



*Credit: MHI Vestas Offshore Wind*

THE BUSINESS NETWORK FOR OFFSHORE WIND

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# OFFSHORE WIND TRANSMISSION WHITE PAPER

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## Foreword

The Business Network for Offshore Wind (Network) is the only 501(c)(3) nonprofit organization exclusively devoted to developing the U.S. offshore wind industry and supply chain. As a result, the Network is uniquely positioned to speak with one leading voice for the U.S. offshore wind business community.

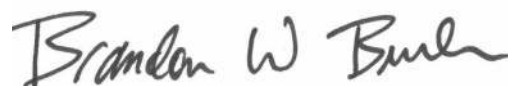
A key objective of many state-level OSW programs, and a central tenet of the Network's mission, is to attract investment in U.S.-based OSW manufacturing facilities and related services. To realize this opportunity, investors and OSW developers must see a steady, predictable, and sustainable pipeline of OSW projects taking shape in the U.S. When the capacity of the existing onshore electricity grid is reached, and low-cost points of interconnection have been utilized, these grid/interconnection constraints could arrest the future growth of the U.S. OSW project pipeline.

The objective of this white paper is to outline grid and transmission recommendations to inform grid operators and U.S. policymakers in the many local, state, and federal regulatory bodies that possess some degree of regulatory responsibility for U.S. offshore wind development and electric transmission. A comprehensive document of this kind has not previously been produced, and it is incumbent upon the U.S. OSW industry to provide input and fill the gap. This white paper may not exhaustively answer every conceivable question now. Nonetheless, at a minimum, on behalf of the industry, we outlined and assessed policy options to facilitate the integration of no less than 30 gigawatts of offshore wind capacity into the electric grid by 2035.

The white paper was developed via a collaborative and iterative process that leveraged the depth and breadth of knowledge of the Network's Grid and Transmission Working Group (G&T WG), a select group of participants drawn from the Business Network's Leadership-level membership. The G&T WG was convened and facilitated on behalf of the Network by Fara Courtney, of Outer Harbor Consulting. To assist in finalizing the white paper, the Network retained nationally recognized transmission experts, Rob Gramlich and Michael Goggin, of Grid Strategies LLC.

Consensus-building is intended to be a central aim of this white paper process, but we recognize that opinions can – and will – diverge.

With a vision of the deployment of 30 GW of offshore wind capacity in U.S. waters by 2035, we present this white paper.



Brandon W. Burke  
October 2020

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## Terminology

Precision in terminology is important when considering the topics covered by this white paper.

In this document, **“grid”** means, generally, the electricity transmission system, which is comprised of transformers, transmission lines, and distribution lines.<sup>1</sup>

**“Interconnection”** refers to the physical connection point between an electricity generation facility and the grid, or between two or more transmission facilities. The “interconnection process” is the transmission provider-led process of queuing generation or transmission projects, studying their system impacts, and assigning costs of needed grid upgrades to achieve the desired level of service.

**“Integration”** is the broader set of issues covering how new electricity generation resources are integrated into the grid. Grid integration includes planning, physical connection, and system operations activities.<sup>2</sup>

**“Offshore transmission”** refers to the components (offshore substation(s), export cables, transformers) of an offshore wind facility that transmit the generated electricity to the point of injection into the onshore grid.

A **“generator tie-line”** or **“gen-tie”** transmission system connects only one generator to a single point on the grid. All first-round U.S. offshore wind projects (i.e. those projects that were awarded offtake prior to October 2020) will utilize this transmission configuration. Other terms for this configuration include generator lead-line and proprietary transmission.

**“Radial”** refers to a transmission system design that connects one or more generating facilities to a single point on the grid. This term can include the tie line to a single generator, or a line that connects multiple generators to shore.

**“Shared network”** refers to a transmission system design that connects more than one generation facility to the grid. Some level of upfront planning and coordination will be necessary to execute a shared transmission design. Shared networks are subject to Federal Energy Regulatory Commission open access rules, and third parties can reserve available capacity. Also referred to as **“planned transmission”** in this paper.

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<sup>1</sup> U.S. Energy Information Administration. (October 11, 2019). *Electricity explained: How electricity is delivered to consumers*. Retrieved from <https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php>.

<sup>2</sup> Jain, P. & Wijayatunga, P. (April 2016). *Grid Integration of Wind Power: Best Practices for Emerging Wind Markets*. Asian Development Bank. Retrieved from <https://www.adb.org/sites/default/files/publication/183785/sdwp-043.pdf>.

## I. Introduction

Offshore wind (OSW) is a revolutionary renewable energy technology. Sometimes described as variable baseload power, OSW installations now routinely achieve capacity factors in the 40 to 50% range. Importantly, offshore wind output also tends to coincide with periods of peak electricity demand, providing higher value for meeting power system energy and capacity needs.<sup>3</sup> With appropriate policy support, OSW could dramatically reshape the electricity supplies of many coastal U.S. states. It is already doing so in parts of Europe, with some Asian countries close behind. In November 2019, the International Energy Agency estimated that the worldwide OSW technical resource potential is enough to generate more than 420,000 terawatt-hours of electricity annually.<sup>4</sup> This equates to more than 18 times current global electricity demand, meaning that the potential contributions of OSW are not limited by the quantity of resource.

The U.S. OSW industry surges into the 2020s on the heels of tremendous recent progress. During 2019 alone, U.S. states procured 7,056 megawatts (MW) of OSW capacity. During 2020, both New York and New Jersey opened their second OSW capacity solicitations; the two states together intend to procure 4 to 5 additional gigawatts (GW) by mid-2021. There now exist three principal regional “clusters” of OSW activity along the East Coast: (1) New England; (2) New York/New Jersey; and (3) the Mid-Atlantic (Maryland, Virginia, and North Carolina). There is also growing interest in deploying floating offshore wind turbines in the Gulf of Maine and off of the West Coast.

Yet, to maintain this progress and drive to scale, the U.S. OSW industry must overcome barriers. The Business Network for Offshore Wind approaches this issue through its lens as convener of the principal industry participants, and as stimulator of the U.S. OSW supply chain. For the reasons discussed more fully below, the Network views

transmission issues as an existential constraint upon the ability of the OSW industry to reach its full potential in the U.S. market.

As of September 2020, U.S. states have committed to bring just under 30 gigawatts (GW) of OSW capacity online by 2035 – less than 15 years from now. Additionally, as summarized in Appendix 1, more than 52 GW of proposed offshore wind interconnections are currently in the queues for PJM, NYISO, and ISO-NE. All projects presently in the interconnection queues may not ultimately be built, and

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### Comprehensive and coordinated transmission planning will best position the U.S. offshore wind industry to achieve sustained success.

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some projects have proposed multiple potential interconnection points, resulting in their capacity being counted multiple times. However, the 52 GW total does indicate that regional grid operators are already facing the challenge of planning transmission to accommodate large-scale injections of offshore wind. Twenty-nine years (1991 – February 2020) were required for Europe to progress from the OSW industry’s inception to Europe’s currently deployed cumulative capacity of approximately 22 GW.<sup>5</sup> Prior experience with land-based and offshore wind facilities in both Europe and the U.S. suggests that careful planning and extensive coordination will increase the likelihood that 30 GW can be integrated by 2035.

The accelerating interest in the U.S. OSW market is largely attributable to the state-level OSW capacity procurement targets set forth via legislation or gubernatorial executive orders. However, the U.S. OSW sector does not operate in a vacuum. In fact, OSW is surging worldwide. 2019 was the best year ever for offshore wind, with 6.1 GW of OSW capacity installed globally; 2.4 GW were installed in China

<sup>3</sup> See, e.g., Mills, A. D., Millstein, D., Jeong, S., Lavin, L., Wiser, R., & Bolinger, M. (2018). *Estimating the Value of Offshore Wind Along the United States’ Eastern Coast*. Lawrence Berkeley National Laboratory. Retrieved from [https://www.energy.gov/sites/prod/files/2018/04/f50/offshore\\_eri\\_lbnl\\_format\\_final.pdf](https://www.energy.gov/sites/prod/files/2018/04/f50/offshore_eri_lbnl_format_final.pdf).

<sup>4</sup> International Energy Agency. (November 2019). *Offshore Wind Outlook 2019*. Retrieved from <https://www.iea.org/reports/offshore-wind-outlook-2019>.

<sup>5</sup> As of the end of 2019. See, WindEurope. (February 2, 2020). *Offshore Wind in Europe: Key trends and statistics 2019*. Retrieved from <https://windeurope.org/about-wind/statistics/offshore/european-offshore-wind-industry-key-trends-statistics-2019/>.



alone.<sup>6</sup> It must not be forgotten that the U.S. OSW market is – and will continue to be – competing with Europe and Asia for the attention and bandwidth of OSW suppliers.

OSW suppliers are the firms that manufacture and provide the component parts (turbines, transition pieces, foundations, cables, etc.) that are assembled during the construction phase of an OSW project. These suppliers recognize the potential for misalignments between state OSW goals, federal regulatory actions, and grid operator interconnection queue processes.

Thus, it is of primary importance to address transmission policy constraints that can limit U.S. OSW development, including cost allocation of transmission upgrades; interstate planning and coordination; and seams issues between grid operators. Uncertainty about whether these grid limitations will be resolved could disincentivize suppliers from locating OSW manufacturing facilities in the U.S.

Moreover, the current cumulative state OSW capacity target of 30 GW by 2035 is likely an underestimation. In 2014, the National Offshore Wind Energy Grid Interconnection Study (NOWEGIS) examined a scenario involving 54 GW of OSW integrated by 2030.<sup>7</sup> Looking further into the future, the Department of Energy’s Wind Vision and National Offshore Wind Strategy envision deployment of up to 86 GW of OSW – encompassing all U.S. regions, including both coasts and the Great Lakes – by 2050.<sup>8</sup> If states decide to proceed with aggressive decarbonization goals, total OSW development along the entire East Coast could be well over 100 GW.<sup>9</sup>

To build OSW projects, developers must navigate complex regulatory processes at both the state and federal levels.



Credit: MHI Vestas Offshore Wind

Among other things, OSW developers must secure site control, a power offtake mechanism, project financing arrangements, and must also define how they will comply with all necessary permitting requirements. In parallel with state and federal regulatory processes, OSW developers must navigate the interconnection queue process with grid operators.

The interconnection queue process involves complex and lengthy studies to assess the cost of grid upgrades needed to integrate a particular project. Estimated grid upgrade costs are uncertain and can change drastically as other generators enter and exit the interconnection queue. In addition to securing interconnection rights – the right to inject power into the grid at a particular point – OSW developers must also obtain the land rights that enable projects to physically access injection points.

Comprehensive and coordinated transmission planning will best position the U.S. offshore wind industry to achieve sustained success. Via this white paper, the Business Network for Offshore Wind and Grid Strategies offer analysis and observations for the consideration of regulators, policymakers, grid operators, and the offshore wind industry.

<sup>6</sup> Global Wind Energy Council. (August 2020). *Global Offshore Wind Report 2020*. Retrieved from <https://gwec.net/global-offshore-wind-report-2020/#:~:text=Offshore%20wind%20will%20surge%20to,GW%20of%20floating%20offshore%20wind>.

<sup>7</sup> Daniel, J., Liu, S., Ibanez, E., Pennock, K., Reed, G., & Hanes, S. (July 30, 2014). *National Offshore Wind Energy Grid Interconnection Study, Final Technical Report*. U.S. Department of Energy. Retrieved from <https://www.energy.gov/sites/prod/files/2014/08/f18/NOWEGIS%20Full%20Report.pdf>.

<sup>8</sup> U.S. Department of Energy & U.S. Department of the Interior. (2016). *National Offshore Wind Strategy*. Retrieved from <https://www.boem.gov/National-Offshore-Wind-Strategy/>.

<sup>9</sup> See, Weiss, J., Hagerty, J. M., Castañer, M., & Higham, J. (September 2019). *Achieving 80% GHG Reduction in New England by 2050*. Retrieved from [https://brattlefiles.blob.core.windows.net/files/17233\\_achieving\\_80\\_percent\\_ghg\\_reduction\\_in\\_new\\_england\\_by\\_20150\\_september\\_2019.pdf](https://brattlefiles.blob.core.windows.net/files/17233_achieving_80_percent_ghg_reduction_in_new_england_by_20150_september_2019.pdf). In this report, the Brattle Group estimated that 43 GW of OSW capacity – amounting to an annual addition of 1.5 GW each year from now through 2050 – would be required if the New England region intends to reduce its greenhouse gas emissions 80% by 2050. If the higher load regions of NYISO and PJM are taken into account, this figure could more than double.

## II. Background on Offshore Wind Transmission

### a. Transmission System Topologies: Generator Tie-Line vs. Networked

OSW installations are generally connected to the onshore grid in one of two ways. In a generator tie-line transmission configuration, each individual OSW facility has its own dedicated grid connection infrastructure (i.e. offshore substation(s) and export cables, often utilizing alternating current [AC] technology). Due to the technological limitations of commercially available power transmission cables, a larger OSW facility may require multiple generator tie-lines to deliver all of its power to the onshore grid. By contrast, in a shared network transmission model, multiple OSW installations are connected to shore via one or more

shared offshore substations and export cables (often, but not always, utilizing direct current [DC] technology). Figure 1, below, provides stylized depictions of several possible offshore wind transmission system topologies.

Contemporary OSW transmission system design is a function of numerous factors, including length of shoreline; distance to, and availability of, suitable onshore interconnection points; the overall nameplate capacity of the project to be interconnected; proximity to other OSW projects; commercially available transmission technologies/capacities; and many others.

The vast majority of currently operational OSW installations, especially those in the North Sea and the United Kingdom (U.K.), deliver their power to shore via individual project-associated tie-line connections.<sup>10</sup> The principal advantage of tie-line transmission configurations is the sim-

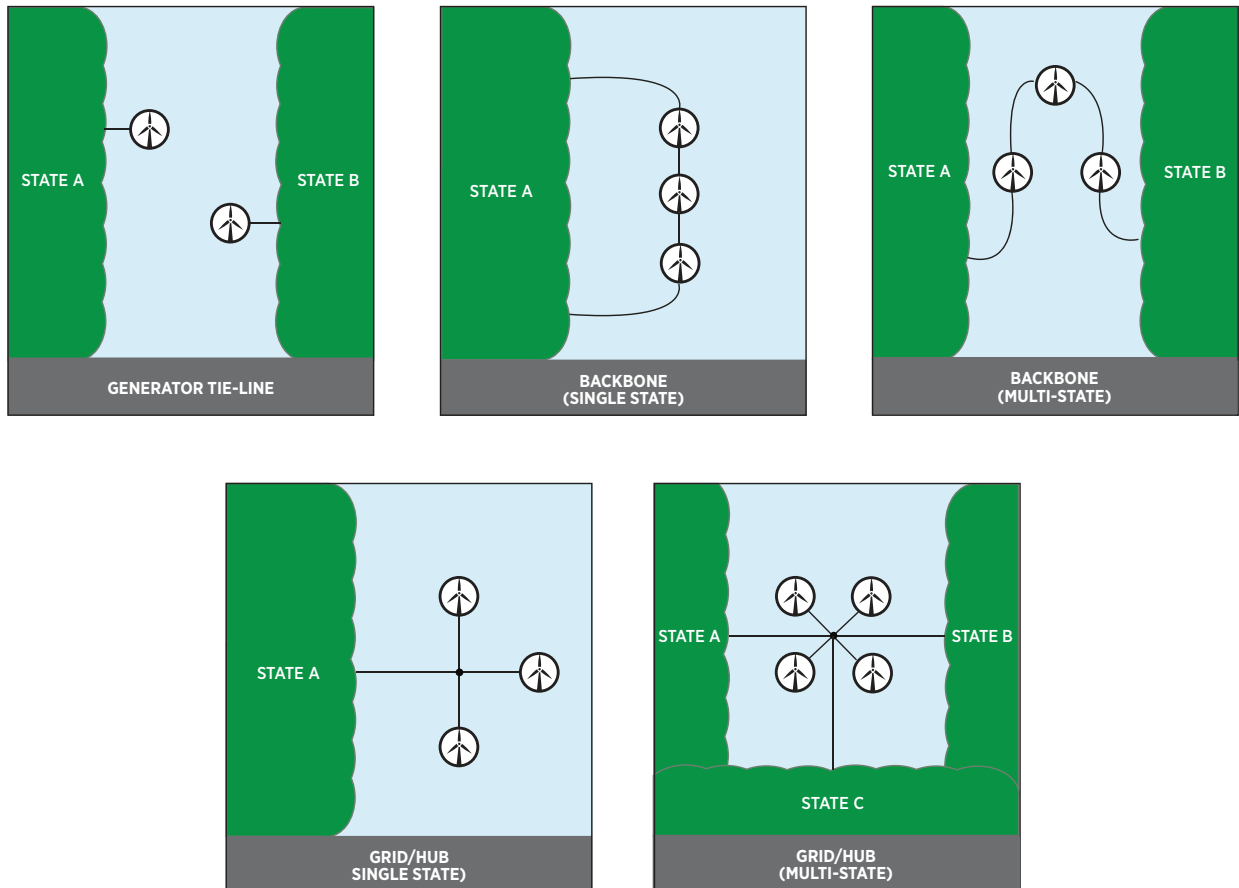


Figure 1: Offshore Wind Transmission System Topologies

<sup>10</sup> Hannah Müller (2016). A Legal Framework for a Transnational Offshore Grid in the North Sea.

plicity and speed at which offshore wind developers can move their project forward, without having to wait for other projects or larger transmission plans. At this time, only Germany has implemented a truly networked transmission grid for OSW facilities.

However, in the U.K., the Department of Business, Energy and Industrial Strategy (BEIS) is leading an effort – along

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**“In the context of increasingly ambitious targets for offshore wind, constructing individual point to point connections for each offshore wind farm may not provide the most efficient approach and could become a major barrier to delivery given the considerable environmental and local impacts, particularly from the associated onshore infrastructure required to connect to the national transmission network.”**

*- U.K. Office of Gas and Electricity Markets*

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with the Office of Gas and Electricity Markets (Ofgem) and National Grid Electricity System Operator (ESO) – to develop a more coordinated approach to U.K. OSW transmission planning. Ofgem noted that “constructing individual point to point connections for each offshore wind farm may not provide the most efficient approach and could become a major barrier to delivery[.]”<sup>11</sup> Ofgem has also opined that continuing to interconnect OSW facilities on an individual basis may prevent the U.K. from reaching its goal of 40 GW by 2030. On September 30, 2020, ESO initiated a stakeholder consultation process, and released a report which estimated that a planned network approach to OSW transmission could result in savings of nearly 18 percent (approximately £6 billion) between now and 2050.<sup>12</sup>

<sup>11</sup> Department for Business, Energy & Industrial Strategy. (August 24, 2020). Offshore Transmission Network Review terms of reference. Retrieved from <https://www.gov.uk/government/publications/offshore-transmission-network-review/offshore-transmission-network-review-terms-of-reference>.

