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New Jersey Board of Public Utilities
44 S. Clinton Avenue
Trenton, NJ 08625

Date: August 28, 2020
Attn: Aida Camacho-Welch, Secretary of the Board
Subject: New Jersey Offshore Wind Transmission Information Gathering (NJBPU Docket No. QO20060463)

Ms. Camacho-Welch:

The comments included herein were developed by a team of students and faculty mentors at Tufts University in response to the New Jersey Board of Public Utilities (NJBPU) Docket No. QO20060463, which provides notice of New Jersey Offshore Wind Transmission Information Gathering.

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 New Jersey Board of Public Utilities' (NJBPU) efforts to gather information about offshore wind (OSW) transmission, this report focuses on the status of wind energy areas (WEAs) and state commitments in the northeast region and assesses implications for New Jersey decision making related to transmission.

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 New Jersey's 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. The slated OSW installations could overwhelm and congest the existing land-based grid along the East Coast, damaging the industry's reputation and short-changing its growth potential. In order to make the build-out of OSW cost-efficient and timely, states must look ahead for problems and change regulatory frameworks in anticipation of what will come. Namely, New Jersey should consider in advance the prospects of independent transmission, interconnection, and regional competition for WEAs.

Through evaluation of regional state commitments, procurement schedules, and federal progress, we have reached the following conclusions to inform New Jersey's process:

- State commitments to OSW have grown faster than expected, prompting a need to consider the full build-out capacity of existing WEAs with respect to proposed procurement schedules. States will struggle to hit their 2035 targets unless additional lease areas in the New York Bight are made available from the Bureau of Ocean Energy Management (BOEM).
- Based on a review of New Jersey power plants and system topology, we feel it is unlikely that New Jersey's coastal transmission infrastructure can integrate large quantities of OSW capacity without significant reinforcements. A system-wide planning approach could help moderate upgrade costs and would likely reveal some degree of offshore transmission networking to be favorable.

As a result of our analysis, we suggest the following steps for the NJBPU:

- Study the limits of New Jersey's existing transmission system and develop scenarios to identify where additional OSW capacity can be interconnected most efficiently to reach 7,500 MW by 2035 and several times that amount by 2050. ISO-NE recently published a study to this effect for the New England system.[2]
- Consider the fact that a networked offshore grid will not develop organically under current frameworks. Inaction in this regard is tantamount to choosing a radial system in which PJM ratepayers are left footing the bill for onshore transmission upgrades that could have been mitigated or avoided with better foresight.

The remainder of this submittal details the analysis supporting our conclusions and recommendations.

2. STATUS OF STATE COMMITMENTS AND WIND ENERGY AREAS

State commitments and procurement timelines provide clear insight into how aggressively top-level officials are pursuing OSW power and economic development for their states. Achieving these state commitments will require overcoming a multitude of logistical hurdles, one of which relates to the availability of BOEM lease areas.

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.

2 ISO New England Inc. "2019 Economic Study: Offshore Wind Integration." 20 Jun. 2020. Web. https://www.iso-ne.com/static-assets/documents/2020/06/2019_nescoe_economic_study_final.docx

2.1. State Commitments and Upcoming Procurements

The American Wind Energy Association (AWEA) recently compiled a fact sheet with all state activities related to OSW procurements and commitments.[3] The New York state commitment enacted by Governor Andrew Cuomo is the most ambitious, setting a target for 9,000 MW of OSW by 2035. The New Jersey commitment to 7,500 MW by 2035 is a similarly bold target issued by Governor Phil Murphy. As shown in Table 1, states have procured approximately 9,000 MW (31%) of their 29,000 MW commitments. All commitments must be met by 2035 at the latest, although some states have more aggressive timelines or intermediate milestones to achieve.

Table 1: State Commitments to Offshore Wind, Megawatts (MW)

State	Offshore Wind Capacity (MW) Committed [3]	Procured	Remaining	Completed Procurements	Procurements Slated by 2022
Massachusetts	3,200	1,604	1,596	*Vineyard Wind (800 MW)* *Mayflower Wind (804 MW)*	1,600 MW [4]
Rhode Island	430	430	0	*Block Island (30 MW)* *Revolution Wind (400 MW)*	
Connecticut	2,300	1,104	1,196	*Revolution Wind (300 MW)* *Park City Wind (804 MW)*	
New York	9,000	1,826	7,174	*South Fork Wind (130 MW)* *Sunrise Wind (880 MW)* *Empire Wind (816 MW)*	2,500 MW [5]
New Jersey	7,500	1,100	6,400	*Ocean Wind (1,100 MW)*	2,400 MW [6]
Maryland	1,568	368	1,200	*MarWin (248 MW)* *Skipjack (120 MW)*	1,200 MW [7]
Virginia	5,200	2,662	2,538	*CVOW Pilot (12 MW)* *CVOW (2,650 MW)*	
Total	**29,198 MW**	**9,094 MW**	**20,104 MW**	**9,094 MW**	**7,700 MW**

These bold commitments to renewables are warranted to combat the urgent threat of climate change. However, OSW is still new to the U.S., so developers and supply chain will be stretched to meet the challenge. Regulators must think ahead in support of the energy transition, overhauling regulatory frameworks where they advantage market incumbents.

Of equal relevance to state commitments are the schedules for new procurements and the estimated available capacity within existing WEAs leased from BOEM. States are recognizing the economies of scale evident in developer project proposals. As a result, procurements are getting larger to make more efficient use of supply chain and transmission technology.

By 2022, it is likely that Massachusetts,[4] New York,[5] New Jersey,[6] and Maryland[7] will have collectively procured 7,700 MW of new OSW capacity (see Table 1). In July 2020, the Commissioner of the Massachusetts Department of Energy Resources (DOER), recommended that the state's next OSW solicitation, scheduled for 2022, allow for

3 American Wind Energy Association (AWEA). "U.S. Offshore Wind Industry: Status Update June 2020." Jun. 2020. Web. https://www.awea.org/Awea/media/Resources/Fact%20Sheets/Offshore-Fact-Sheet.pdf

4 Woodcock, Patrick C. "RE: Offshore Wind Energy Transmission under Section 21 of Chapter 227 of the Acts of 2018 (An Act to Advance Clean Energy)." Massachusetts Department of Energy Resources. 28 Jul. 2020. Web. https://www.mass.gov/doc/offshore-wind-transmission-letter-07-28-20/download

5 NYSERDA. "2020 Offshore Wind Solicitation (Open)." 21 Jul. 2020. Web. https://www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Focus-Areas/Offshore-Wind-Solicitations/2020-Solicitation

6 New Jersey's Clean Energy Program. "NJ Governor Phil Murphy Releases Offshore Wind Solicitation Schedule to Meet New 2035 Goals." New Jersey Board of Public Utilities. 28 Feb. 2020. Web. https://njcleanenergy.com/nj-offshore-wind

7 Best, Amanda. "Re: Maryland OSW State Commitment and Procurement Schedule." Message to Harry Warren. 26 Aug. 2020. E-mail.

bids of up to 1,600 MW.[4] New York's next solicitation, scheduled for 2020, allows for up to 2,500 MW.[5] The New Jersey schedule seeks 1,200 MW in 2020 and another 1,200 MW in 2022.[6] Finally, the Maryland schedule has three application periods to authorize a minimum of 1,200 MW by 2022.[7] With such large procurement capacities slated for the next two years, state decision makers would benefit from understanding the limitations of existing lease areas in the region.

