Tufts Power Systems and Markets Research Group
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The Fletcher School of Law and Diplomacy

Massachusetts Department of Energy Resources
100 Cambridge Street
Suite 1020
Boston, MA 02114

Date: April 21, 2020
Attn: Marian Swain, Energy Policy Analyst
Subject: Second Round Comments on Offshore Wind Transmission

Ms. Swain:

In response to a second request for comments on offshore wind transmission from the Massachusetts Department of Energy Resources (DOER), a team of students and faculty mentors at Tufts University submits these comments. This work builds upon our first round of comments and incorporates insights from additional independent analysis, the technical conference co-hosted by the DOER and the Massachusetts Clean Energy Center (MassCEC) on March 3, 2020, and consultation with key industry players.

Best regards,

Tufts Power Systems and Markets Research Group

Submission Contents

1. INTRODUCTION

The Tufts University Power Systems and Markets research group provides public information on the global transition to renewables.[1] In recognition of the Massachusetts Department of Energy Resources (DOER) 2020 requests for comment regarding offshore wind (OSW) transmission, this report focuses on the Wind Energy Areas (WEAs) Offshore Massachusetts and Rhode Island and their role in ISO New England's (ISO-NE) transition to renewables.

Our analysis is predicated on the belief that the future electricity grid will require systems-level upgrades both onshore and offshore in order to reach our stated goals for a carbon-neutral 2050. The necessary build-out of interconnections between these two grids (onshore and offshore) is unprecedented in scale and speed in the United States. Since 2018, Massachusetts has procured two 800-megawatt (MW) offshore wind projects that will both be located within federal waters. During this time, New York, Connecticut and Rhode Island have also procured similarly sized projects within the WEAs Offshore Massachusetts and Rhode Island for a total of over 4,000 MW. In 2019 alone, over 7,000 MW of offshore wind was procured by states up and down the East Coast, for total U.S. commitments of over 12,000 MW. At this rate, the size and speed of OSW installations could overwhelm and congest our current land-based coastal grid, damaging the industry's reputation and short-changing its growth potential. To avoid these issues—and as noted in Tufts' previous submission to the DOER—there are four externalities that DOER must consider as it evaluates transmission proposals. Quantitative analysis of these externalities is the subject of a forthcoming white paper by the Tufts research group.

- **Sustainability of the OSW Industry:** Massachusetts aspires to achieve net-zero emissions by 2050. While offshore wind is poised to play a major role in these efforts, its ultimate relationship to the overall energy system remains to be determined. Stakeholder engagement identifying objectives for the regional energy system in 2050 will set up the industry for success. In acknowledgement of the tension between the objectives to move quickly and to move thoughtfully, we recognize the need for an adaptive management approach that allows the earliest projects to move forward. At the same time, the exploration of independent systems-level OSW transmission and grid integration must progress as quickly as possible.
- **Grid Performance:** Reliability, resilience, and redundancy are essential to a functioning grid and must be weighted similarly to short-term ratepayer benefits in any serious decision-making framework. Networked offshore connections would provide more paths for each developer to deliver power to shore.
- **Environmental Impacts:** By channeling the generated power into fewer transmission corridors, the OSW industry could reduce impacts to the benthic environment, fisheries, and marine mammals.
- **Social Impacts to Coastal Communities:** Reducing the total number of export cables would result in fewer landfall locations and less disruption to coastal communities. Additionally, a systems-level approach would lend itself to a broader and more comprehensive stakeholder engagement process, which could prioritize equitable distribution of these lines. Low-income communities and communities of color are disproportionately required to bear the social costs of facilities deemed undesirable by the public. In our view, a regionally coordinated offshore transmission network would encourage stakeholder engagement by driving a discussion around efficient and equitable utilization of points of interconnection (POIs).

These four externalities motivated our group to develop two interconnection scenarios for full build-out of the WEAs Offshore Massachusetts and Rhode Island (see Section 3.2). These scenarios help visualize the impact of different offshore transmission topologies. Envisioning networked offshore transmission as a natural part of the

1 Any and all views expressed herein represent the opinions of Power Systems and Markets seminar participants and do not represent official positions of Tufts University or its Schools.

build-out process (Scenario 2) is currently hindered by the Massachusetts 83C framework for solicitations, which limits interconnection approaches to 1,600-MW increments. While this framework is set up to facilitate learning on a project-by-project basis, the increasing speed of project development urgently requires a roadmap that considers the full build-out.

1.1. Massachusetts Department of Energy Resources 83C Solicitation Process

The consideration of an independent transmission solicitation is predicated on the idea that separating transmission projects from generation projects could deliver a more desirable and efficient OSW transmission system. Separating transmission from generation opens the opportunity to bundle transmission for multiple generation projects into transmission corridors that reduce construction time, environmental impacts, and cost for the WEAs overall. An independent transmission system can also strategically utilize onshore POIs to reduce the need for upgrades to the land-based grid. With proper legislation, an independent transmission system could stabilize interconnection costs for OSW developers over the long term, thereby ensuring the economic sustainability of the OSW industry in the region.

