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Commissioner Nicholas Ucci
RI Office of Energy Resources
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Date:	March 1, 2021
Attn:	Commissioner Bailey, Director Burgess, Undersecretary Chang, Commissioner Dykes, Commissioner Tierney, and Commissioner Ucci
Subject:	Comments on New England States Technical Conferences on Transmission Planning

Dear Commissioner Bailey, Director Burgess, Undersecretary Chang, Commissioner Dykes, Commissioner Tierney, and Commissioner Ucci,

We submit these comments in response to the Transmission Planning Technical Forum held on February 2, 2021. For this response, we have assembled a team of Tufts University students and faculty with expertise in electrical engineering, civil engineering, environmental engineering, and energy policy to address questions related to long term transmission planning for offshore wind energy (OSW).

Best Regards,

Tufts Power Systems and Markets Research Group

Introduction

The Tufts University Power Systems and Markets research group provides public information on the global transition to renewables[1]. As a student-led team, our goal is to provide an impartial perspective on technical and policy considerations based on a long-term view of the energy transition. Our youngest contributor was born in 1999; that is to say, we have grown up learning about climate change. We know we will bear its impacts, and we recognize that it will be up to us deliver the energy transition by 2050.

The recent tragedies in Texas resulting from a deadly combination of vulnerable power infrastructure and extreme, climate-induced weather patterns are emblematic of the disasters we have grown up watching on the news. Wildfires in California, flooding in Texas, toxic algal blooms in Florida, and massive hurricanes and super-storms have become eerily commonplace as we witness, first-hand, the effects of climate change. We hear such events described as "historic" moments, only for events in the next year to surpass them in scale. We have come of age knowing that the future of our climate is uncertain, and that the decisions made by those in power will determine the course of the rest of our lives. With this in mind, we offer our perspective on and knowledge of offshore wind transmission in support of lasting commitments to decarbonize our energy system.

Our response is organized into a description of the OSW buildout, a summary of transmission on the East Coast, and thoughts on how to apply lessons from abroad to our own transmission planning. The key ideas in this report can be summarized as:

1. Onshore grid infrastructure must be deliberately prepared to incorporate the OSW supply.
2. Affordable and lasting offshore grid infrastructure requires a coordinated, networked approach. The project-by-project radial alternative is haphazard at best and does not represent any particular "virtue" of the open market.
3. Long-term transmission expansion planning (TEP) is essential to imagining and delivering the energy transition.

State commitments to procure OSW have increased at a rapid pace, and this young U.S. industry has entered a critical period where today's decisions will significantly affect tomorrow's outcomes. A carefully planned transmission approach will be required as states procure increasing amounts of OSW energy. As it stands, transmission planning for the OSW industry has received far less attention than project procurements. Clean energy development is essential to decarbonizing the East Coast, and the transmission grid will be the ultimate enabler of renewable energy deployment. In order to reach 2050, we must electrify our energy system. This means we must at least double, if not triple the capacity of our existing grid, while also improving its resilience.

[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.

The Status of Offshore Wind Buildout

Since 2016, offshore wind has become a mainstay of climate goals for several states. Not only can OSW push the New England Region towards a carbon neutral energy system, but the industry also has the potential to create economic development in New England that will last for decades. So far, states on the East Coast have procured 11,600 MW of OSW and committed to 29,810 MW in total. In New England, 3,160 MW of offshore wind has been procured. Another 2,200 MW will be procured by Massachusetts and Rhode Island by 2022. The summary of state commitments and procurements is shown in Table 1 below. These state commitments to OSW must be met by 2035[2].

Table 1: New England States Offshore Wind Commitments and Procurements[2]

