



DOE Offshore Wind Program

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BOEM ITM, New Orleans

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➤ 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



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

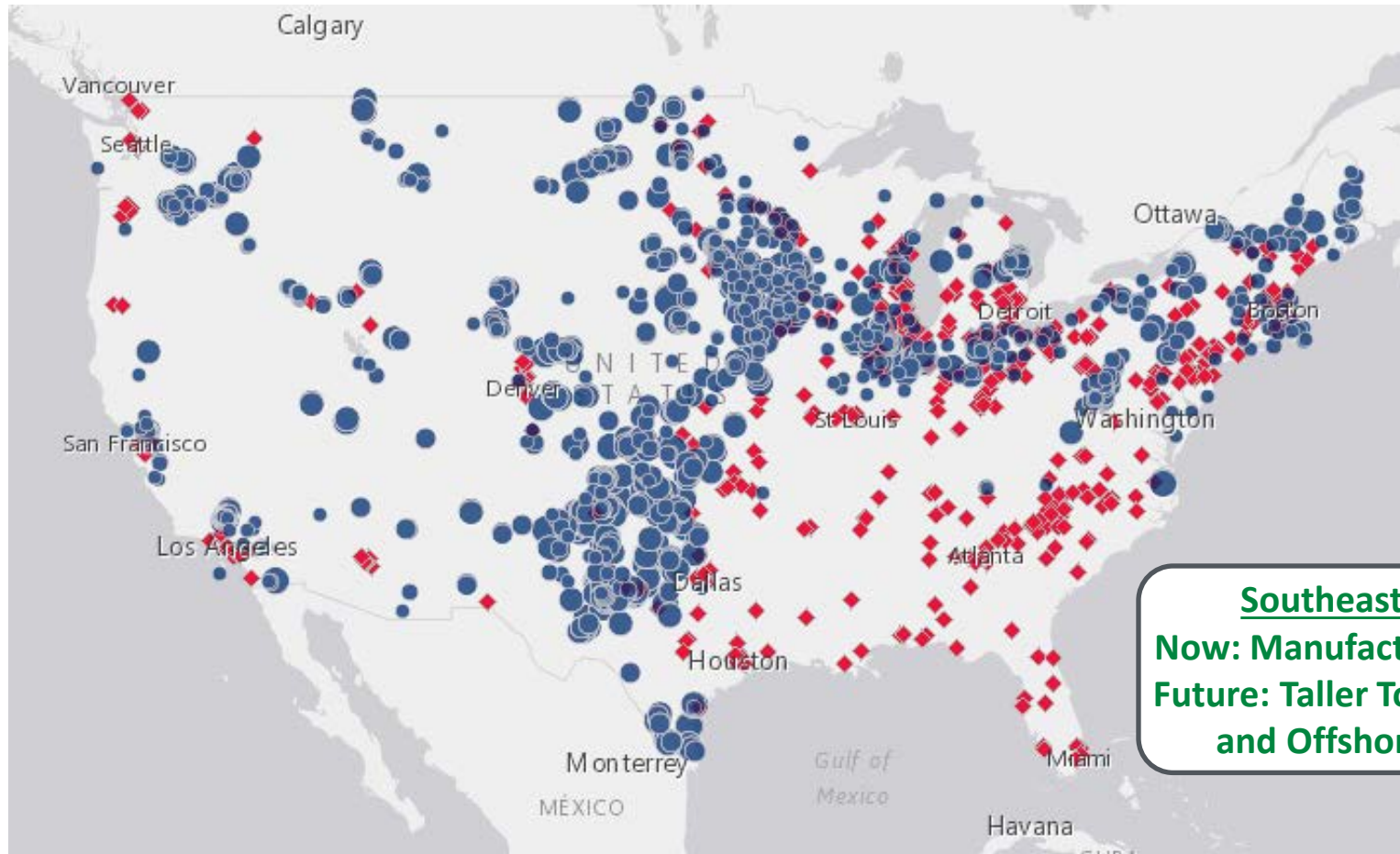


Europe



United States

U.S. Context: Wind Energy is National in Scale



Southeast
Now: Manufacturing
Future: Taller Towers
and Offshore

Blue = Utility-Scale Windfarms