Independent transmission benefits the system when it is planned and built with the full build-out of the WEAs in mind; acquiring transmission incrementally precludes that possibility. The DOER is required to operate within the 83C solicitation process, which mandates bids with maximum capacities of 1,600 MW. This process imposes two limitations on the transmission system. First, it caps the capacity of an individual corridor at 1,600 MW, providing minimal opportunity for bundling. Second, it prevents more than one corridor of reasonable size from being proposed at a time. This forces the system to be planned and built incrementally. Under this framework, the benefits of a network can only be considered as externalities at each step. For the market structure to adequately capture the benefits of a networked offshore transmission system, the limits imposed by the 83C solicitation process must change. Considering an independent transmission solicitation without allowing for the possibility of a networked system undermines the intentions of the independent system.

The comments and analysis at the center of our response consider a networked grid, referred to as Scenario 2. The hypothetical scenario uses four high voltage direct current (HVDC) corridors with 2,400 MW capacity each to deliver the approximately 8,000 MW of yet-unaccounted-for generation in the WEAs to shore. The capacities of the HVDC corridors make Scenario 2 incompatible with the 83C solicitation process. The networked grid onshore took over 130 years to evolve; based on the speed of OSW bids, and the magnitude of states' renewable goals, the offshore grid and its integration with the land-based grid will not have nearly that kind of time to mature organically. A systems-level plan for this offshore grid and an independent transmission solicitation structure which internalizes the benefits of a networked system are necessary to ensure the health of the industry as the WEAs build to scale.

1.2. Interconnection Considerations: ISO-NE Queue and Regional Limitations

In order to interconnect with the grid, generators must apply to join the interconnection queue. ISO-NE then studies the project, its effects on the grid, and any system upgrades needed to absorb the power. This queue is public—it allows developers to see how many projects are filing for interconnection and where they plan to inject their power. The queue is especially useful in analyzing potential offshore transmission networks because the number of accessible and cost-effective POIs is limited.

Since 2008, ISO-NE has provided an annual regional electricity outlook report. These reports contain metadata on the interconnection queues for each year. While approximately 70% of the queue tends to withdraw before coming to fruition,[2] the types and quantities of proposed generation reveal the industry trajectory and trends in

2 ISO New England, Inc. 2016-2020 Regional Electricity Outlook. https://www.iso-ne.com/about/regional-electricity-outlook/.

future generation. Figure 1 shows the most recent five years of proposed generation by type in the ISO-NE interconnection queue. Each of the graphs is reported in MW and scaled with respect to the total generation in the 2020 interconnection queue, which amounts to approximately 20,900 MW. In the last two years, the scale of OSW proposals has come to dwarf that of land-based wind proposals. Despite the pause in procurements, another 4,000 MW of OSW was proposed for study in the last year alone.

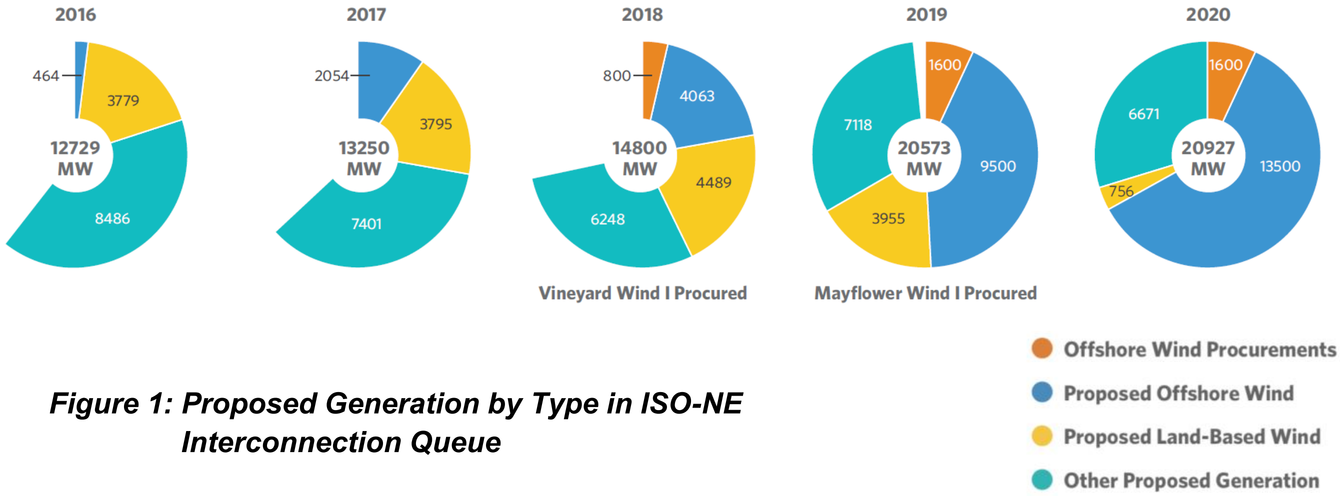

Figure 1: Proposed Generation by Type in ISO-NE Interconnection Queue

We recognize that if interconnection is handled improperly, it could hamstring the OSW industry before its full potential is realized. The ISO-NE queue is a prominent target for transactional gamesmanship within the energy industry. The eagerness of developers to claim a spot should be a clear indicator to regulators that accessible and economical POIs are a precious resource. Determining interconnection on a project-by-project basis can result in sub-optimal utilization of onshore resources. Table 1 presents a list of the most accessible POIs grouped by region using the preliminary results from ISO-NE's 2019 economic studies.[3]

If OSW proposals continue to grow at the rate observed over the last five years, these currently available POIs will be distributed by ISO-NE during the first few rounds of procurement. The 2,400 MW of OSW procured by Massachusetts and Connecticut are already poised to use all the available transmission capacity in the Cape Cod/Pilgrim area. Future developers (OSW or transmission) will be faced with an expensive choice: upgrade coastal substations already serving existing projects or interconnect further inland. It is our opinion that a networked grid would improve the stewardship of existing POIs and facilitate systems planning that reduces conflict and confusion surrounding interconnection.