State	Offshore Wind Capacity (MW)			Completed Procurements	Procurements Slated by 2022
	Committed [10]	Procured	Remaining		
Maine	12	12	0	*Aqua Ventus (12 MW)*	
Massachusetts	3,200	1,604	1,596	*Vineyard Wind (800 MW)* *Mayflower Wind (804 MW)*	1,600 MW [11]
Rhode Island	1,030	430	600	*Block Island (30 MW)* *Revolution Wind (400 MW)*	600 MW [12]
Connecticut	2,300	1,108	1,192	*Revolution Wind (304 MW)* *Park City Wind (804 MW)*	
New York	9,000	4,316	4,684	*South Fork Wind (130 MW)* *Sunrise Wind (880 MW)* *Empire Wind (816 MW)* *Empire Wind 2 (1,260 MW)* *Beacon Wind 1 (1,230 MW)*	
New Jersey	7,500	1,100	6,400	*Ocean Wind (1,100 MW)*	2,400 MW [13]
Maryland	1,568	368	1,200	*MarWin (248 MW)* *Skipjack (120 MW)*	1,200 MW [14]
Virginia	5,200	2,662	2,538	*CVOW Pilot (12 MW)* *Dominion (2,650 MW)*	
Total	**29,810 MW**	**11,600 MW**	**18,210 MW**	**11,600 MW**	**5,800 MW**

A further analysis of the ISO-NE queue (Figure 1) shows a rapid growth in requests for connection for offshore wind projects. In 2016, there were no OSW applications in the queue. By 2020, there were 11,600 MW of OSW, making up more than half of the total ISO-NE queue[2].

[2] Smith, Kelly, et al. OSPRE, 2021, *Offshore Wind Transmission and Grid Interconnection across U.S. Northeast Markets.*

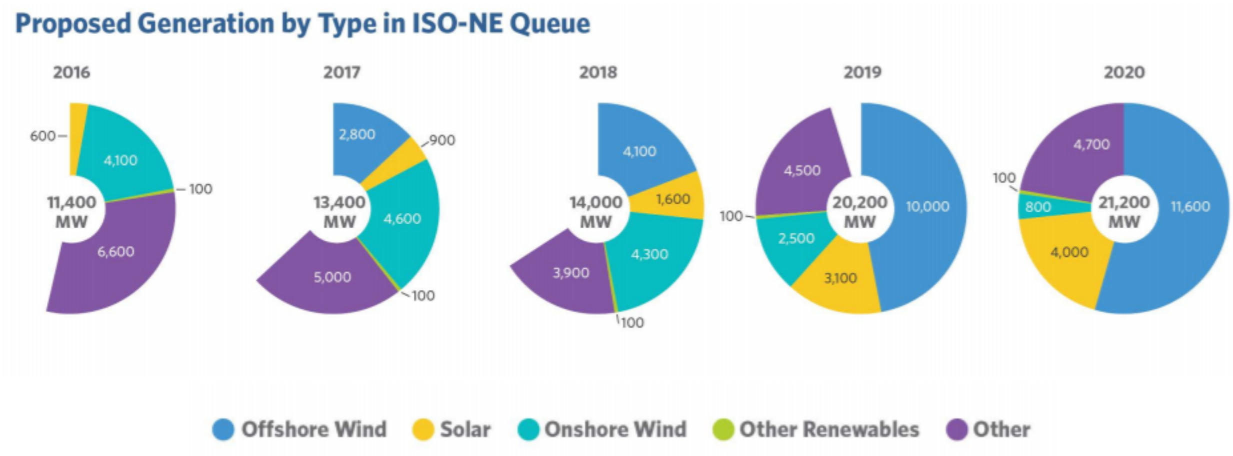


Figure 2: Interconnection Queues by Generation Types[2]

In addition to rapidly growing state commitments, the capacity of the offshore Massachusetts and Rhode Island Wind Energy Areas (WEAs) has grown as well due to larger turbines. A previous report published by the Power Systems and Markets research group at Tufts estimated the offshore wind buildout for the entire East Coast to be over 53,000 MW and 66,000 MW. This estimate assumed 12-MW turbines for the lower bound and 15-MW turbines for the upper bound. GE Haliade-X turbines can be rated for up to 14 MW and Vestas recently announced a 15 MW turbine, and there is no indication that the industry will cease to develop bigger and better turbines[3].

The pace of OSW development and planning is moving at a much faster rate than transmission planning and development in the region. A 2019 ISO-NE economic study indicated that up to 7,000 MW of OSW could be connected to the New England grid without major upgrades to the transmission infrastructure. This is significantly less than the 12,000 MW of capacity in the offshore Massachusetts and Rhode Island WEAs and the 50,000+ MW potential of the current BOEM lease areas. In order to maximize the potential for OSW generation, we must also understand the existing transmission grid. Thus, transmission expansion planning (TEP) studies of the on-shore transmission system with respect to the future OSW build-out are a vital part of the picture for OSW growth.