<sup>12</sup> National Grid Electricity System Operator. (September 30, 2020). *Offshore Coordination Project*. Retrieved from <https://www.nationalgrideso.com/document/177296/download>.

<sup>13</sup> See Appendix 1.

There have also been longer-term proposals to construct “energy islands.” It is envisioned that these islands could serve as large offshore platforms upon which both consolidated transmission infrastructure for numerous surrounding OSW installations, and operations and maintenance-related port facilities, could be located.

## **b. Geographical Considerations**

Along the U.S. East Coast, OSW resources are located in relatively close proximity to load centers, but most OSW lease areas are distant from optimal points of interconnection to the existing onshore transmission networks. In many areas, only lower-voltage transmission and distribution lines extend to the coast, though at certain points high-capacity transmission lines do extend to existing or retired coastal power plants. OSW lease areas, owned by competing developers, will be required to funnel into these limited onshore interconnection points. Interconnection and system design decisions are also influenced by local bathymetry and shoreline characteristics (inlets, salt marshes, essential fish habitat [EFH], etc.). Figure 2, on page 12, depicts the locations of currently existing onshore electricity transmission infrastructure relative to offshore wind lease areas along the U.S. East Coast. See Appendix 2 for more detailed regional maps, and the locations of some points of interconnection selected by developers thus far.

## **c. Commercial Considerations**

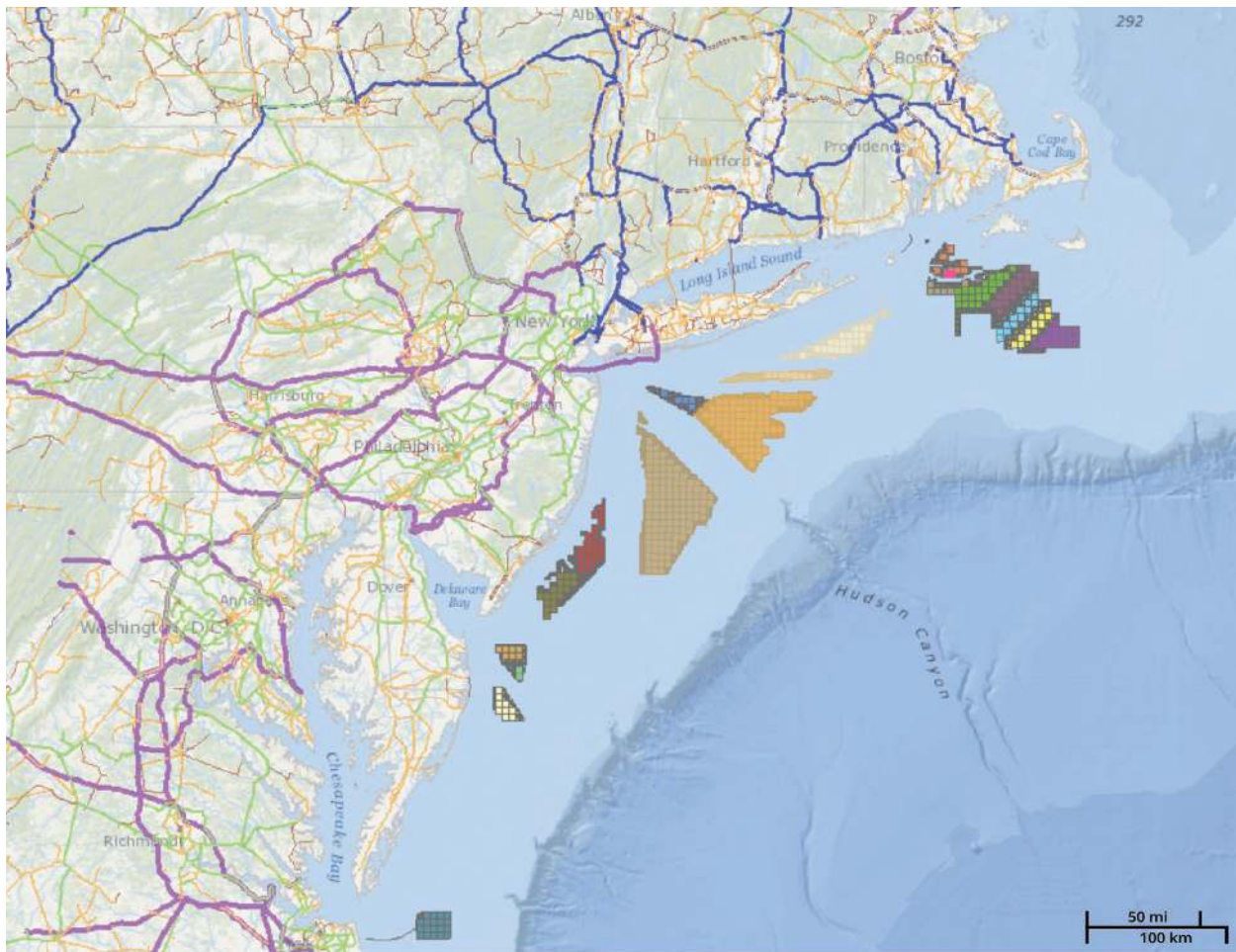
The scale of investment needed to bring 30 GW of OSW online by 2030 is massive, in the neighborhood of \$100 billion total capital expenditure, with offshore transmission representing approximately \$15-20 billion. Onshore grid upgrade costs can be comparably large. PJM Interconnection study results show that \$6.4 billion in onshore grid upgrade costs will be required if all of the 15.6 GW of offshore wind projects that have applied for interconnection move forward.<sup>13</sup> Planning and constructing a transmis-

sion network that is properly configured and sized to serve one or more future OSW generation projects means that significant capital investments remain at risk during the course of an uncertain and protracted development cycle.

As with any competitive industry, cost can be a determinative factor in power solicitations. This does not leave OSW developers with sufficient financial flexibility to prebuild transmission capacity to accommodate future OSW generation assets that could be owned/operated by other firm(s). In addition, OSW developers must commit to fixed commercial operations deadlines. Yet, these deadlines are often mutable, and are influenced by a wide variety of factors and

circumstances, resulting in regulatory uncertainty. This can have ripple effects across the transmission planning process.

These challenges apply to both offshore and onshore transmission. To interconnect an offshore generator, extensive onshore grid upgrades (including improvements to existing substations and transmission lines, as well as new transmission lines) are typically required to prevent overloads and maintain system reliability. Furthermore, congested interconnection queues can significantly influence OSW development timelines. For example, many generator interconnection study results may need to be reexamined if a generator earlier in the queue withdraws.



**Figure 2:** East Coast Existing Onshore Transmission Infrastructure and Offshore Wind Lease Areas

### III. The Benefits of Proactive Planning for Offshore Transmission

While there is debate about the optimal configuration of offshore transmission and the onshore grid upgrades necessary to integrate it, a planned transmission strategy is almost always ultimately more efficient than an unplanned, project-by-project approach. One key question in analyzing the benefits of a planned approach is what the transmission expansion resulting from an “unplanned” approach will look like. In theory, an approach that resembles the status quo, in which individual generators sequentially apply for interconnection, can somewhat optimize and realize economies of scale as the more cost-effective interconnection applications win out and are selected in state OSW capacity procurements.

However, the generator interconnection process does not capture the full benefits of transmission and is thus subject to the “free rider” problem discussed below. For this reason, a centralized transmission planning process, conducted by the grid operator and accounting for all benefits as well as the scale economies of transmission, is likely to yield a more optimal transmission investment for both offshore transmission and the onshore grid upgrades necessary to integrate OSW generation. This outcome has been confirmed by a number of recent studies.

#### a. Analyses Show Billions of Dollars in Benefits from Planned Transmission

The Brattle Group recently found that a planned offshore transmission network and supporting onshore grid upgrades in New England would cost \$500 million less upfront than the current unplanned transmission approach involving the sequential evaluation of individual proposed

generator interconnections, with ongoing savings of \$55 million per year from reduced power losses.<sup>14</sup> In addition, customers could see over \$300 million in annual savings because the offshore network would deliver power to higher-priced locations on the grid, triggering larger reductions in wholesale power prices. A planned approach could reduce the need for onshore transmission upgrades by delivering greater quantities of power to more optimal interconnection points on the grid.

Brattle conducted a similar analysis for New York, finding \$500 million in savings from a planned approach relative to an unplanned approach.<sup>15</sup> A significant share of this benefit was related to the limited space available for sub-sea cables under the Verrazano-Narrows Bridge in New York harbor due to shipping and other restrictions. In an unplanned approach, lower-capacity lines would occupy the four paths that Brattle estimates are available for cables on the seafloor, constraining the delivery of power into New York City and forcing OSW-generated power to be injected at less optimal locations on Long Island that would require more expensive upgrades to the onshore grid. Brattle’s New York and New England studies also found a planned approach could cut the total mileage of offshore transmission cable by around half, which would likely reduce the environmental impact.

In January 2020, the National Renewable Energy Laboratory released a high-level study considering the future grid integration of 2 and 7 GW of OSW generation into the combined ISO-NE and NYISO control areas. Entitled “The Potential Impact of Offshore Wind Energy on a Future Power System in the U.S. Northeast,”<sup>16</sup> the study modeled a 2024 future electricity system generation portfolio. The NREL study similarly concluded that the delivery of 7 GW of OSW to certain locations in the Northeast could trigger costly OSW curtailments due to onshore transmission congestion.<sup>17</sup>

<sup>14</sup> Pfeifenberger, J., Newell, S., & Graf, W. (May 2020). *Offshore Transmission in New England: The Benefits of a Better-Planned Grid*. The Brattle Group. Retrieved from [https://brattlefiles.blob.core.windows.net/files/18939\\_offshore\\_transmission\\_in\\_new\\_england\\_the\\_benefits\\_of\\_a\\_better-planned\\_grid\\_brattle.pdf](https://brattlefiles.blob.core.windows.net/files/18939_offshore_transmission_in_new_england_the_benefits_of_a_better-planned_grid_brattle.pdf), at 17, 19.

<sup>15</sup> Pfeifenberger, J., Newell, S., Graf, W., & Spokas, K. (August 2020). *Offshore Wind Transmission: An Analysis of Options for New York*. The Brattle Group. Retrieved from [https://brattlefiles.blob.core.windows.net/files/19744\\_offshore\\_wind\\_transmission\\_-\\_an\\_analysis\\_of\\_options\\_for\\_new\\_york.pdf](https://brattlefiles.blob.core.windows.net/files/19744_offshore_wind_transmission_-_an_analysis_of_options_for_new_york.pdf), at 4.

<sup>16</sup> Beiter, P., Lau, J., Novacheck, J., Yu, Q., Stephen, G., Jorgenson, J., Musial, W., & Lantz, E. (January 2020). *The Potential Impact of Offshore Wind Energy on a Future Power System in the U.S. Northeast*. National Renewable Energy Laboratory. Retrieved from <https://www.nrel.gov/docs/fy20osti/74191.pdf>.

<sup>17</sup> *Id.* at 24-28.

NREL found OSW curtailment rates of nearly 6% in New England in a scenario in which power was delivered to Millstone and Brayton Point, in large part because of onshore congestion between those locations and densely populated parts of Massachusetts. NREL found lower curtailment rates of around 3% in New York, in part because it modeled the delivery of OSW directly into high load areas around New York City at the Gowanus and Fresh Kills substations.

Onshore transmission upgrade costs are also large in PJM and vary considerably from one interconnection point to another. For this paper, as shown in Appendix 1, Grid Strategies reviewed 24 interconnection studies comprising 15,582 MW of OSW capacity that have proposed to interconnect to PJM. PJM found \$6.4 billion in total onshore grid upgrade costs for those projects, with an average of \$413 per kilowatt (kW) of OSW capacity. Onshore grid



Credit: MHI Vestas Offshore Wind

Relative to Brattle's analysis, this NREL analysis likely underestimates total congestion, because it relies on a zonal model of the transmission system and thus does not account for congestion within those zones. NREL's analysis also does not account for onshore transmission upgrade costs, while Brattle's analysis did calculate those costs.

Brattle's analysis found significant levels of curtailment in both New England and New York under the current unplanned approach. Using generator tie-lines to interconnect the remaining ~8 GW of capacity in the New England OSW lease areas to nearby shore locations would lead to 13% curtailment, versus 4% curtailment under a planned approach. In New York, the planned scenario saw negligible (0.1%) curtailments, versus 4.2% curtailments under the unplanned approach for the first 4,200 MW of interconnection. In the full 9,000 MW buildout, both unplanned and planned scenarios led to ~18% curtailments. Curtailments were found to be heavily dependent on overall sequencing and optimal utilization of points of interconnection for the full 9,000 MW, which is unlikely to occur under the current project-by-project interconnection process.

upgrade costs range from \$10/kW at one interconnection site to a high of \$1,850/kW at another site.

The current interconnection process also imposes risks on developers that further reinforce the need for planning. System Impact Studies (SIS) and Facility Studies (FS) in PJM can produce misleading results, as projects are studied in clusters based on the date of the interconnection request submission. Actual system reinforcement costs are only determined when a developer accepts their allocated costs, by which time other projects in their cluster may have withdrawn, changing the initial upgrade cost projection. Similarly, in NYISO, System Reliability Impact Studies (SRIS) are only studied with projects that have accepted their Class Year allocation and posted security. Once the SRIS is completed, the developer moves to the Facility Study stage, where they are studied with other projects in the same stage or grouped as a Class Year. As the Class Year process is completed, projects will either accept or reject their allocations. Each time a project rejects their allocation, the Class Year is restudied to determine the impact of that withdrawal on the remaining projects, which

often results in an increase in their cost allocation. Final System Reinforcement costs are only determined when the Class Year is finalized, and the results are often very different from those in the SRIS stage.

The PJM results in Appendix 1 also illustrate that most interconnection sites have a finite amount of capacity for new power injection before upgrade costs increase considerably. To use economics terminology, the supply curve of available injection capacity slopes steeply upward, both among sites and at individual sites. For example, at one interconnection site, the first tranche of 605 MW can be accommodated for an upgrade cost of around \$275/kW, while the second tranche of 605 MW incurs an upgrade cost of over \$1,100/kW, and the third tranche of 300 MW incurs an upgrade cost of over \$1,300/kW. However, the upgrades required for the later tranches involve rebuilding large segments of the transmission system. These investments benefit both subsequent interconnecting generators and consumers, who receive lower-cost and more reliable electricity from a stronger grid.

The goal of coordinated transmission planning should be to minimize the total cost of offshore and onshore transmission upgrades, while also selecting upgrades that maximize benefits for consumers and generators that will be interconnecting later in time.

## **b. Potential Benefits of a Network Transmission Model**

As noted above, in the long run, a planned transmission approach is almost always at least as efficient as an unplanned approach. However, there is considerable debate regarding whether a planned offshore transmission network connecting multiple OSW facilities to shore versus an incremental approach driven by generator tie-lines serving individual OSW installations will better facilitate the steady expansion and long-term success of the U.S. OSW industry.

An offshore transmission network that connects multiple OSW projects and optimizes onshore upgrades could provide the following benefits:

- More efficient use of the finite number of more optimal onshore interconnection sites.
- Achieving economies of scale from higher-capacity transmission lines and converter stations. However, this benefit may not be realized for larger OSW projects that on their own can fully subscribe the maximum capacity current technology allows for offshore transmission lines. Once established, a network also reduces the cost of incremental expansion because, in many cases, some existing infrastructure can be used.
- Providing a path for OSW plants to continue delivering their power in the event of an interruption or maintenance on a single shore tie-line. The ability to instantly re-route power to alternate paths can also mitigate local or regional reliability concerns associated with the loss of a large tie-line to shore.
- Increasing the utilization factor of individual network lines, because geographic diversity causes wind plants to have different output patterns, allowing sharing of network capacity.
- In general, an offshore transmission solution requiring the installation of a greater overall length of cable will likely result in more environmental disturbance than a configuration that requires the installation of less cable. Network transmission lines are typically built with higher capacities and have higher utilization factors, resulting in fewer total lines being needed to deliver the same amount of power to shore. As noted above, Brattle's analyses of New England and New York found that a planned approach could reduce the total length of installed cable by around one-half. The relative impact of network versus generator tie-lines is highly site specific and depends upon the environmental sensitivities that may be present in any given location.

Offshore networks with multiple onshore interconnection points can provide additional benefits:

- An ability to shift deliveries of power in real time to locations where it can provide the greatest economic and reliability value.
- Because the network will seldom be fully utilized by output from OSW plants, when spare capacity is available it can be used to carry other sources of power as

an additional element of the bulk power system network. This can provide significant benefit to electricity consumers across the region by providing access to lower-cost and more reliable power to another region or to what is currently a congested part of the same region. Revenue from delivering this power can help defray the cost of the transmission network for offshore wind.

The benefits of a network with multiple interconnection points on land can be quite significant in terms of reducing transmission congestion within and between the Northeastern grid operators. The Northeast has some of the most congested onshore electricity transmission infrastructure in the country, as well as some of the greatest exposure to natural gas price fluctuations. Extreme weather events, like the Polar Vortex and Bomb Cyclone cold snaps, are typically most severe across a limited geographic area, so expanding transmission ties to increase import capacity from neighboring regions is extremely valuable. Electrification of heating in the New England region will drive growing winter electricity demand, so high winter OSW capacity values will help the region cost-effectively meet its winter loads.<sup>18</sup> OSW tends to provide high output during many winter cold snap events.<sup>19</sup>

Using spare offshore network capacity to move electricity within and between grid operator control areas in response to supply-demand imbalances can be extremely valuable. Because OSW has zero marginal cost for producing electricity, it would take economic precedence over network grid flows, and DC lines can be controlled to meet any contractual obligations to OSW customers. In addition to the value of arbitraging energy, a transmission network may be able to realize greater value in the centralized

capacity market auctions conducted by PJM, NYISO, and ISO-NE. These auctions procure generating capacity<sup>20</sup> and account for a large and growing share of total wholesale market revenues in these three grid operators.

