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June 28, 2018

State of New Jersey
Board of Public Utilities
44 South Clinton Avenue, 3rd Floor, Suite 314
Post Office Box 350
Trenton, NJ 08625-0350

Re: Docket No. QX18040466 – In the Matter of Offshore Wind Renewable Energy Certificate (OREC) Funding Mechanism

Dear Sir/Madam:

I am writing to share with you the specific experience that Princeton University has had with analysis relating to offshore wind, energy storage and the electric grid, and explain how this experience demonstrates that it is critically important for BPU to adopt a principled approach to the design of New Jersey's electricity generation portfolio and network that is planned to meet the needs of New Jersey, reliably and at the lowest possible cost.

The Andlinger Center for Energy and the Environment at Princeton University, founded in 2008, is focused on developing solutions to ensure our energy and environmental future. To this end, the center supports a vibrant and expanding program of research and teaching in the areas of sustainable energy-technology development, energy efficiency, and environmental protection and remediation. A chief goal of the center is to translate fundamental knowledge into practical solutions that enable sustainable energy production and the protection of the environment and global climate from energy-related anthropogenic change. The Princeton Laboratory for Energy Systems Analysis (PENSA) works regularly with the Andlinger Center. PENSA and the Andlinger Center work jointly to conduct research into energy systems modeling to address and clarify technical issues raised in the BPU's Straw Proposal concerning the OREC funding mechanism.

In 2015, we completed the Mid-Atlantic Offshore Wind Integration (MAOWIT) Study working with Willett Kempton and Cristina Archer at the University of Delaware. (The study was funded by DOE through the University of Delaware). The MAOWIT Study investigated four core questions concerning the integration of large amounts of non-dispatchable energy (in this case, offshore wind) into a generation and transmission market:

1. Will the existing generation capacity be able to handle the discrepancy between the forecasts used in the commitment phase and the actual energy observed in real-time?

2. Will the planning process be able to handle the much higher level of variability and uncertainty (even if there is enough generation capacity)?

3. What reserve levels will be required to handle the uncertainty introduced with high penetrations of wind?

4. Will the transmission grid be able to handle the additional load?

Sophisticated Energy Modeling Capabilities

To conduct this analysis, we used SMART-ISO, a model developed by PENSA over a five-year period with funding from SAP as well as other sources (including DOE). I led a team of students and staff to develop SMART-ISO, working jointly with PJM to ensure that the model closely replicated PJM planning processes. After several years, of development and calibration, SMART-ISO was found to closely replicate historical performance.

SMART-ISO is a highly detailed simulator of the PJM power grid, with special care given to the flow of information and the handling of uncertainty. The model simulates day-ahead and hour-ahead commitment and generation decisions, in addition to real-time economic dispatch at 5-minute intervals. It uses the full PJM power grid (over 9,000 buses and 14,000 transmission lines as of 2010), along with detailed models of PJM's generator fleet. SMART-ISO is intended as a simulator for performing a wide range of policy studies.