2.2. Anticipated Capacity of Wind Energy Areas

BOEM awarded 17 OSW leases in East Coast federal waters between December 2012 and April 2019.[8] Another ten East Coast BOEM call areas remain under review.[8] The first leases were awarded offshore Delaware, and a second batch of leases followed ten months later offshore Massachusetts and Rhode Island.[8] The state of New York was the first to approve a power purchase agreement (PPA) in the post-Cape-Wind era of OSW in U.S. federal waters. The milestone occurred on January 25, 2017, when the Long Island Power Authority (LIPA) approved a PPA from the Deepwater Wind (now Ørsted) South Fork Wind Farm.[9] From the very start, New York demonstrated that a state can authorize a PPA from any lease area it so chooses. On the flipside, states have no guaranteed right to obtain power from their namesake WEA. Developing projects is competitive, and so is the state-level process of procuring them.

The lease areas offshore Massachusetts and Rhode Island are unique in how they abut one another. That fact, combined with an established history and culture of fishing, has led to strong stakeholder opposition from regional fishermen concerned about safe navigation around turbines. In response to multiple rounds of engagement, all lease holders from the WEAs offshore Massachusetts and Rhode Island came together in 2019 to support a proposal for uniform 1 x 1 nautical mile (nm) grid spacing of wind turbines.[10] The proposal included a study by Baird into vessel navigation through the WEAs with supporting geospatial maps of turbine locations and navigation corridors (Figure 1).[10] Developers appear to have moved forward with siting projects according to this plan, and we feel the uniformity of the layout provides a sound base assumption for estimating WEA capacity along the entire east coast.

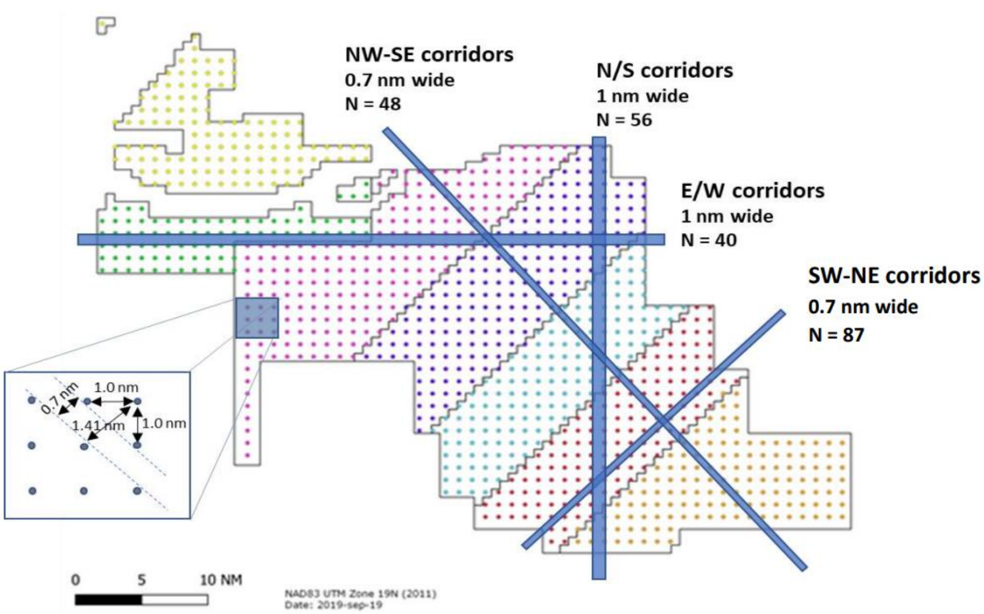

Figure 1: Developer Proposal for a Uniform 1x1 nm Wind Turbine Layout for New England Offshore Wind [10]

8 BOEM. "BOEM-Renewable-Energy-Geodatabase.zip." 13 Apr. 2020. Web. https://www.boem.gov/BOEM-Renewable-Energy-Geodatabase.zip

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

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

Using ArcGIS, we estimated full WEA build-out capacity by overlaying a uniform 1 x 1 nm grid of turbine locations across each BOEM lease and planning area along the east coast. The Equinor Wind lease offshore New York (OCS-A 0512) provided the singular exception to that configuration. In September 2019, Equinor published an indicative turbine layout for the full build-out of their entire lease area, depicting a uniform layout with minimum spacing of 0.71 nm.[11] Our analysis incorporated Equinor's indicative layout. Figure 2 depicts our resulting turbine layout scenario for the east coast, which we estimate could provide approximately 65,800–80,700 MW of nameplate OSW capacity if fully leased and built out.

The planning areas shown in Figure 2 are consistent with what is depicted throughout the New Jersey Offshore Wind Strategic Plan Draft; however, they do not reflect the most up-to-date information.[12] BOEM facilitated an Intergovernmental Renewable Energy Task Force in November 2018 that winnowed down the New York Bight planning areas into much smaller regions flagged as primary or secondary recommendations for lease.[13] Our team created Figure 3 to illustrate the effect of these recommendations, which reduce our estimated full build-out capacity by 20% to 52,600–64,100 MW. Table 2 summarizes the turbine counts and capacity estimates shown in Figure 3 for our lower-bound estimate, which uses a 12-MW turbine as the base assumption, barring the availability of project-specific information about turbine model selection. Table 3 goes into significantly greater detail, enumerating the findings of our analysis for each subsection of a given lease or call area. The color-coding scheme is consistent across the set of figures and tables.