The capacity market price differential within and among grid operators is quite large. In PJM's most recent capacity auction, the Dominion zone in Virginia cleared at a price of



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\$140/MW-day, versus \$165/MW-day across much of southern New Jersey and the Delmarva Peninsula. In the PJM and NYISO auctions, northern New Jersey, New York City, and Long Island cleared at significantly higher prices, the equivalent of around \$205-215/MW-day. New England's most recent auction cleared at a price of around \$125/MW-day.

By capturing the diversity in supply and demand fluctuations across large regions, transmission also allows regions to reliably meet peak demand needs with lower capacity reserve margins. This phenomenon was one of the principal drivers for, and a main source of savings resulting from, the creation of power pools, independent system operators (ISOs), and regional transmission organizations (RTOs). It provides billions of dollars per year in benefits.<sup>21</sup> For the same reasons, an offshore network that connects

<sup>18</sup> In an ISO-New England Operational Fuel-Security Analysis where three of the four most reliable scenarios included large quantities of renewable generation, winter cold snap conditions were the main reliability concern. See, ISO-New England. (January 17, 2018). *Operational Fuel-Security Analysis*. Retrieved from [https://www.iso-ne.com/static-assets/documents/2018/01/20180117\\_operational\\_fuel-security\\_analysis.pdf](https://www.iso-ne.com/static-assets/documents/2018/01/20180117_operational_fuel-security_analysis.pdf), at 33, Figure 4.

<sup>19</sup> Mills, A. D., Millstein, D., Jeong, S., Lavin, L., Wisner, R., & Bolinger, M. (2018). *Estimating the Value of Offshore Wind Along the United States' Eastern Coast*. Lawrence Berkeley National Laboratory. Retrieved from [https://www.energy.gov/sites/prod/files/2018/04/f50/offshore\\_erl\\_lbnl\\_format\\_final.pdf](https://www.energy.gov/sites/prod/files/2018/04/f50/offshore_erl_lbnl_format_final.pdf).

<sup>20</sup> For example, PJM's capacity market is called the Reliability Pricing Model (RPM). Its aim is to ensure "long-term grid reliability by securing the appropriate amount of power supply resources needed to meet predicted energy demand in the future." See, PJM Interconnection. (2020). *Capacity Market (RPM)*. Retrieved from <https://www.pjm.com/markets-and-operations/rpm.aspx>.

<sup>21</sup> Midcontinent Independent System Operator, Inc. (2020). *Value Proposition*. Retrieved from <https://www.misoenergy.org/about/miso-strategy-and-value-proposition/miso-value-proposition/>. See also, PJM Interconnection. (2019). *PJM Value Proposition*. Retrieved from <https://www.pjm.com/about-pjm/-/media/about-pjm/pjm-value-proposition.ashx>.



different RTO/ISOs can reduce the required reserve margin in each region.

Under current transmission policy, there are some challenges to realizing the capacity benefit of offshore transmission. RTOs do not appear to have clear rules for allocating the capacity benefit of an intra- or inter-regional network that serves as both a merchant transmission tie and a generator interconnection tie. Much of the benefit of a transmission tie within or between RTOs stems from diversity in sources of supply and demand across a larger geographic area. RTOs use complex statistical methods to calculate this benefit, and in the case of an intra-regional merchant line, this credit is not typically awarded to the transmission developer.

Capacity market considerations may end up being moot if the Federal Energy Regulatory Commission (FERC) maintains its current approach to the Minimum Offer Price Rule (MOPR) in PJM and Buyer Side Mitigation (BSM) in NYISO. In December 2019, following a 2018 decision regarding renewables within the ISO-NE control area, FERC issued an order<sup>22</sup> directing PJM to amend its Minimum Offer Price Rule (MOPR) as it relates to PJM’s capacity market, the Reliability Pricing Model (RPM). RPM is the mechanism through which PJM ensures future electricity supply and grid reliability (“resource adequacy”). FERC concluded that PJM’s Open Access Transmission Tariff (OATT) was unjust and unreasonable because PJM’s existing MOPR “fails to address the price-distorting impact of resources receiving out-of-market support.”

Out-of-market support refers to generation resources participating in PJM’s capacity markets (like OSW) that receive subsidies from state governments. This MOPR ruling “mitigates potential exercise of market power by restricting the offer prices of certain suppliers to prevent them from offering their capacity at a low level that would unfairly drive down the price received by other suppliers

participating in the capacity auction.”<sup>23</sup> FERC has also issued several similar rulings that have narrowed buyer-side mitigation (BSM) rule exemptions in NYISO, which have been likened to the MOPR ruling in PJM.<sup>24</sup>

MOPR and BSM limit the participation of OSW resources in capacity markets. By design, they undermine state policies to incentivize OSW. The result is that OSW facilities in PJM and NYISO are artificially denied capacity revenues. The details of the implementation are still being determined, and it remains to be seen whether FERC will continue this policy over the long term. The courts and a future FERC might undo the current policy, allowing OSW facilities to receive capacity revenues.

An offshore transmission network with multiple interconnection points on land also provides grid reliability and resilience benefits that are not fully compensated by wholesale power markets, and in some cases are difficult to quantify. As noted in Section IV, this is further justification for RTOs to move the planning of offshore transmission from the generator interconnection queue process to their regional transmission planning process, where such benefits can be at least partially quantified.

Nearly 10 years ago, Brattle analyzed the proposed Atlantic Wind Connection network, which would have connected multiple OSW generation projects to multiple points on

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## Under current transmission policy, there are some challenges to realizing the capacity benefit of offshore transmission.

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shore between Virginia and northern New Jersey. While some of the economic analysis may be dated, the study nonetheless concluded that the project would yield annual fuel cost reductions of \$1.1 billion in PJM and \$1.6 billion in annual consumer savings.<sup>25</sup> Brattle also discussed, but did

<sup>22</sup> *Calpine Corporation, et al. v. PJM Interconnection, L.L.C.*, 169 F.E.R.C. ¶ 61,239 (2019).

<sup>23</sup> Barrowes, B. & Fleishman, R. (February 14, 2020). *MOPR Migration: Implications of FERC’s PJM Capacity Market Order in the New York and New England Electricity Markets*. Retrieved from <https://www.kirkland.com/publications/blog-post/2020/02/mopr-migration>.

<sup>24</sup> Cleary, K. & Palmer, K. (March 6, 2020). *Buyer-Side Mitigation in the NYISO: Another MOPR?* Resources for the Future. Retrieved from <https://www.resourcesmag.org/common-resources/buyer-side-mitigation-nyiso-another-mopr/>.

<sup>25</sup> Pfeifenberger, J. & Newell, S. (December 21, 2010). *An Assessment of the Public Policy, Reliability, Congestion Relief, and Economic Benefits of the Atlantic Wind Connection Project*. The Brattle Group. Retrieved from [https://brattlefiles.blob.core.windows.net/files/19689\\_8015\\_an\\_assessment\\_wind\\_connection\\_project\\_exec\\_summary\\_pfeifenberger\\_newell\\_dec\\_21\\_2010.pdf](https://brattlefiles.blob.core.windows.net/files/19689_8015_an_assessment_wind_connection_project_exec_summary_pfeifenberger_newell_dec_21_2010.pdf).

not quantify, the potential reliability benefits of a controllable HVDC project with multiple interconnection points. These benefits included:

- Alleviating congestion in the constrained Mid-Atlantic region and reducing the need for future onshore grid reinforcements.
- Redirecting power away from landing points with temporary reliability-related transmission constraints.
- Providing additional flexibility to address reliability challenges by re-routing power on the controllable HVDC network whenever and wherever needs arise, including contingency events from the loss of generation or transmission, threats to system stability, a need for voltage and reactive support, or the need to black start the system following a widespread outage.

### c. Potential Risks of a Network Transmission Model

At the same time, there are real and immediate risks with the larger, longer-term network transmission model. These risks must be addressed or at least mitigated before OSW developers will be sufficiently incentivized to interconnect with an offshore network system. As the scale of the proposed transmission solution increases, from an individual offshore wind facility tie-line, to a line serving multiple OSW projects, to a network line with multiple onshore points of interconnection, and finally to an inter-regional offshore network, there are increases in both the potential benefits and the policy and political challenges that must be overcome. Stakeholders must weigh those challenges against the benefits and develop an approach that is realistic and does not allow the perfect to become the enemy of the good. Many of the potential solutions identified below can be pursued in parallel, with earlier offshore projects using easier solutions while more complex solutions are at least explored for later offshore projects.

OSW developers would need a very clear understanding of the revenues available for a planned network relative to individualized generator tie-line transmission. For example, developers would need to understand the average revenue at the point of interconnection; expected revenue over the lifetime of the OSW generation and transmission

assets; risk of curtailment; and impacts of line upgrades, congestion and interconnection of future OSW at this point or other electrically connected points. Importantly, developers need to understand the risk of revenue loss from cable failures and delays in installation and what mechanisms are available to compensate for losses. If no clear mechanisms exist, developers would include an estimate of the risks into their OSW bid price. FERC rules for onshore transmission do not currently provide compensation to generators for downtime due to cable failures or congestion. For offshore assets, a compensatory mechanism will be required because the cables are significantly longer, and the cost and time to repair considerably greater.

Developers need to understand the distance from lease areas to the ocean grid. This will impact many elements associated with accessing the offshore shared interconnection point, including offshore cable routing, environmental implications, and crossing agreements. It also influences technology selection (HVAC/HVDC).

Detailed physical connection requirements need to be outlined in advance of bid submission. It is critical to ensure that interconnection requirements are well-understood prior to commencement of electrical designs. As with onshore interconnection, a great deal of due diligence is undertaken in assessing the system's capability to handle an injection of power. Uniform interconnection standards will also be necessary so that all OSW developers operate on a level playing field when interconnecting to an ocean grid.

As discussed in Section IV, there are greater regulatory, political, and other risks associated with planning, paying for, and permitting an offshore network relative to generator tie-lines, which can be detrimental to the business certainty needed by investors in OSW generation and transmission assets. For one offshore wind facility in the Baltic Sea, development of the offshore transmission system was delayed, resulting in a timing mismatch in which the generation portion of the project was complete but forced to sit idle while the offshore transmission assets were completed. No shared offshore transmission systems have been built in the U.S. and the permitting process is at best unclear. FERC recently ruled that PJM can deny injection rights to merchant offshore transmission networks

unless the project also connects to another grid operator.<sup>26</sup> This tariff issue needs to be resolved prior to any planning for offshore transmission in PJM.

Another challenge with waiting for the larger regionally planned grid is the potential timing mismatch with commercial arrangements, such as securing power offtake (whether via power purchase agreements [PPAs] or offshore wind renewable energy certificates/credits [ORECs]), financing, and necessary permits. Renewable energy project development proceeds on a tight schedule, and a developer lacking control over an essential project component that can be prone to delays, like the transmission interconnection, can

tranches of OSW projects are already in advanced stages of development and are proceeding under a generator tie-line model. This is optimal, given the much faster timeline for building an OSW project than a transmission line. However, planning for later tranches of OSW projects should be proceeding in parallel to ensure that the long lead-time needed to develop a transmission network does not preclude a more optimal solution for later expansions.

As is the case for all components of the power system, nearly all costs ultimately flow to electricity consumers. That includes the cost of risk, which significantly increases the cost of capital for generation and transmission de-



Credit: MHI Vestas Offshore Wind

add an unacceptable amount of risk.

Effective transmission planning, as well as state guidance through the procurement process, will weigh the potential benefits and risks and determine the optimal configuration. As noted previously, it is highly unlikely that a planned approach will be less efficient in the long run than an unplanned approach. The potential downsides of a network model are mostly driven by risk, and those risks can be addressed by effective transmission policies that provide clear information to OSW project developers. The potential transmission policy changes discussed below would reduce policy and regulatory risk by clearly specifying how transmission will be planned, paid for, and permitted.

The optimal outcome will almost certainly involve a mix of both generator tie-line and network elements. The first

developers. As a result, government officials can potentially save their customers billions of dollars by implementing more effective policies that govern how transmission is planned, paid for, and permitted. States, in particular, have the political clout to push RTOs and FERC to develop better transmission policies.

<sup>26</sup> Order Denying Complaint, *Anbaric Development Partners, L.L.C. v. PJM Interconnection, L.L.C.*, 171 F.E.R.C. ¶ 61,241 (2020).

## IV. The Transmission Policy Problem, and Solutions

Like many forms of infrastructure, the benefits of high-capacity transmission lines are widely dispersed across all electricity consumers. This aspect of transmission, along with transmission being a “natural monopoly” due to the inefficiency of building redundant competing systems, make transmission and similar types of infrastructure “public goods.” As a result, there is an essential role for government policy in ensuring that adequate transmission is built to realize these societal benefits, similar to the role governments play for highways, sewer systems, and rail networks.

Nationally, transmission policies have not kept pace with changes in how electricity is produced and sold. Many of these transmission policies are relics of an era when vertically integrated utilities primarily served customers in their

state using their own generation, with ties to neighboring utilities/states primarily utilized during emergency events. With the expansion of generation competition through wholesale electricity markets in recent decades, electricity is increasingly sold across multiple state lines and balancing areas, yet the regulatory framework for transmission remains fragmented along state and regional boundaries. As one would expect, a balkanized patchwork of regulations and planning structures yields a balkanized patchwork of an electric grid.

The OSW leases being developed off the U.S. East Coast lie near the intersection of eight states and three grid operators. Decisions in the New England and PJM RTOs are driven by their six and 13 (plus DC) diverse member states, respectively. The result is that a total of 20 states have a role in determining transmission planning and cost allocation for U.S. East Coast offshore wind.

The policy recommendations outlined below call for greater cooperation among these states in how transmission is planned, paid for, and permitted. We refer to these as the “three Ps” of transmission policy.

### a. Planning

A fundamental challenge for all types of renewable energy development has been the mismatch between the relatively short time it takes to develop a renewable generation project versus the long time needed to plan and permit transmission infrastructure. This has been dubbed the “chicken and the egg” problem, as both the generation and transmission network developers are waiting for the other to proceed first. Fortunately, several regions of the U.S. have figured out how to overcome that challenge through proactively planning transmission to access renewable resource areas.

Transmission planning is also inherently linked to the crucial question of transmission cost allocation, or who will pay for transmission. Many of the failures in transmission planning are driven by fundamental underlying conflicts regarding cost allocation. For example, for planning purposes, PJM inefficiently categorizes proposed transmission projects into economic (upgrades that reduce transmission



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congestion), reliability (help meet NERC<sup>27</sup> criteria), public policy (meet state renewable requirements), or generator interconnection categories. Each category of project has its costs allocated differently. As explained below, a more efficient approach to planning is to simultaneously evaluate how potential transmission projects meet economic, reliability, public policy, and generator interconnection needs.

The most fundamental problem with transmission planning in regions with RTOs is that the RTOs are currently using the generator interconnection queue process to determine what transmission should be built, even though the lens of generator interconnection is just one of many benefits of those transmission upgrades. This occurs because many stakeholders in these RTOs do not want to pay for transmission, so they support requiring interconnecting generators to pay for transmission, even multi-billion-dollar upgrades that provide benefits to the entire region. It would be more efficient for such large transmission projects to be evaluated as part of the regional planning process that is conducted by all RTOs, and for the cost to be allocated to those who benefit, which is almost entirely the customers. Individual states can also plan and/or procure independent transmission to fill this gap.

### **1. Integrated transmission planning should weigh all benefits.**

Many regions silo transmission planning studies for economic, reliability, public policy, and generator interconnection transmission projects. Requiring a transmission project to be categorized as only one type of project fails to recognize all of the values and benefits of a transmission investment, since the system ends up being used for various purposes, like reliability and economics.<sup>28</sup> Regions that have taken an integrated approach to planning a network that optimizes across all categories of benefits have seen far better results. See, Section V(b).

### **2. Transmission planning should incorporate public policy requirements.**

Most states have implemented renewable energy requirements – often called renewable portfolio standards (RPS) – and several states have passed legislation or issued executive orders setting state OSW procurement targets. However, these requirements are often not fully incorporated into RTO transmission planning needs. This has occurred in part because FERC’s Order 1000 on transmission planning and cost allocation only required regions to “consider” public policy requirements. State OSW mandates and procurements need to be integrated into transmission planning, as they are law and the procured offshore projects are being built.

### **3. Plan proactively.**

Proactive transmission planning solves the so-called “chicken and egg” timing mismatch problem in which renewable generators are not built because transmission does not exist, and transmission is not built because generators are not yet constructed. It takes a few years at most to plan and build a renewable power plant, while it takes many years to plan, permit, and build transmission infrastructure. Using advanced computing power and modeling techniques, it is now possible to co-optimize transmission and generation planning.<sup>29</sup> Regions should be: (a) looking at where new generation is expected to be developed over at least a 15-year horizon, and (b) co-optimizing combined transmission and generation investment to minimize total costs for ratepayers.

### **4. Plan for a longer time horizon.**

Traditionally, transmission planners have chosen short-time horizons, often 10 years, to calculate the benefits of transmission because of future uncertainty around gener-

<sup>27</sup> North American Electric Reliability Corporation.

<sup>28</sup> Chang, J. & Pfeifenberger, J. (August 21, 2015). *Presentation: Toward More Effective Transmission Planning*. The Brattle Group. Retrieved from [http://files.brattle.com/files/5907\\_eei\\_2015-08-21\\_transmission\\_planning.pdf](http://files.brattle.com/files/5907_eei_2015-08-21_transmission_planning.pdf). See also, Chang, J. (June 15, 2015). *Presentation: Scenarios-Based Transmission Planning for Texas*. The Brattle Group. Retrieved from [http://files.brattle.com/files/5926\\_scenarios-based\\_transmission\\_planning\\_for\\_texas.pdf](http://files.brattle.com/files/5926_scenarios-based_transmission_planning_for_texas.pdf).

<sup>29</sup> Krishnan, V., Ho, J., Hobbs, B., Liu, A., McCalley, J., Shahidehpour, M., & Zheng, Q. (August 2015). *Co-optimization of electricity transmission and generation resources for planning and policy analysis: review of concepts and modeling approaches*. Energy Systems, 7, 297-332. Retrieved from [https://www.researchgate.net/publication/281123009\\_Co-optimization\\_of\\_electricity\\_transmission\\_and\\_generation\\_resources\\_for\\_planning\\_and\\_policy\\_analysis\\_review\\_of\\_concepts\\_and\\_modeling\\_approaches](https://www.researchgate.net/publication/281123009_Co-optimization_of_electricity_transmission_and_generation_resources_for_planning_and_policy_analysis_review_of_concepts_and_modeling_approaches).

ation and load. With renewable resources, however, future generation additions will occur in the locations with optimal resources. Those locations are known today and are unlikely to significantly change over time. Transmission

## Benefits that are widely acknowledged as real but that are too difficult to quantify are typically ignored in transmission planning and benefit-cost assessments.

assets typically have a useful life of 40 years or more, and that lifetime can often be indefinitely extended by replacing key pieces of equipment. Because transmission investments are mostly up-front capital expenditures with few ongoing costs, using a short time horizon for transmission benefit-cost analysis results in a significant under-investment in transmission infrastructure. Planning horizons and benefit-cost analysis should be consistent with the expected useful life of transmission.