3 McBride, Alan. ISO New England. Massachusetts Offshore Wind Transmission Technical Conference.3 Mar. 2020, https://www.mass.gov/doc/technical-conference-slide-presentations-morning-session-hosted-by-masscec-pdf/download. PowerPoint Presentation, p. 49.

Table 1: Estimated OSW Interconnection Capacity Available in Key Regions

Interconnection Regions	Estimated Available Capacity	Generators & Substations of Interest	Location
Cape Cod, Pilgrim	2,400 MW	Barnstable Switching	Barnstable, MA
		West Barnstable	Barnstable, MA
		Pilgrim	Plymouth, MA
		Canal	Sandwich, MA
		Bourne Switching	Bourne, MA
Kent, Davisville, Manchester St	1,500 MW	Kent County	Warwick, RI
		Davisville	Washington, RI
		Manchester St	Providence, RI
Millstone, Montville	2,100 MW	Millstone	Waterford, CT
		Montville	Uncasville, CT
Brayton Point	1,600 MW	Brayton Point	Somerset, MA
Mystic	1,200 MW	Mystic	Charlestown, MA
Long Island	unknown	East Hampton	East Hampton, NY
		Ruland Rd	Farmingdale, NY
		Holbrook	Ronkonkoma, NY
Total	**8,800 MW +**		

2. STATUS OF PROCURED PROJECTS

To date, six OSW projects have been procured from the WEAs Offshore Massachusetts and Rhode Island through state solicitations. The procured projects total over 4,000 MW of OSW capacity, 3,000 MW of which are expected to connect to ISO-NE at substations on Cape Cod, Massachusetts and in Rhode Island. The remaining 1,000 MW have been procured by New York and will connect to Long Island. Table 2 summarizes key information about these projects.

New projects from the WEAs are moving from concept through procurement at a staggering rate. In 2017, South Fork Wind was the only project to finalize a PPA.[4] Two major projects—Vineyard Wind 1 and Revolution Wind—followed with contract awards in 2018.[5, 6] The most recent wave of projects includes Sunrise Wind, Mayflower Wind 1, and Park City Wind, all of which received contract awards in the latter half of 2019.[7, 8, 9]

4 NYSERDA. "Governor Cuomo Announces Approval of Largest Offshore Wind Project in the Nation." 25 Jan. 2017. https://www.nyserda.ny.gov/About/Newsroom/2017-Announcements/2017-01-25-Governor-Cuomo-Announces-Approval-of-Largest-Offshore-Wind-Project.

5 NS Energy. "Revolution Wind Project." NS Energy.com. Web. https://www.nsenergybusiness.com/projects/revolution-wind-project/.

6 Murphy, Matt. "Mass. Selects Vineyard Wind For 800-Megawatt Offshore Wind Farm" 23 May 2018. WBUR. Web. https://www.wbur.org/bostonomix/2018/05/23/vineyard-wind-massachusetts-offshore-farm.

7 NYSERDA. "Governor Cuomo Executes the Nation's Largest Offshore Wind Agreement and Signs Historic Climate Leadership and Community Protection Act." 18 Jul. 2018. https://www.nyserda.ny.gov/About/Newsroom/2019-Announcements/2019-07-18-Governor-Cuomo-Executes-the-nations-largest-osw-agreements.

8 EDP Renewables. "Massachusetts selects mayflower wind energy's 804 MW low cost energy proposal." EDPR News. 31 Oct. 2019. Web. https://www.edpr.com/en/news/2019/10/31/massachusetts-selects-mayflower-wind-energys-804-mw-low-cost-energy-proposal.

9 Vineyard Wind. "Vineyard Wind Selected to Deliver 804 MW of Clean Offshore Wind Power to Connecticut Electricity Customers." 5 Dec. 2019. Web. https://www.vineyardwind.com/press-releases/2019/12/5/vineyard-wind-selected-to-deliver-804-mw-of-clean-offshore-wind-power-to-connecticut-electricity-customersnbspnbsp.

There are multiple objectives to balance as the industry expands. We understand the need to allow the earliest projects to proceed without further delay. We wish to emphasize, however, the importance of developing a thorough systems-level assessment as soon as possible. Legislative, technological, and contractual barriers to implementation must be evaluated and addressed in parallel. With immediate mobilization, it is possible to imagine some of the later projects in Table 2 as part of an offshore network.

