Virginia’s Offshore Wind Resource: Size, Economics, and Future Development

George Hagerman
VCERC Director of Research
Virginia Tech Advanced Research Institute
4300 Wilson Blvd., Suite 750
Arlington, VA  22203
Email:  hagerman@vt.edu
Phone:  703-387-6030

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Virginia’s Realistic Near-Term Offshore Wind Development Potential
Greatest Near-Term Mid-Atlantic Offshore Wind Potential is off Dominion’s VA-NC Service Area
GIS Analysis and Mapping of Resource

- 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.m.i., turbines would be barely visible, and then only on the clearest days.

Total available area of Class 6 beyond 12 n.m.i. is 575.6 sq.km (142,500 acres); could support 3,680 MW of wind capacity.
Preliminary GIS Calculations

- At density of 6.4 MW per km$^2$, could support ~4.5 GW, avoiding all excluded areas

Assuming capacity factors of 35% for Class 5 and 40% for Class 6, annual generation potential is ~5,500 and ~14,100 GWh/yr from Class 5 and Class 6 areas, respectively.
Near-Term Offshore Wind Generation Potential Compared with Virginia’s Other Electricity Sources

At 17,900 GWh per year, offshore wind power in non-excluded areas within 50 MMS lease blocks off Virginia Beach has the potential to become Virginia’s third largest electricity source.
Offshore Wind Project
Layout and Construction
Typical Offshore Wind Farm Layout

Typically 30 - 100 wind turbines
Total power 100-500 MW

35 kV submarine cables

Offshore Transformer Platform
E.g. 35 kV / 138 kV

138 kV submarine cable to shore

Shore

138 kV Grid Substation existing grid

NRDC 2006.08.01
Monopile Foundations Driven into Seabed and Transition Pieces Grouted on Top
Horns Rev 2-MW Turbines Installed Using Self-Propelled A2 SEA Vessels
North Hoyle 2-MW Turbines
Installed Using Towed Seacore Jack-Up Rigs
Wind as Hedge Against Future Price Increases in PJM
PJM Energizes About One-Fifth of the U.S. Gross Domestic Product

KEY STATISTICS
- PJM member companies: 390+
- Millions of people served: 51
- Peak load in megawatts: 135,000
- MWs of generating capacity: 163,806
- Miles of transmission lines: 56,070
- GWh of annual energy: 700,000
- Generation sources: 1,271
- Square miles of territory: 164,260
- Area served: 13 states + DC

26% of generation in Eastern Interconnection
23% of load in Eastern Interconnection
19% of transmission assets in Eastern Interconnection

19% of U.S. GDP produced in PJM
Financial Assumptions

• Taxes and depreciation
  • Composite tax rate: 38.8% (35% Federal, 5.85% State)
  • General depreciation declining balance is used
    – GDS life of 15 years for conventional fuels
    – GDS life of 5 years (bonus depreciation) for wind

• Project financing
  • 100% of the plant is financed up front
    – 43.2% Debt and 56.8% Equity
    – Debt interest rate: 5.586%
    – Equity rate of return: 13.75% common, 7.174% preferred
    – Includes 3-year construction loan (7.5% debt rate)
  • Debt is paid monthly, equity quarterly
  • Financing term: 25 years
  • Service life: 25 years for gas, wind; 50 years for coal
Buckingham County Combined Cycle Gas-Fired Project

- Capital cost basis
  - As published in PUE-2008-00014 (Filed 03/11/2008)
  - Plant Cost $614 million
  - Transmission Cost $5.1 million
- 580 MW rated capacity
- 89.9% annual operational capacity factor
- Plant heat rate: 6.09 MMBtu per MWhr
- 25 plant operators
- Emissions
  - CO₂ 1,829,088 ton/year
  - NOₓ 178 ton/year
- Actual in-service date: 2011 (used 2012 for all projects)
Wise County Coal-Fired Project

- Capital cost basis
  - As published in PUE-2007-00066 (Filed 03/31/2008) & PUE-2007-00111 (Filed 12/03/2007)
  - Plant Cost $1.8 billion
  - Transmission Cost $23 million
- 585 MW rated capacity
- 98.9% annual operational capacity factor
- Plant heat rate: 10.00 MMBtu per MWhr
- Coal heat content: 15.4 MMBTU per short ton
- 75 plant operators
- Emissions
  - $CO_2$ 4,838,060 ton/year
  - $NO_x$ 1,755 ton/year
  - $SO_x$ 3,009 ton/year
- Actual in-service date: 2013 (used 2012 for all projects)
V90-3MW Offshore Wind Project

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

- **Plant cost at offshore busbar**: $1,748 million
- **Transmission cost to Fentress**: $153 million
- **Total plant investment**: $1,901 million (~$3,230/kW)

588 MW installed rated capacity

38% annual capacity factor

20% PJM capacity factor

Kentish Flats
Projected Coal Prices by 2012

NYMEX Coal Futures – Central Appalachia

July 2000 – December 2013

Eastern Rail CSX Coal Swap - Forward Strip
New Offshore Wind Compared with New Coal