Red = Supply Chain

Interactive Wind Industry Map at AWEA.org

Offshore Turbines are Massive Machines



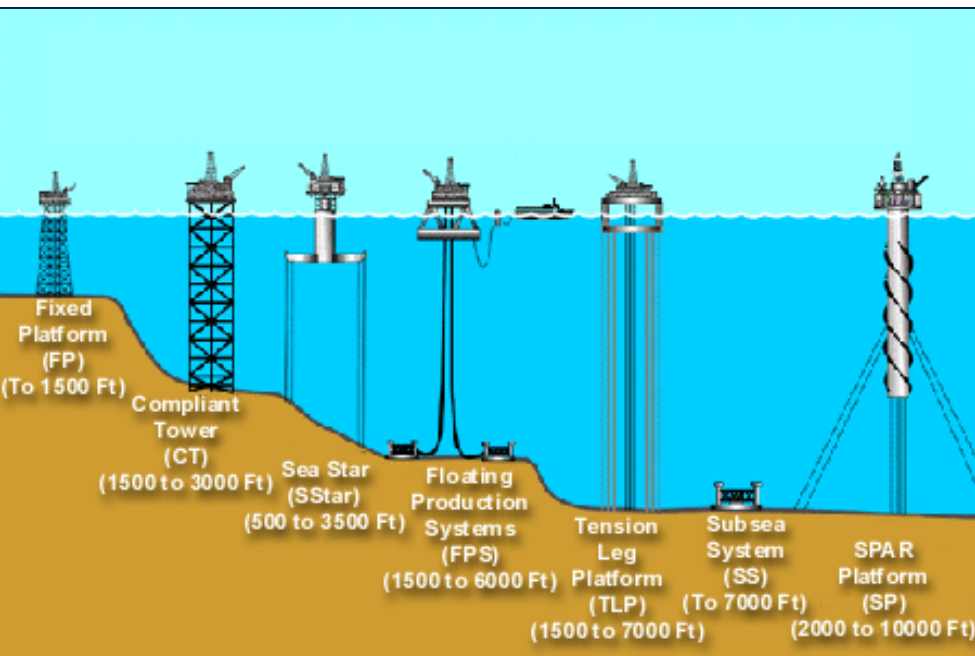
Vestas V164-8MW Turbine

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

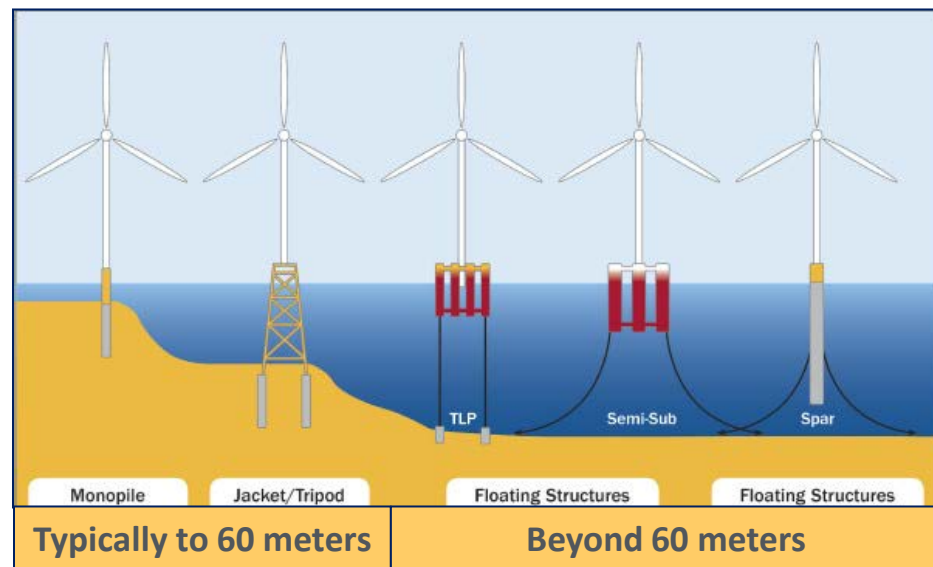
Offshore Wind Turbine Foundation Types

Turbine = Dynamic Thrust Load

Turbines are standardized

Blade lengths and foundations can vary with conditions

Replicability is key to project economics





Oil & Gas



Wind



Offshore Wind