The Status of Transmission on the East Coast

In order to accommodate at least 30,000 MW of OSW power committed by East Coast states, the future electric grid will require both onshore and offshore upgrades. The sheer number of offshore procurements could easily overwhelm the transmission grid if there is no focus on long-term TEP for the energy transition.

[2] Smith, Kelly, et al. OSPRE, 2021, *Offshore Wind Transmission and Grid Interconnection across U.S. Northeast Markets.*

[3] Durakovic, Adnan. "Vestas Launches 15 MW Offshore Wind Turbine." *Offshore Wind,* 11 Feb. 2021, www.offshorewind.biz/2021/02/10/vestas-launches-15-mw-offshore-wind-turbine/.

Figure 2 shows the Northeast transmission grid. From this figure, we observe that there is a ring of 500 kV lines in New York and New Jersey, a pair of high-capacity conduits from Canada, and a network of 345 kV lines serving New England. A 345 kV line can connect power to the grid from a large offshore farm, but there are relatively few points of interconnection (POIs) along the coast. This is particularly true along the southern shore of Massachusetts, Rhode Island, and Connecticut, which would be the nearest place for New England OSW developers to connect their projects. Nevertheless, this relatively small POI capacity in New England still outstrips New York and NJ coastal POI capacity by a significant margin.