Table 2: Offshore Wind Capacity Summary using 12-MW Turbine Assumption

Status	Description	Turbine Count	Capacity MW
●	Procured Project Area	763	8,456
●	Leased Wind Energy Area	1,459	17,508
●	BOEM Primary Recommendation	368	4,416
●	BOEM Secondary Recommendation	602	7,224
●	BOEM Planning Area/Call Area	1,250	15,000
Total		**4,442**	**52,604 MW**

During the November 2018 Task Force meeting, a BOEM presentation indicated that the timeline from announcement of final WEAs in the New York Bight through to lease sale would take approximately 1-2 years, with an estimated lease sale by early 2020.[14] Based on public record within the Federal Register,[15] no such announcements or notices have been issued, putting BOEM more than 1.5 years behind their original estimated schedule. Movement on these prospective WEAs seems to have stalled, with no indication that there will be new lease areas in the NY Bight in the near future. State procurements slated for the next two years will likely source projects from existing lease areas.

11 Equinor. "Empire/Boardwalk Wind Farm Layouts Consultations" Sep. 2019. Web. https://www.equinor.com/content/dam/statoil/documents/empirewind/equinor-empire-boardwalk-wind-farm-layouts-consultations-september2019.pdf

12 Ramboll US Corporation. "New Jersey Offshore Wind Strategic Plan Draft." Prepared for New Jersey Board of Public Utilities and the Interagency Taskforce on Offshore Wind. 13 Jul. 2020. Web. https://www.nj.gov/bpu/pdf/Draft_NJ_OWSP_7-13-20_highres.pdf

13 BOEM. "Intergovernmental Renewable Energy Task Force Meeting On The New York Bight." 28 Nov. 2018. Web. https://www.boem.gov/renewable-energy/state-activities/intergovernmental-renewable-energy-task-force-meeting-new-york-0

14 Feinberg, Luke. "Next Steps in the Renewable Energy Leasing Process." BOEM. New York Bight Intergovernmental Renewable Energy Task Force Meeting." 28 Nov. 2018. Web. https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/NY/Next-Steps-Feinberg.pdf

15 Federal Register. Accessed 25 Aug 2020. Web. https://www.federalregister.gov/documents/search?conditions%5Bagencies%5D%5B%5D=ocean-energy-management-bureau&conditions%5Bterm%5D=wind&order=newest

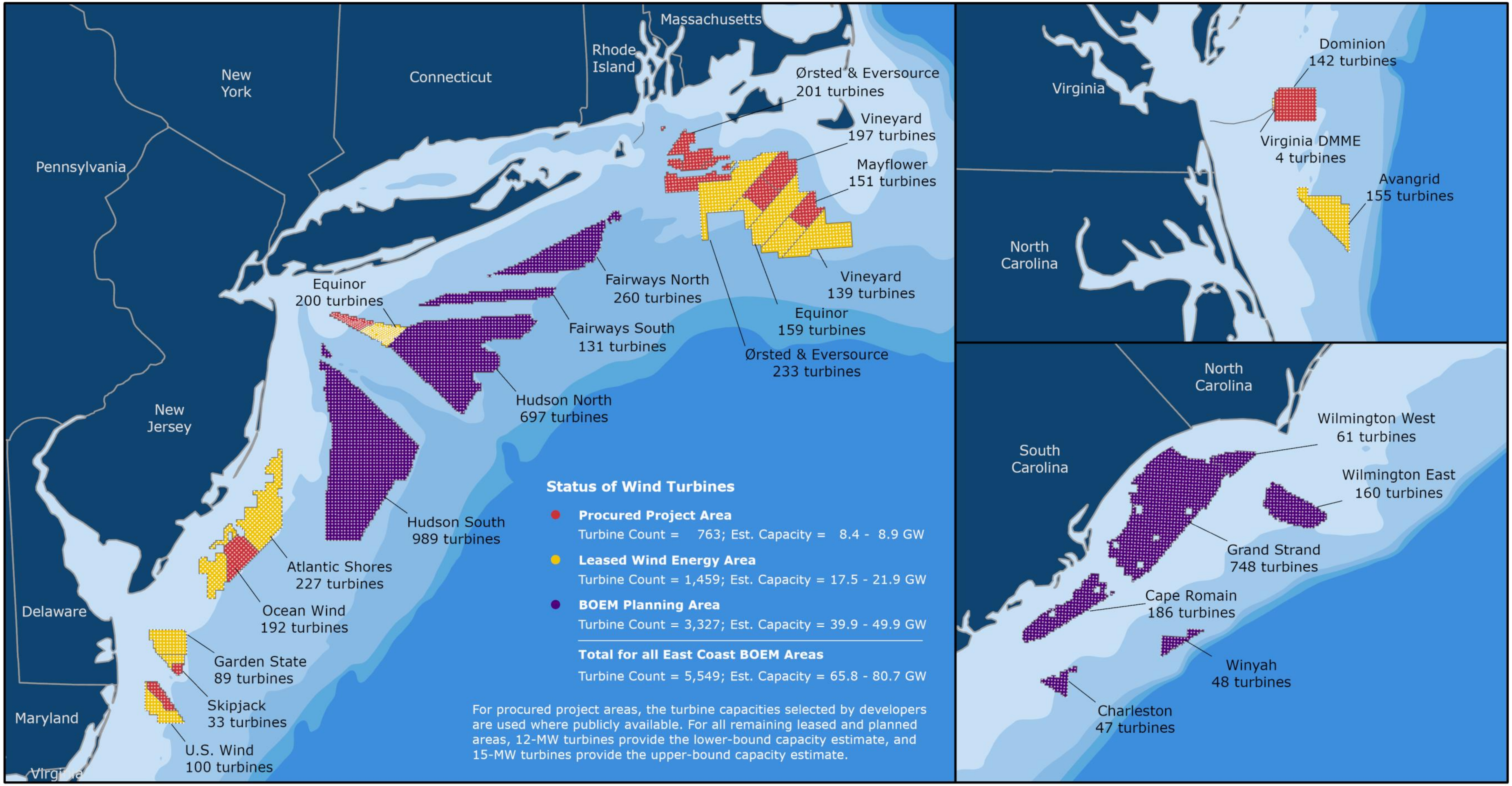

Figure 2: Turbine and Capacity Estimates for BOEM Wind Energy Areas and Call Areas

Total Estimated Capacity = 65.8 - 80.7 GW

July 13, 2020

0 30 60 90 120+ Meters (Depth)

0 20 40 80 Miles (Distance)