Substation

Floating Foundation Types



Oil & Gas

← Spar →



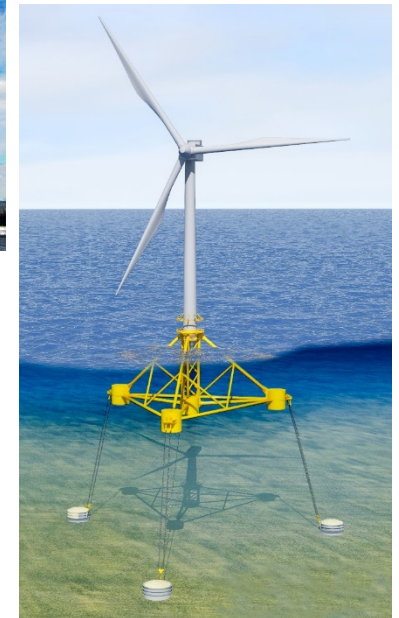
Wind



← Semi-submersible →



← Tension Leg →



Enable U.S. Industry Growth and Competitiveness

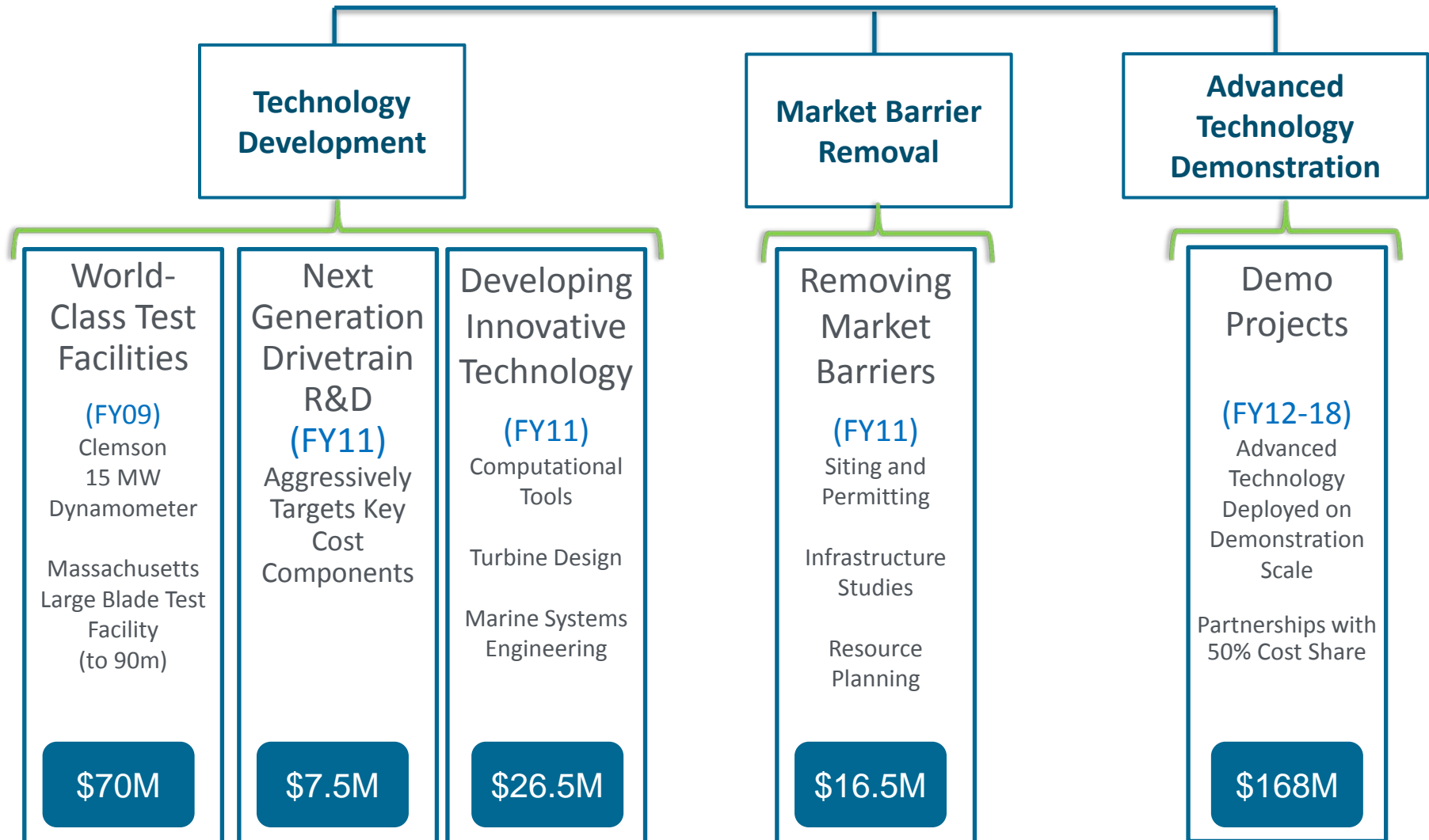
Enhance Energy Security and Independence

Strengthen Domestic Manufacturing and Local Economic Value

- 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

Scale and scope of activities are tied to congressional appropriations and directives

