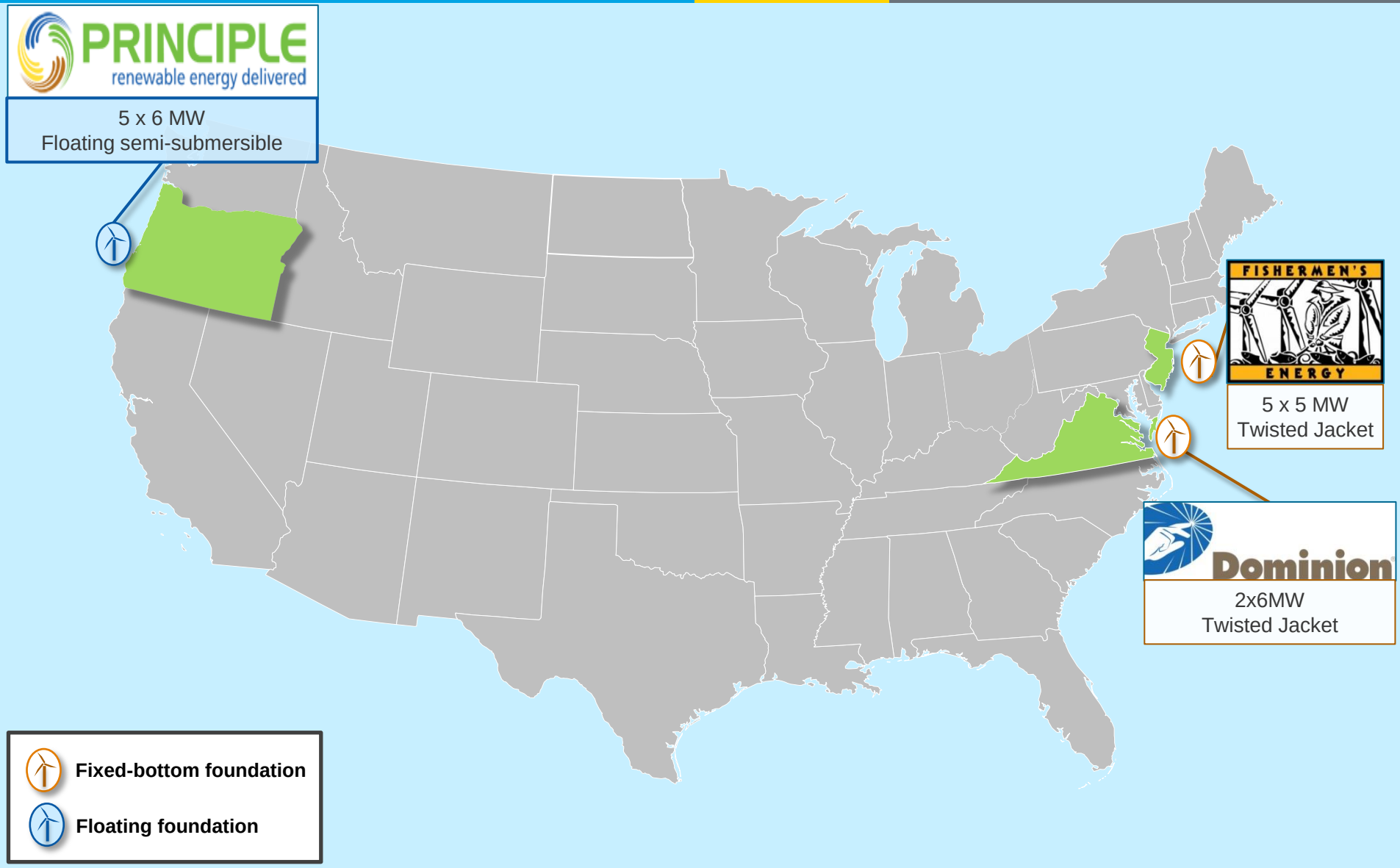
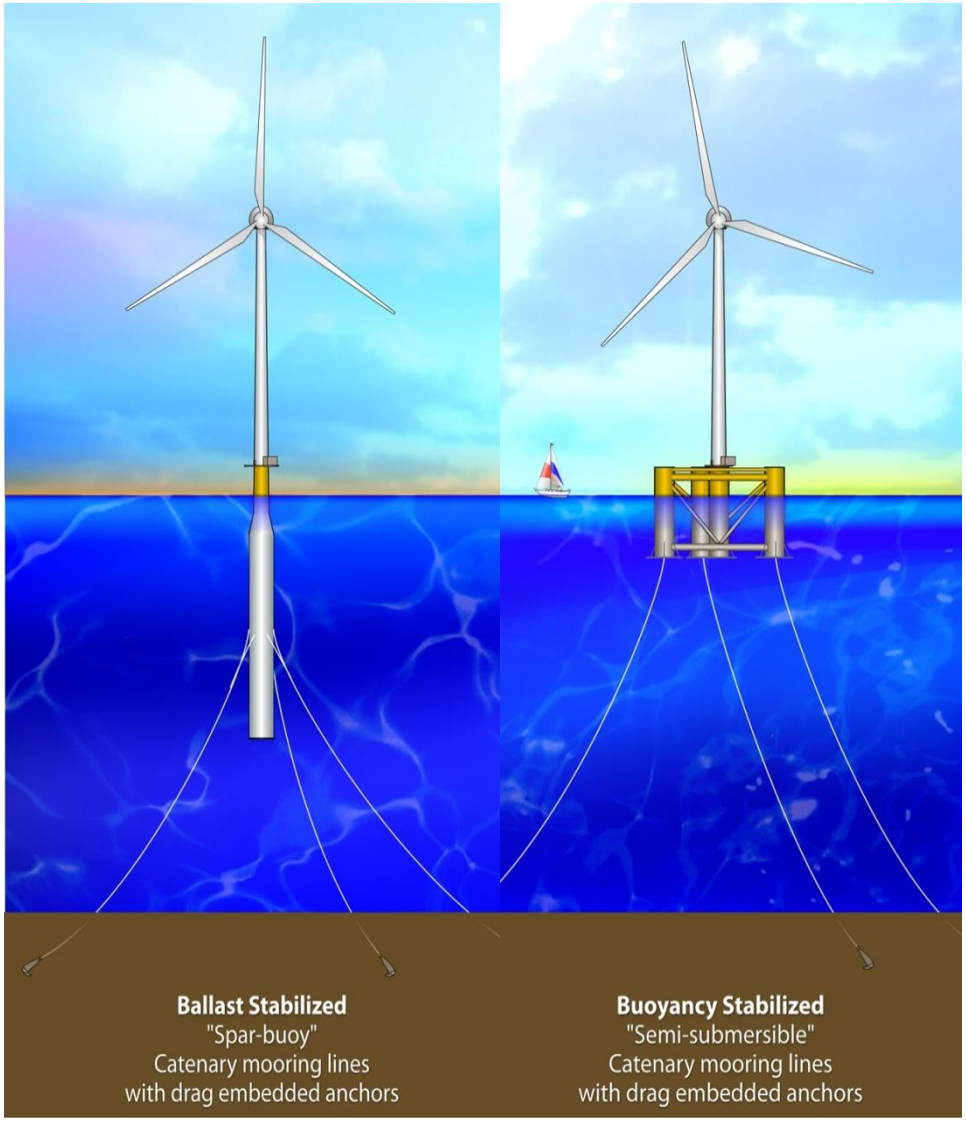
