DOE Offshore Wind Program
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BOEM ITM, New Orleans

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Presentation Overview

- The Offshore Wind Industry
  - Global and U.S. overview
  - Technology perspective
  - Tie-ins to offshore oil & gas industry

- DOE Actions
  - Support technology innovation to lower cost of energy
  - Facilitate environmental assessment and site characterization
  - Issue *National Offshore Wind Strategy* w/BOEM
  - Provide objective source of industry information
Offshore Wind Status

A very real global industry.....

- Installed capacity: ~13 GW
- Number of turbines: ~ 3,900 (MW scale)
- 2016 investment: ~ $24 billion
- Project development pipeline: ~ 230 GW (6 GW under construction)
- Countries with active projects: 15 (Europe, Asia, U.S.)
- Major O&G players now include Statoil, Shell, DONG, Eni SpA, Total SA
- 1st European project decommissioned after 25 years (5 more than anticipated)

...beginning to take hold in the U.S.

- Block Island (RI) is operating (5 x 6 MW turbines)
- Pipeline: ~ 15 GW of projects in active development
- Key players: BOEM, states, US and European developers, wind energy and O&G supply chains, marine industry
U.S. Context:
Wind Energy is National in Scale

Blue = Utility-Scale Windfarms
Red = Supply Chain

Interactive Wind Industry Map at AWEA.org
Offshore Turbines are Massive Machines

Vestas V164-8MW Turbine
Total Height: 220 m (720 ft)
Rotor Diameter: 164 m (538 ft)
Blade Weight (each): 33 - 35 tonnes
Turbine Weight: 1,300 tonnes
Foundation Weight: 4,000 tonnes

Burbo Bank (UK); 32 turbines; DONG Energy, 2016
Similar Foundation Types - Different Functional Depths

Offshore Oil and Gas Platform Types

Topside = “Static” Load
Topside size and configuration highly dependent on mission
Design solutions generally specific to single installation

Offshore Wind Turbine Foundation Types

Turbine = Dynamic Thrust Load
Turbines are standardized
Blade lengths and foundations can vary with conditions
Replicability is key to project economics
Fixed-Bottom Foundations

Oil & Gas

Wind

Offshore Wind Substation
Floating Foundation Types

Oil & Gas
- Spar
- Semi-submersible
- Tension Leg

Wind
Enable U.S. Industry Growth and Competitiveness

- Facilitate cost of energy reductions through R&D
- Address market barriers and environmental sustainability
- Optimize grid integration and transmission
- Convene stakeholders and partners
- Disseminate data and results
- Enable wind development in all U.S. regions

Enhance Energy Security and Independence

Strengthen Domestic Manufacturing and Local Economic Value

Scale and scope of activities are tied to congressional appropriations and directives
Three Prime Focus Areas

Technology Development

- World-Class Test Facilities
  (FY09)
  Clemson 15 MW Dynamometer
  Massachusetts Large Blade Test Facility (to 90m)
  $70M

- Next Generation Drivetrain R&D
  (FY11)
  Aggressively Targets Key Cost Components
  $7.5M

- Developing Innovative Technology
  (FY11)
  Computational Tools
  Turbine Design
  Marine Systems Engineering
  $26.5M

Market Barrier Removal

- Removing Market Barriers
  (FY11)
  Siting and Permitting
  Infrastructure Studies
  Resource Planning
  $16.5M

Advanced Technology Demonstration

- Demo Projects
  (FY12-18)
  Advanced Technology Deployed on Demonstration Scale
  Partnerships with 50% Cost Share
  $168M
Offshore Environmental Projects (examples)

- High definition **baseline surveys of birds, sea turtles, and marine mammals** from NJ to VA/NC border
  
  Partners: NCSU; CUNY: Duke U; USFWS; USGS; Memorial U-Newfoundland; BOEM

- Study of **offshore bat activity and species composition** in Gulf of Maine, Great Lakes, and Mid-Atlantic including spatial and temporal use patterns

- Software for **detection and classification of birds and bats** by tracking in 3-D infrared video using wing beat frequency and other variables

- Design and testing of synchronized array of sensors for **remote monitoring of bird and bat turbine interaction**, including accelerometers, visual and infrared spectrum cameras, and acoustic monitors

- International Energy Agency Task 34 (WREN) **collaboration to resolve environmental effects of wind energy**.
  