Table 2: Procured Offshore Wind Project Information [10, 11, 12]

Project Name	Date Award Announced	Turbine Count	Turbine Capacity	Project Capacity	Point of Grid Interconnection	Export Cables
South Fork Wind *Ørsted/Eversource*	Jan. 25, 2017 *NY PPA finalized*	15	8 MW	120 MW	Buell Lane Substation (NY)	1 x 138 kV AC
Vineyard Wind 1 *Vineyard Wind*	May. 23, 2018 *MA contract awarded*	84	9.5 MW	798 MW	Barnstable Switching Sta. (MA)	2 x 220 kV AC
Revolution Wind *Ørsted/Eversource*	May. 23, 2018 *RI contract awarded* Jun. 13, 2018 *CT contract awarded*	88	8 MW	704 MW	Davisville Substation (RI)	AC
Sunrise Wind *Ørsted/Eversource*	Jul. 18, 2019 *NY contract awarded*	110	8 MW	880 MW	Holbrook Substation (NY)	AC
Mayflower Wind 1 *Mayflower Wind*	Oct. 31, 2019 *MA contract awarded*	67	12 MW	804 MW	Bourne Switching Sta. (MA)	AC
Park City Wind *Vineyard Wind*	Dec. 5, 2019 *CT contract awarded*	67	12 MW	804 MW	West Barnstable Substation (MA)	AC
Total Procured Capacity				**4,110 MW**		

Note: White cells indicate researched, publicly available information. Light grey cells are assumed or calculated.

3. GENERATOR LEAD LINES VERSUS NETWORKED TRANSMISSION

Our analysis focused on comparing system-wide effects of the current generator lead line approach to a regionally coordinated transmission network. Using technical and legislative assumptions discussed in Section 3.2, we estimate that full build-out of the WEAs Offshore Massachusetts and Rhode Island can provide approximately 12,000 MW of power. Scenarios 1 and 2 envision the final, full build-out with two different topologies described below and depicted in the attached figures:

Scenario 1— Presumes that all developers wish to interconnect individually to shore using generator lead lines. This is the route that Vineyard Wind 1, Mayflower Wind 1 and Ørsted/Eversource are currently pursuing.

10 Massachusetts Clean Energy Center. Massachusetts Offshore Wind Transmission Technical Conference. 3 Mar. 2020, https://www.mass.gov/doc/technical-conference-slide-presentations-morning-session-hosted-by-masscec-pdf/download. PowerPoint Presentation, p. 15-18.

11 Bragg, Ann. "Vineyard Wind Picks Turbine Supplier." Cape Cod Times, 27 Nov. 2018, www.capecodtimes.com/news/20181127/vineyard-wind-picks-turbine-supplier.

12 Siemens Gamesa. "Siemens Gamesa conditionally awarded largest U.S. offshore wind power order to date: 1.7 GW from Ørsted and Eversource." 18 Jul. 2019, https://www.siemensgamesa.com/en-int/newsroom/2019/07/190718-siemens-gamesa-offshore-orsted-usa.

Scenario 2— Presumes that ISO-NE, DOER, and/or independent transmission developer(s) collaborate with OSW developers to implement networked transmission for all projects without contracts awarded. Although we feel that earlier and broader implementation of a networked system would greatly enhance its benefits, we have opted to assess a narrower and more conservative implementation of a networked system.

Scenario 2 would require significant planning to generate a network that could be expanded over the coming decades in several phases. For instance, the Mystic substation in Boston is unlikely to be a POI in the first several procurements while closer substations are still available. It is included in the Scenario 2 topology diagram as a late addition to the modular network.

3.1. Status of Current Technology

Recognizing the dynamic nature of this industry, we wish to state clearly our assumptions regarding policy and technical limitations used to develop the scenarios. We recognize that these limitations may change significantly as technology improves and policy progresses.

Table 3: Offshore Transmission Technology and Installation Assumptions

Description	Value	Notes and Sources
Maximum HVDC line capacity	1,200 MW	ISO-NE single-sourced contingency limits[13]
Maximum HVAC (345 kV) line capacity	400 MW	PJM Training Presentation[14]

3.2. Offshore Transmission Topologies for Full Build-Out of the WEAs

The offshore transmission lines depicted in the topologies for Scenario 1 and Scenario 2 incorporate publicly available grid information and insights from knowledgeable industry professionals. These scenarios are intended to illustrate potential outcomes and identify high-level issues that need to be addressed. We recognize that regional power systems are complex, and future transmission installations will require data collection, analysis, permitting, design, and public engagement over multiple iterations.

Both transmission topologies in Scenarios 1 and 2 are built from the same base assumptions about the number of turbines the WEAs will contain and how large those turbines will be. In 2019, the lease holders came together to support a proposal for uniform 1 x 1 nautical mile (nm) grid spacing of wind turbines. The proposal included a study by Baird into vessel navigation through the WEAs with supporting geospatial maps of turbine locations and navigation corridors.[15] We applied the information shown in Table 2 to the turbine map to allocate procured project areas and estimate the total capacity of the WEAs, arriving at an estimate of approximately 12,000 MW. For all areas without known turbine specifications, we assumed a nameplate turbine capacity of 12 MW.

Wind lease areas were divided into projects of reasonable size varying from 552 MW to 1,008 MW (see Figure 2). Our team recognizes that ISO-NE procurements have been in 800-MW increments thus far, but we anticipate that future projects could be larger in size as developers seek to maximize the potential of their lease areas and the capabilities of existing transmission technology.