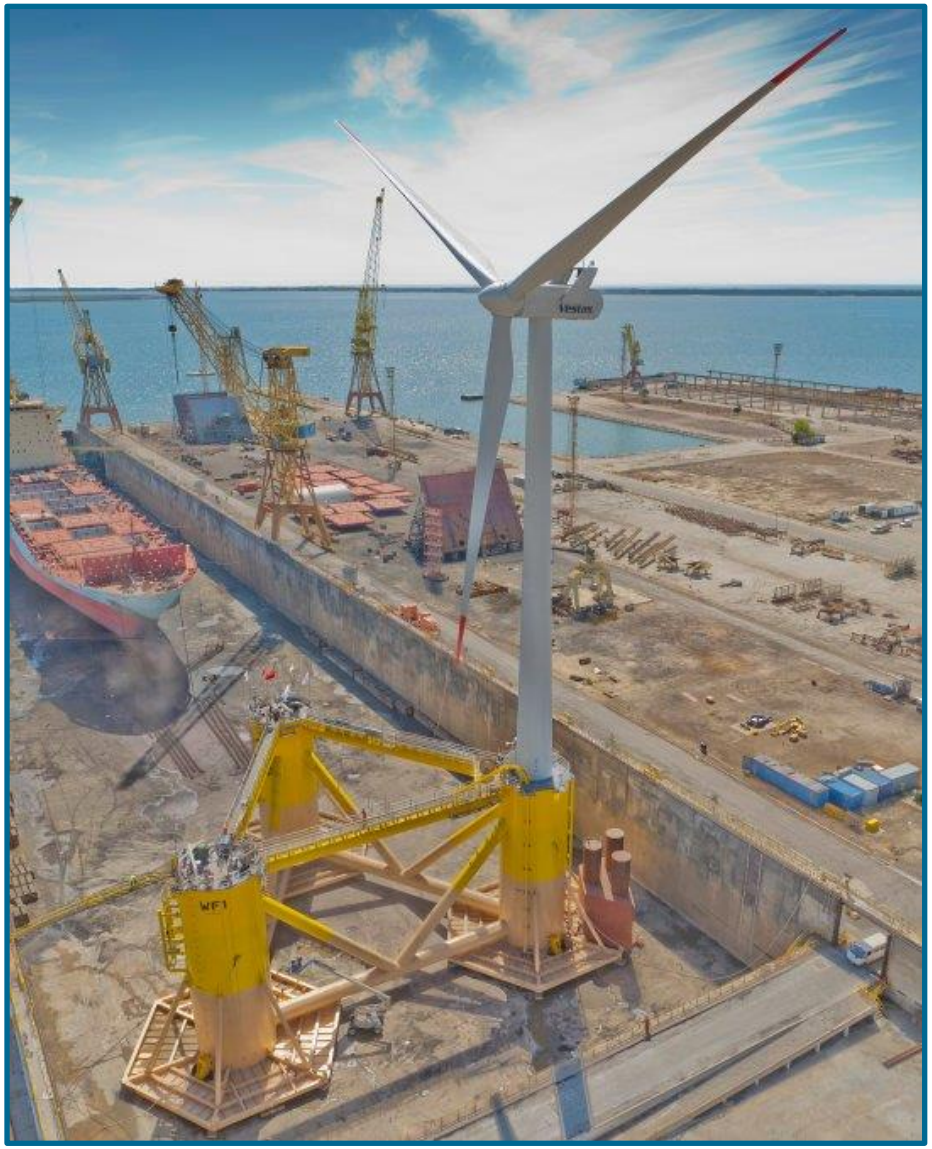