Three Prime Focus Areas

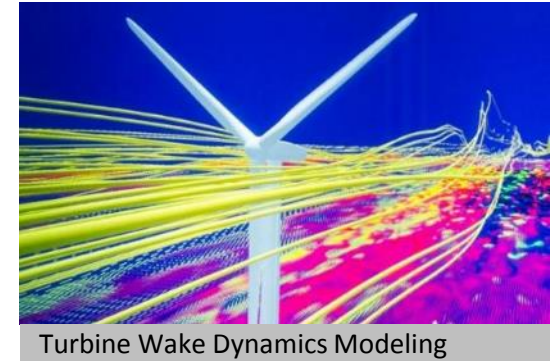


- High definition baseline surveys of birds, sea turtles, and marine mammals from NJ to VA/NC border
 - Partners: NCSU; CUNY; Duke U; USFWS; USGS; Memorial U-Newfoundland; BOEM
- Study of offshore bat activity and species composition in Gulf of Maine, Great Lakes, and Mid-Atlantic including spatial and 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



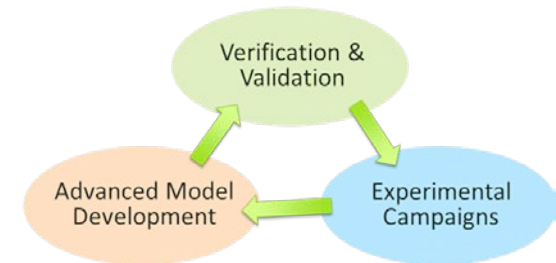
Atmosphere to Electrons (A2e) Program

- 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

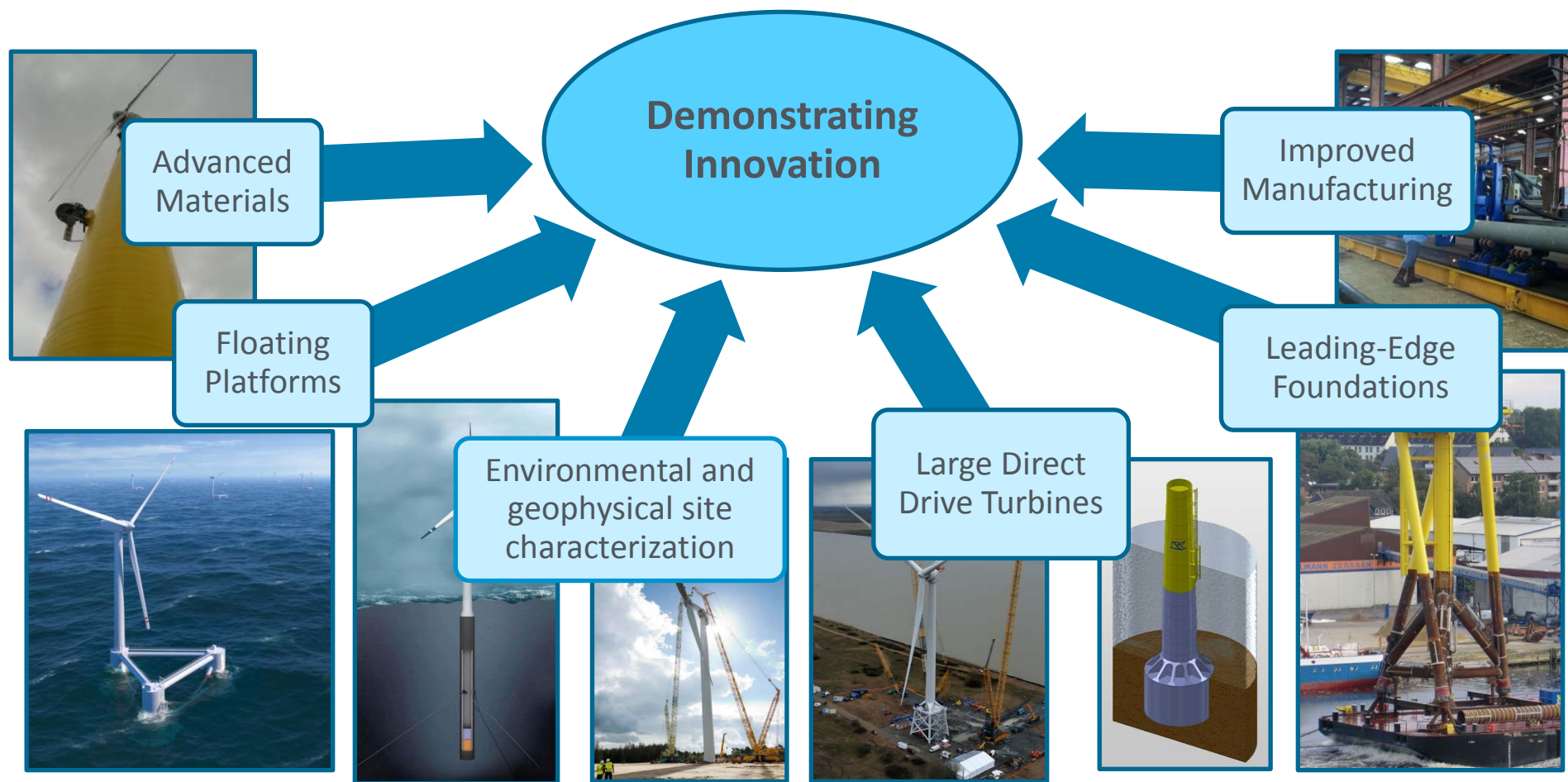
- Wind maps; Wind Forecasting Improvement Project
- Radar impact analysis and mitigation measures