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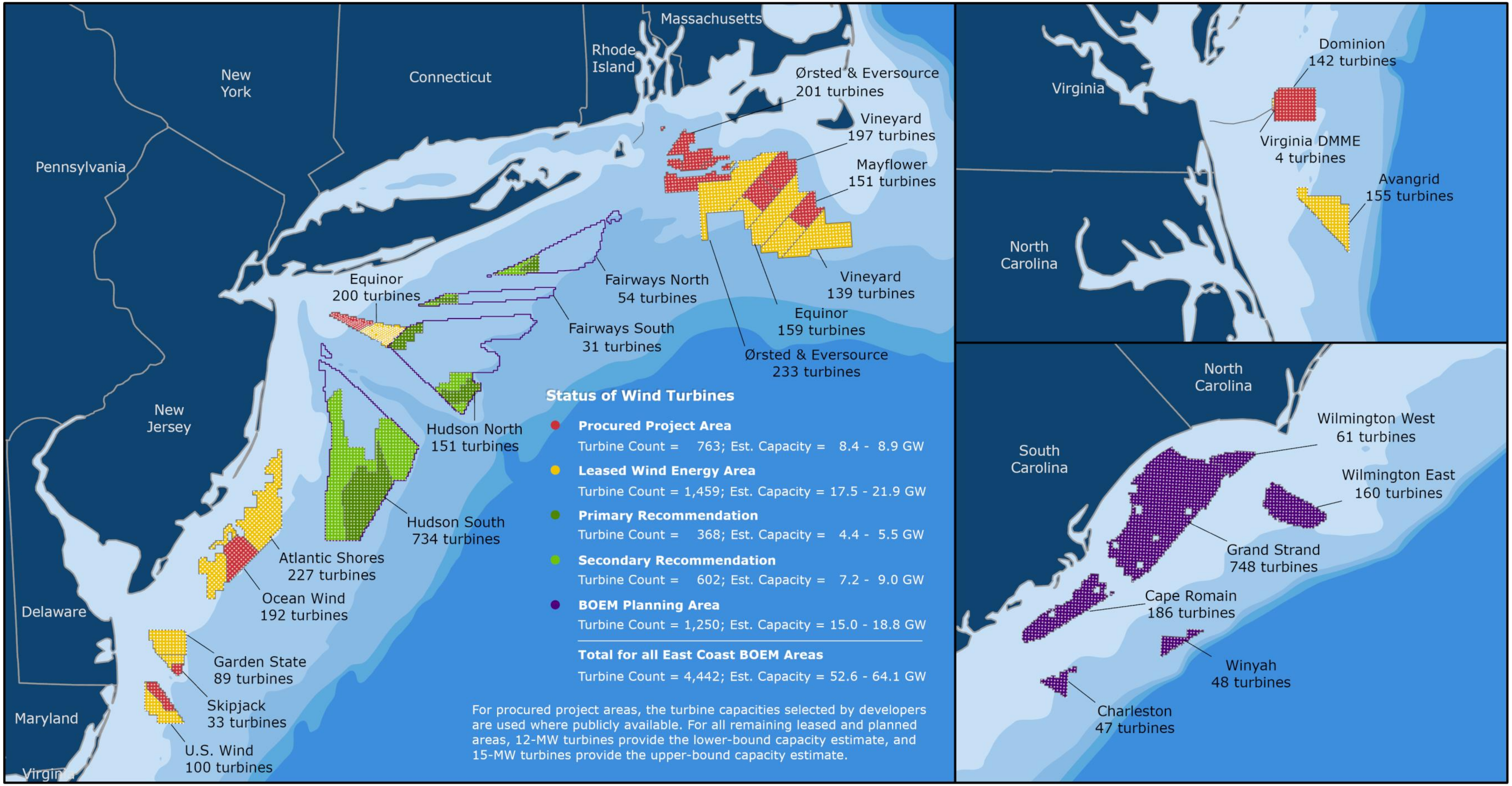

Figure 3: Turbine and Capacity Estimates for BOEM Wind Energy Areas and Reduced Call Areas

Total Estimated Capacity = 52.6 - 64.1 GW

August 27, 2020

0 30 60 90 120+ Meters (Depth)

0 20 40 80 Miles (Distance)

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Table 3: Offshore Wind Capacity Analysis using 12-MW Turbine Assumption

State	Lease Number	Lessee or Area Description	Status	Project Name	Turbine Count	Turbine MW	Capacity MW
MA/RI	OCS-A 0486	Ørsted / Eversource	●	Revolution Wind	88	8	704
MA/RI	OCS-A 0517	Ørsted / Eversource	●	South Fork Wind	15	8	120
MA/RI	OCS-A 0487	Ørsted / Eversource	●	Sunrise Wind	98	8	784
MA	OCS-A 0500	Ørsted / Eversource	●	—	233	12	2,796
MA	OCS-A 0501	Vineyard Wind	●	Vineyard Wind	84	10	840
			●	Park City Wind	67	12	804
			●	—	46	12	552
MA	OCS-A 0520	Equinor	●	—	159	12	1,908
MA	OCS-A 0521	Mayflower Wind	●	Mayflower Wind	67	12	804
			●	—	84	12	1,008
MA	OCS-A 0522	Vineyard Wind	●	—	139	12	1,668
NY	Call Area	Fairways North	●	—	16	12	192
			●	—	38	12	456
NY	Call Area	Fairways South	●	—	10	12	120
			●	—	21	12	252
NY	OCS-A 0512	Equinor	●	Empire Wind	68	12	816
			●	—	132	12	1,584
NY	Call Area	Hudson North	●	—	96	12	1,152
			●	—	55	12	660
NY	Call Area	Hudson South	●	—	246	12	2,952
			●	—	488	12	5,856
NJ	OCS-A 0499	Atlantic Shores	●	—	227	12	2,724
NJ	OCS-A 0498	Ocean Wind	●	Ocean Wind	90	12	1,080
			●	—	102	12	1,224
DE	OCS-A 0482	Garden State	●	—	89	12	1,068
DE	OCS-A 0519	Skipjack	●	Skipjack	10	12	120
			●	—	23	12	276
MD	OCS-A 0490	U.S. Wind	●	MarWin	32	12	384
			●	—	68	12	816
VA	OCS-A 0497	Virginia DMME	●	CVOW Pilot	2	6	12
			●	—	2	12	24
VA	OCS-A 0483	Dominion	●	CVOW	142	14	1,988
NC	OCS-A 0508	Avangrid	●	—	155	12	1,860
NC	Call Area	Wilmington East	●	—	160	12	1,920
NC	Call Area	Wilmington West	●	—	61	12	732
SC	Call Area	Grand Strand	●	—	748	12	8,976
SC	Call Area	Cape Romain	●	—	186	12	2,232
SC	Call Area	Winyah	●	—	48	12	576
SC	Call Area	Charleston	●	—	47	12	564
Total					**4,442**		**52,604 MW**

Note: See Table 1 for descriptions matching colored dots. Grey shaded cells use an assumed 12-MW turbine capacity.

