Offshore Wind: Virginia’s Largest Cost-Effective, Commercially Available, Renewable Energy Resource

VIMS Industry Partnership Meeting

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VCERC Industry partner
V90-3MW Offshore Wind Project

Capital cost estimated in March 2008 dollars using Virginia specific bids and published data

- **Plant Cost:** $1,747,539,503
- **Transmission Cost:** $153,245,992 (shoreward of the Electronic Service Platform)

588 MW rated capacity

38.3% annual operational capacity factor
Monopile Foundations Driven into Seabed and Transition Pieces Grouted on Top
North Hoyle 2-MW Turbines
Installed Using Towed Seacore Jack-Up Rigs
Northern Project Footprint Locations
Selected for Proximity to CHLV2 Wind & Wave Data

ODU’s Center for Coastal Physical Oceanography is compiling data on offshore wind and wave climate.

ODU’s Coastal Engineering Program is developing wind turbine tower foundation design alternatives.

ODU’s Electrical Engineering Department is developing turbine electrical interconnection design alternatives.

Waves and solar radiation are also measured on CHLV2.
What Coal Price to Use?
Central Appalachian Coal No Longer Stably Priced

NYMEX Central Appalachian Coal Futures Near-Month Contract
Final Settlement Price History
What Coal Price to Use? Used 2008 Year Average

NYMEX Central Appalachian Coal Futures Near-Month Contract
Final Settlement Price 2008

$90 per short ton average

Data as of 12/26/2008
Cost of Energy Comparison with Fossil Fuel Fired Generation

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Operating Costs</th>
<th>Capital Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>$90 per short ton</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>$12 per short ton</td>
<td></td>
</tr>
<tr>
<td>Wind 3 MW</td>
<td>$10 per short ton</td>
<td></td>
</tr>
<tr>
<td>Wind 2 MW</td>
<td>$10 per short ton</td>
<td></td>
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</tbody>
</table>
Cost of Energy Comparison with Fossil Fuel Fired Generation

- Natural Gas: $9.11 per MMBtu
- Coal: $90 per short ton
- Wind 3 MW
- Wind 2 MW

Fuel Costs: $14, $16, $18
Operating Costs: $8, $10, $12
Capital Costs: $0, $0, $20

Real 2007 After-tax ¢/kWh
## Cost of Energy Comparison with Fossil Fuel Fired Generation

<table>
<thead>
<tr>
<th></th>
<th>Natural Gas</th>
<th>Coal</th>
<th>Offshore Wind V90-3MW</th>
<th>Offshore Wind V90-2MW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name Plate Capacity (MW)</strong></td>
<td>580</td>
<td>585</td>
<td>588</td>
<td>588</td>
</tr>
<tr>
<td><strong>Operational Capacity Factor</strong></td>
<td>89.9%</td>
<td>89.9%</td>
<td>38.3%</td>
<td>47.9%</td>
</tr>
<tr>
<td><strong>PJM Capacity Factor</strong></td>
<td>89.9%</td>
<td>89.9%</td>
<td>19.6%</td>
<td>27.7%</td>
</tr>
<tr>
<td><strong>Energy Produced (MWh/Year)</strong></td>
<td>4,568,080</td>
<td>4,607,460</td>
<td>1,972,069</td>
<td>2,466,471</td>
</tr>
<tr>
<td><strong>Economic Life</strong></td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NOx (lbs/MWh)</strong></td>
<td>0.08</td>
<td>0.76</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>SOx (lbs/MWh)</strong></td>
<td>-</td>
<td>1.31</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>CO2 (lbs/MWh)</strong></td>
<td>800.81</td>
<td>2,100.10</td>
<td>-</td>
<td>-</td>
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<tr>
<td><strong>Overnight Plant Cost ($/kW)</strong></td>
<td>1,058</td>
<td>3,077</td>
<td>3,135</td>
<td>3,943</td>
</tr>
<tr>
<td><strong>Levelized Energy Cost ($/kWh)</strong></td>
<td>10.9</td>
<td>14.2</td>
<td>12.2</td>
<td>12.2</td>
</tr>
<tr>
<td>...with PTC and Bonus Dep ($/kWh)</td>
<td>10.9</td>
<td>14.2</td>
<td>9.9</td>
<td>9.8</td>
</tr>
</tbody>
</table>
Virginia’s Wind Energy Resources Offshore are Much Larger than on Land

- **Class 4+ areas needed for economical offshore projects** are largely on ridges in national forests and parks, and even projects on private land seem difficult to permit.