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:
 - *A Framework for Assessing Initial U.S. Offshore Wind Project Costs* (2017)
 - *An Assessment of the Economic Potential of Offshore Wind in the U.S. from 2015 to 2030* (2018)
 - *Estimating the Value of Offshore Wind on the U.S. Eastern Coast* (2018)

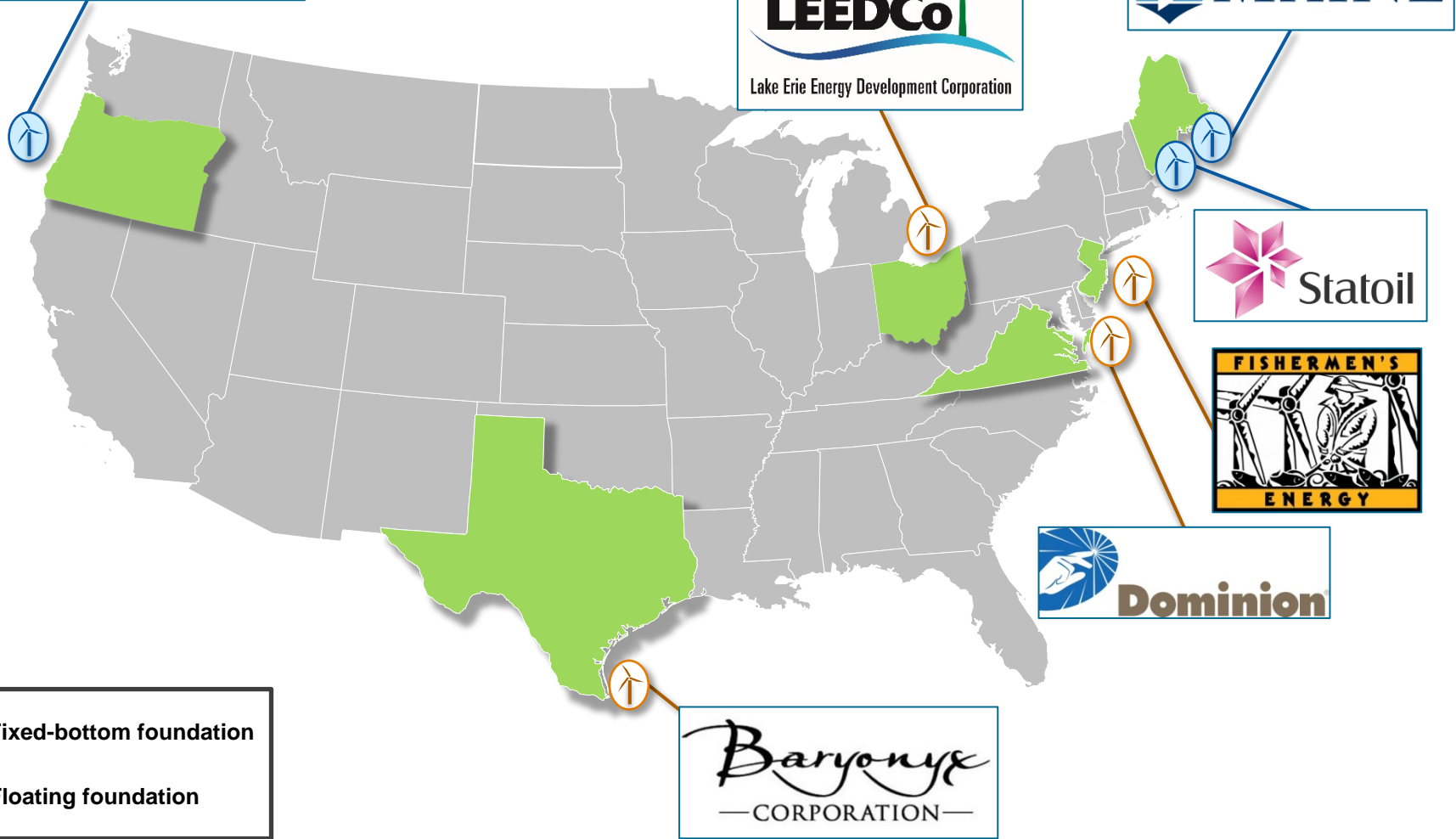
Drive down the cost of offshore wind by
de-risking innovative technologies in US conditions