Delays at the federal level are sharply contrasted by an accelerating pace at the state level. Given the rapid growth in state commitments, the region's plans for OSW could become more challenging from a sourcing and transmission perspective as soon as 2022. We estimate that collectively, the remaining portions of the Equinor (OCS-A 0512), Atlantic Shores (OCS-A 0499), Ocean Wind (OCS-A 0498), Garden State (OCS-A 0482), Skipjack (OCS-A 0519), and U.S. Wind (OCS-A 0490) lease areas can provide approximately 7,700 MW if fully built out with 12-MW turbines (see Table 3 for data corresponding to yellow regions). By 2022, New York, New Jersey, and Maryland will be looking to source a combined 6,100 MW (see Table 1), which accounts for 80% of the estimated 7,700 MW available nearby. If New York sources its next procurement from the WEAs offshore Massachusetts and Rhode Island, New Jersey and Maryland will have a bit more breathing room in the near term.

Given the shrinking amount of available WEA capacity, New Jersey's future procurements may comprise a few small projects from the remainders of different lease areas. This option has always been available, but economies of scale favored a single large project for New Jersey's first round. Independent transmission could aggregate power from a few small projects, using fewer points of interconnection (POIs) than radial interconnection. These findings do not account for land-based interconnection challenges, which have often been flagged as a primary driver for considering networked offshore transmission.

3. NEW JERSEY TRANSMISSION AND POINTS OF INTERCONNECTION

Studying the topology of the land-based grid is critical for envisioning build-out scenarios for OSW transmission. Each state and ISO has a unique history with its own assets and challenges. We recognize that the NJBPU is intimately familiar with their system, but we feel it is worth highlighting key elements to frame the discussion about interconnecting 7,500 MW of OSW.

3.1. New Jersey's Onshore Grid

The New Jersey transmission grid has a few dominant features that become apparent with a map of the topology, as shown in Figure 4. The extra-high voltage, 500-kV lines capable of moving large amounts of power are located inland. This configuration made sense when the goal of the 1970s and 1980s was to move coal power from western Pennsylvania and nuclear power from the Salem-Hope Creek Complex, but existing infrastructure is not well configured to serve the OSW industry. Along the coast and in the populous counties to the northeast of the state, most transmission infrastructure is in the range of 230 kV.

Power stations are generally located around the perimeter of the state near water sources. Figure 4 shows all New Jersey power stations with greater than 100-MW maximum operational or retired capacity.[16] The three reactors that make up the Salem-Hope Creek Nuclear Complex combine to make it the state's largest generation asset. In the northeast corner of the state, a cluster of power stations serves urban consumers in Hudson, Richmond, Essex, and Union Counties as well as New York City and Long Island.

16 Homeland Infrastructure Foundation-Level Data (HIFLD). "Power Plants." Accessed 9 Mar. 2020. Web. https://hifld-geoplatform.opendata.arcgis.com/datasets/power-plants?layer=0

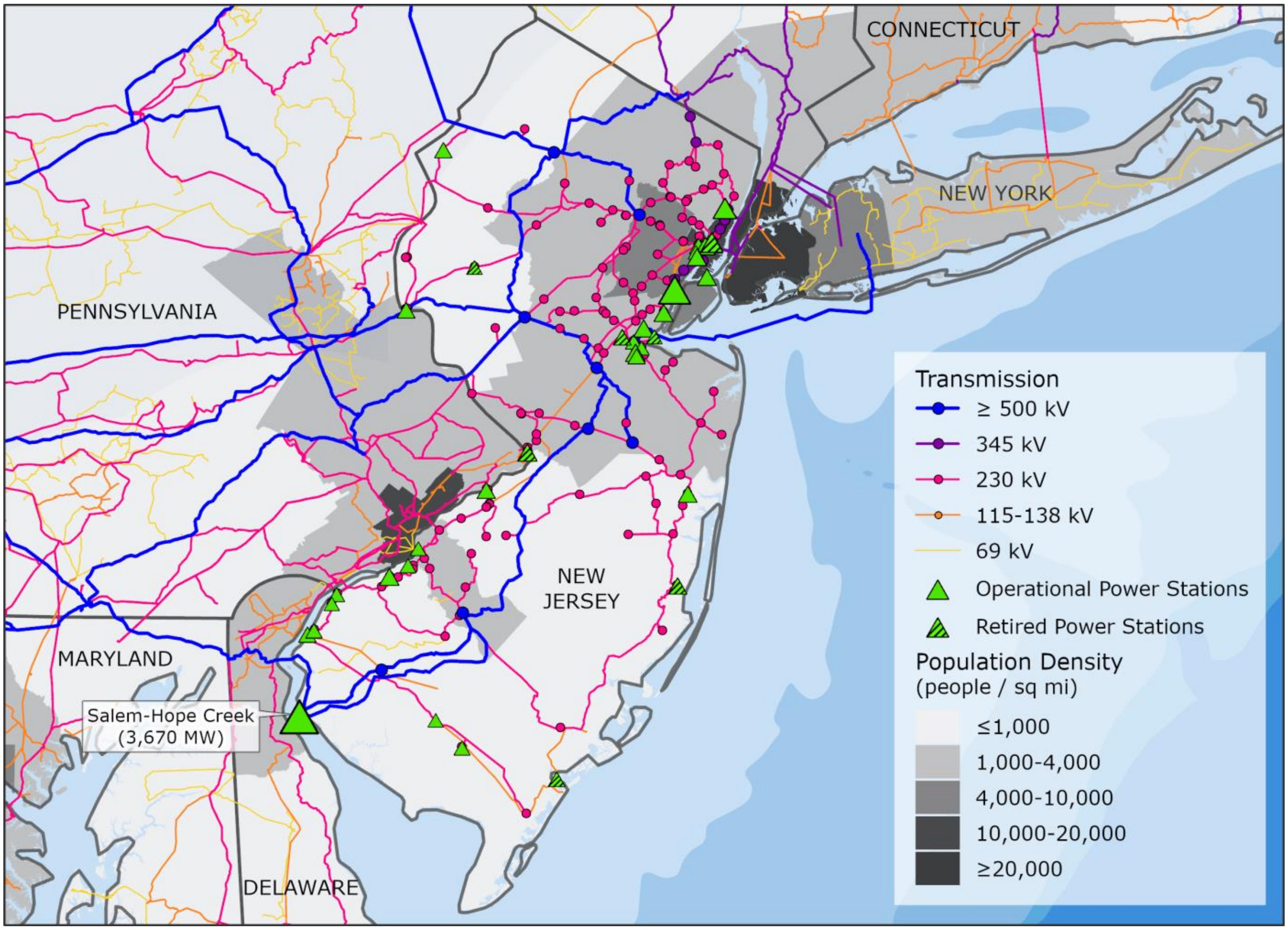

Figure 4: New Jersey Onshore Grid and Load Centers

3.2. Inventory of Coastal POIs

Recommendations for OSW POIs usually start with retired or at-risk coastal power stations, which are obvious locations for new generators to take advantage of existing transmission infrastructure. A simple presumption is that a power station could be replaced by an OSW interconnection of similar nameplate capacity, and minimal onshore transmission upgrades would be necessary.