Floating Wind Advantages

- Versatility
- Serial production
- No pile-driving needed — 3 or 4 mooring lines and anchors for station keeping
- Quayside assembly and tow-out to site
- No heavy lift ships
- Equipment is removable – not like a hydroelectric dam



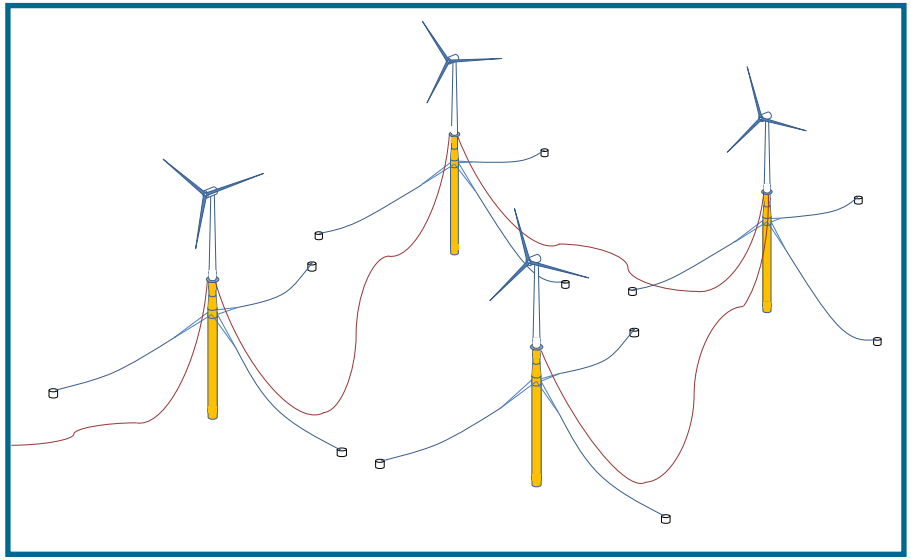
Floating Wind Advantages



Floating Wind Advantages

Floating Foundations: Statoil Hywind Spar

- Floating spar foundation
- 3-point mooring
- Potential for “float-and-flip” installation concept
- 2-MW demonstration off of Norway in operation since 2009
- Demonstration has experienced extreme wave conditions



Floating Foundations: Principle Power WindFloat

Project Highlights

- Semi-submersible foundation
- 16 nm of Coos Bay, Oregon in 1,200 ft of water (350 m)
- Five, 6-MW Siemens turbines
- No heavy-lift vessels required – quayside assembly, tow-out installation and tow-in O&M
- Mooring and anchors are pre-installed
- Dynamic electrical cable connecting turbines together
- Potential for mass production
- 2-MW WindFloat 1 off of Portugal since 2012

MHK Development Opportunities

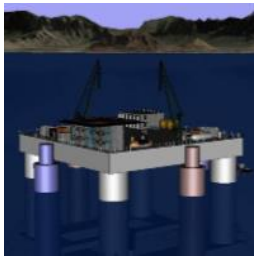
Wave

Tidal

Ocean Current

Instream Hydrokinetic

Ocean Thermal



A range of marine resources, each with its own set of unique characteristics and challenges…

leading to a wide variety of technology types and device designs…

none yet mature nor optimized for performance (technical, environmental, cost).