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13 ISO-NE. "Single-Sourced Contingency." Operations Reports. Web. https://www.iso-ne.com/isoexpress/web/reports/operations/-/tree/single-src-cont.

14 PJM. "Transmission System Operations T01." 2014. Web PPT. https://www.pjm.com/~/media/training/nerc-certifications/TO1-transmissionops.ashx.

15 Baird. "Vessel Navigation through the Proposed Rhode Island/Massachusetts and Massachusetts Wind Energy Areas." 31 Oct. 2019.

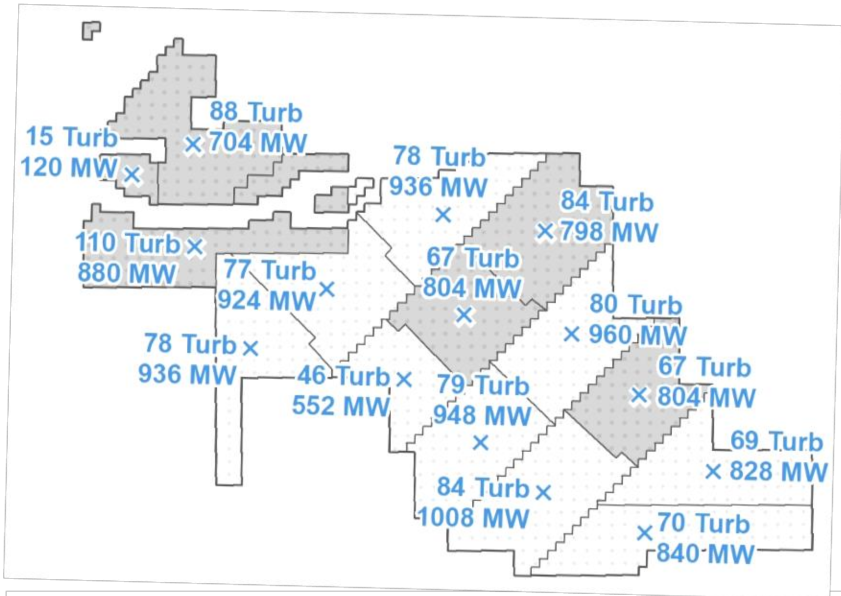

Figure 2: Locus of Estimated Project Capacities

For Scenario 1, we assume that HVDC transmission is used for export cables exceeding 60 miles in length, unless developers of procured projects have indicated otherwise. HVDC transmission provides less power loss per unit length than high voltage alternating current (HVAC), resulting in a tradeoff where the additional cost of HVDC components is outweighed by the power loss over long-distance HVAC. While HVAC lines can be extended using midpoint reactive compensation to operate at comparable distances to HVDC, this still requires an additional, costly platform. Furthermore, networking OSW farms would be simpler with DC technology than with AC technology because AC components require synchronization.[16] HVDC systems are limited by the nameplate capacity of the voltage source converter (VSC) platform. For this analysis, we assumed that a single VSC could handle up to 1,200 MW, which is also the largest single-sourced contingency allowed by ISO-NE.[13]

For the required capacity in Scenario 2, each of the four export cable routes in the HVDC network would need to accommodate 2,400 MW. This may necessitate additional electrical infrastructure such as VSC platforms and redundancy in cables to avoid the single contingency limit. Our analysis assumes that each 2,400-MW HVDC export route would require two VSC platforms each rated to 1,200 MW. Scenario 2 also assumes that all procured projects listed in Table 2 will proceed as currently planned, utilizing generator lead lines to the POIs identified by their respective developers.

The transmission connections to shore reflect the information about select POIs summarized in Table 1. Callouts are used to identify the estimated available transmission capacity for a given substation or set of substations. Substations are grouped together when they share transmission lines and their available interconnection capacities are presumed to be interdependent. The label “Sent” is used to indicate the amount of OSW capacity being routed to a given substation, ignoring line losses. For Scenario 2, we omit the “Sent” label for networked interconnections. An advantage of the networked system is that it reduces congestion by providing multiple routes for power to get to shore. Due to the time-varying nature of line utilization, we are unable to directly correlate offshore capacity to individual onshore points.

16 In an AC network, the time-varying nature of voltage and current causes significant loss of power if not synchronized across the entire transmission system. HVDC transmission has little or no time-varying element; therefore, HVDC lines do not require synchronization. This makes it simpler to connect two or more HVDC cables from different sources. We recognize that a combination of HVAC and HVDC will likely be used in the final build out. While synchronization of networked transmission is standard practice onshore, a benefit of HVDC transmission is avoiding this need, which eliminates cost and potential points of failure to the system.

The labels for Mystic, Millstone, and Manchester Street are identified with asterisks because those locations are not currently viable, but they remain promising POIs for the future:

- Mystic could have available capacity as of 2024, contingent on the proposal ISO-NE selects under Federal Energy Regulatory Commission (FERC) Order 1000.[17]
- The Millstone Nuclear Power Station, owned by Dominion Energy, has a PPA with Connecticut state utilities amounting to half of its 2,100-MW capacity through 2029.[18] After the PPA expires, continued operation of the plant may prove uneconomical, opening the door for OSW to take advantage of the existing onshore transmission infrastructure serving the plant.
- Manchester Street is a 500-MW natural gas facility in Providence that has not been identified by ISO-NE as an at-risk generator. However, it could still be a contender for future OSW interconnection, as Governor Raimondo has committed Rhode Island to 100% carbon-free power by 2030.[19]

4. POTENTIAL POLICY IMPLICATIONS

As the DOER and other regulators consider the path forward for OSW in the region, multiple system-wide objectives should be considered. In our opinion, the overarching goals of this new system should be carbon neutrality, grid function, ratepayer costs, regional workforce development, and environmental justice.

