Why Offshore Wind Energy?

Great potential near dense coastal populations where electricity prices are highest.
Two Critical Objectives:

1) Reducing the cost of energy through innovation
2) Reducing deployment timelines and uncertainties

Announced 2011 by Secretaries of Energy and Interior

DOE Activities Aligned with National Offshore Strategy

<table>
<thead>
<tr>
<th>World Class Test Facilities</th>
<th>Removing Market Barriers</th>
<th>Next Generation Drivetrain R&amp;D</th>
<th>Developing Innovative Technology</th>
<th>Demonstrate Next-Generation Designs</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARRA Projects</td>
<td></td>
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</tr>
<tr>
<td>Clemson 15 MW Dynamometer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Massachusetts Large Blade Test Facility (to 90m)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>$70M</td>
<td>$16.5M</td>
<td>$7.5M</td>
<td>$26.5M</td>
<td>$168M</td>
</tr>
</tbody>
</table>
### Offshore Solicitation #1 (2011)

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removing Market Barriers</td>
<td></td>
</tr>
<tr>
<td>Siting and Permitting Infrastructure</td>
<td></td>
</tr>
<tr>
<td>Resource Planning</td>
<td></td>
</tr>
<tr>
<td>Market and Economic Analysis</td>
<td></td>
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<tr>
<td>Environmental Risk Reduction</td>
<td></td>
</tr>
<tr>
<td>Manufacturing and Supply Chain Development</td>
<td></td>
</tr>
<tr>
<td>Transmission Planning and Interconnection Studies</td>
<td></td>
</tr>
<tr>
<td>Optimized Infrastructure and Operations</td>
<td></td>
</tr>
<tr>
<td>Resource Characterization and Design Conditions</td>
<td></td>
</tr>
<tr>
<td>Impact on Electronic Equipment</td>
<td></td>
</tr>
</tbody>
</table>

- $16.5M
- 22 Awards
- 3 Years

### DOE Infrastructure Reports & Tools

- **Offshore Wind Resources for U.S. Decision-Makers and Planners**
  1. **Annual Market Analysis**
     - Navigant 2012 (Available on-line)
  2. **Manufacturing & Supply Chain Report**
     - Navigant (Available on-line)
  3. **Vessels Report**
     - Douglass-Westwood (October, 2013)
  4. **Ports Report & Web-based Assessment Tool**
     - GL Garrad Hassan (October, 2013)
  5. **Installation, Operations & Maintenance Strategies**
     - NREL Optimization Modeling (Available on-line)
     - GL GH Overview Report & Modeling Tool (October, 2013)
Offshore Wind Port Readiness Study

Understand current US port infrastructure

Help ports stakeholders characterize opportunities & barriers

Assess long term market needs & technology trends

Develop user-friendly ports info & analysis tool

Organize workshops on findings and tool

Carried out on behalf of DOE by GL Garrad Hassan
- Largest global dedicated renewables consultancy
- 1,000 staff, in 43 locations, across 25 countries
- Over 100 offshore staff worldwide, supporting projects since 1993

Assumptions – Industry Build-Out

DOE moderate growth scenario: 28 GW offshore by 2030

doc ref: DE-E0005364, 22nd February 2013
Assumptions – Project Parameters

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100 km</td>
<td>250 MW</td>
<td>500 MW</td>
<td>500 MW</td>
</tr>
<tr>
<td>&gt; 100 km</td>
<td>250 MW</td>
<td>500 MW</td>
<td>500 MW</td>
</tr>
<tr>
<td>Project Capacity</td>
<td>4 MW</td>
<td>6 MW</td>
<td>8 MW</td>
</tr>
<tr>
<td>Turbine Capacity</td>
<td>63</td>
<td>84</td>
<td>63</td>
</tr>
<tr>
<td>Number of Turbines</td>
<td>20 m</td>
<td>25 m</td>
<td>&gt; 25 m</td>
</tr>
<tr>
<td>Water Depth</td>
<td>1 x 250 MW</td>
<td>1 x 500 MW</td>
<td>1 x 500 MW</td>
</tr>
</tbody>
</table>

Elements of an Offshore Wind Farm
## Major Component Considerations

<table>
<thead>
<tr>
<th>Structure</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Turbine</td>
<td>Blade</td>
</tr>
<tr>
<td></td>
<td>Nacelle</td>
</tr>
<tr>
<td></td>
<td>Tower</td>
</tr>
<tr>
<td>Foundation</td>
<td>Monopile (20m)</td>
</tr>
<tr>
<td></td>
<td>Jacket (40m)</td>
</tr>
<tr>
<td></td>
<td>GBS (40m)</td>
</tr>
<tr>
<td>Substation</td>
<td>Topside</td>
</tr>
<tr>
<td></td>
<td>Foundation (jacket)</td>
</tr>
</tbody>
</table>