Advanced Technology Demonstration Projects – 2013

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ENERGY

Energy Efficiency &
Renewable Energy



 Fixed-bottom foundation

 Floating foundation

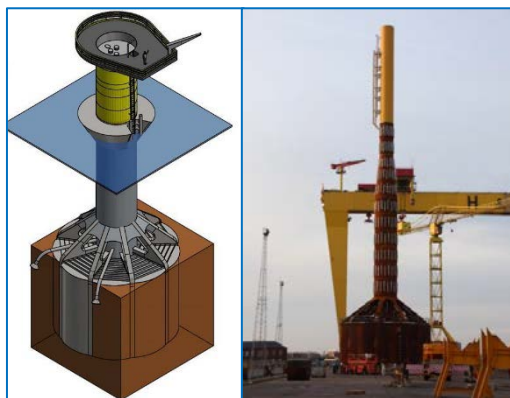
University of Maine

- 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

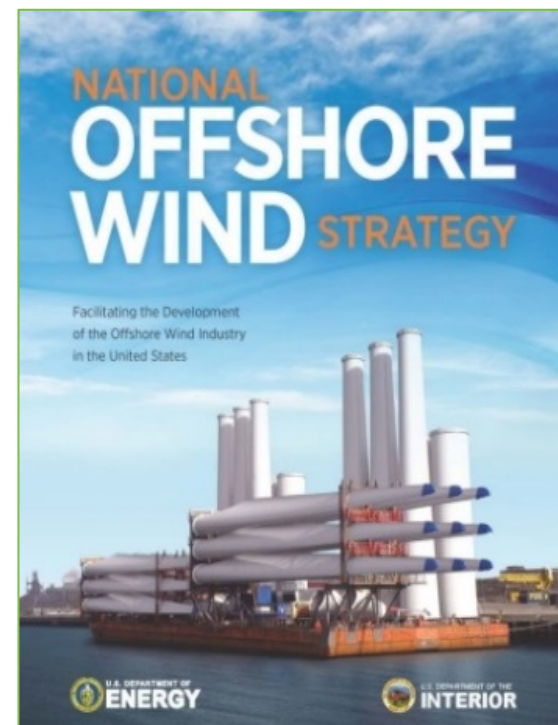
- 27 miles off Virginia Beach
- No longer funded by DOE
- DONG Energy (Denmark) partnering with Dominion to implement project plan
- Two 6-MW GE turbines
- Tech challenges: hurricane conditions



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

- 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

Strategic Themes	Action Areas
 <p>Reducing Technology Costs & Risks</p>	<ol style="list-style-type: none"> 1. Offshore Wind Power Resource & Site Characterization 2. Offshore Wind Plant Technology Advancement 3. Installation, Operation & Maintenance, & Supply Chain Solutions
 <p>Supporting Effective Stewardship</p>	<ol style="list-style-type: none"> 4. Ensuring Efficiency, Consistency & Clarity in the Regulatory Process 5. Managing Key Environmental & Human Use Concerns
 <p>Improving Understanding of the Benefits of Offshore Wind</p>	<ol style="list-style-type: none"> 6. Offshore Wind Electricity Delivery & Grid Integration 7. Quantifying / Communicating the Costs and Benefits of Offshore Wind