When planning for transmission infrastructure intended to serve large quantities of remote resources, underestimating future demand can present a challenge. ERCOT's Competitive Renewable Energy Zones and MISO's Multi-Value Projects – which are discussed more fully in Section V(b) (2) and (3) – have already reached capacity, and there is great demand for more transmission now. Transmission studies considering up to 800 MW in Maryland,<sup>30</sup> 2,400 MW in New York,<sup>31</sup> and 7,000 MW in New England<sup>32</sup> suggest relatively low cost and uncomplicated network transmission upgrades to integrate those amounts. However, those figures may be grossly underestimated, perhaps by

an order of magnitude, if one considers the quantities of offshore wind capacity that must be integrated into the onshore electricity grid if all East Coast states are to meet their decarbonization goals.

### 5. Quantify all benefits.

Benefits that are widely acknowledged as real but that are too difficult to quantify are typically ignored in transmission planning and benefit-cost assessments. Failing to fully account for these benefits harms consumers by under-investing in transmission, leaving economic, reliability, resilience, hedging, and other benefits on the table.<sup>33</sup> To remedy this, grid planners should quantify as many benefits as possible. A Brattle Group study provides a useful guide to studies and approaches that have attempted to quantify almost all of transmission's benefits.<sup>34</sup> In cases in which precise quantification is not possible, using an estimate will result in a more optimal level of transmission investment than arbitrarily assigning zero value to a benefit that is widely acknowledged to be large. If benefits are not quantified, they should be at least qualitatively taken into account in the planning process.

### 6. Better synchronize inter-regional planning.

The current inter-regional transmission planning processes under Order 1000 are not properly identifying large projects between regions that would yield large economic, reliability, operational, and public policy benefits for consumers.<sup>35</sup> This is largely due to the fact that, although Order 1000 requires neighboring transmission planning regions to coordinate planning, it does not require a joint

<sup>30</sup> Axum Energy Ventures, LLC. (August 31, 2020). *Maryland Public Service Commission Offshore Wind Analyses and Review II: Generation Interconnection System Impact Study Report*. Retrieved from [https://mdoffshorewindapp.com/sites/default/files/public/residential/faq/MD%20OSW%20Generation%20Interconnection%20System%20Impact%20Study%20Report\\_FINAL\\_1.pdf](https://mdoffshorewindapp.com/sites/default/files/public/residential/faq/MD%20OSW%20Generation%20Interconnection%20System%20Impact%20Study%20Report_FINAL_1.pdf).

<sup>31</sup> New York State Energy Research and Development Authority. (January 29, 2018). *Offshore Wind Policy Options Paper*. Retrieved from <https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Biomass-Solar-Wind/Master-Plan/Offshore-Wind-Policy-Options-Paper.pdf>. Note that New York State subsequently increased its offshore wind goal to 9,000 MW. At the time of publication, these updated study results were still pending.

<sup>32</sup> ISO New England Inc. (June 30, 2020). *2019 Economic Study: Offshore Wind Integration*. Retrieved from [https://www.iso-ne.com/static-assets/documents/2020/06/2019\\_nescoe\\_economic\\_study\\_final.docx](https://www.iso-ne.com/static-assets/documents/2020/06/2019_nescoe_economic_study_final.docx).

<sup>33</sup> Trabish, H. (June 15, 2016). *'Should have started yesterday': Why better transmission planning is urgently necessary for tomorrow's grid*. Utility Dive. Retrieved from <http://www.utilitydive.com/news/should-have-started-yesterday-why-better-transmission-planning-is-urgent/420754/>.

<sup>34</sup> Chang, J., Pfeifenberger, J., Newell, S., Tsuchida, B. & Hagerty, J. (October 2013). *Recommendations for Enhancing ERCOT's Long-Term Transmission Planning Process*. Retrieved from [https://brattlefiles.blob.core.windows.net/files/6112\\_recommendations\\_for\\_enhancing\\_ercot%e2%80%99s\\_long-term\\_transmission\\_planning\\_process.pdf](https://brattlefiles.blob.core.windows.net/files/6112_recommendations_for_enhancing_ercot%e2%80%99s_long-term_transmission_planning_process.pdf).

<sup>35</sup> For more details, see, Post-Technical Conference Comments from American Wind Energy Association. (October 3, 2016). Federal Energy Regulatory Commission Docket AD16-18-000. Retrieved from <https://elibrary.ferc.gov/eLibrary/filedownload?fileid=14368721>.

process or evaluation of inter-regional solutions and their benefits. FERC has significant authority to set inter-regional transmission planning and cost allocation policies.

A significant hurdle for many inter-regional transmission planning processes is that regions employ different planning assumptions, categories, and methods. Consistency and standardization between neighboring regions for inter-regional planning would help avoid the “triple hurdle” – the situation where proposed inter-regional transmission projects must first meet the requisite inter-regional criteria, then again qualify under each transmission planning region’s planning criteria – subjecting inter-regional projects to three or more distinct approval processes. Instead, one inter-regional process with a common model and assumptions should replace the “triple hurdle.”

Inter-regional planning could also be improved by enabling projects to address different needs in different regions, such as reliability benefits in one region, but economic or public policy in another. Once benefits are considered and findings of benefits are agreed upon in an inter-regional study, these determinations should not be subject to re-assessment by a subsequent regional evaluation. Further, there should not be exclusions on projects of certain voltage levels or cost. Nationally, Order 1000’s inter-regional planning process has failed to yield any large transmission projects to date.

## b. Paying

The question of who pays, or cost allocation, is the hardest single problem for transmission. In many regions, the cost of large upgrades to the grid are assigned to interconnecting generators. An analogy to that policy would be requiring the last vehicle entering a congested highway to pay the full cost of adding another lane to the highway. As one would expect, most generators balk at paying for these upgrades and instead drop out of the generator interconnection queue. This can cascade to generators that are next in line, and ultimately nothing may end up getting built.

RTO interconnection studies require proposed OSW plants to pay for large additions to the onshore transmission grid, even though those upgrades benefit the entire region. For example, one proposed wind project off of New Jersey was assigned \$400 million of the \$1.7 billion total cost to rebuild major elements of the onshore transmission system.<sup>36</sup> Dominion Energy’s offshore projects in Virginia were assigned part of the cost of a \$1 billion set of upgrades that includes a new 500-kV line. PJM’s study shows that many interconnecting generators benefit from that upgrade.<sup>37</sup>

Any transmission upgrade paid for by an individual generator can be used by competing generators, and for most grid upgrades, benefits largely flow to customers and other users of the grid. This is the fundamental “free rider” problem that afflicts all public goods. Additionally,



Credit: MHI Vestas Offshore Wind

as noted previously, another key challenge is that the onshore transmission upgrade cost assigned to an individual generator can shift as other generators withdraw from the interconnection queue.

The solution has been well-established by the success of transmission policies in regions like ERCOT, SPP, CAISO, and MISO. These approaches allocated the cost of high-voltage transmission infrastructure to all consumers across the region. Broadly allocating the cost of transmission to ratepayers across a large region recognizes that the benefits of transmission are widely distributed. Broad

<sup>36</sup> PJM Interconnection. (February 2020). *Generation Interconnection Impact Study Report for Queue Project AE2-022*. Retrieved from [https://www.pjm.com/pub/planning/project-queues/impact\\_studies/ae2022\\_imp.pdf](https://www.pjm.com/pub/planning/project-queues/impact_studies/ae2022_imp.pdf).

<sup>37</sup> PJM Interconnection. (August 2020). *Generation Interconnection Impact Study Report for Queue Project AF1-125*. Retrieved from [https://www.pjm.com/pub/planning/project-queues/impact\\_studies/af1125\\_imp.pdf](https://www.pjm.com/pub/planning/project-queues/impact_studies/af1125_imp.pdf).

cost allocation simply creates a mechanism by which the costs of transmission investment are allocated to those who benefit from transmission. This is consistent with FERC's long-standing and court-affirmed principle that those who benefit from investments should pay for them. More importantly, this mechanism works, as it recognizes that transmission is a public good.

PJM's State Agreement approach for public policy transmission under Order 1000 contains a similar free rider problem. If a state will benefit from another state's transmission investment whether they pay for it or not, they have little incentive to pay for it. However, if each state refuses to pay for transmission upgrades that benefit the entire region,



*Credit: MHI Vestas Offshore Wind*

nothing gets built and the entire region suffers. Even if several states join forces to pay for transmission, a large share of the benefits will still accrue to other states in the region, even though they did not pay for the transmission. That said, PJM's State Agreement approach may provide a useful starting point for planning and paying for offshore transmission in PJM, as it provides an opening for eastern PJM states with OSW targets to partner to plan and pay for transmission. Ideally, PJM's State Agreement policy would be improved to achieve greater cost-sharing to reduce the free rider problem. See, Section VI(b)(3)(ii). Similarly, in ISO-NE, states can individually procure independent transmission for offshore wind generation facilities. While some of the benefits of this transmission may flow to other states, the significant benefits of planning and procuring independent transmission outlined in this paper could

justify states acting individually and expeditiously while working toward broader regional coordination.

While the potential benefits are even greater for inter-regional transmission, the cost allocation free rider problem becomes even harder between regions. Although FERC Order 1000 required neighboring transmission planning regions to coordinate cost allocation, it has resulted in very little expansion of inter-regional transmission capacity. The cost allocation of inter-regional projects should reflect the benefits recognized in the inter-regional benefit calculation, which are typically broadly spread between the regions.<sup>38</sup> Those benefits, and the resulting cost allocation, should fully reflect the economic and public policy benefits as well as other quantifiable benefits that will accrue. FERC has significant authority to require regions to develop inter-regional transmission planning and cost allocation methodologies, though FERC has hesitated to do so without coordinated political will from state and regional actors.

### c. Permitting

Permitting for offshore transmission is not a major focus of this document. However, policies that enable development of offshore transmission in state and federal waters, by promoting certainty and minimizing risk and delays for projects, are essential for both generator tie-line and shared offshore transmission network configurations. See Section VI for further discussion regarding government agency and RTO/ISO roles in transmission planning.

<sup>38</sup> For more detailed recommendations, see, Post-Technical Conference Comments from American Wind Energy Association. (October 3, 2016). Federal Energy Regulatory Commission Docket AD16-18-000. Retrieved from <https://elibrary.ferc.gov/eLibrary/filedownload?fileid=14368721>.



## V. Lessons Learned from Renewable Energy-Driven Transmission Expansion

### a. Lessons from European Offshore Wind

In August 2019, the New York Power Authority (NYPA) published *Offshore Wind: A European Perspective*.<sup>39</sup> The purpose of this report was to “gain lessons from the European experience with a focus on the transmission and interconnection of OSW.”<sup>40</sup> The report effectively outlined the various approaches pursued by the U.K., Germany, the Netherlands, and Denmark in developing OSW generation and associated transmission infrastructure.

NYPA identified four key lessons from European OSW experiences:

- The most effective path to low cost wind power is through scale and healthy competition.
- The offshore transmission model used is dependent on a variety of physical and non-physical factors including geography. Regardless of model chosen, the coordination and incentive alignment between all parties is critical and needs to match their levels of respective capabilities.
- Visible, long-term grid planning on and offshore removes barriers to entry, improves coordination, and lowers costs.
- Cross-border coordination helps countries leverage planned transmission infrastructure, achieve resource flexibility and gain economies of scale.<sup>41</sup>

European countries have taken different approaches to transmission system ownership. In Denmark, the Netherlands, and Germany, the transmission system operator (TSO) is responsible for onshore grid planning, and also develops and owns the offshore transmission grid. This centralization helps facilitate longer-range grid planning. In Denmark, Energinet is the TSO; in Germany, TenneT and 50Hertz; and in the Netherlands, TenneT.

By contrast, the U.K. utilizes an “unbundled” privatized approach. In this model, separate private entities own, operate, and maintain OSW generation and transmission assets. OSW developers in the U.K. construct the transmission assets for their OSW generation facilities but are later obligated to sell off the transmission portion to a third-party Offshore Transmission Owner (OFTO). The U.K.’s TSO, National Grid ESO, discussed above in Section II(a), is still responsible for planning the onshore grid, but OSW developers must bear the cost of grid expansions from which they benefit. As referenced previously, the U.K. is currently re-evaluating its OSW transmission planning mechanism.

There are also differences between European and U.S. onshore transmission system models. All four of the European countries referenced – Denmark, Germany, the Netherlands, and the U.K. – have a single TSO that plans, owns, and operates the electricity transmission system. Focusing on the U.S. Northeast, as noted in Section IV, the expansion of generation competition led to a restructuring of the electric utility industry, including the separation of ownership of transmission from operations and planning. As a result, responsibility for planning and operating the transmission system in the Northeast falls to ISOs/RTOs.

Despite this difference in the separation of transmission planning and operations from ownership, the European experience provides valuable lessons that apply in the U.S.

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**The most effective path to low cost wind power is through scale and healthy competition.**

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context. Energy policy in European countries is generally driven at the national level, while in the U.S., states typically have a role in determining their own individual fuel mixes for electricity generation. In Europe, the inter-regional transmission planning issues are across countries, whereas in the U.S. these issues are across states and/or ISOs/RTOs.

<sup>39</sup> New York Power Authority. (August 2019). *Offshore Wind: A European Perspective*. Retrieved from <https://www.nypa.gov/-/media/nypa/documents/document-library/news/offshore-wind.pdf>.

<sup>40</sup> *Id.* at 5.

<sup>41</sup> *Id.* at 17-18.

However, whether considering state lines or national borders, both the European and U.S. examples involve multiple neighboring jurisdictions that are pursuing varying energy policies but have a shared interest in developing OSW capacity. In each case, coordinated planning efforts across jurisdictions present an opportunity to provide lower cost access to OSW.

## b. Lessons from U.S. Transmission Planning Successes

The chicken and egg problem of matching up the long timeline for large-scale transmission development with the short timeline for renewable energy development has been addressed in a number of ways across the U.S.

### 1. CAISO Location Constrained Resource Interconnection Facilities

The California Independent System Operator (CAISO)'s experience with onshore wind-associated transmission planning may prove to be instructive to offshore wind transmission planning methodologies. California constructed some 3,000 MW of competitive wind capacity in the Tehachapi Resource Area near Los Angeles with the help of a high-capacity transmission system, built by Southern California Edison (SEC), that connected Tehachapi directly to load centers. In addition to wind, the Tehachapi Resource Area also accommodated solar and storage resources. Most of the transmission to the region was built via standard network upgrade processes to meet reliability criteria. However, CAISO sought and received FERC approval for an innovative transmission cost allocation scheme for a generation-interconnection portion of the project. This approach could prove useful for overcoming the aforementioned chicken and egg problem associated with the risk of building transmission to serve OSW generation.<sup>42</sup> This portion, designated as a "trunkline" network transmission asset, interconnected to the power system at multiple points. It thus helped resolve existing local transmission congestion and reliability concerns, as opposed to a radial line that is only interconnected at a single point.

SCE initially proposed that the trunkline project be fully ratepayer-funded, along with the rest of the project, which FERC rejected in 2005. In 2007, FERC accepted a revised proposal from CAISO for Location Constrained Resource Interconnection Facilities (LCRIF) which broadly allocated the initial cost of the trunkline to ratepayers. This proposal required subsequently interconnecting generators to pay back some of the cost, with the risk of under-subscription borne by ratepayers. To qualify for this treatment, FERC required that the project must: serve remote generation, be designated by state agencies as serving an important "energy resource area," meet a minimum threshold of interest from interconnecting generators before proceeding, and be approved by the RTO's planning process. An offshore transmission project should be able to meet those criteria.

### 2. Electricity Reliability Council of Texas (ERCOT) Competitive Renewable Energy Zones

The Texas Interconnection Electricity Reliability Council of Texas (ERCOT) is unique in that it is neither part of the Eastern nor Western Interconnections. In most respects, ERCOT is not subject to FERC jurisdiction. Texas was able to more than double its deployed onshore wind capacity after completing a large transmission expansion into the Western and Panhandle parts of the state nearly a decade ago. Known as the Competitive Renewable Energy Zone (CREZ) projects, Texas used a competitive procurement process to build high-voltage trunk lines, which were constructed by existing Texas utilities and new independent transmission companies.

The CREZ process serves as the main model for proactive transmission planning to address the chicken and egg problem of transmission and generation expansion. In its 2005 expansion of the state's RPS, the state legislature directed the Public Utility Commission of Texas (PUCT) to work with the ERCOT grid operator to identify high-quality wind resource zones and proactively plan the transmission lines needed for wind generation development to occur in those zones. That analysis was completed in 2008, and the PUCT approved what ended up being a nearly \$7 billion expansion of 345-kV lines to those remote, high-quality

<sup>42</sup> Bracewell LLP. (May 1, 2007). *FERC Tailors Transmission to Connect Renewables*. Retrieved from <https://www.energylegalblog.com/blog/2007/05/01/ferc-tailors-transmission-connect-renewables>.

wind resource areas. Consistent with long-standing PUCT rules, the costs of the transmission were broadly allocated to all ratepayers in ERCOT, recognizing that all customers benefit from the transmission and the increased competition it drives in the wholesale electricity market.

### 3. Midcontinent Independent System Operator (MISO) Multi-Value Projects

In the late 2000s, the generator interconnection queue for the Midcontinent Independent System Operator (MISO) grew to unworkable levels as it was flooded with newly economical wind projects. MISO and its member states, learning from ERCOT's success, developed an alternative solution to move the billions of dollars in needed transmission

overall portfolio. All Multi-Value Projects planned through this process received broad cost allocation to all MISO ratepayers.

### 4. Southwest Power Pool (SPP) Priority Projects

Building on the success of ERCOT and MISO, the Southwest Power Pool (SPP) also implemented a proactive, multi-value transmission planning effort, with "Priority Projects" identified through that process eligible for broad transmission upgrade cost allocation called the "Highway/Byway" method. This led to large transmission upgrades that have enabled SPP's emergence as the RTO with the highest wind energy penetration as a share of generation.



*Credit: MHI Vestas Offshore Wind*

upgrades from the generator interconnection process to MISO's centralized transmission planning process. In its Regional Generation Outlet Study, MISO conducted proactive transmission planning to minimize total transmission and generation cost by accessing lower-cost wind resources.