## Component Considerations (weight)

<table>
<thead>
<tr>
<th>Structure</th>
<th>Component</th>
<th>4 MW</th>
<th>5 MW</th>
<th>6 MW</th>
<th>7 MW</th>
<th>8 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Turbine</td>
<td>Blade</td>
<td>19</td>
<td>23</td>
<td>28</td>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Nacelle</td>
<td>162</td>
<td>239</td>
<td>330</td>
<td>390</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td>Tower</td>
<td>185</td>
<td>215</td>
<td>250</td>
<td>280</td>
<td>310</td>
</tr>
<tr>
<td>Foundation</td>
<td>Monopile (20m)</td>
<td>500</td>
<td>788</td>
<td>1076</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Jacket (40m)</td>
<td>-</td>
<td>609</td>
<td>684</td>
<td>759</td>
<td>834</td>
</tr>
<tr>
<td></td>
<td>GBS (40m)</td>
<td>-</td>
<td>-</td>
<td>5970</td>
<td>8009</td>
<td>9691</td>
</tr>
<tr>
<td>Substation</td>
<td>Topside</td>
<td>500 – 4000 Tonnes at approximately 6.5 tonnes per MW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Foundation (jacket)</td>
<td>800 – 1700 Tonnes depending on capacity and design depth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Assumptions – Vessels for US Projects

**Scenario 1**  
Use existing US-built vessels to construct first ~1 GW of capacity

**Scenario 2**  
Utilise foreign-flagged specialized installation vessels on-site, with US ‘feeder’ vessels

**Scenario 3**  
New-build US vessels, beyond first ~1 GW of capacity

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### Various Installation Methodologies

**Installation Type**

- Single Blade Lift
- “Bunny-ears” Lift
- Full Rotor Lift
- Full Wind Turbine

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Example of Offshore Port Facilities

Port of Belfast, N. Ireland
• Staging for Robin Rigg offshore wind farm (UK)
• 60 Turbines, 180 MW,
• Service port is Workington, Scotland
• Monopile foundations fabricated in Belgian Port

Port Suitability Considerations

Access
- Access channel width [m] 411
- Water depth [m] 13.7
- Overhead clearance [m] Unrestricted
- Heavy duty quayside length [m] 1,188

Quaysides
- Heavy duty quayside area [m²] 40,469
- Heavy duty quayside capacity [tons/m²] 12.7
- Sea bed suitable for jacking-up Yes

Storage
- Open storage [m²] 161,800
- Ground bearing capacity [tons/m²] 17.09
- Haul route width [m] 152
- Haul route capacity [tons/m²] 3.9
- Floating storage [m³] 27,870

Fabrication Workshop Area
- Workshop available No
- Workshop length [m] -
- Workshop area [m²] -

Port Information from Case Study for Morehead City, NC
Six Representative Case Studies: MA, NJ, NC, OH, TX, OR
Port Readiness Assessment Tool

www.OffshoreWindPortReadiness.com

Intended purpose
- Identify opportunities to remove market barriers
- Inform economic development discussions on infrastructure improvements
- Enable users to run sophisticated what-if scenarios on their own

Intended users
- Project developers
  - What port facilities are required for various deployment configurations/strategies?
  - What ports are available to support my proposed project?
  - What, if any, improvements would need to be made to support my project?
- Port operators
  - What types of support can/should my facility offer the offshore wind industry?
  - What improvements would I need to make? At what cost?
  - How may industry needs change over time (e.g. technology, market volume)?

Port officials have authority to manage facility data in tool directly

Southeastern Ports

- Tool Currently contains entries for a number of SE Ports:
  - Norfolk, VA Beach, Morehead City, Wilmington, Charleston, Jacksonville
- More ports and data being added with collaboration of port officials
- Ports officials from VA, NC, SC and GA participated in GL GH webinar July, 2013
Points to Remember

- Various regional/local ports will be needed for offshore project manufacturing, project staging, and O&M
- Number of ports depends on number and location of projects. Under moderate growth scenario, 4 very large Atlantic South region projects would be built by 2030 (or more smaller projects)
- Opportunities for large and small ports
  - Skilled short and long term jobs
  - Up-and-coming industry – high growth potential
- Port readiness assessment tool is available for public use. Port data will be added by users
- Stay informed and get your information from various sources

Thank You!

Gary Norton
DOE/SRA International
gary.norton@ee.doe.gov
http://www1.eere.energy.gov/wind/

Chris Elkinton (Project PI)
GL Garrad Hassan
chris.elkinton@gl-garradhassan.com
www.gl-garradhassan.com

Ports Tool: www.OffshoreWindPortReadiness.com

Currently Available Offshore Infrastructure Reports:
Offshore Wind Market and Economic Analysis (Navigant Consulting)

U.S. Offshore Wind Manufacturing and Supply Chain Development (Navigant Consulting)

Installation, Operation, and Maintenance Strategies to Reduce the Cost of Offshore Wind Energy (NREL)
http://www.nrel.gov/docs/fy13osti/57403.pdf