We encourage regulators to look at full build-out of the WEAs with an eye toward how the system should function regardless of the limitations inherent to the current legislative frameworks. Land-based grid limitations can be difficult to overcome[20, 21] and thus deserve attention as an integral part of the offshore transmission discussion. To realize the benefits associated with improved offshore and onshore transmission networks, New England states will need to work together to standardize offshore transmission elements. Building an offshore network will require coordination between legislators, developers, and equipment manufacturers to create benchmark specifications for transmission infrastructure. This infrastructure will include but is not limited to cable ratings, transmission voltages, collectors, and converters. The task of standardizing offshore transmission infrastructure in large part falls upon the FERC and the North American Electric Reliability Council (NERC).

New York and New Jersey have made bold commitments to procure large quantities of OSW, and these commitments have helped the industry visualize the scale and speed of growth for the East Coast as a whole. New England should follow suit—the industry will not see the need for system-wide transmission planning in this region without states taking a lead role in the discussion. A bold commitment is needed to instill confidence and garner acceptance for system-wide planning.

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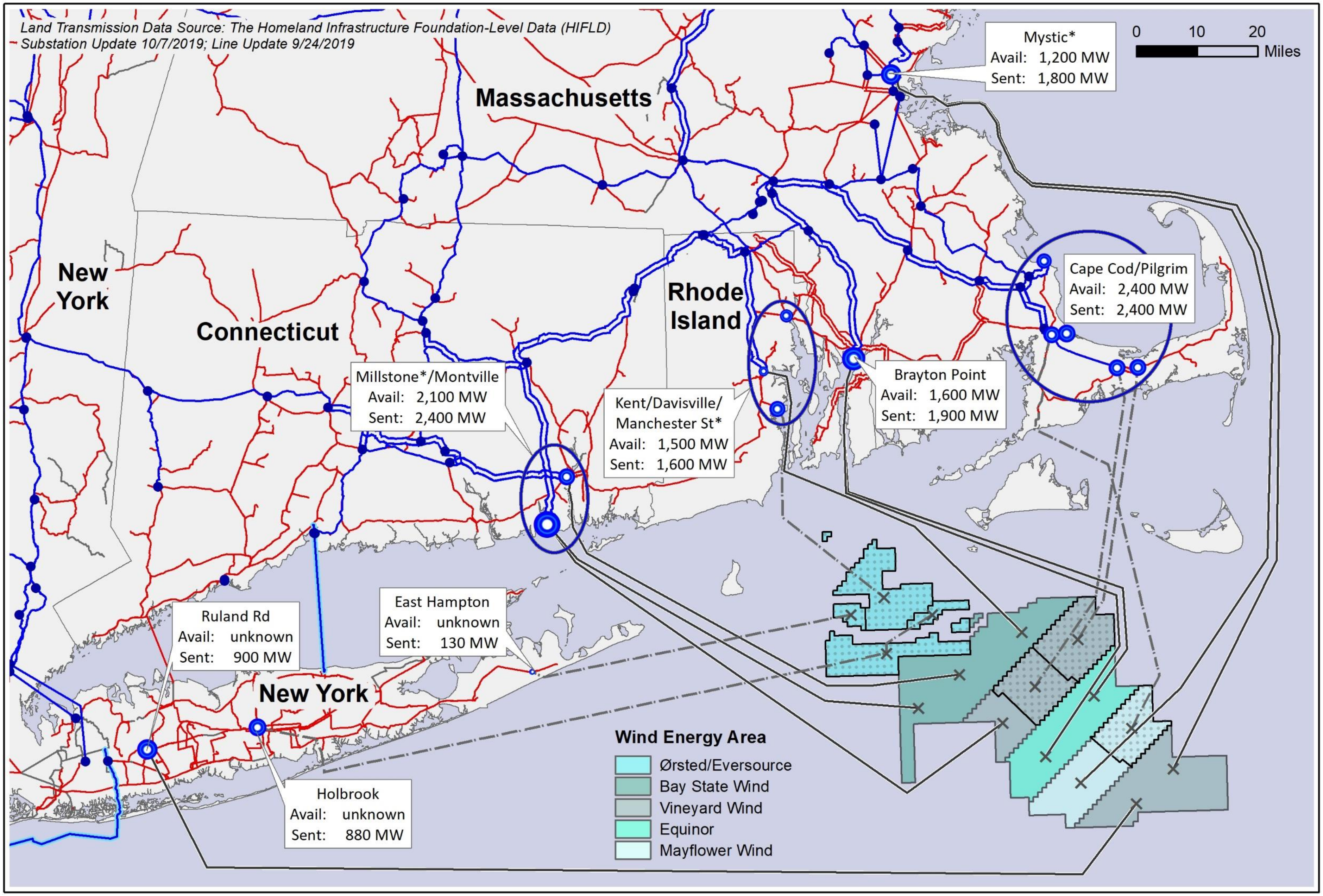
17 Oberlin, Brent. "Boston 2028 Request for Proposal—Change in Mystic Generation Station Retirement Date." ISO-NE. 13 Jan. 2020. Web. https://www.iso-ne.com/static-assets/documents/2020/01/mystic-retirement-boston-2028-final.pdf.