- **Class 5+ areas needed for economical offshore projects** are in federal waters beyond 3-n.mile limit of state jurisdiction.

- National Forests, Blue Ridge Parkway, Appalachian Trail, state parklands, and county-by-county zoning variability.

- Only one regulatory authority (US Minerals Management Service).

Power Density

- **Class 1-** < 100 W/m²
- **Class 1+** 100 - 200 W/m²
- **Class 2** 200 - 300 W/m²
- **Class 3** 300 - 400 W/m²
- **Class 4** 400 - 500 W/m²
- **Class 5** 500 - 600 W/m²
- **Class 6** 600 - 800 W/m²

Three Nautical Miles
Hampton Roads Area has Unique Features Favorable for Offshore Wind Power Development

Class 6 (red) wind energy resource located within 10-15 miles (16-24 km) of shoreline and close to major, growing centers of power demand.

Robust coastal transmission grid

115 kV
500 kV
230 kV

Minimal probability of major hurricane strike (Categories 3 through 5)

Pale blue region indicates uncertain wind map accuracy beyond 25 km offshore.

Saffir-Simpson Categories of Landfalling Hurricanes:
- Category 3
- Category 4
- Category 5

Major United States Landfalling Hurricanes 1899 - 2004
Focus on 50 MMS lease blocks and avoid all excluded areas

MMS lease blocks are 4.8 km x 4.8 km, with each block having 7 x 7 turbines.

Turbines spaced 685 m apart (7.6 rotor diameters)

Each lease block could contain 49 turbines

= 147 MW per block with Vestas model V-90 3 MW

= 6.4 MW per km²

GIS layers and calculations by James Madison University
Class 6 Winds are Largely Beyond the Visual Horizon

Beyond the Territorial Sea Limit of 12 n.mi., turbines would be barely visible, and then only on the clearest days.

Total available area of Class 6 beyond 12 n.mi. is 575.6 sq.km (142,500 acres); could support 3,680 MW of wind capacity.
Consider Decades-Long Enterprise Involving Commercial Development of 30 Lease Blocks

30 lease blocks for possible long-term lease to Virginia or U.S. Navy or both.

Developing 20 of these at ~150 MW per block would yield 3,000 MW.

With the same development team initiating a new 300 MW project every two years, this would entail a 20-year build-out, ensuring sustained activity in Hampton Roads maritime industry, creating career-length jobs and learning curve cost reductions.
Planning For Positive Impact

Determine the impact a wind farm would have on Virginia’s maritime industries, specifically:

- Shipping
- Fishing
  - Commercial
  - Recreational
- Navy/DoD Operations
- Wallops Island NASA Facility

Design methods to create positive impacts for such offshore activities.

Learn from our own research as well as the experiences of others:

In 2004, a Draft Environmental Impact Statement (DEIS) released by the Army Corps of Engineers found that the proposed Cape Cod offshore wind project would have significantly less environmental impact than speculated.

The 3,800 page DEIS report was the product of three years of scientific, environmental, and economic analysis and included the input of 17 federal and state cooperating agencies as well as public comments.
Positive Impact Site Selection

Subtracting restricted military zones and shipping lanes illustrates viable sites within lease blocks.

Total available area of Class 6 winds beyond 12 nautical miles is 575.6 square kilometers (142,500 acres); could support 3,680 MW of wind capacity.

(additional shipping traffic beyond 75.5 W does not affect site selection)
Thank You!

Any questions?

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