One of MISO's most important innovations was simultaneously accounting for multiple values of transmission projects. More specifically, MISO's approach considers the value of transmission for meeting economics, reliability, and public policy (renewable interconnection to meet state RPS requirements) needs. MISO made sure to spread planned transmission projects across the entire MISO footprint to ensure that all zones received projects and had a strong benefit-to-cost ratio, ensuring their support for the

### 5. Bonneville Power Administration (BPA) Open Season

The Bonneville Power Administration (BPA)'s Open Season process was another innovation to overcome the inefficiency of the serial generator interconnection study process. Under the serial process, each generator was studied independently, and upgrade costs for that project were calculated. This approach resulted in the inability to capitalize upon potentially large economies of scale that could be achieved from building large transmission upgrades able to accommodate multiple generator interconnection requests in the same area. Modeled on a similar approach that is used for natural gas pipeline capacity, the Open Season process designed the transmission needed to ac-

commodate multiple interconnecting generators. Those generators provided non-refundable deposits to ensure they would proceed and pay for their share of the total transmission upgrade.

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Another approach to solve the chicken-and-egg problem is for a state authority to help plan and finance beneficial transmission lines.

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Many RTOs have adopted a variation on this approach through the interconnection queue cluster process, in which a large number of interconnection applications are evaluated simultaneously, and upgrade costs are shared among them. While this approach does, to some extent, help achieve economies of scale, it does not address the fundamental problem that many of the benefits of those transmission upgrades accrue to others. Moving transmission planning and cost allocation to the regional transmission planning process is the only solution for that problem.

## 6. Anchor Tenant Model

In 2009, FERC approved a policy for merchant transmission for land-based wind that may be well-suited for offshore transmission.<sup>43</sup> This policy provides an exception to FERC transmission open access rules by giving the transmission developer the ability to use negotiated rates instead of market-based rates when an “anchor tenant” subscribes a large share of the line’s capacity. This provides enough critical mass to allow a transmission project to move forward, helping to overcome the chicken and egg timing mismatch between generation and transmission discussed earlier. Due to reasons mostly related to transmission permitting, no transmission lines using this model have yet come online, though many are still in advanced stages of development.

## 7. New Mexico Renewable Energy Transmission Authority

Another approach to solve the chicken-and-egg problem is for a state authority to help plan and finance beneficial transmission lines. Created in 2013 by the New Mexico Renewable Energy Transmission Authority Act, the state’s Renewable Energy Transmission Authority (RETA) is a good example. RETA is working on two high voltage transmission projects in partnership with private developers to bring renewable resources to load. Tax-free state financing affords a lower cost of capital than securing comparable private financing.

## 8. Western Area Power Administration Transmission Infrastructure Program

Housed within the U.S. Department of Energy (DOE), U.S. Power Marketing Administrations (PMAs) have built tens of thousands of miles of transmission lines to access and deliver electricity generated by remote renewable generation resources. In this case, the resource was hydropower and the construction occurred in the middle of the 20th century. More recently, in the 2009 American Reinvestment and Recovery Act, PMA borrowing authority was expanded to help plan and build transmission that has largely been used to access and deliver remote wind energy. In 2009, the Western Area Power Administration (WAPA) used its \$3.25 billion of borrowing authority to create a Transmission Infrastructure Program that has been helping to plan and finance transmission lines around its large footprint in the Central and Western parts of the United States. PMAs can access low-cost tax-free financing, which brings a cost advantage over private financing.

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<sup>43</sup> Order Authorizing Proposals and Granting Waivers, *Chinook Power Transmission, L.L.C., et al.*, 126 F.E.R.C. ¶ 61,134 (2009).

## VI. Roles in U.S. Offshore Wind Transmission Planning

### a. Overview

Governmental entities at the federal, state, and local levels have their own planning processes, jurisdictional authority, decision-making responsibilities, and/or procurement timelines that affect the development process for both OSW generation and transmission assets. No single regulatory authority at the federal, regional, or state level has broad or sole responsibility for planning the offshore and onshore transmission that will be needed. States and RTOs/ISOs are also taking different approaches to transmission planning.

The existing key roles are:

- State energy policy goals largely drive demand for OSW generation,
- OSW generation and some transmission system components are sited on federally regulated portions of the Outer Continental Shelf,
- OSW facility export cable landfalls are regulated by state governments, and often require separate approvals/acceptance from local governments,
- grid integration of OSW facilities is influenced by many factors, including the RTO/ISO interconnection queue process, and
- there is potential for misalignment between the federal OSW leasing process, the federal OSW permitting process, state OSW capacity procurements, state OSW permitting processes, and the RTO/ISO queue processes.

To meet cumulative state offshore wind goals of 30 GW by 2035, these inter- and intra-governmental interfaces must be navigated. Commencing the transmission planning process now will provide the best opportunity for achieving this goal. It is important to understand the motivations and constraints of these various agencies, and we take them in turn below.



Credit: MHI Vestas Offshore Wind

### b. Federal Energy Regulatory Commission

#### 1. Transmission

Under the authority of the Federal Power Act, the Federal Energy Regulatory Commission (FERC) regulates interstate transmission and wholesale sales of electricity, including transmission planning and market operations. FERC also maintains reliability standards for high voltage interstate transmission projects and has certified the North American Electric Reliability Corporation (NERC) as the Electric Reliability Organization.<sup>44</sup> However, states retain jurisdiction over the physical transmission facilities, their specific siting, and construction.

<sup>44</sup> Federal Energy Regulatory Commission. (April 2020). *Reliability Primer*. Retrieved from [https://www.ferc.gov/sites/default/files/2020-04/reliability-primer\\_1.pdf](https://www.ferc.gov/sites/default/files/2020-04/reliability-primer_1.pdf).

FERC’s authority to require regional transmission planning and broad cost allocation has been bolstered by court decisions over the last decade.<sup>45</sup> However, the U.S. Court of Appeals for the D.C. Circuit upheld the FERC Order 1000 planning requirements based, in part, upon the fact that the Commission “expressly declined to impose obligations to build or mandatory processes to obtain commitments to construct transmission facilities.”<sup>46</sup> Accordingly, plans

preme Court of the United States upheld these decisions by the Seventh Circuit, affirming FERC’s ability to assign the costs of regionally beneficial transmission broadly in a way that is “roughly commensurate” with those who benefit.

As mentioned in Section IV, the historical transition from “traditional” vertically integrated utilities<sup>49</sup> to restructured competitive wholesale electricity markets spanning mul-



Credit: MHI Vestas Offshore Wind

must be developed through the RTO stakeholder process, and likely would be subject to legal challenge if directed by FERC.

In *Illinois Commerce Commission v. FERC*, the U.S. Court of Appeals for the Seventh Circuit upheld FERC’s approval of MISO’s cost allocation proposal.<sup>47</sup> The court noted that FERC must have “an articulable and plausible reason to believe that the benefits are at least roughly commensurate” with how the costs are allocated.<sup>48</sup> FERC is not obligated to “calculate benefits to the last penny, or for that matter to the last million or ten million or perhaps hundred million dollars,” and it “can presume that new transmission lines benefit the entire network.” By denying certiorari, the Su-

multiple states fundamentally reshaped the electric utility industry in the Northeast. This shift also required FERC to rethink transmission policy. In 1996, FERC issued Order No. 888.<sup>50</sup> In the interest of advancing the shift to competitive markets, this Order was intended to ensure that all wholesale buyers and sellers of electricity can obtain non-discriminatory transmission access. Order No. 2000, issued in 1999, defined and encouraged the formation of Regional Transmission Organizations (RTOs).

Order No. 890, issued in 2007, made some reforms, including “requiring an open, transparent, and coordinated transmission planning process.”<sup>51</sup> In 2011, building upon the framework of Order No. 890, FERC issued Order No.

<sup>45</sup> *South Carolina Public Service Authority v. FERC*, 762 F.3d 41, 57 (D.C. Cir. 2014).

<sup>46</sup> *Id.*

<sup>47</sup> *Ill. Comm. Comm’n v. FERC*, 576 F.3d 470 (7th Cir. 2009), *Ill. Comm. Comm’n v. FERC*, 721 F.3d 764 (7th Cir. 2013), and *Ill. Comm. Comm’n v. FERC*, 756 F.3d 556 (7th Cir. 2014).

<sup>48</sup> *Ill. Comm. Comm’n v. FERC*, 576 F.3d at 477.

<sup>49</sup> Speaking generally, vertically integrated electric utilities own and operate all three components of the modern electric grid – generation, transmission, and distribution. This is a regulated monopoly model.

<sup>50</sup> Order No. 888, *Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities*, 75 F.E.R.C. ¶ 61,080 (1996).

<sup>51</sup> Order No. 890, *Preventing Undue Discrimination and Preference in Transmission Service*, 118 F.E.R.C. ¶ 61,119 (2007).

1000.<sup>52</sup> FERC Order No. 1000 requires public utility transmission providers to

(1) participate in a regional transmission-planning process that satisfies the requirements set out in Order 890 and produce a regional transmission plan, (2) establish procedures to identify transmission needs based on public policy requirements in state or federal laws or regulations and evaluate proposed solutions to those transmission needs, and (3) coordinate with public utility transmission providers in neighboring transmission-planning regions to determine if there are more efficient or cost-effective solutions to mutual transmission needs.<sup>53</sup>

Order No. 1000 also eliminated the “right of first refusal” regarding transmission construction and operation, which encourages construction of transmission assets by third-party (i.e., non- incumbent) firms, thereby introducing competition to the transmission sector.

FERC Order 1000 encouraged public policies to be taken into account in transmission planning. It specifically states that “regional transmission planning could better identify transmission solutions for reliably and cost-effectively integrating location-constrained renewable energy resources needed to fulfill Public Policy Requirements such as the renewable portfolio standards adopted by many states.”<sup>54</sup> As of October 2020, OSW represents a sizeable portion of the renewable portfolio standards for virtually every coastal state between Cape Cod and Cape Hatteras. In fact, most – if not all – of these states consider OSW to be a cornerstone of their clean energy goals and broader decarbonization efforts. Given its identification as a key energy policy objective for more than half of the Eastern Seaboard, offshore wind presents an ideal opportunity to implement the regional planning framework outlined by Order 1000.

In February 2018, FERC approved an independent transmission developer’s request to conduct a transmission solicitation and charge negotiated transmission rates for a proposed merchant offshore transmission system in the New England region. The developer is also pursuing an independent transmission system in the New York-New Jersey region, but is experiencing difficulties securing a position in PJM’s interconnection queue, because its “unbundled” (i.e. transmission-only) project proposal lacks a generation component.<sup>55</sup> See discussion at Section III(c).

## 2. Wholesale Markets

FERC also regulates the rates, terms, and conditions of sales of electricity for resale in interstate commerce. In the Northeast and in California, since generation was separated from transmission and distribution for most utilities, almost all sales from generators are considered “sales for resale,” or wholesale sales. Thus, FERC decisions directly impact the energy and capacity market compensation that OSW facilities receive.

As considered in greater detail in Section III(b), FERC’s broad MOPR/BSM policy approach excludes OSW facilities from providing or being compensated for capacity services in each of the Northeast RTO/ISOs. The controversial issue has been challenged in court and could be changed in the future as FERC Commissioners change.

## 3. RTO/ISO Interconnection Processes

The interconnection queue processes of Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs)<sup>56</sup> are essential components of OSW transmission planning and are subject to FERC jurisdiction and oversight. These interconnection processes provide independent access to transmission service across multiple utility service territories, while simultaneously allowing utilities to maintain ownership of transmission assets.

<sup>52</sup> Order No. 1000, *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, 136 F.E.R.C. ¶ 61,051 (2011).

<sup>53</sup> Klass, A. & Wilson, E. (2012). *Interstate Transmission Challenges for Renewable Energy: A Federalism Mismatch*, 65 Vand. L. Rev. 1801, 1824-24 (2012).

<sup>54</sup> Order No. 1000, 136 F.E.R.C. ¶ 61,057, at para. 81.

<sup>55</sup> Order Denying Complaint, *Anbaric Development Partners, L.L.C. v. PJM Interconnection, L.L.C.*, 171 F.E.R.C. ¶ 61,241 (2020).

<sup>56</sup> RTOs and ISOs are also sometimes referred to as “grid operators.” The terms ISO and RTO are interchangeable for all intents and purposes.

Generally, Northeast RTO/ISOs employ a fairly standardized interconnection queue process:

- Interested generator files an Interconnection Request to the RTO/ISO;
- Scoping meeting is held between developer and RTO/ISO;
- Three technical studies are completed: feasibility, system impact study, facilities study. The facilities study identifies the costs of transmission upgrades that may be needed and assigned to a generator, and these can be significant.

### i. Independent System Operator-New England (ISO-NE)

ISO-NE's territory includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. OSW currently constitutes a significant portion of ISO-NE's interconnection queue. ISO-NE has been responsive to state clean energy goals and has enabled elective transmission



Credit: MHI Vestas Offshore Wind

upgrade (ETU) rules (which help transmission upgrade projects hold firm queue positions). It has also instituted new technical data requirements to help facilitate the study process for inverter-based generators, like wind facilities.

Annually, ISO-NE conducts up to three economic studies at the request of regional stakeholders regarding various power system scenarios. Two requests during 2019 pertained to offshore wind.<sup>57</sup> The two requests envision different transmission expansion scenarios out to 2030.

ISO-NE has estimated that the addition of approximately 7,000 MW of OSW capacity, if injected at optimal locations, may avoid major additional reinforcements to the 345-kV transmission system. ISO-NE anticipates that injections above 7,000 MW would require additional power plant retirements, or significant reinforcements to the on-shore transmission system.<sup>58</sup>

In October 2020, the New England states – through the New England States Committee on Electricity (NESCOE) – outlined a vision for a 21st century regional electric grid.<sup>59</sup> NESCOE called for significant changes to ISO-NE's governance, wholesale market design, and transmission system planning, as well as a robust stakeholder process to inform development of necessary interventions. The driving force behind this bold, collaborative, regional effort is the New England states' collective clean energy ambitions – which include significant levels of offshore wind – along with a desire for greater engagement and transparency in ISO-NE's planning and priority-setting processes.

### ii. PJM Interconnection (PJM)

PJM serves power to more than 65 million people across all or part of 13 states, including Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and District of Columbia. It is one of the largest competitive wholesale electricity markets on the planet. Resources seeking interconnection to PJM's system must, in addition to the standard process and studies,<sup>60</sup> request treatment

<sup>57</sup> New England States Committee on Electricity. (April 25, 2019). *2019 Economic Study Request: Offshore Wind Integration*. Retrieved from [https://www.iso-ne.com/static-assets/documents/2019/04/a2\\_nescoe\\_2019\\_economic\\_study\\_request\\_presentation.pptx](https://www.iso-ne.com/static-assets/documents/2019/04/a2_nescoe_2019_economic_study_request_presentation.pptx). See also, Anbaric. (April 1, 2019). *Letter regarding 2019 ISO New England Economic Study Request for Offshore Wind Impacts*. Retrieved from [https://www.iso-ne.com/static-assets/documents/2019/04/anbaric\\_2019\\_economic\\_study\\_request.pdf](https://www.iso-ne.com/static-assets/documents/2019/04/anbaric_2019_economic_study_request.pdf).

<sup>58</sup> Massachusetts Clean Energy Center. (March 3, 2020). *Massachusetts Offshore Wind Transmission Technical Conference*. Retrieved from <https://www.mass.gov/doc/technical-conference-slide-presentations-morning-session-hosted-by-masscec-pdf>, at 49.

<sup>59</sup> New England States Committee on Electricity. (October 2020). *New England States' Vision for a Clean, Affordable, and Reliable 21st Century Regional Electric Grid*. Retrieved from [http://nescoe.com/wp-content/uploads/2020/10/NESCOE\\_Vision\\_Statement\\_Oct2020.pdf](http://nescoe.com/wp-content/uploads/2020/10/NESCOE_Vision_Statement_Oct2020.pdf)

<sup>60</sup> PJM Interconnection. (November 1, 2016). *PJM Manual 14A: Generation and Transmission Interconnection Process*. Retrieved from <https://pjm.com/-/media/documents/manuals/archive/m14a/m14av19-generation-and-transmission-interconnection-process-11-01-2016.ashx>.



as either a Capacity Resource (may participate in PJM's capacity market), or an Energy Resource (may participate in PJM's energy market based on locational marginal pricing).

PJM's rules provide for a State Agreement approach to transmission planning,<sup>61</sup> which relies upon states voluntarily agreeing to accept cost allocations, creating the free rider problem examined in Section IV(b) of this paper. The practical effect is that public policies are only incorporated into transmission plans if states volunteer to pay for the upgrades, and this has not occurred in the ten years since FERC issued Order 1000. It is possible that, in the future, the State Agreement approach could serve as a mechanism for transmission expansion in a way that facilitates multiple states achieving their offshore wind goals.

As discussed in Section III(b), FERC's recent rulings concerning PJM's MOPR may have significant impacts on the revenues that OSW can earn in PJM's capacity market. However, capacity revenues are a relatively minor share of the total market value of OSW generation.<sup>62</sup> It is very possible that the courts or a future FERC could undo broad application of MOPR on the basis of it being discriminatory and causing unjust and unreasonable rates.

### iii. New York Independent System Operator (NYISO)

Unlike ISO-NE and PJM, which both cover multiple states, NYISO serves only New York State. In 2017, at the request of the New York Department of Public Service, NYISO conducted a power flow assessment<sup>63</sup> related to the injection of 2,400 MW of OSW generation into New York City (Zone J) and Long Island (Zone K). Note that a power flow assessment, which focuses on transmission system thermal violations associated with a particular injection of power, is different than an interconnection study. The

study concluded that, "from a thermal bulk transmission security perspective[,] the injection of 2,400 MW of OSW generation into NYISO Zones J and K is feasible, though it would require the reduction of power output from existing generators within those areas.

Like PJM's State Agreement Approach, NYISO has the Public Policy Transmission Planning Process (PPTPP), which is one element of NYISO's periodic Comprehensive System Planning Process. The PPTPP is outlined in Attachment Y



Credit: MHI Vestas Offshore Wind

of NYISO's FERC-approved tariff.<sup>64</sup> Under the PPTPP, once transmission needs driven by Public Policy Requirements are identified by the New York Public Service Commission (NYPSC), NYISO requests that interested parties submit proposed solutions. After evaluating these proposals, and a confirmation from the NYPSC that the transmission need still exists, NYISO may select "the more efficient or cost-effective transmission solution to the identified need."<sup>65</sup>

## c. Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) has regulatory responsibility over the development of renewable energy generation and transmission assets sited

<sup>61</sup> PJM Interconnection. (July 14, 2011). *Amended and Restated Operating Agreement of PJM Interconnection, L.L.C.* Retrieved from <https://www.pjm.com/directory/merged-tariffs/oa.pdf>.