New Jersey has few power stations along its coast, and almost all of them have a lower maximum capacity than a single 1,200-MW OSW procurement. Table 4 and Figure 5 provide an accounting of the maximum operational or retired capacity of coastal power stations.[16] Ocean Wind plans to interconnect its 1,100 MW project via generator lead lines to BL England and Oyster Creek.[17]

17 Johnson, Tom. "BPU Green-Lights Agreement to Bring Offshore Wind Power Ashore at B.L. England." NJ Spotlight. 31 Mar. 2020. Web. https://www.njspotlight.com/2020/03/bpu-green-lights-agreement-to-bring-offshore-wind-power-ashore-at-b-l-england/

Table 4: New Jersey Coastal Power Stations

Map Label	Plant Name	County	Max Capacity (MW) [16]	Status
Bayonne Facilities	Bayonne Energy Center	Hudson	510	Operational
	Bayonne Plant Holding LLC	Hudson	190	Operational
Linden Facilities	PSEG Linden Generating Station	Union	1,740	Operational
	Linden Cogen Plant	Union	980	Operational
PSEG Sewaren	PSEG Sewaren Generating Sta.	Middlesex	720	Operational
Woodbridge	Woodbridge Energy Center	Middlesex	800	Operational
Werner	Werner	Middlesex	210	Retired (2015)[18]
PSEG Edison	PSEG Edison Generating Station	Middlesex	500	Retired (2015)[18]
Sayreville	Sayreville	Middlesex	280	Operational
Parlin	Parlin Power Plant	Middlesex	140	Operational
Red Oak Power	Red Oak Power LLC	Middlesex	820	Operational
Sayreville Cogen	Sayreville Cogeneration Facility	Middlesex	430	Operational
NAEA Facilities	NAEA Ocean Peaking Power LLC	Ocean	380	Operational
	NAEA Lakewood LLC	Ocean	250	Standby
Oyster Creek	Oyster Creek	Ocean	640	Retired (2018)[18]
BL England	BL England	Cape May	340	Retired (2019)[18]
Cumberland	Cumberland	Cumberland	230	Operational
Sherman Ave	Sherman Avenue	Cumberland	110	Operational
Salem-Hope Creek	PSEG Salem Generating Station	Salem	2,380	Operational
	PSEG Hope Creek Generating Sta.	Salem	1,290	Operational
Total			**12,940 MW**	

3.3. Interconnection Considerations

In total, the Salem-Hope Creek Nuclear Complex and the Linden facilities (PSEG Linden Generating Station and Linden Cogen Plant) represent almost half of the 12,940 MW tallied in Table 4. The transmission infrastructure connecting the remaining, smaller POIs is less robust, particularly along New Jersey's Atlantic Coast near the established WEAs. Although their procured project is 1,100 MW, Ocean Wind filed in the PJM queue for 1,248 MW of nameplate capacity interconnecting at BL England and Oyster Creek. The BL England study finds that $58.6 million in system reinforcements would be required to interconnect 432 MW of nameplate OSW capacity.[19] At Oyster Creek, the projected system upgrades cost $111.3 million to accommodate 816 MW.[20] PJM's impact studies help us understand the viability of a given POI, but we recognize that queue dependencies have a large role in dictating costs. Due to the competitive nature of selecting POIs, we anticipate that future projects will face steeper interconnection costs—possibly by an order of magnitude.

18 PJM. "Generation Deactivations." Accessed 22 Aug. 2020. Web. https://www.pjm.com/planning/services-requests/gen-deactivations.aspx

19 PJM. "Generation Interconnection System Impact Study Report for PJM Generation Interconnection Request Queue Position AE1-104: B L England 138 kV." Revised Dec. 2019. Web. https://www.pjm.com/pub/planning/project-queues/impact_studies/ae1104_imp.pdf

20 PJM. "Revised Generation Interconnection System Impact Study Report for Queue Project AE2-000 (AE1-020) Oyster Creek 230 kV 229.3 MW Capacity / 816 MW Energy." Revised Jul. 2020. Web. https://www.pjm.com/pub/planning/project-queues/impact_studies/ae1020_imp.pdf