  - US partners: BOEM, FWS, NOAA
  
  - Open knowledge base of international environmental and site characterization studies
Technical Research & Analysis

Atmosphere to Electrons (A2e) Program

- Fundamental physics-based research supporting holistic wind plant design optimization including factors such as turbine-to-turbine wake interaction
- Includes both simulations through supercomputing and field experiments

Improving Tools and Resources

- Wind maps; Wind Forecasting Improvement Project
- Radar impact analysis and mitigation measures

Analyses and Reports

- Assist the U.S. industry in determining the factors leading to cost of energy reduction, and the potential electricity market value of offshore wind:
Advanced Technology Demonstration Projects

Drive down the cost of offshore wind by de-risking innovative technologies in US conditions

- Advanced Materials
- Floating Platforms
- Environmental and geophysical site characterization
- Improved Manufacturing
- Leading-Edge Foundations
- Large Direct Drive Turbines
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Advanced Technology Demonstration Projects – 2017

**University of Maine**
- 2.5 miles off Monhegan Island
- 90-120m water depth
- 2 concrete semi-submersibles
- 6-MW GE turbines
- Tech challenges: deep water

**LEEDCo**
- 7-10 miles off Cleveland
- 15-20m water depth
- 6 “Monobucket” foundations
- 3.45-MW Vestas turbines
- Tech challenges: ice accumulation; weak soils

**Dominion**
- 27 miles off Virginia Beach
- No longer funded by DOE
- DONG Energy (Denmark) partnering with Dominion to implement project plan
- Two 6-MW GE turbines
- Tech challenges: hurricane conditions

All 7 projects have made significant contributions to industry growth regarding technical design, site assessment, project development and market factors
National Offshore Wind Strategy

- Jointly issued with BOEM in 2016
- Aimed at facilitating the responsible development of a robust and sustainable offshore wind industry in the U.S
- Over 30 DOE and DOI initiatives to address 7 action areas; three strategic themes

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<tr>
<th>Strategic Themes</th>
<th>Action Areas</th>
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| Reducing Technology Costs & Risks         | 1. Offshore Wind Power Resource & Site Characterization  
                                           2. Offshore Wind Plant Technology Advancement  
                                           3. Installation, Operation & Maintenance, & Supply Chain Solutions  |
| Supporting Effective Stewardship          | 4. Ensuring Efficiency, Consistency & Clarity in the Regulatory Process  
                                           5. Managing Key Environmental & Human Use Concerns  |
| Improving Understanding of the Benefits of Offshore Wind | 6. Offshore Wind Electricity Delivery & Grid Integration  
                                           7. Quantifying / Communicating the Costs and Benefits of Offshore Wind |
2016 Offshore Wind Technologies Market Report

• Released August 8
• Quantitative information about the global offshore wind market
• Data through 2016; important developments tracked through June, 2017
• Key Sections:
  o Overview of Global Project Development
  o U.S. Market Assessment
  o Cost and Pricing Trends
  o Technology Trends
  o Appendix of U.S. Policies
• Excellent reference for all planned U.S. projects; lease areas; state policies; etc.
U.S. Offshore Wind Lease Prices Have Increased as Major European Developers Enter Market and State Policies Become More Favorable to Development
Contract Electricity Prices for European Offshore Wind Farms Have Fallen to Unsubsidized Levels in Recent Power Purchase Auctions

Note: prices shown are normalized to account for differences between countries in allocation of transmission and development costs.
Moving Forward: Reducing Industry Risks and Costs

- Advanced Metocean data characterization methods
- Continued collaboration with BOEM on environmental assessment
- Deployment of Demonstration projects
- Quantify value of OSW in electricity markets
- Facilitate Joint Industry Projects to address U.S. challenges
- Innovation in installation and balance of system design
- Support standards development
- Support U.S. supply chain
Thank you.

Offshore Wind Market Report:

National OSW Strategy:

Environmental Knowledge Base for Marine and Wind Energy (TETHYS):
tethys.pnnl.gov