MHK Strategic Objectives

Technology Development

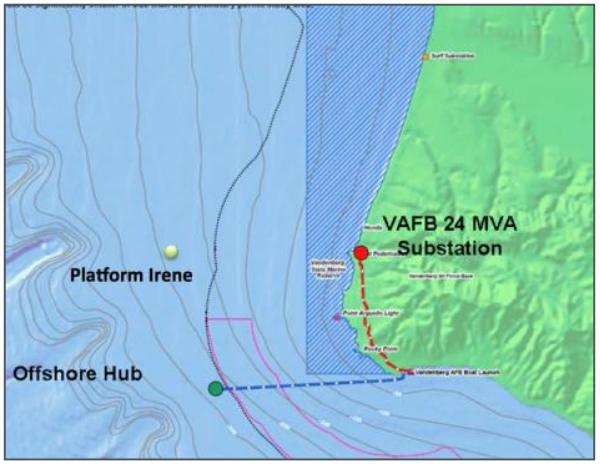
- Prove technical credibility and optimize performance through technology advancement and demonstration
- Strengthen MHK device quality and rigor through comprehensive testing infrastructure and instrumentation
- Quantify operating conditions and reduce siting risk through resource characterization

Market Acceleration

- Boost investor confidence and reduce regulatory barriers through addressing a wide range of environmental and market barriers.

DOE aims to compress technology development timelines with the goal of **reducing the LCOE for MHK devices** to local coastal hurdle rates of 12-15 cents per kilowatt hour (kWh) by 2030.

Wave Device Testing Facilities on the West Coast



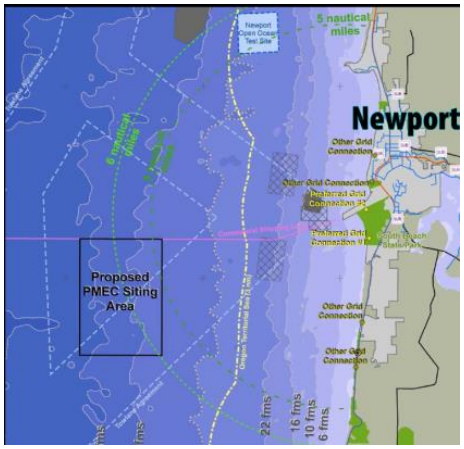
California Polytechnic State University California Wave Energy Test Center

- Open water, grid connected full scale wave test site preliminary design
- Will select from two potential sites near Eureka and Vandenberg AFB
- Builds on previous work from WaveConnect project

Pacific Marine Energy Center

(Newport, OR)

- Grid-connected test facility, to evaluate utility scale wave energy conversion (WEC) device performance, environmental interactions, and survivability
- Builds on previous NNMREC test infrastructure work

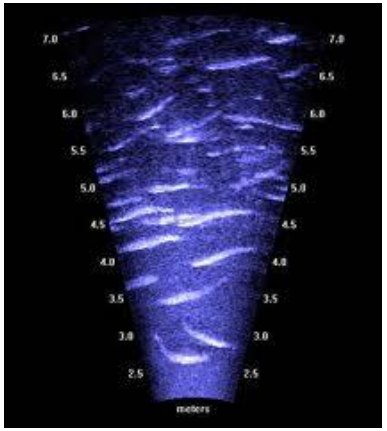


Environmental Monitoring of MHK Projects

Fish behavioral responses to MHK devices

Oregon State University

- Behavioral response and reefing around WEC devices



Characterization of generated noise

Oregon State University

- Characterization of WEC generated noise

University of Washington

- Characterization of turbine generated noise and marine mammal response

Conclusion

- The Offshore Wind Demonstration Projects are a learning opportunity
  - Highly instrumented with many data collection opportunities
  - Opportunity to study offshore wind before moving into commercial scale development
- Data sharing opportunities for future offshore wind and marine hydrokinetic development
- Communication and collaboration
  - Keep lines of communication open
  - Collaboration with key parties

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Thank you.

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