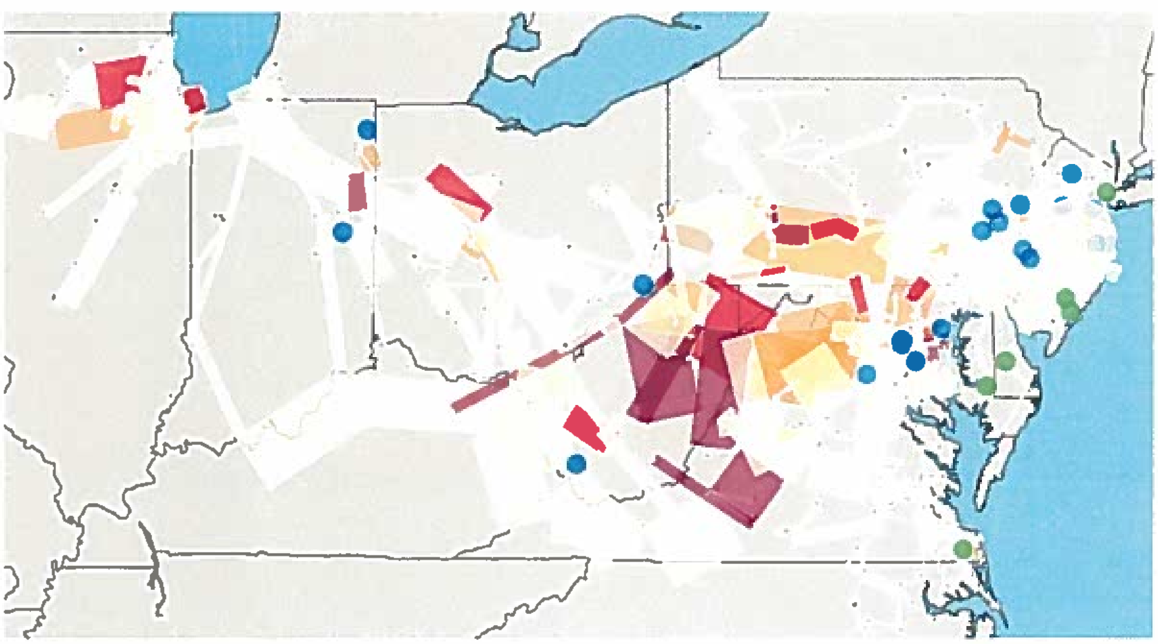
Modeling supports effective planning by helping to uncover cost-effective choices about how the energy system in New Jersey and across the region should evolve. Modeling the energy system is relevant to New Jersey's offshore wind program in several respects. It can help policy makers understand the costs and benefits of various policy decisions, including the impact of different generation decisions on the cost of energy. Our model can show Locational Marginal Price (LMP) impacts throughout the system which would clarify whether and to what degree offshore wind delivered to New Jersey would reduce wholesale energy prices. Our model also can show the impact of offshore wind on the dispatch of generation which will show the amount of spinning reserves required to balance offshore wind and whether, given uncertainty between weather and loads, there will be times when offshore wind generation combined with conventional resources will fall short of loads or exceed the amount of generation required and result in offshore wind curtailment (i.e., spilling of generation). As noted above, the model incorporates PJM's power grid and our model also can be used to demonstrate where congestion on the grid would restrict power flows and cause increased costs.

At Princeton, we also have developed SMART-Storage, a scalable algorithmic strategy that can optimize energy storage around the grid. SMART-Storage has some attractive features:

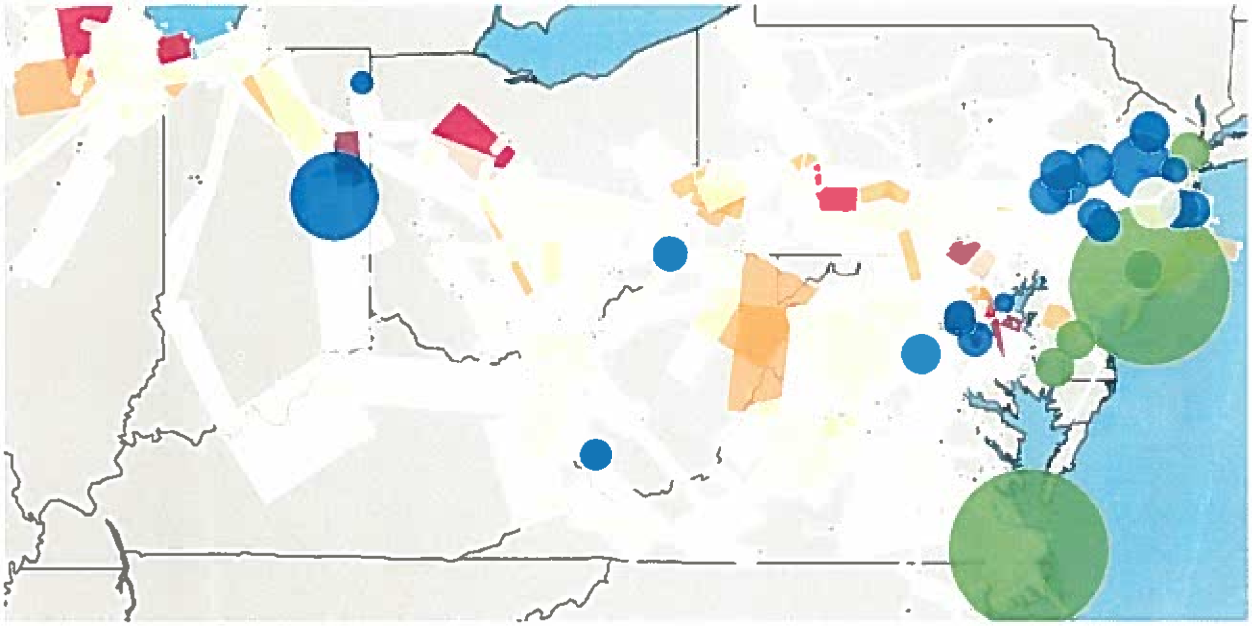
- It can simultaneously determine charge/discharge decisions over the grid, coordinating hundreds of storage devices.
- It can handle heterogeneous storage devices, producing different charging behaviors that reflect the size of the storage device and conversion losses.
- It will learn behaviors that depend on time of day, day of week, in five minute increments.
- It works with a full model of the PJM grid, optimizing power around the grid while simultaneously performing economic dispatch. It will not perform unit commitment, but it can model the adjustment of generators within allowable ramp rates.