18 Proctor, Darrell. "Dominion Brokers 10-Year Deal to Keep Millstone nuclear Plant Open." Powermag. 16 Apr. 2019, https://www.powermag.com/dominion-brokers-10-year-deal-to-keep-millstone-nuclear-plant-open/.

19 DiSavino, Scott. "Rhode Island Governor aims for 100% renewable power by 2030." Reuters. 17 Jan. 2020, https://www.reuters.com/article/us-usa-rhode-island-renewables/rhode-island-governor-aims-for-100-renewable-power-by-2030-idUSKBN1ZG2BI

20 The Northern Pass, a proposed 1,100 MW transmission project connecting hydropower in Québec to consumers in Massachusetts, failed after an investment of $300 million and nearly a decade of effort. An alternative project, the New England Clean Energy Connect (NECEC), is still working its way through Maine regulatory bodies.

21 Ropeik, Annie. "In Unanimous Vote, N.H. Supreme Court Upholds Northern Pass Denial," New Hampshire Public Radio, 19 Jul. 2019. https://www.nhpr.org/post/unanimous-vote-nh-supreme-court-upholds-northern-pass-denial#stream/0.



Scenario 1: Generator Lead Lines

Total Estimated Wind Energy Area Capacity – 12 GW

April 21, 2020

OSW Points of Interconnection
Procured OSW Projects
OSW AC Transmission (<60 mi)
OSW DC Transmission (>60 mi)
≥ 345 kV Substations
≥ 345 kV AC Transmission
69- 230 kV AC Transmission
150- 500 kV DC Transmission

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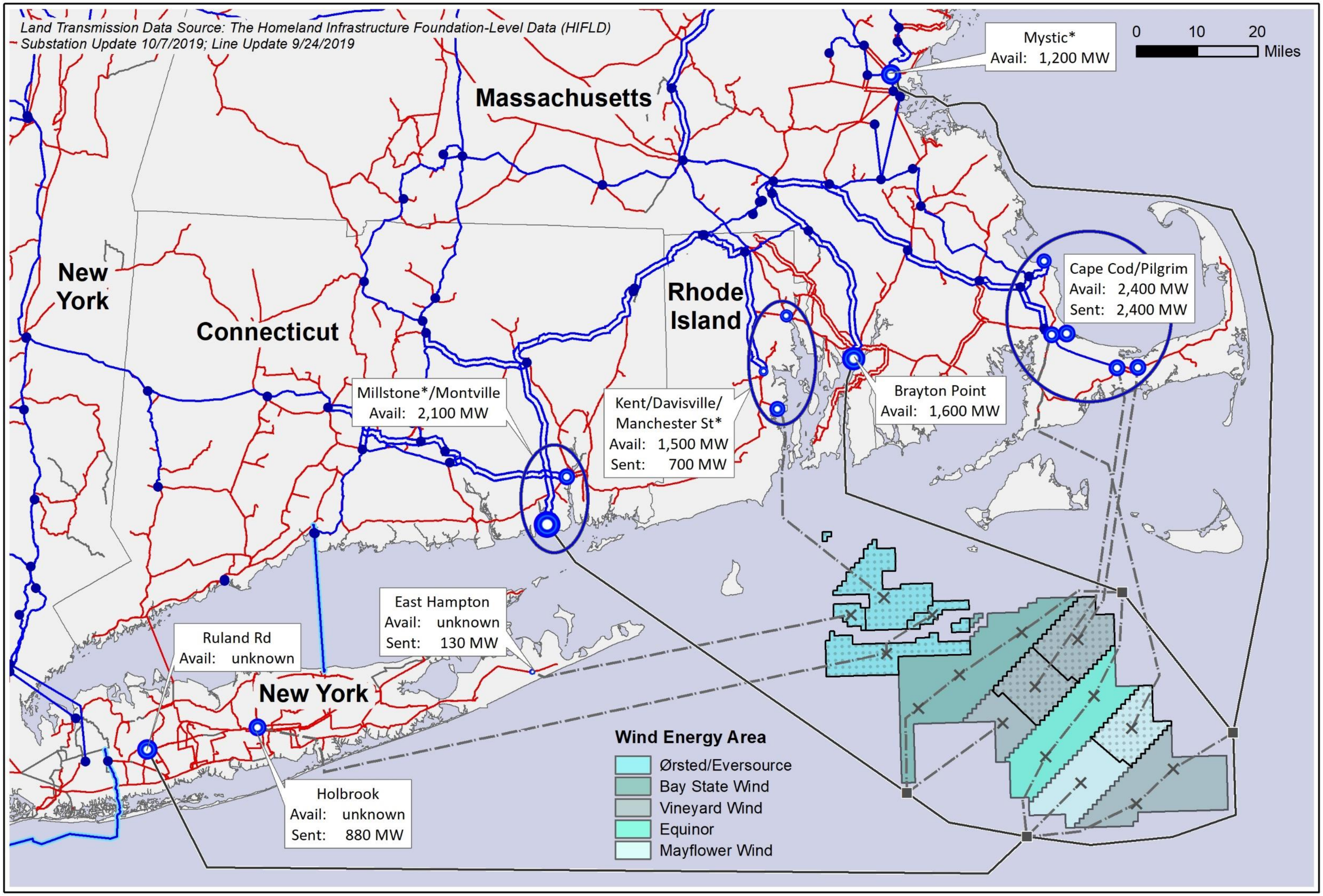