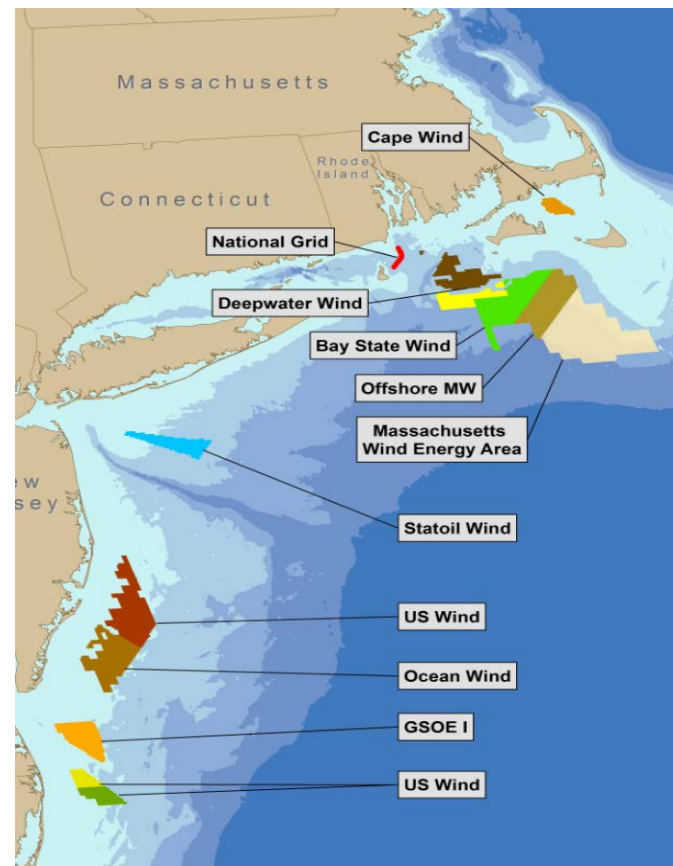
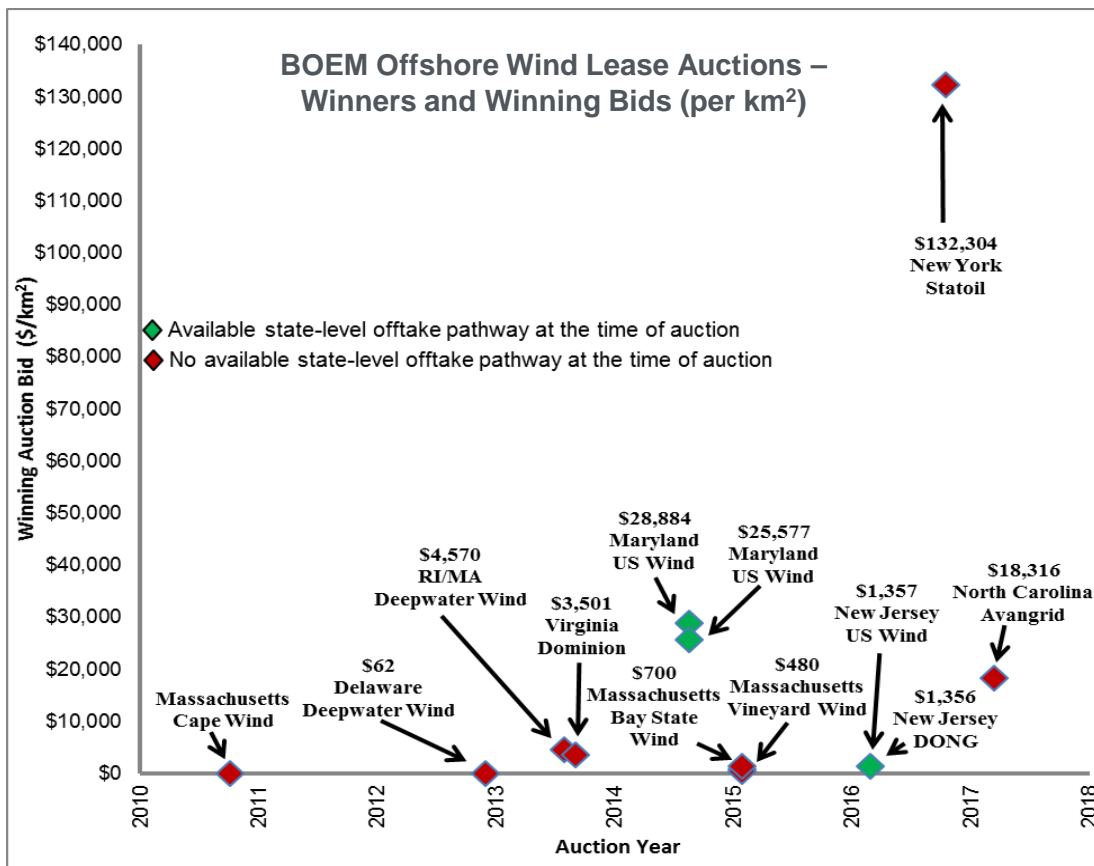