SMART-Storage could be used to determine where storage could be efficiently deployed in New Jersey as the level of renewable energy, including offshore wind, increases in the state. This is particularly important as the state seeks to promote CO2 reduction and maximize the use of its nuclear generation fleet and renewable energy resources, both of which will be concentrated in southern New Jersey, while continuing to reliably serve the state's consumers and businesses which are concentrated in northern New Jersey.

To illustrate, the graphic immediately below shows a simulation of the PJM grid without energy storage, with orange/red showing areas of high congestion. The lower graphic shows the grid at the same point in time, with significantly reduced congestion. The green circles indicate storage near points of generation (this is a simulation of off-shore wind), while the blue circles represent storage near major load points.



PJM grid without energy storage, with orange/red showing grid congestion.



PJM grid with energy storage, showing reduced congestion. Green circles indicate storage near points of generation (this is a simulation of off-shore wind), while the blue circles represent storage near major load points.

Energy Modeling Addresses Issues Raised by the Straw Proposal

The BPU's Straw Proposal concerning the OREC funding mechanism raises certain technical issues that could be clarified through energy system modeling and planning exercises. For example, the proposal contemplates that "PJM revenues" from offshore wind projects would be refunded to ratepayers, acting as an offset to OREC payments. Estimating the PJM revenues of different project proposals would allow the state to select the projects that provide the most energy at the lowest cost. Energy value, capacity value and ancillary services revenues will depend on offshore wind variability and the timing of energy production, the location of energy delivery and the LMP obtained, and whether pairing offshore wind with other resources such as storage, demand side management and summer-peaking resources is likely.

The Straw Proposal also raises the issue of transmission for offshore wind. Transmission may be provided in an unplanned, haphazard fashion driven by the interest of individual wind developers. Alternatively, transmission for offshore wind could be developed in a planned fashion informed by models such as SMART-ISO which considers weather variability, generator attributes, power flows, generator dispatch, voltage levels, grid congestion and LMPs. Our models could be used to help the state plan transmission that would minimize costs and CO_2 emissions by ensuring that the state's nuclear, offshore wind and other renewable generation is able to operate without curtailment, that the expense of spinning reserves is minimized, and that storage, demand side management and flexible generation resources are sited cost effectively.

It is essential to recognize that electricity generation, storage and the interconnecting power grid must be managed as a portfolio. The value of each type of resource must be measured in terms of how it interacts with all the other types of resources. This is particularly important on a larger grid, which emphasizes the value of a network. Access to an unconstrained grid, with its ability to tap an array of generators and demand-side resources, usually reduces total system costs. A well-considered modeling effort that supports long-term planning would add transparency and efficiency to the State's offshore wind program.

In short, I would encourage the BPU to adopt a principled approach to the design of New Jersey's electricity generation portfolio and network that is planned to meet the needs of New Jersey, reliably and at the lowest possible cost.

Sincerely,

Professor Warren Powell
Director, Princeton Laboratory for Energy Systems Analysis
Professor, Department of Operations Research and Financial Engineering