Scenario 2: Networked Transmission

Total Estimated Wind Energy Area Capacity – 12 GW

April 21, 2020

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5. CONTRIBUTORS

Samuel Lenney is a master's student studying electrical engineering. Within the Tufts power systems and markets seminar, he focuses on trends in developing technologies related to offshore wind transmission and the challenges and opportunities they bring. Beyond offshore wind he researches novel semiconductor materials that will enable the next generation of photovoltaic and solar energy devices. He received his B.S. in physics from Tufts University in 2019.

Oliver Marsden is an electrical engineering senior. He competes in mock trial and is pursuing an economics minor. Oliver will stay for a 5th year to complete a master's in electrical engineering. His aim is to apply his specialized technical knowledge, public speaking experience, and financial proficiency to budding interdisciplinary fields within renewable technology. He spent the last two summers honing those skills: in 2018, at a mine in eastern Arizona operated by Freeport McMoran, and in 2019, at Community Energy Inc., a solar development firm in Philadelphia.

Sean Murphy is a civil engineering senior who has focused his studies on water, transportation, and energy. Sean has worked on energy from government, utility, and now academic perspectives. He spent a summer in the Medford Office of Energy and Environment, which led him to explore the discipline academically, and gave him the opportunity to work for Central Maine Power as an intern in the high voltage lines projects unit in 2019. He is also researching water resources methods to develop optimal control rules for merchant energy storage systems.

Kelly Smith, P.E., CFM, is a master's student offshore wind energy engineering. She works as a part-time contractor for the National Offshore Wind Research and Development Consortium. Prior to her graduate studies, Kelly spent eight years working in water resources engineering and environmental consulting, most recently for Hodge Water Resources, LLC. Her analytical expertise is in the numerical modeling of environmental systems. She currently serves on the board of New England Women in Energy and the Environment. Kelly holds a B.S. in environmental engineering, summa cum laude, from Tufts University.

Chisaki Watanabe is a master's student at the Fletcher School. Her research focuses on climate change diplomacy and energy security. She was an energy reporter for Bloomberg News in Tokyo and covered power markets and renewable energy in Japan and other Asian countries. She has a M.S. in mass communication from the College of Communication, Boston University, and B.S. in journalism from Sophia University in Tokyo, Japan

Eric Hines, Ph.D., P.E., F.SEI directs the offshore wind energy graduate program at Tufts University, where he is the Kentaro Tsutsumi Professor of the Practice in structural engineering. Dr. Hines has over 20 years of experience engineering innovative infrastructure and large-scale testing. Major projects include the Wind Technology Testing Center in Charlestown, MA, the New Bedford Marine Commerce Terminal, Beijing's Yin Tai Center, the digital twin verification processes for the new San Francisco-Oakland Bay Bridge and the Block Island Wind Farm. He works at the technology/policy interface to develop systems-level design concepts. He studied engineering and public policy as an undergraduate at Princeton University and a Fulbright Fellow in Germany. He holds a Ph.D. in structural engineering from the University of California, San Diego.

Barbara Kates-Garnick, Ph.D. is a professor of practice at the Fletcher School. She recently served as Undersecretary of Energy for the Commonwealth of Massachusetts (EEA). Her prior work in public service includes Commissioner of Public Utilities (MA DPU)., Assistant Secretary of Consumer Affairs, and Director of Rates and Research (MA DPU). Dr. Kates-Garnick has been a Vice President of Corporate Affairs at KeySpan. She was on the founding team of NewEnergy. She currently sits on the Boards of Anbaric Transmission and PowerOptions. She also serves on the Energy and Environmental Systems (BEES) Board of the National Academies of Science, Engineering and Medicine. She has a Ph.D. in international political economy from the Fletcher School of Tufts University, an A.B., cum laude, in political science from Bryn Mawr College and was a pre-doctoral fellow at the Center for Science and International Affairs at the Kennedy School of Government, Harvard University.

Aleksandar Stanković, Ph.D., F.IEEE, is the Alvin H. Howell Professor of Electrical Engineering at Tufts University. Dr. Stanković has over 30 years of experience in power systems engineering and control. He has chaired the Power Systems subcommittee of the Institute for Electrical and Electronics Engineers (IEEE) Power Engineering Society and served as a distinguished lecturer for the IEEE Circuits and Systems Society. He has edited the IEEE transactions of Smart Grids and co-edited a book series on Power Systems and Power Electronics for Springer. His work on power system stability and grid blackouts has over 2000 citations, making him one of the most sought-after voices on grid reliability in the Northeastern United States. Dr. Stanković completed his undergraduate and masters work at the University of Belgrade and holds a Ph.D. from MIT.