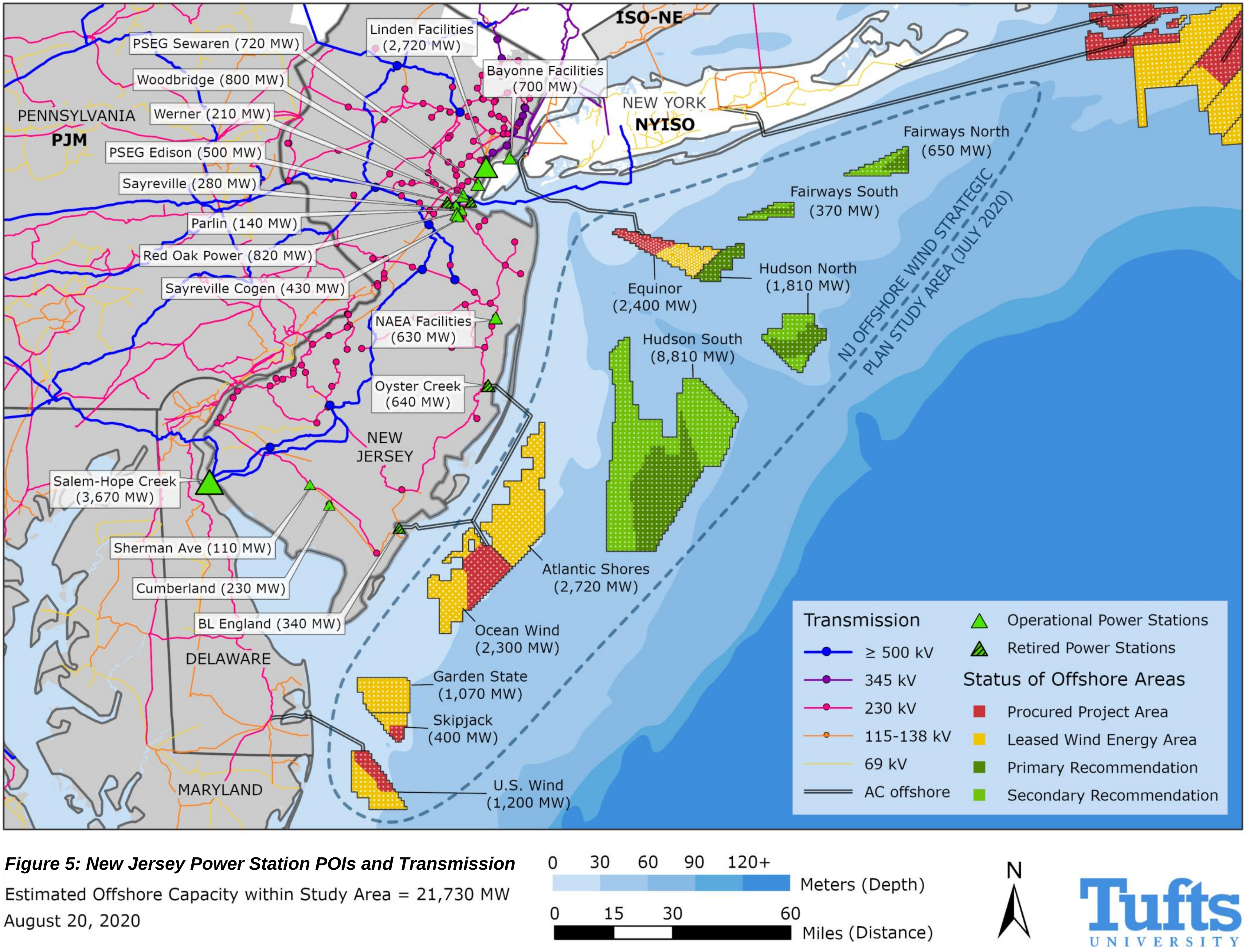

Figure 5: New Jersey Power Station POIs and Transmission

Estimated Offshore Capacity within Study Area = 21,730 MW

August 20, 2020

If the NJBPU replicates their Round 1 guidelines in future OSW procurements, applicants will likely choose to pass the cost of onshore transmission upgrades directly to ratepayers by including only a small percentage of onshore transmission costs in their OREC prices.[21] By providing the option for applicants to defer transmission cost risks and "true-up" later, the NJBPU has chosen to assume a more difficult role in assessing the "best value" among future applicant pools. To compare applicants, the NJBPU needs a good understanding of how much it would cost to upgrade its most promising POIs to accept varying capacities of OSW.

We suggest that the NJBPU undertake a study of the existing transmission system and develop scenarios to identify where additional OSW capacity can be interconnected most efficiently to reach 7,500 MW of OSW capacity by 2035. ISO-NE recently published a study to this effect for the New England system.[22]

Based on our review of New Jersey's power plants and system topology, we suspect that significant transmission reinforcements and additional ancillary services will be needed to integrate thousands of megawatts of OSW. Recent well-intentioned but unsuccessful large-scale transmission projects have demonstrated that land-based grid limitations can be difficult to overcome,[23,24] and thus they deserve attention as an integral part of the offshore transmission discussion. If these upgrades are undertaken on a project-by-project basis, the outcome will be inefficient and more costly to ratepayers. System-wide planning would result in more strategic use of POIs and could allow for offshore transmission configurations other than radial interconnection.

4. OFFSHORE TRANSMISSION CONFIGURATIONS

The questions provided by Levitan & Associates to facilitate the information gathering meeting placed a clear emphasis on the choice between radial export cables or a networked ocean grid. We feel it would be better to evaluate the merits of a planned system versus an unplanned system. A planned system is likely to result in more strategic use of POIs and a mix of radial and networked interconnections. An unplanned system would be a continuation of the status quo, in which radial generator lead lines are proposed and installed one at a time.

4.1. Generator Lead Lines

There are risks associated with continuing the unplanned, status quo approach. Under the status quo, generator lead lines will continue to be developed in a radial fashion. If lessons from the New England lease areas are any indication, developers are likely to favor POIs near the coastline and close to their lease areas, rather than connecting directly to load centers that may be further away. In New England, developers have shown preference for interconnecting to nearby Cape Cod, with the Vineyard Wind, Mayflower Wind, and Park City Wind projects all slated to make landfall there.

This model of build-out benefits earlier projects rather than considering the bigger picture of how POIs are used and how the grid functions. Onshore transmission upgrades will likely occur only as needed to support a project, which could have the unfortunate outcome of the same site being revisited for major upgrades multiple times. Development in this fashion would waste ratepayer money and garner ill will from the public and host communities.

21 Levitan & Associates, Inc. "Evaluation of New Jersey Solicitation for ORECs for Offshore Wind Capacity Framework for Evaluation of Impacts: Public Version." Prepared for the New Jersey Board of Public Utilities. 21 Jun. 2019. Web. https://www.state.nj.us/bpu/pdf/boardorders/2019/20190621/6-21-19-8D%20-%20Public%20Version%20-%20Levitan%20NJ%20OREC%20Final%20Report.pdf

22 ISO New England Inc. "2019 Economic Study: Offshore Wind Integration." 20 Jun. 2020. Web. https://www.iso-ne.com/static-assets/documents/2020/06/2019_nescoe_economic_study_final.docx

23 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's regulatory and judicial bodies.

24 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.

Community engagement is a critical component of any transmission project, and if a community perceives an ad hoc approach being taken, objections are likely to compound.

4.2. Planned Approach to Establishing POIs

A planned approach to OSW transmission is likely to yield better financial, environmental, and social outcomes than the status quo methodology of relying exclusively on generator lead lines. Through a planned approach, the NJBPU can make strategic use of key POIs:

- New Jersey may wish to pursue a future OSW interconnection at the Salem-Hope Creek Nuclear Complex. The three units at the Salem and Hope Creek Generating Stations are licensed by the U.S. Nuclear Regulatory Commission (NRC) to operate until 2036, 2040, and 2046.[25] However, they are unlikely to remain financially viable for that long unless the NJBPU extends subsidies beyond the three-year bailout that was approved in 2019.[26] We recognize the nuclear plants provide New Jersey's baseload power, and OSW is a variable energy resource. The artificial island that hosts the nuclear plants may be a good location for OSW interconnection and accompanying storage facilities to help level the variability. With a new port facility planned for the island, a transition appears to be underway already.[27] Nevertheless, OSW developers are unlikely to pick the Salem-Hope Creek Complex as a first choice for interconnection due to a myriad of technical complexities.[28] If a planned approach is taken by the NJBPU, a partial or full transition from nuclear to OSW would become more viable.
- Another logical area for interconnection is the northeast corner of the state, which is a densely populated region with quite a few supporting power stations (see Figure 5). The lease areas near the southeast corner of New Jersey are unlikely to choose POIs this far north, although it may prove the most favorable option from the perspective of the land-based grid. Significant infrastructure is already in place, and consumers are close by, so few upgrades may be needed to support OSW integration.