2016 Offshore Wind Technologies Market Report

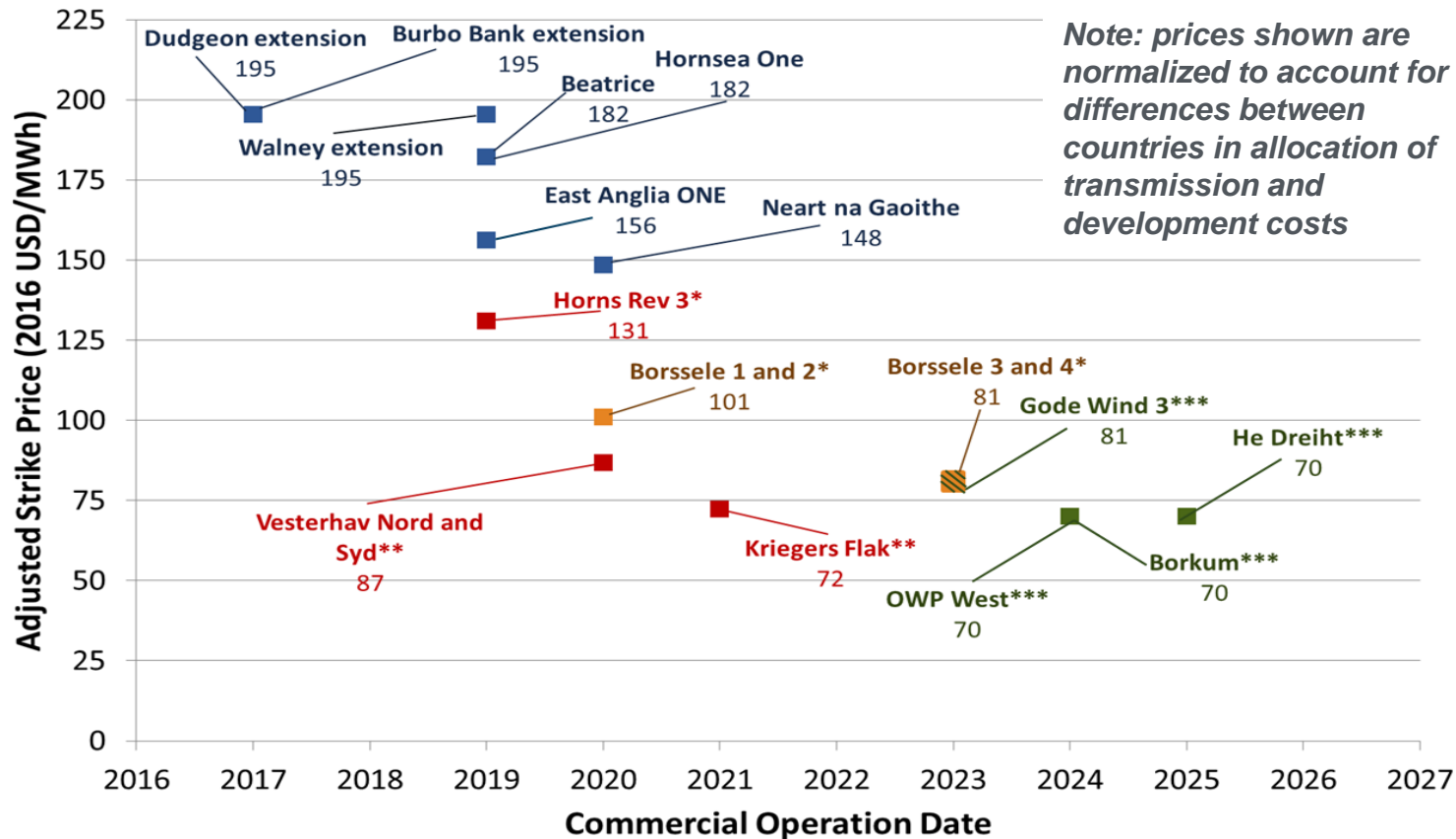
- Released August 8
- Quantitative information about the global offshore wind market
- Data through 2016; important developments tracked through June, 2017
- Key Sections:
 - Overview of Global Project Development
 - U.S. Market Assessment
 - Cost and Pricing Trends
 - Technology Trends
 - Appendix of 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

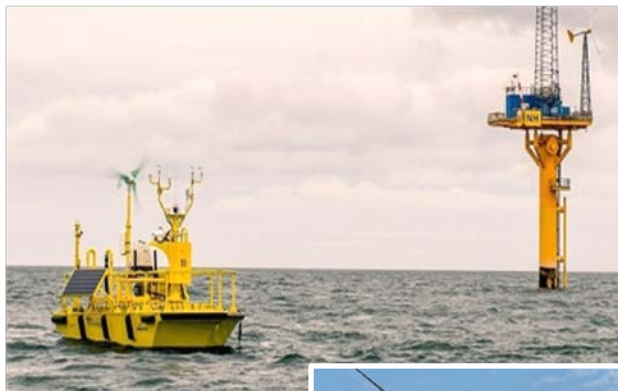


Contract Electricity Prices for European Offshore Wind Farms Have Fallen to Unsubsidized Levels in Recent Power Purchase Auctions



■ United Kingdom ■ Netherlands ■ Denmark ■ Germany

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**



U.S. DEPARTMENT OF **ENERGY**

Thank you.

Offshore Wind Market Report:

<https://www.energy.gov/eere/wind/downloads/2016-offshore-wind-technologies-market-report>

National OSW Strategy:

<https://energy.gov/sites/prod/files/2016/09/f33/National-Offshore-Wind-Strategy-report-09082016.pdf>

Environmental Knowledge Base for Marine and Wind Energy (TETHYS):

tethys.pnnl.gov