![Graph showing comparison between Offshore Wind and Coal](image-url)
Delivered Coal Prices Already Seem to Exceed Projections

Delivered Coal Prices

January 2007 – March 2009

$/ton

Central Appalachia  Northern Appalachia
Illinois Basin  Powder River Basin

Source: Ventyx, Inc., The Velocity Suite from modeled data
Projected Natural Prices by 2012

NYMEX Natural Gas Futures — Henry Hub

July 2009 — December 2014

Henry Hub Natural Gas Swap - Forward Strip
New Offshore Wind Compared with New CCGT

![Diagram showing the cost comparison between Offshore Wind and CCGT. The x-axis represents the Year 1 Natural Gas Price (per MMBTU), while the y-axis shows the Levelized Real Cost of Energy (per MWh). The diagram includes lines for different real annual escalation rates: 5%, 4%, 3%, 2%, and 1%. The Offshore Wind and CCGT costs vary depending on the gas price and escalation rate.]
Valuing Fossil Fuel Generation Assets in a Green Economy

by James Heidell & Mike King

From the Editor

This second EMI focuses on the quantitative assessment of key risks affecting the valuation of electricity generation assets. Mike King and Jim Heidell outline the stochastic model NERA has developed to help investors gain insights into the critical valuation issues surrounding fossil fuel generation plants. Challenges for valuing fossil fuel plants will increase going forward as the result of the potential impact of greenhouse gas regulation and policies designed to encourage the development of renewable generating technology. These environmental policies are prominent in many jurisdictions world-wide, providing wide applicability for the techniques discussed in this edition.

—Ann Whitfield, Editor
Case Study

The following case study highlights our assessment process for an actual portfolio of coal-fired and gas-peaking plants located in the PJM region. On a MW basis, the existing portfolio consists of approximately two-thirds coal-fired assets and one-third peaking assets. Our case study incorporates uncertainty related to fossil fuel prices, RPS standards, greenhouse gas regulations, load growth and power plant replacement costs. In the case study, each of the key variables had three associated forecasts. This created 729 potential permutations or cases.
VCERC preliminary estimate of merchant power offshore wind Year 1 bid price is ~$120/MWh
VCERC preliminary estimate of merchant power offshore wind
Year 1 bid price is ~$120/MWh

Merchant offshore wind bilateral power purchase contracts for a weighted price of 1/3 on-peak and 2/3 off-peak likely to be competitive by 2017-2018 time frame
Anticipated Commercial Development Timetable
Development of Greater Gabbard: 504 MW (UK)

- **December 2003**
  - Fluor/Airtricity JV awarded 500MW Greater Gabbard Offshore Wind Farm Project

- **December 2004**
  - Grid Connection Offer received from National Grid for connection at Sizewell, Suffolk

- **October 2005**
  - Consents application submitted

- **February 2007**
  - All onshore and offshore consents received
  - Siemens selected for wind turbines

- **May 2008**
  - Financial Close & Notice to Proceed

- **October 2003**
  - Bids submitted for UK Round 2

- **2004**
  - Conceptual design
  - Offshore Site Surveys
  - Environmental
  - Geophysical

- **September 2005**
  - Met Mast installed

- **Summer 2006**
  - Offshore geotechnical survey

- **October 2007**
  - Project definition completed
  - Estimate prepared

**2.5 Year Build-Out**

- Onshore work starts: mid-2008
- Offshore work starts: mid-2009
- First phase power: mid-2010
- Full project power: end 2011

From lease award to construction start = ~4.5 years
Development of Horns Rev II: 209 MW (Denmark)

Timetable for Horns Rev 2

- Concession
- Env. Impact Ass.
- Tenders
- Investment decision
- Offshore constr.
- Foundation install.
- Gridnet installation
- Turbine installation
- Commissioning
- Operation

From lease award to construction start = ~2.5 years
Construction of Horns Rev II: 209 MW (Denmark)

From construction start to fully commissioned = 1.5 years
US Offshore Wind Commercial Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>State</th>
<th>MW</th>
</tr>
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<tbody>
<tr>
<td>Cape Wind</td>
<td>MA</td>
<td>468</td>
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<tr>
<td>Hull Municipal</td>
<td>MA</td>
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<td>Patriot Renewables</td>
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<td>Rhode Island (OER)</td>
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<td><strong>Total MW</strong></td>
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<td><strong>2,063</strong></td>
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US projects in offshore Atlantic will require 1-2 years to obtain non-competitive commercial lease, 3-4 years to obtain competitive commercial lease. To this must be added 4-7 years for development and build-out of any large (350-500 MW) project.

VCERC has recommended that Governor form federal-state-local task force to guide MMS offshore wind leasing process such that projects can become operational at projected time of commercial viability, namely by 2017-2018.
Thank You!

Any questions?

Email: hagerman@vt.edu