<sup>62</sup> Mills, A. D., Millstein, D., Jeong, S., Lavin, L., Wiser, R., & Bolinger, M. (2018). *Estimating the Value of Offshore Wind Along the United States' Eastern Coast*. Lawrence Berkeley National Laboratory. Retrieved from [https://www.energy.gov/sites/prod/files/2018/04/f50/offshore\\_eri\\_lbnl\\_format\\_final.pdf](https://www.energy.gov/sites/prod/files/2018/04/f50/offshore_eri_lbnl_format_final.pdf).

<sup>63</sup> Lin, Y. (December 1, 2017). *Offshore Wind Injection Assessment*. New York Independent System Operator. Retrieved from <https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Biomass-Solar-Wind/Master-Plan/17-25n-Offshore-Wind-Injection-Assessment.pdf>.

<sup>64</sup> New York Independent System Operator. (September 29, 2020). *NYISO Open Access Transmission Tariff*. Retrieved from <https://nyisoviewer.etariff.biz/ViewerDocLibrary/MasterTariffs/9FullTariffNYISOOATT.pdf>.

<sup>65</sup> New York Independent System Operator. (July 16, 2019). *2019-2028 Comprehensive Reliability Plan*. Retrieved from <https://www.nyiso.com/documents/20142/2248481/2019-2028CRP-FinalReportJuly-2019.pdf/51b573b7-9edb-bbb9-8a87-742e9e7c3b7f>.



Credit: MHI Vestas Offshore Wind

on the portion of the Outer Continental Shelf that is between 3 and 200 nautical miles (NM) offshore. BOEM is the lead agency for the National Environmental Protection Act (NEPA) as it relates to OSW projects. For a “bundled” OSW facility combining generation and transmission assets, BOEM would be responsible for leasing the offshore area upon which the turbines would be sited, and for granting the right of way (ROW) for the cable run to the state waters boundary, generally 3 NM offshore. The U.S. Army Corps of Engineers (USACOE) permits the installation of structures within the navigable waters of the United States, including within the 3 NM state waters boundary. Under the single record of decision (ROD) policy, the BOEM permitting decisions should, as a matter of course, incorporate the issuance of the necessary USACOE permits.

BOEM would also be responsible for approving the Construction and Operations Plan (COP) for the facility. For an offshore transmission-only project, BOEM would have similar ROW leasing and construction approval responsibilities for that portion of the system which lies upon the OCS outside the 3 NM state waters boundary. BOEM has a mandate to respect state-level coastal zone management (CZM) policies.

In addition to approving renewable energy activities on the OCS, BOEM has responsibility for conducting auctions of OCS lease areas. This responsibility, and the timing of OCS lease auctions relative to state-level capacity procurements, has direct implications for OSW transmission planning.

For the sake of completeness, many other federal entities beyond FERC, BOEM, and USACOE, including the Bureau

of Safety and Environmental Enforcement, United States Coast Guard, the National Oceanic and Atmospheric Administration’s National Marine Fisheries Service, and others, have jurisdiction over aspects of an OSW facility.

#### d. U.S. Department of Energy

The U.S. Department of Energy (DOE) has responsibility for supporting reliability and resiliency of the electrical grid across the United States, possesses technical expertise in its applied energy programs and national laboratories, and has access to appropriate funding sources (e.g. RD&D grants, Loan Program, etc.). DOE could therefore play a significant role in supporting the coordinated planning efforts necessary for an offshore transmission network. To date, DOE has played only small roles through Power Marketing Administrations and supporting some studies. DOE has a formal relationship with FERC and, during the Obama Administration, collaborated closely with the U.S. Department of the Interior when the two agencies jointly issued the first National Offshore Wind Strategy in September 2016.<sup>66</sup>

In addition to working hand-in-hand with its Federal counterparts, FERC and BOEM, DOE could work closely with the relevant RTOs/ISOs and states in such a process.

#### e. States

##### 1. The Importance of State OSW Targets

State-level OSW capacity procurement targets have been the primary drivers of the U.S. OSW industry, and decisions made at the state level will be the most important factors determining the choice between transmission options. In terms of transmission siting, state governments must approve the routing of OSW facility export cables as they traverse state waters, make landfall, and run to the point(s) of interconnection, which may be close to the point of cable landfall, or could be dozens of miles inland.

The structure of state-level OSW capacity procurements is also influential. If a state’s bid eligibility requirements only permit “bundled” (i.e., combined OSW generation and

<sup>66</sup> U.S. Department of Energy & U.S. Department of the Interior. (2016). *National Offshore Wind Strategy*. Retrieved from <https://www.boem.gov/National-Offshore-Wind-Strategy/>.

transmission) bids, a proposal by a merchant transmission developer would not even be considered. States are in different stages of evaluating their options for shared OSW transmission configurations.

States must also issue permits for land-side transmission and substation assets pursuant to certificate of public necessity and convenience statutes. State condemnation statutes govern rights of way and other real property acquisitions. There are also a patchwork of local government land use and related permits that may also be required, often with coastal zone management (CZM) overlays. We will consider Massachusetts, New Jersey, New York, and Virginia.

## 2. Massachusetts

In 2016, Massachusetts enacted “An Act to Promote Energy Diversity,” (Section 83C) which directed Massachusetts utilities to negotiate PPAs with developers for 1,600 MW of

**State-level OSW capacity procurement targets have been the primary drivers of the U.S. OSW industry, and decisions made at the state level will be the most important factors determining the choice between transmission options.**

OSW capacity. This 1,600 MW statutory directive was satisfied by the 83C Round 1 procurement of the Vineyard Wind project (800 MW), and 83C Round 2 procurement of the Mayflower Wind project (804 MW). In 2018, Massachusetts enacted “An Act to Advance Clean Energy,” which granted the Massachusetts Department of Energy Resources (DOER) authority to procure up to an additional 1,600 MW of OSW capacity, subject to the results of a DOER Offshore Wind Study, which was completed in May 2019.<sup>67</sup>

DOER determined that the cost-benefit analysis of the Offshore Wind Study justified procuring an additional 1,600 MW of OSW capacity, meaning that Massachusetts’ offshore wind target is now 3,200 MW by 2035. The study also recommended that DOER conduct “a technical conference to assess whether and/or how a solicitation for independent transmission should occur and if necessary, issue a separate contingent solicitation for independent transmission in 2020 prior to additional solicitations for offshore wind.”<sup>68</sup>

This technical conference was jointly hosted by DOER and the Massachusetts Clean Energy Center (MassCEC) in Boston on March 3, 2020.<sup>69</sup> It noted that the 83C Round 1 procurement required two bids – a generator lead line (GLL) configuration,<sup>70</sup> and an expandable transmission network (ETN). Vineyard Wind’s prevailing bid included a GLL transmission configuration.

ETN proposals were not required for 83C Section 2 bids. However, two bids were required – a GLL bid, and a GLL bid with a Commitment Agreement. The Commitment Agreement means that the bidding OSW generation developer promises to “negotiate in good faith and use commercially reasonable best efforts” if a third-party OSW developer subsequently requests interconnection with, or expansion of, the bidder’s transmission assets. The Mayflower Wind project bid, which prevailed in Section 83C Round 2, included a Commitment Agreement.

The afternoon session of the March 3, 2020 technical conference outlined three different proposed structures for Massachusetts forthcoming OSW solicitations.<sup>71</sup> On July 28, 2020, Massachusetts subsequently decided not to proceed, at this time, with an independent solicitation for “unbundled” offshore transmission.<sup>72</sup>

<sup>67</sup> Massachusetts Department of Energy Resources. (May 2019). *Offshore Wind Study*. Retrieved from <https://www.mass.gov/doc/offshore-wind-study/download>.

<sup>68</sup> *Id.* at 15.

<sup>69</sup> The agenda and presentation materials from the March 3, 2020 technical conference can be found at <https://www.mass.gov/service-details/offshore-wind-study>.

<sup>70</sup> Generator lead line (GLL) is the term that Massachusetts uses for a generator tie-line transmission configuration.

<sup>71</sup> Massachusetts Department of Energy Resources. (March 3, 2020). *Offshore Wind Independent Transmission*. Retrieved from <https://www.mass.gov/doc/technical-conference-slide-presentations-afternoon-session-hosted-by-doer-pdf/download>.

<sup>72</sup> Massachusetts Department of Energy Resources. (July 28, 2020). Letter to Joint Committee on Telecommunication, Utilities and Energy regarding Offshore Wind Energy Transmission Under Section 21 of Chapter 227 of the Acts of 2018 (An Act to Advance Clean Energy). Retrieved from <https://www.mass.gov/doc/offshore-wind-transmission-letter-07-28-20/download>.

Massachusetts was the first U.S. state to procure a utility-scale OSW project (Vineyard Wind), followed by Rhode Island's own utility-scale OSW procurement of 400 MW from Revolution Wind. Connecticut then secured 304 MW (in two tranches, sized at 200 MW and 104 MW) from Revolution Wind, and, later in 2019, selected the 804 MW Park City Wind project.

This series of capacity procurements presents one example of the extensive coordination involved in OSW development. Revolution Wind, a single project sited on OCS-A 0486, plans to deliver power to two separate states – Rhode Island and Connecticut. Similarly, Vineyard Wind 1 and Park City Wind (both CIP/Avangrid projects proposed for OCS-A 0501) will be delivering power to Massachusetts and Connecticut, respectively. Massachusetts will also receive power from Mayflower Wind.

These OSW lease areas are geographically oriented – running, one abutting the next, from northwest to southeast, and held by four (4) different developers – in a manner that might lend itself to consideration of a shared transmission approach. See, Section III(a), discussing benefits of shared offshore transmission in New England.

### 3. New Jersey

OSW development in New Jersey has proceeded pursuant to the legislative framework of the Offshore Wind Economic Development Act (OWEDA), though Governor Phil Murphy's executive orders – Executive Order No. 8 in January 2018 (3,500 MW) and Executive Order No. 92 in November 2019 (7,500 MW) – kickstarted the state's offshore wind program and raised the state's OSW capacity goal. As of October 2020, the 7,500 MW goal has not yet been codified in state legislation.

OWEDA originally defined a “qualified offshore wind project” as “a wind turbine electricity generation facility in the

Atlantic Ocean and connected to the electric transmission system in [New Jersey], and includes the associated transmission-related interconnection facilities and equipment[.]”<sup>73</sup> In early 2020, New Jersey amended OWEDA to “unbundle” OSW generation and transmission. The amendment adjusted the definition of “qualified offshore wind project,” and modified OWEDA's legislative structure to add “open access offshore wind transmission facility” as

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### New Jersey and New York are well-suited for interstate collaboration on OSW transmission.

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a separately defined term within OWEDA.<sup>74</sup> The legislation also enables the New Jersey Board of Public Utilities (NJBPU) to conduct separate competitive transmission-only solicitations.

New Jersey has conducted some stakeholder outreach as it investigates its OSW transmission options. In connection with the development of the New Jersey Offshore Wind Strategic Plan,<sup>75</sup> the NJBPU conducted roundtable discussions regarding transmission and wholesale market issues associated with OSW development in New Jersey. Additionally, during November 2019, NJBPU held a technical conference (similar to the March 3, 2020 conference in Massachusetts) to consider New Jersey's transmission options for offshore wind.<sup>76</sup>

New Jersey and New York are well-suited for interstate collaboration on OSW transmission. The two states have outlined a massive combined goal of 16,500 MW (7,500 MW by NJ; 9,000 MW by NY) of OSW capacity by 2035. New Jersey has more than 130 miles of oceanic coastline, but New York's Atlantic coastline is limited to New York City and Long Island. For New Jersey, two of the state's OSW lease areas (held by Ocean Wind and Atlantic Shores) are situated off the coast of the relatively sparsely

<sup>73</sup> S. 2036, 214<sup>th</sup> Legis. (N.J. 2010).

<sup>74</sup> S. 3985, 218<sup>th</sup> Legis. (N.J. 2019).

<sup>75</sup> New Jersey Board of Public Utilities. (September 2020). *New Jersey Offshore Wind Strategic Plan*. Retrieved from [https://www.nj.gov/bpu/pdf/Final\\_NJ\\_OWSP\\_9-9-20.pdf](https://www.nj.gov/bpu/pdf/Final_NJ_OWSP_9-9-20.pdf).

<sup>76</sup> New Jersey Board of Public Utilities. (October 28, 2019). *Notice of New Jersey Offshore Wind Transmission Stakeholder Meeting on November 12, 2019*. Retrieved from <https://www.bpu.state.nj.us/bpu/pdf/publicnotice/Offshore%20Wind%20Transmission%20Stakeholder%20Meeting%2011-12-19.pdf>.

populated southern portion of the state. However, locational marginal prices (LMPs) are considerably higher in the more densely populated northern part of New Jersey.

#### 4. New York

The New York Public Service Commission (NYPSC), in issuing an Order<sup>77</sup> permitting New York's Phase 1 OSW solicitation to proceed, identified a backbone/shared transmission system as a primary consideration for New York's Phase 2 OSW solicitation. The New York State Energy Research and Development Authority (NYSERDA)'s Policy Options paper<sup>78</sup> – part of the broader New York State Offshore Wind Master Plan initiative<sup>79</sup> – recommended that only generator tie-line transmission be utilized for Phase 1 projects. NYSERDA also conducted a technical conference focused on OSW transmission.

On July 21, 2020, New York issued its Phase 2 OSW solicitation.<sup>80</sup> The PSC Order authorizing this solicitation observed that new OSW lease areas in the New York Bight will likely not be available until 2021 at the earliest. The PSC therefore elected to proceed with generator tie-line connections for Phase 2 while NYSERDA and PSC staff continue to evaluate alternative OSW transmission approaches.<sup>81</sup>

#### 5. Virginia

Virginia is a leader in the U.S. OSW market, and is employing a unique approach. Dominion Energy is pursuing a utility-owned OSW development model. It intends to construct a 2,640 MW OSW project (3 x 880-MW phases) within lease area OCS-A 0483. This is currently the largest single proposed U.S. OSW project. This approach contrasts with all other U.S. OSW projects procured to date, which

are owned, constructed, and operated by third-party generation developers who deliver power to onshore electric utilities. Beyond Dominion Energy's proposed multi-GW project, the Commonwealth of Virginia codified a 5,200 MW OSW goal via the Virginia Clean Economy Act.<sup>82</sup>

Dominion Energy already intends to construct OSW generation and transmission assets, operate the entire facility, and deliver the power generated to customers. This all-in-one centralized approach enables Dominion Energy (and Virginia more broadly) to be first movers in deploying planned transmission assets for U.S. OSW.

The conditions therefore appear ripe for Dominion Energy/Virginia to strongly consider the benefits of constructing a planned expandable OSW transmission system that can accommodate Virginia's entire 5.2 GW goal (approximately six 880-MW phases), relative to constructing individual generator tie-line transmission assets for each tranche. The entire 5,200 MW facility could be designed at once, with the intention that the generation and transmission assets would be incrementally expanded over time.



Credit: MHI Vestas Offshore Wind

<sup>77</sup> Case 18-E-0071, *In the Matter of Offshore Wind Energy*, Order Establishing Offshore Wind Standard and Framework for Phase 1 Procurement (issued July 12, 2018).

<sup>78</sup> New York State Energy Research and Development Authority. (January 29, 2018). *Offshore Wind Policy Options Paper*. Retrieved from <https://www.nyserdera.ny.gov/-/media/Files/Publications/Research/Biomass-Solar-Wind/Master-Plan/Offshore-Wind-Policy-Options-Paper.pdf>.

<sup>79</sup> New York State Energy Research and Development Authority. (2017). *New York State Offshore Wind Master Plan*. Retrieved from <https://www.nyserdera.ny.gov/All%20Programs/Programs/Offshore%20Wind/About%20Offshore%20Wind/Master%20Plan>.

<sup>80</sup> New York State Energy Research and Development Authority. (2020). *2020 Offshore Wind Solicitation*. Retrieved from <https://www.nyserdera.ny.gov/All%20Programs/Programs/Offshore%20Wind/Focus%20Areas/Offshore%20Wind%20Solicitations/2020%20Solicitation>.

<sup>81</sup> Case 18-E-0071, *In the Matter of Offshore Wind Energy*, Order Authorizing Offshore Wind Solicitation in 2020 (issued April 23, 2020).

<sup>82</sup> H.B. 1526, 2020 Session (Va. 2020).