With increasing competition for WEA capacity, New Jersey's future 1,200-MW procurements may be sourced from a few smaller projects. If a network of open-access offshore substations were already being built, developers would not be concerned with interconnecting to the onshore grid, since they would only have to go as far as the nearest public-access offshore platform. Such a configuration would make a procurement of multiple, smaller projects more financially viable. If it were built on a regional scale from New England to New Jersey, sourcing projects from more distant WEAs would not be a problem. With such an aggressive procurement target and limited suitable POIs, New York will face challenges of its own and may prove to be a willing collaborator.

4.3. Risks and Regulations for an Ocean Grid

The primary objections to an ocean grid approach are the risk of stranded assets and the lack of an established regulatory framework to facilitate its development. Stranded asset compensation is something that will need to be addressed, but it should not be a prohibitive hurdle. Early OSW projects are already poised to use generator lead lines, which will allow the industry to gain footing and confidence in U.S. markets before independent transmission

25 U.S. Nuclear Regulatory Commission. "Operating Nuclear Power Reactors." Accessed 22 Aug. 2020. Web. https://www.nrc.gov/info-finder/reactors/

26 NJ.com. "N.J. approves $300M nuclear bailout — and your utility bill just went up." 18 Apr. 2019. Web. https://www.nj.com/news/2019/04/nj-approves-300m-nuclear-bailout-and-your-utility-bill-just-went-up.html

27 NJ.com. "New port coming to South Jersey to support offshore wind power industry." 16 Jun. 2020. Web. https://www.nj.com/salem/2020/06/new-port-coming-to-south-jersey-to-support-offshore-wind-power-industry.html

28 One example is the potential for subsynchronous torsion interactions (SSTI) between new HVDC systems and the steam turbine-generator shafts operating at nuclear facilities.

is introduced. Different transmission models have been implemented across Europe, giving U.S. regulators plenty of examples to emulate and lessons to learn from.

The existing PJM tariff language related to merchant transmission needs to change in order for an ocean grid to be possible.[29] The existing frameworks for compensating new transmission, capacity, and ancillary services are all worth re-evaluating in the context of a carbon-neutral grid. Markets that worked successfully in an era of fossil fuel dominance may no longer be appropriate in the face of a massive shift to variable renewable resources. Although ISOs function on a regional level within their own borders, coordination across borders is far from seamless. Conversations about regional offshore transmission at the inter-ISO and Federal Energy Regulatory Commission (FERC) levels should be undertaken as early as possible to increase the likelihood for success.

We acknowledge the legal and regulatory complexities facing an ocean grid, but we do not find them to be compelling reasons to forego big-picture, regional thinking. We urge the NJBPU to consider the fact that a networked offshore grid will not develop organically under current frameworks. Inaction in this regard is tantamount to choosing a radial system in which PJM ratepayers are left footing the bill for onshore transmission upgrades that could have been mitigated or avoided with better foresight. Coordination across ISOs may not be an easy task, but the Neptune Project connecting Sayreville, New Jersey to Nassau County on Long Island is an example of a recent success.[30] The Neptune Project made use of high voltage direct current (HVDC) technology to provide up to 660 MW of capacity to Long Island.[30]

4.4. Transmission Technology

OSW developers have not yet opted to employ HVDC for their generator lead lines, but there are compelling reasons to choose it over high voltage alternating current (HVAC), particularly in a networked scenario. HVDC transmission provides less power loss per unit length than HVAC. While HVAC lines can be extended using midpoint reactive compensation to operate at comparable distances to HVDC, they also require additional platforms. Furthermore, networking OSW farms would be simpler with DC technology than with AC technology. AC components require synchronization and are susceptible to loop power flows, whereas DC power electronics allow for explicit control of power flow.[31]

HVDC cables can move more power to shore than their HVAC counterparts. Table 5 presents our current understanding of transmission technology limitations in PJM, bearing in mind that policy and technical limitations continue to evolve. A single HVDC cable can deliver more capacity than three HVAC cables. By channeling the generated power into fewer transmission corridors, the OSW industry could reduce impacts to the benthic environment, fisheries, and marine mammals by choosing HVDC. On the land side, a reduction in the number of export cables would likely translate to fewer landfall locations and less disruption to coastal communities.

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29 PJM. “Offshore Wind Development through the Interconnection Queue.” 16 Apr. 2019. Web. https://www.pjm.com/-/media/committees-groups/committees/pc/20190416-special/20190416-item-02-problem-statement-issue-charge.ashx

30 Neptune Regional Transmission System. Accessed 23 Aug. 2020. Web. https://neptunerts.com/

31 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.

Table 5: Offshore Transmission Technology and Installation Assumptions

Description	Value	Notes and Sources
Maximum HVDC line capacity	1,350 MW	PJM single-sourced contingency limits[32]
Maximum HVAC (345 kV) line capacity	400 MW	PJM Training Presentation[33]

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.

To realize the benefits associated with improved offshore and onshore transmission networks, northeast 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).

5. RECOMMENDATIONS

We urge the NJBPU to proceed with its plans to conduct a Wholesale Energy and Transmission Evaluation, as discussed in the New Jersey Offshore Wind Strategic Plan Draft.[34] We agree that the state needs to develop scenarios that look at how to get to 7,500 MW efficiently and economically. Further, we are pleased that the scenarios under consideration include a state ocean grid and a regional ocean grid. This work should proceed as quickly as possible.

While economic and power systems modeling is underway, we recommend parallel evaluation of existing regulatory and market frameworks at the state, ISO, and federal levels. A regional networked offshore grid will not develop organically under current frameworks, and as such, those frameworks must be changed. Regulatory decisions take time and require public buy in. A lot of the work to advance those conversations can be done before quantitative study results are complete.

As the NJBPU 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 frameworks.

32 Stefanowicz, Vince. “Real-Time Reserves.” PJM Operating Committee. 1 May 2018. Web. Slide 10. https://pjm.com/-/media/committees-groups/committees/oc/20180501/20180501-item-33-real-time-reserves.ashx

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

34 Ramboll US Corporation. “New Jersey Offshore Wind Strategic Plan Draft.” Prepared for New Jersey Board of Public Utilities and the Interagency Taskforce on Offshore Wind. 13 Jul. 2020. Web. https://www.nj.gov/bpu/pdf/Draft_NJ_OWSP_7-13-20_highres.pdf

6. CONTRIBUTORS

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Sean Murphy holds a B.S. in 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.

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