EXECUTIVE SUMMARY

Feasibility-Level Design and Economic Assessment

For investor-owned utilities in Virginia, balance-sheet financing of new generation projects having an in-service date of 2012 and an installed capacity just under 600 MW yields the following levelized cost of energy (LCOE) estimates, in constant March 2008 dollars:

- $105-130 per megawatt-hour (MWh) for an offshore wind farm
- $85-100 per MWh for a coal-fired plant
- $80-100 per MWh for a combined-cycle gas turbine (CCGT) plant.

The above LCOE estimates do not include carbon capture and sequestration (CCS) as potential added costs for fossil fuel projects. Assuming that CCS has a levelized cost of $50 per ton of carbon dioxide (tCO_2) over the service life of a generation project commissioned in 2012, with emission rates of 1.0 tCO_2 per MWh for a coal-fired project and 0.4 tCO_2 per MWh for a CCGT project, then levelized electricity costs would increase to $135-150 per MWh for coal-fired generation and $100-120 per MWh for CCGT generation. Thus, *when CCS has a levelized cost of $50 per* tCO_2 *utilities can anticipate that a new offshore wind project will yield a lower energy cost than a new coal-fired project, and may be marginally competitive with a new CCGT project.*

VCERC's offshore wind cost model has been validated with data from actual large offshore wind projects in Europe for three major cost centers that account for 80-85% of the total project cost: wind turbines, submarine power cables, and monopile foundations. *This supports our estimate that offshore wind projects can be built off Virginia at a cost of $3,000 to $3,600 per kilowatt.*

A recent forecast of wholesale power prices in the PJM regional electricity market indicates that nominal-dollar on-peak and off-peak prices will more than double by 2018, and triple by 2028. Based on this forecast, our estimated LCOE for utility-generated offshore wind is unlikely to be competitive with purchased power before 2017. This is consistent with our mid-range estimate of the first year when a several-hundred-megawatt offshore wind project could become fully operational in federal waters off Virginia, based on European offshore wind experience for similarly sized projects and even the most optimistic U.S. federal permitting scenarios.

The greatest downside risk in our offshore wind energy cost estimates is the large uncertainty associated with the vertical distribution of wind speeds, which yield a standard deviation in the range of 20% to 25% in annual energy generation estimates at hub height. *This can be mitigated by an aggressive program of wind resource modeling validated by tall mast wind measurements.*

The greatest upside opportunity for reducing the cost of offshore wind energy in Virginia is to attract major elements of a Mid-Atlantic offshore wind supply chain to the state. These would include turbine assembly plants in Hampton Roads, having large component staging areas on deep-water wharves with unconstrained access to the open ocean, being fed by 1st- and 2nd-tier suppliers in Virginia and neighboring states. Virginia's existing shipbuilding capabilities also would be leveraged to fabricate large steel components. *If the turbine and tower package was manufactured in Virginia, we estimate that the capital cost of an offshore wind project would decrease by $480 per kilowatt, yielding a LCOE range of $90 to $115 per MWh.*

Preliminary Mapping of Offshore Areas

By working collaboratively with many organizations, James Madison University has compiled a large geospatial database of more than 25 different data layers. Organizations that contributed data and/or shape files to this VCERC project included the U.S. Minerals Management Service, the U.S. National Renewable Energy Laboratory, the U.S. Navy, the Virginia Institute of Marine Sciences, the Virginia Aquarium & Marine Science Center, and The Nature Conservancy.

The Chesapeake Bay and Atlantic state waters within 3 nautical miles offshore are dominated by Class 4 winds, while Atlantic federal waters on Virginia's Outer Continental Shelf (OCS) are dominated by Class 5 and Class 6 winds. The total potential wind farm capacity in Class 5 and Class 6 winds on Virginia's OCS between 3 and 50 nautical miles offshore is 47,900 MW, having a maximum potential annual energy output of 176 million megawatt-hours per year.

Avoiding conflicting uses such as shipping lanes, Navy live-ordnance training ranges, a space launch hazard area, and dredge spoil disposal sites, *VCERC has identified 25 OCS lease blocks of entirely Class 6 winds beyond 12 nautical miles offshore (the approximate visual horizon), in water depths less than 30 m (suitable for commercially available monopile foundations), which could support approximately 3,200 MW of offshore wind farm capacity. Assuming an array efficiency of 89%, these 25 lease blocks could generate 11 million megawatt-hours per year* or approximately 10% of Virginia's annual electricity consumption.

Evaluation of Economic Development Potential

VCERC has identified 25 lease blocks with 3,200 MW of potential offshore wind capacity in relatively shallow Class 6 waters beyond the visual horizon. Build-out of this potential would require a total of 125,000 job-years, including direct, indirect, and induced jobs, assuming that it can be supported by Virginia-based turbine and power cable manufacturing plants. If sustained at a build-out rate of 160 MW per year (equivalent to one 320-MW project being commissioned every two years), this would support 6,200 jobs that could last for a two-decade career. To this would be added operation and maintenance jobs, which are estimated to accrue at 1.1 to 1.7 jobs per cumulative megawatt, reaching 3,500 to 5,400 jobs after the first 3,200 MW of near-term commercial potential off Virginia has been built out over the next 20 years.

Thus, within two decades, 9,700 to 11,600 career-length jobs can be created, solely associated with developing the 3,200 MW of offshore wind potential that VCERC has identified in shallow waters beyond the visual horizon off Virginia Beach. Since offshore foundations and submarine power cables are designed for a service life of 40 to 50 years, a second generation of jobs could be created for simply repowering the first 3,200 MW. Beyond this is a vast, deeper water potential that remains to be developed farther offshore.

Any development of deeper water wind resources farther offshore must manage potential conflicts with routinely expended debris from rocket launches at the NASA Wallops Flight Facility and the Mid-Atlantic Regional Spaceport (MARS). Likewise, the Navy has several training ranges farther offshore that involve live ordnance, which also would be incompatible with offshore wind energy development. The NASA Wallops and MARS launch hazard area and Navy live ordnance training ranges are east of the 25 VCERC-identified lease blocks and so do not represent an impediment to commercial development over the next two decades.