## VII. Weighing Transmission Policy Options and Assessment

The below chart presents transmission policy options that could enable the large-scale grid integration of offshore wind. We are not the first to consider the pros and cons of these options,<sup>82</sup> but we provide some additional detail regarding the various options and their interaction with FERC policies.

| OPTION   | PROS   | CONS   |
|--|--|--|
| 1. Private generator lead line. This is the transmission configuration that is being utilized for the first tranche of U.S. offshore wind projects. The transmission is bundled with generation in the same single project, with no open access to third parties.  | <ul style="list-style-type: none"> <li>- Quicker, simpler, and less risk for developers in the near-term, before network upgrade needs rapidly increase.</li> </ul>  | <ul style="list-style-type: none"> <li>- May utilize onshore interconnection points less efficiently, and smaller projects will not be able to capitalize upon economies of scale.</li> </ul>  |
| 2. Proactively planned, regionally cost-shared open access transmission. Similar to MISO MVP, SPP priority projects, ERCOT CREZ. State policies would be accounted for in the regional transmission plans.   | <ul style="list-style-type: none"> <li>- Incorporates state and utility generation plans. Can incorporate interconnection queues. Can optimize the efficient amount and configuration, taking all purposes and benefits into account, including reliability, resilience, congestion cost reduction, and public policy.</li> <li>- Costs can be broadly allocated to beneficiaries, enabling realization of more efficient outcomes.<sup>83</sup></li> </ul>  | <ul style="list-style-type: none"> <li>- Requires RTO stakeholder support to propose to FERC, and FERC support to approve it.</li> <li>- Stakeholders typically object to paying for “public goods” like regional shared transmission.</li> </ul>  |
| 3. Proactively planned shared gen-tie, with risk-sharing by all RTO customers. Based on the CAISO Location Constrained Resource Interconnection Facilities (LCRIF) tariff. Current wholesale RTO customers finance the line but are paid back over time by generators as they interconnect in the future.  | <ul style="list-style-type: none"> <li>- Proactive planning for gen-ties facilitates interconnections, reduces costs and environmental footprint and promotes new resource development.</li> </ul>   | <ul style="list-style-type: none"> <li>- May not consider/capture all the reliability, economic, public policy, and other benefits of transmission.</li> <li>- A policy question for regulators is whether there is too much risk that the future generators will not seek interconnection, leaving existing wholesale customers saddled with costs.</li> </ul>  |
| 4. Merchant offshore transmission with anchor tenant, no cost allocation. Early projects sign up for most of the capacity on the transmission line, leaving capacity open for others.  | <ul style="list-style-type: none"> <li>- Enables larger scale and greater efficiencies than the project-by-project generator tie-line approach.</li> </ul>   | <ul style="list-style-type: none"> <li>- May not achieve the broader efficiencies of a regionally planned network.</li> </ul>  |
| 5. Regionally planned onshore grid, with merchant offshore. The onshore connection points would be upgraded, with costs allocated to existing customers in a “beneficiary pays” approach. Could be used in tandem with the merchant anchor tenant model offshore.  | <ul style="list-style-type: none"> <li>- Can achieve savings in the use of transmission interconnection points on land. In the Brattle Group’s NY study, one-third of the transmission costs were onshore, and two-thirds offshore, yet almost all of the savings were from more efficient utilization of onshore points of interconnection.</li> </ul>  | <ul style="list-style-type: none"> <li>- May leave efficiencies offshore untapped.</li> </ul>  |
| 6. Inter-regionally planned and cost allocated transmission. A plan across two or three ISOs would jointly plan and reach a cost allocation agreement for a network among them. The transmission could increase reliability, resilience, and efficiency of each of the grids in ways unrelated to offshore wind.   | <ul style="list-style-type: none"> <li>- Captures efficiencies and provides reliability and resilience to all three regional grids.</li> </ul>   | <ul style="list-style-type: none"> <li>- Very hard to achieve cost allocation agreements within regions, let alone across three. Each RTO would have to agree and make their own filing to FERC, and FERC would have to approve the cost allocation (the “triple hurdle”).</li> </ul>  |
| 7. Transmission at least partially funded by the federal government. Large transmission lines, and particularly inter-regional lines, could be eligible for some cost-sharing from the federal government. Federal money can help grease the skids for each region to contribute a share of costs. Under almost any of the options in this table, U.S. DOE could assist with stakeholder engagement and funding for technical studies. | <ul style="list-style-type: none"> <li>- Federal support recognizes large and broadly spread benefits of transmission, particularly offshore transmission, and helps get over parochial fights regarding which region benefits more and should pay more.</li> <li>- History of federal support for transmission through the Power Marketing Agencies, TVA, and New Deal programs. Analogous to federal highway funding.</li> <li>- Federal investment or financing can reduce risk and the cost of capital.</li> </ul> | <ul style="list-style-type: none"> <li>- Requires building Congressional support and finding funding.</li> <li>- Using non-refundable tax credits requires entities with sufficient tax liability or tax equity investors, and Congress does not typically support refundable tax credits.</li> <li>- Any federal government discretion to select or decide on lines would trigger a programmatic EIS review, which can take considerable time.</li> </ul> |
| 8. Individual state approach. An individual state could procure, plan, and/or finance independent transmission to enable interconnection of offshore wind, and subsequently procure offshore wind generation connecting to the state-procured independent transmission.  | <ul style="list-style-type: none"> <li>- Can be undertaken expeditiously using existing state-level authorities</li> <li>- Massachusetts deemed that this approach could provide benefits to “accommodate future expansion of offshore wind energy, including beyond the next 1,600 MW.”</li> <li>- States can typically access low-cost capital.</li> </ul>   | <ul style="list-style-type: none"> <li>- Falls short of full regional coordination</li> </ul>  |

<sup>83</sup> New York State Energy Research and Development Authority. (January 29, 2018). *Offshore Wind Policy Options Paper*. Retrieved from <https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Biomass-Solar-Wind/Master-Plan/Offshore-Wind-Policy-Options-Paper.pdf>.

<sup>84</sup> See, Hogan, W. (February 1, 2020). *Transmission Investment Beneficiaries and Cost Allocation: New Zealand Electricity Authority Proposal*. Retrieved from [https://scholar.harvard.edu/files/whogan/files/hogan\\_ea\\_report\\_020120.pdf](https://scholar.harvard.edu/files/whogan/files/hogan_ea_report_020120.pdf).

## VIII. Conclusions and Recommendations

The questions facing East Coast states with regard to offshore wind transmission reflect the same challenges that the United States and other countries have faced when integrating large quantities of electricity generated by remotely located renewable resources. Many regions have successfully employed a proactive planning process that achieves economies of scale in grid upgrades and overcomes the foundational “chicken and egg” timing mismatch between transmission and generation. These regions have also utilized a cost allocation method that addresses the free rider problem inherent in public goods like electricity transmission infrastructure. The options presented in Section VII above outline various methods to proactively plan and fund a more efficient and larger-scale transmission plan that will enable the grid integration of 30 GW of offshore wind capacity by 2035. Stakeholders, including states, should seriously consider these options, particularly because the 30 GW figure may be an order



Credit: MHI Vestas Offshore Wind

of magnitude lower than the actual amount of offshore wind capacity needed to meet the decarbonization goals of East Coast states.

We encourage stakeholders to keep the following transmission planning principles, which are discussed in greater detail in Section IV(a), in mind as they engage and collaboratively develop an appropriate model for East Coast offshore wind transmission:

1. Integrated transmission planning should weigh all benefits.
2. Transmission planning should incorporate public policy requirements.
3. Plan proactively.
4. Plan for a longer time horizon.
5. Quantify all benefits.
6. Better synchronize inter-regional planning.

Currently, there is no entity responsible for considering transmission needs for the overall build out of offshore wind on the east coast. The U.S. Department of Energy, along with national energy laboratories, could collaborate with FERC to fill this gap and provide technical research and play a critical convening role with stakeholders across states and RTOs. Potential studies include analyzing the benefits of different scales and configurations of transmission expansion, quantifying how expanded transmission can reduce capacity and energy costs by capturing inter-regional diversity in electricity supply and demand, and finding solutions that minimize the total cost of onshore and offshore transmission. States could also request Congress or the President to instruct DOE to assume this role.

The more difficult hurdles of transmission planning and cost allocation will also require coordinated action at the state, regional, and federal level. States can push, and FERC can require, regional entities like RTOs to develop proactive transmission plans and workable cost allocation methodologies.

## Appendix 1: PJM, NYISO, and ISO-NE Interconnection Queues

### PJM Queue: 15,582 MW

| QUEUE POSITION | MW    | REQUEST DATE | COD        | INTERCONNECTION POINT     | STATE | COUNTY                 | TRANS. OWNER | FEASIBILITY STUDY | SYSTEM IMPACT STUDY | FACILITIES STUDY | UPGRADE COST (\$)            |
|----------------|-------|--------------|------------|---------------------------|-------|------------------------|--------------|-------------------|---------------------|------------------|------------------------------|
| ZI-035         | 18    | 7/5/2013     | 9/30/2017  | Lake Road 11.5 kV         | OH    | Unknown                | ATSI         | Complete          | Complete            | Not required     | \$2,468,558                  |
| ABI-056        | 255.1 | 8/31/2015    | 10/31/2021 | Indian River 230kV I      | DE    | Sussex                 | DPL          | Complete          | Complete            | Complete         | \$2,556,112                  |
| AE1-020        | 816   | 5/22/2018    | 6/1/2023   | Oyster Creek 230 kV       | NJ    | Ocean                  | JCPL         | Complete          | Complete            | In Progress      | \$111,316,644                |
| AE1-104        | 432   | 9/6/2018     | 6/1/2023   | BL England 138 kV         | NJ    | Cape May               | AEC          | Complete          | Complete            | In Progress      | \$65,050,000                 |
| AE1-117        | 152   | 9/14/2018    | 6/1/2022   | Bethany 138 kV            | DE    | Sussex                 | DPL          | Complete          | Complete            | In Progress      | \$9,698,945                  |
| AE1-238        | 816   | 9/28/2018    | 6/1/2024   | Oceanview Wind 230 kV     | NJ    | Monmouth               | JCPL         | Complete          | Complete            | In Progress      | \$13,498,200                 |
| AE2-020        | 604.8 | 12/14/2018   | 12/1/2024  | Cardiff 230 kV I          | NJ    | Atlantic               | AEC          | Complete          | Complete            | In Progress      | \$167,856,800                |
| AE2-021        | 604.8 | 12/14/2018   | 12/1/2025  | Cardiff 230 kV II         | NJ    | Atlantic               | AEC          | Complete          | Complete            | In Progress      | \$668,716,213                |
| AE2-022        | 300   | 12/14/2018   | 12/1/2024  | Cardiff 230 kV III        | NJ    | Atlantic               | AEC          | Complete          | Complete            | In Progress      | \$399,595,257                |
| AE2-024        | 882   | 12/14/2018   | 12/1/2025  | Larrabee 230 kV I         | NJ    | Ocean                  | JCPL         | Complete          | Complete            | In Progress      | \$179,417,245                |
| AE2-025        | 445.2 | 12/14/2018   | 12/1/2026  | Larrabee 230 kV II        | NJ    | Ocean                  | JCPL         | Complete          | Complete            | In Progress      | \$171,405,063                |
| AE2-122        | 800.1 | 2/28/2019    | 12/31/2025 | Birdneck-Landstown 230 kV | VA    | City of Virginia Beach | Dominion     | Complete          | Complete            | In Progress      | \$304,108,327                |
| AE2-123        | 800.1 | 2/28/2019    | 12/31/2027 | Birdneck-Landstown 230 kV | VA    | City of Virginia Beach | Dominion     | Complete          | Complete            | In Progress      | \$243,757,023                |
| AE2-124        | 800.1 | 2/28/2019    | 12/31/2029 | Landstown 230 kV          | VA    | City of Virginia Beach | Dominion     | Complete          | Complete            | In Progress      | \$215,266,218                |
| AE2-222        | 300   | 3/22/2019    | 6/1/2023   | Higbee 69 kV              | NJ    | Atlantic               | AEC          | Complete          | Complete            | In Progress      | \$285,840,760                |
| AE2-251        | 1200  | 3/26/2019    | 6/1/2024   | Cardiff 230 kV            | NJ    | Monmouth               | AEC          | Complete          | Complete            | In Progress      | \$923,771,404                |
| AE2-257        | 120   | 3/27/2019    | 6/1/2022   | Cedar Neck 69 kV          | DE    | Sussex                 | DPL          | Complete          | Complete            | In Progress      | \$105,062,883                |
| AF1-101        | 800   | 9/6/2019     | 11/23/2022 | Oyster Creek 230 kV III   | NJ    | Atlantic               | JCPL         | Complete          | Complete            |                  | \$572,211,265                |
| AF1-123        | 880   | 9/17/2019    | 12/31/2025 | Fentress 500 kV           | VA    | City of Chesapeake     | Dominion     | Complete          | Complete            |                  | \$76,200,000                 |
| AF1-124        | 880   | 9/17/2019    | 12/31/2026 | Fentress 500 kV           | VA    | City of Chesapeake     | Dominion     | Complete          | Complete            |                  | \$156,865,407                |
| AF1-125        | 880   | 9/17/2019    | 12/31/2024 | Fentress 500 kV           | VA    | City of Chesapeake     | Dominion     | Complete          | Complete            |                  | \$149,505,894                |
| AF1-222        | 1326  | 9/27/2019    | 12/30/2025 | Oceanview Wind 2 230 kV   | NJ    | Monmouth               | JCPL         | Complete          | Complete            |                  | \$131,556,667                |
| AF2-193        | 440   | 3/23/2020    | 10/31/2026 | Indian River 230 kV I     | DE    | Sussex                 | DPL          | Complete          |                     |                  | \$534,708,000                |
| AF2-194        | 880   | 3/23/2020    | 10/31/2026 | Indian River 230 kV II    | DE    | Sussex                 | DPL          | Complete          |                     |                  | \$664,582,000                |
| AF2-196        | 150   | 3/23/2020    | 6/1/2022   | Cedar Neck 69 kV II       | DE    | Sussex                 | DPL          | Complete          |                     |                  | \$277,459,000                |
|                |       |              |            |                           |       |                        |              |                   |                     |                  | <b>\$6,432,473,885 total</b> |



## Appendix 1 (cont.)

### NYISO Queue: 25,638 MW

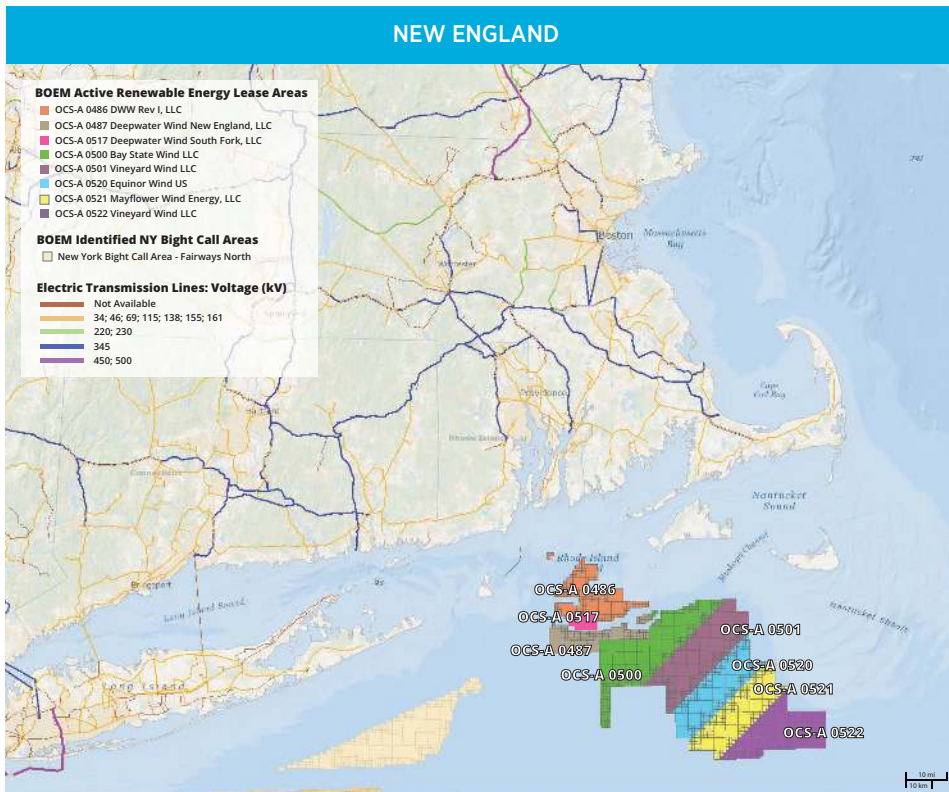
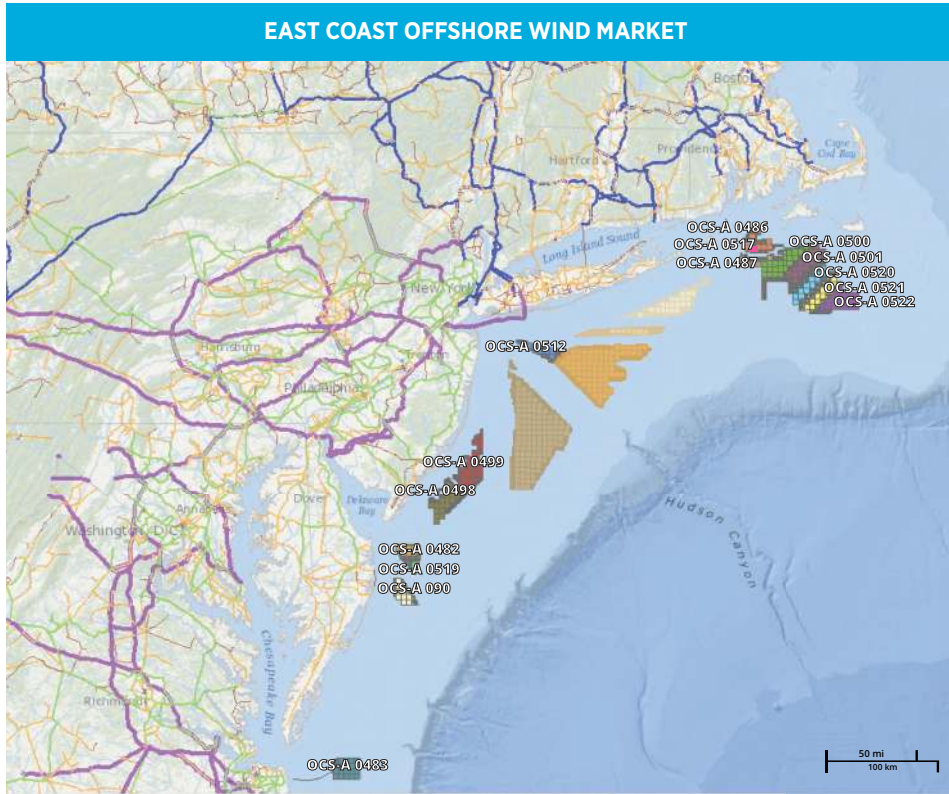
| QUEUE POSITION | OWNER/ DEVELOPER        | PROJECT NAME                         | MW   | REQUEST DATE | COD    | COUNTY     | ZONE | INTERCONNECTION POINT             | UTILITY | AVAILABILITY OF STUDIES |
|----------------|-------------------------|--------------------------------------|------|--------------|--------|------------|------|-----------------------------------|---------|-------------------------|
| 363            | Anbaric                 | Poseidon Offshore                    | 500  | Apr-2011     | Jan-21 | Suffolk    | K    | Ruland Rd. 138kV                  | LIPA    | FES, SRIS, FS           |
| 612            | Deepwater Wind          | South Fork Wind Farm                 | 96   | Feb-2017     | Nov-22 | Suffolk    | K    | East Hampton 69kV                 | LIPA    | SRIS                    |
| 679            | Anbaric                 | New York City Offshore Wind          | 1200 | Nov-2017     | Dec-25 | Kings      | J    | Gowanus 345kV                     | ConEd   | FES                     |
| 680            | Anbaric                 | Long Island Offshore Wind            | 700  | Nov-2017     | Dec-25 | Suffolk    | K    | Ruland Rd. 138kV                  | LIPA    | FES                     |
| 695            | Deepwater Wind          | South Fork Wind Farm II              | 40   | Feb-2018     | Dec-22 | Suffolk    | K    | East Hampton 69kV                 | LIPA    | SRIS                    |
| 737            | Equinor Wind US         | El Sunset Park                       | 816  | Jun-2018     | Dec-24 | New York   | J    | Gowanus Substation 345kV          | ConEd   | SRIS                    |
| 738            | Equinor Wind US         | El Melville                          | 816  | Jun-2018     | Dec-24 | Suffolk    | K    | Ruland Rd. Substation 138kV       | LIPA    | SRIS                    |
| 754            | Anbaric                 | New York Ocean Grid - Canal          | 800  | Aug-2018     | Dec-25 | Suffolk    | K    | Canal Substation 138kV            | LIPA    | FES                     |
| 755            | Anbaric                 | New York Ocean Grid - Shoreham       | 800  | Aug-2018     | Dec-25 | Suffolk    | K    | Shoreham Substation 138kV         | LIPA    | FES                     |
| 764            | Bay State               | NY Wind Canal                        | 440  | Sep-2018     | Jan-24 | Suffolk    | K    | Canal Substation 138kV            | LIPA    |                         |
| 765            | Bay State               | NY Wind Brookhaven                   | 880  | Sep-2018     | Jan-24 | Suffolk    | K    | Brookhaven 138kV                  | LIPA    |                         |
| 766            | Bay State               | NY Wind Holbrook                     | 880  | Sep-2018     | Jan-24 | Suffolk    | K    | Holbrook 138kV                    | LIPA    |                         |
| 767            | Bay State               | NY Wind Gowanus                      | 1200 | Sep-2018     | May-24 | New York   | J    | Gowanus Substation 345kV          | ConEd   |                         |
| 788            | Atlantic Shores 3       | Atlantic Shores Offshore Wind 7      | 880  | Jan-2019     | Dec-25 | Nassau     | K    | East Garden City 345kV Substation | LIPA    |                         |
| 789            | Atlantic Shores 3 (EDF) | Atlantic Shores Offshore Wind 8      | 880  | Jan-2019     | Dec-25 | Kings      | J    | Gowanus Substation 345kV          | ConEd   |                         |
| 790            | Atlantic Shores 2 (EDF) | Atlantic Shores Offshore Wind 9      | 880  | Jan-2019     | Dec-25 | Richmond   | J    | Fresh Kills 345kV                 | ConEd   |                         |
| 792            | Anbaric                 | Long Island Offshore Wind Connection | 300  | Jan-2019     | Dec-25 | Suffolk    | K    | Ruland Road 138kV Substation      | LIPA    |                         |
| 812            | Diamond Generating Corp | CWW 200 Wind                         | 200  | Feb-2019     | Dec-23 | Erie       | A    | Harbor Front 115kV                | NM-NG   |                         |
| 813            | Diamond Generating Corp | CWW 300 Wind                         | 300  | Apr-2019     | Dec-23 | Erie       | A    | Harbor Front 115kV                | NM-NG   |                         |
| 814            | Diamond Generating Corp | CWW 300 MW DUN                       | 300  | Apr-2019     | Dec-23 | Chautauqua | A    | Dunkirk Substation 230kV          | NM-NG   |                         |
| 958            | Equinor Wind US         | El Oceanside                         | 1000 | Dec-2019     | Dec-24 | Nassau     | K    | Barrett 138 kV Substation         | LIPA    |                         |
| 959            | Equinor Wind US         | El Oceanside 2                       | 1500 | Dec-2019     | Dec-24 | Nassau     | K    | Barrett 138 kV Substation         | LIPA    |                         |
| 987            | Bay State               | NY Wind Holbrook 2                   | 924  | Jan-2020     | May-24 | Suffolk    | K    | Holbrook 138kV                    | LIPA    |                         |
| 1010           | Vineyard Wind           | Vineyard Wind I                      | 1403 | Apr-2020     | Dec-26 | Nassau     | K    | East Garden City Substation       | NYPA    |                         |
| 1011           | Vineyard Wind           | Vineyard Wind II                     | 1403 | Apr-2020     | Dec-26 | Suffolk    | K    | Pilgrim Substation                | LIPA    |                         |
| 1016           | Equinor Wind US         | El Steinway 1                        | 1300 | May-2020     | Nov-27 | Queens     | J    | Astoria West 138 kV               | ConEd   |                         |
| 1017           | Equinor Wind US         | El Steinway 2                        | 1300 | May-2020     | Nov-28 | Queens     | J    | Astoria East 138 kV               | ConEd   |                         |
| 1020           | Equinor Wind US         | El Fort Salonga                      | 1300 | May-2020     | Nov-27 | Suffolk    | K    | Northport 138 kV                  | LIPA    |                         |
| 1021           | Equinor Wind US         | El East Shoreham                     | 1300 | May-2020     | Nov-27 | Suffolk    | K    | Shoreham 138 kV                   | LIPA    |                         |
| 1022           | Equinor Wind US         | El Glenwood Landing                  | 1300 | May-2020     | Nov-27 | Nassau     | K    | Shore Road 345 kV                 | LIPA    |                         |

## Appendix 1 (cont.)

### ISO-NE Queue: 11,581 MW

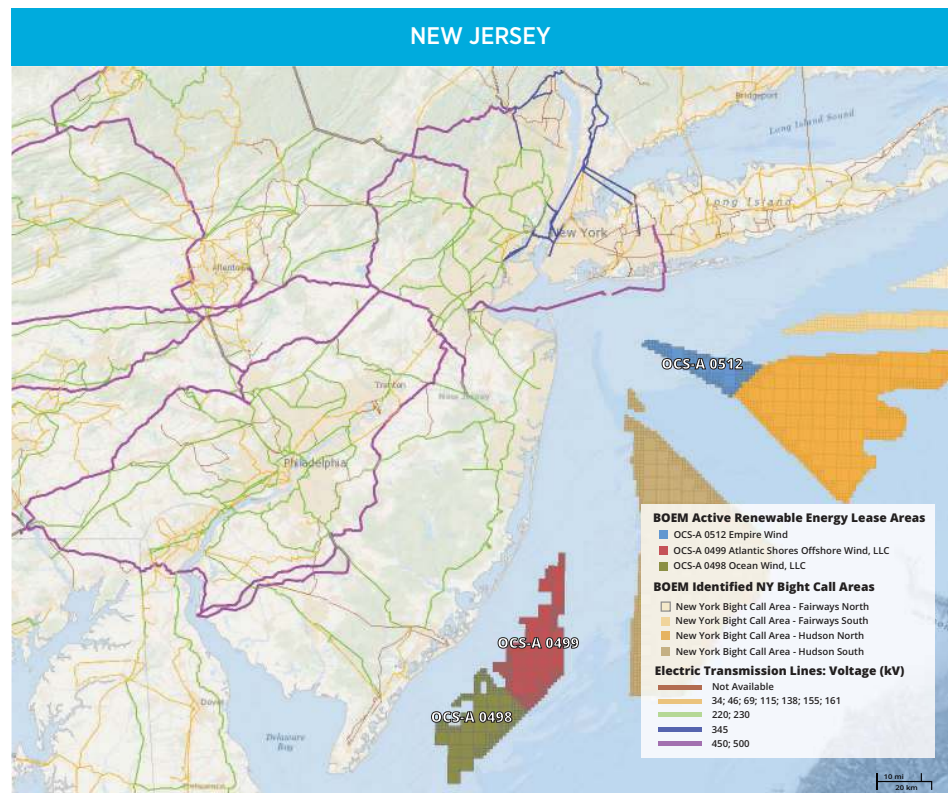
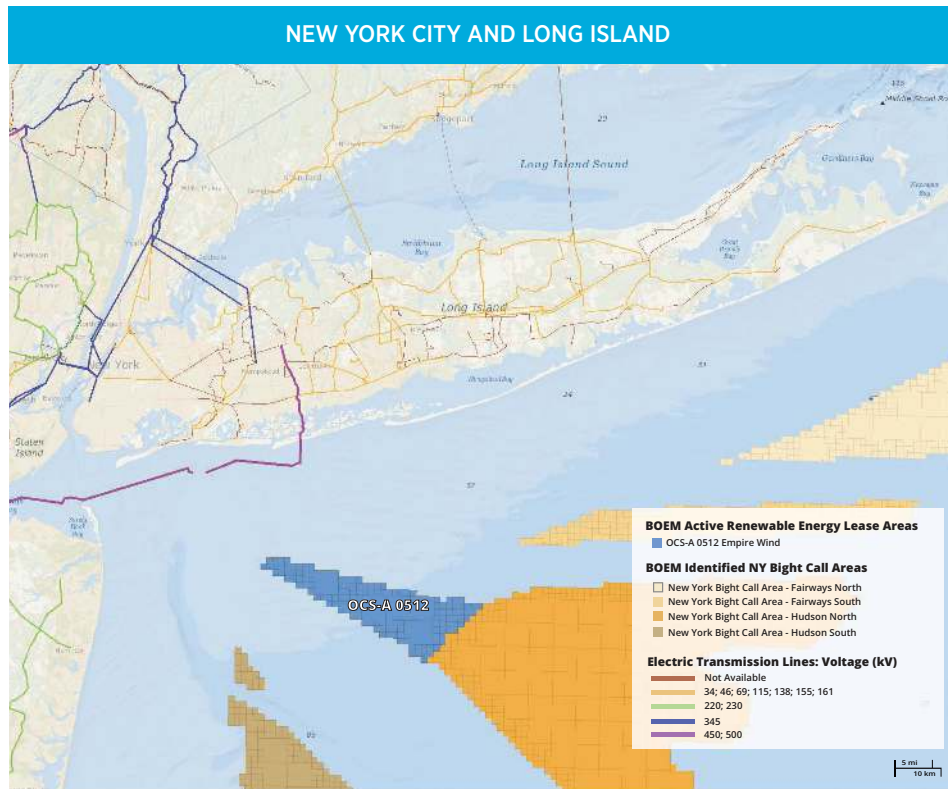
| QUEUE POSITION | MW   | REQUEST DATE | COD        | STATE | INTERCONNECTION POINT   | FEASIBILITY STUDY | SYSTEM IMPACT STUDY | FACILITY STUDY  | INTERCONNECTION AGREEMENT | NOTES               |
|----------------|------|--------------|------------|-------|---|-------------------|---------------------|-----------------|---------------------------|---------------------|
| 618            | 800  | 08/01/2016   | 05/31/2026 | MA    | National Grid, 345 kV Brayton Point Substation, Somerset, MA  | Document Posted   | Document Posted     | In Progress     | In Progress               |                     |
| 624            | 800  | 11/08/2016   | 10/05/2023 | MA    | 115 kV Barnstable Substation  | Document Posted   | Document Posted     | Document Posted | Executed                  |                     |
| 700            | 820  | 12/15/2017   | 07/01/2024 | MA    | Eversource 345 kV West Barnstable Substation  | Document Posted   | In Progress         |                 |                           |                     |
| 781            | 704  | 09/13/2018   | 12/01/2023 | RI    | NG 115 kV Davisville substation, Washington County  | Document Posted   | Document Posted     | Document Posted | In Progress               |                     |
| 792            | 805  | 10/19/2018   | 05/31/2023 | CT    | Eversource (CL&P) 345kV Montville, alternatively Eversource (CL&P) 345kV Millstone                    | Document Posted   | In Progress         |                 |                           |                     |
| 806            | 880  | 12/11/2018   | 05/31/2023 | MA    | Eversource 345kV West Barnstable Substation, Alternatively 115kV West Barnstable Substation           | Document Posted   | Not Started         |                 |                           |                     |
| 829            | 1000 | 12/19/2018   | 07/02/2025 | MA    | NSTAR Electric Company 345 kV lines 322 and 342   | Document Posted   | Not Started         |                 |                           |                     |
| 830            | 876  | 12/19/2018   | 07/01/2025 | MA    | NSTAR Electric Company West Barnstable 345 kV.  | Document Posted   | Not Started         |                 |                           |                     |
| 846            | 40   | 03/19/2019   | 05/31/2026 | MA    | National Grid, 345 kV Brayton Point Substation, Somerset, MA  | Document Posted   | Not Started         |                 |                           | MW increase to #618 |
| 893            | 1200 | 06/07/2019   | 05/31/2025 | CT    | Millstone 345kV alternate: lines 348 and 310  | In Progress       |                     |                 |                           |                     |
| 909            | 880  | 08/01/2019   | 05/31/2023 | MA    | Primary National Grid 115kV Bell Rock, alt: Eversource 115kV Wings Lane, National Grid 115kV Somerset | Document Posted   | Not Started         |                 |                           |                     |
| 922            | 200  | 09/03/2019   | 07/01/2025 | MA    | NSTAR Electric Company 345 kV lines 322 and 342   | In Progress       |                     |                 |                           | MW increase to #829 |
| 926            | 176  | 09/11/2019   | 12/01/2023 | RI    | National Grid's 115kV Davisville Substation   | In Progress       |                     |                 |                           | MW increase to #781 |
| 927            | 1200 | 09/13/2019   | 05/01/2026 | CT    | Primary: Eversource (CL&P) 345kV Montville, Alternatively Eversource (CL&P) 345kV Millstone.          | In Progress       |                     |                 |                           |                     |
| 944            | 1200 | 12/18/2019   | 05/31/2026 | MA    | National Grid Brayton Point 345kV   | Document Posted   | Not Started         |                 |                           |                     |

## Appendix 2: Maps of Existing Onshore Transmission Infrastructure and Offshore Wind Lease Areas



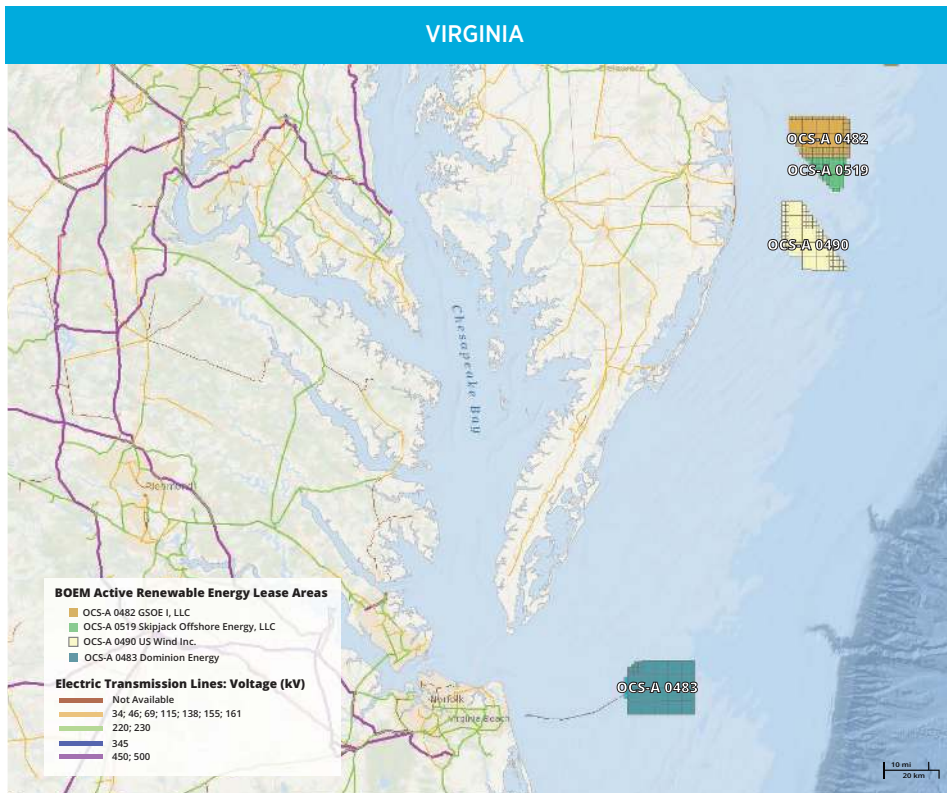
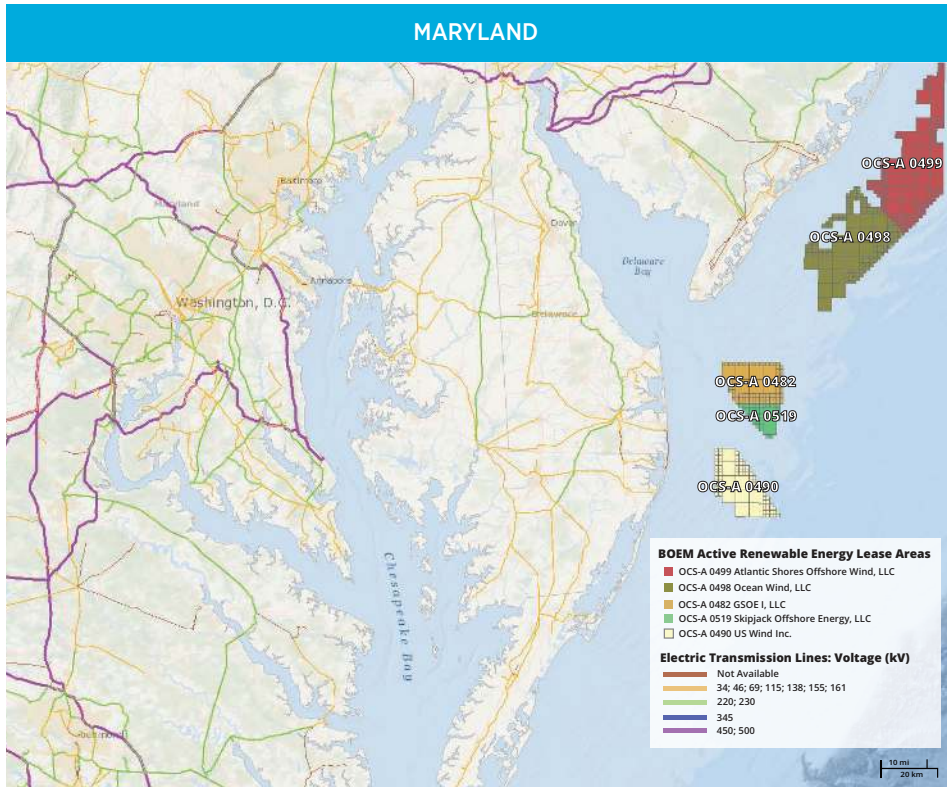
Sources for Maps: MARCO, BOEM, Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and others

## Appendix 2 (cont.)



Sources for Maps: MARCO, BOEM, Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and others

## Appendix 2 (cont.)



Sources for Maps: MARCO, BOEM, Esri, GEBCO, NOAA, National Geographic, DeLorme, NAVTEQ, Geonames.org, and others

Appendix 2 (cont.)