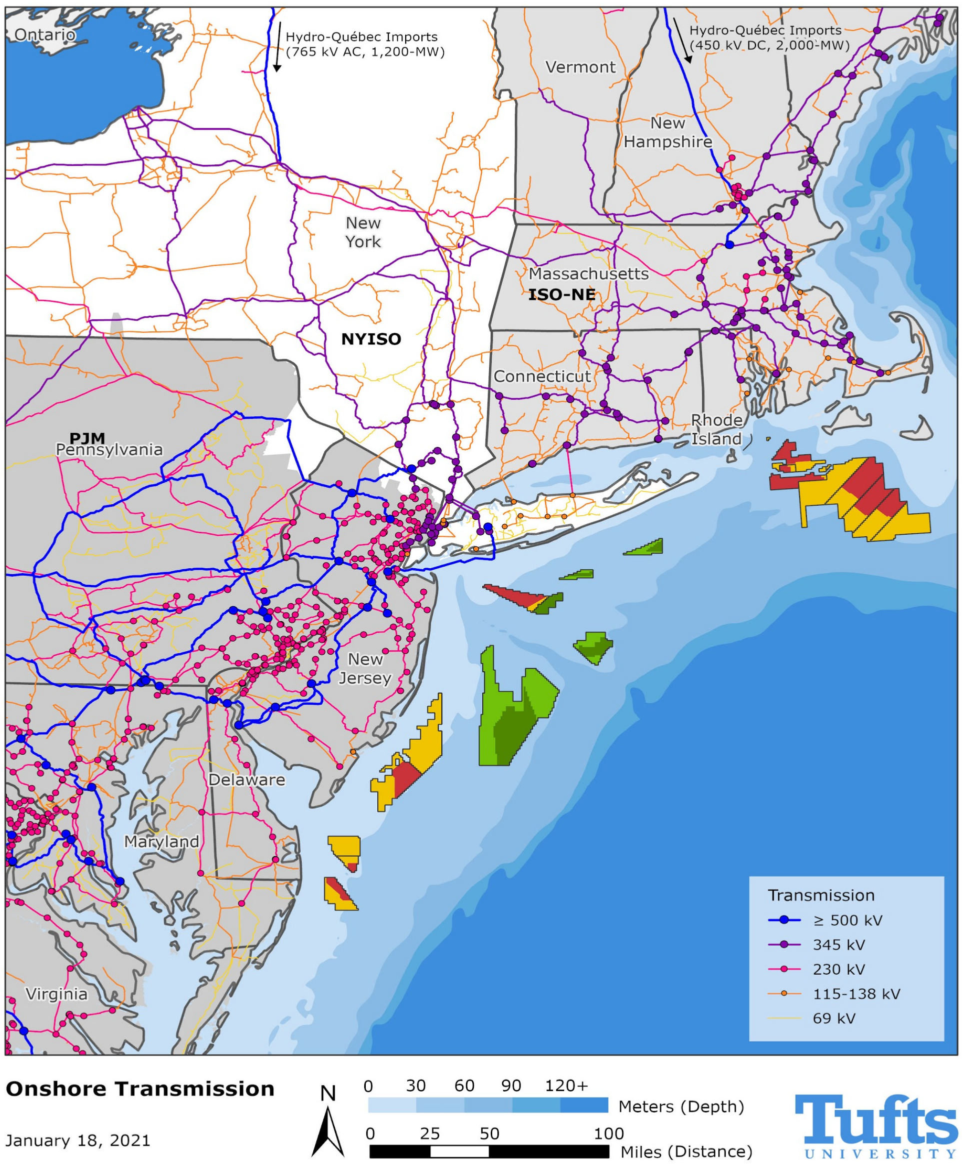


Figure 1: Regional Transmission Grid and RTOs

In 2019, ISO-NE published three economic studies, two of which examined offshore wind expansion in New England. As stated previously, the studies determined that up to 7,000 MW of offshore wind energy can be interconnected without major 345 kV reinforcements. Of those 7,000 MW, 5,800 MW can be connected to Southern Shore POIs and 1,200 MW can be connected to Mystic Station in Boston when the generator is retired[4]. This study also reveals an interesting feature of New England's transmission: OSW interconnection potential is not equally distributed throughout the states. Of the 7,000 MW, 5,200 MW can be connected in Massachusetts, 1,000 MW in Rhode Island, and 800 MW can be connected in Connecticut. This disparity is significant, as Massachusetts Undersecretary of Energy Judy Chang stated in the forum, Connecticut alone is anticipating 10,500 MW of OSW by 2040. Massachusetts has already procured 1,600 MW of OSW and aims to procure another 1,600 MW by 2022, which would allocate more than half of the easily available transmission capacity in the state.

To complicate the problem, there is no clear incentive for OSW developers to plan their transmission in a holistic way. The cost of upgrading transmission infrastructure falls on the generator that is seeking to connect to the grid. The transmission cost is therefore included in the levelized price per megawatt hour of a project. In order to keep transmission costs low, developers are incentivized to connect their projects to the most desirable coastal substations on a project-by-project basis. This will likely be the process for the next round of OSW procurements in Massachusetts, with the Request for Proposals to be issued this year. By including the cost of transmission in the levelized price per megawatt hour of an OSW bid, the state procurement process encourages developers to keep the project bid price low. Developers therefore work to avoid transmission upgrades and plan their connections to the nearest available POIs—which in Massachusetts are on Cape Cod. Once the easily accessible POIs have been selected for early projects, developers will have to connect further inland or pay for transmission system upgrades, likely driving up the cost of future OSW projects[5]. New England has already been faced with barriers to clean energy deployment, particularly in Maine, where five wind projects were abandoned due to excessive cost for necessary transmission upgrades[5]. In the future, ISO-NE must adapt their planning process to align with long term state policy goals for renewable energy. Currently, the ISO-NE Tariff authorizes the ISO to plan for reliability up to 10 years in the future[6]. This must change as part of the market overhaul required to deliver the energy transition.

Considering the size of the energy transition as a whole, OSW interconnections will clearly benefit from a planned, networked transmission approach. In 2020, the Brattle Group conducted a study on the benefits of a planned offshore transmission grid. Even in this near-term study, the authors determined that Cape Cod could face as much as $787 million in onshore transmission upgrades if already procured projects connect to the grid on a project-by-project basis. The study also found a planned transmission approach could lead to 49% less marine cables, 40% less transmission losses, and a 10% lower cost for total onshore and offshore transmission upgrades[5]. The recent National Grid study, *Offshore Coordination Phase 1 Final Report*, clearly shows the effects of

[4] ISO New England, 2020, *2019 Economic Study: Significant Offshore Wind Integration.*

[5] Pfeifenberger, Joh5annes, et al. The Brattle Group, 2020, *Offshore Transmission in New England: The Benefits of a Better Planned Grid.*

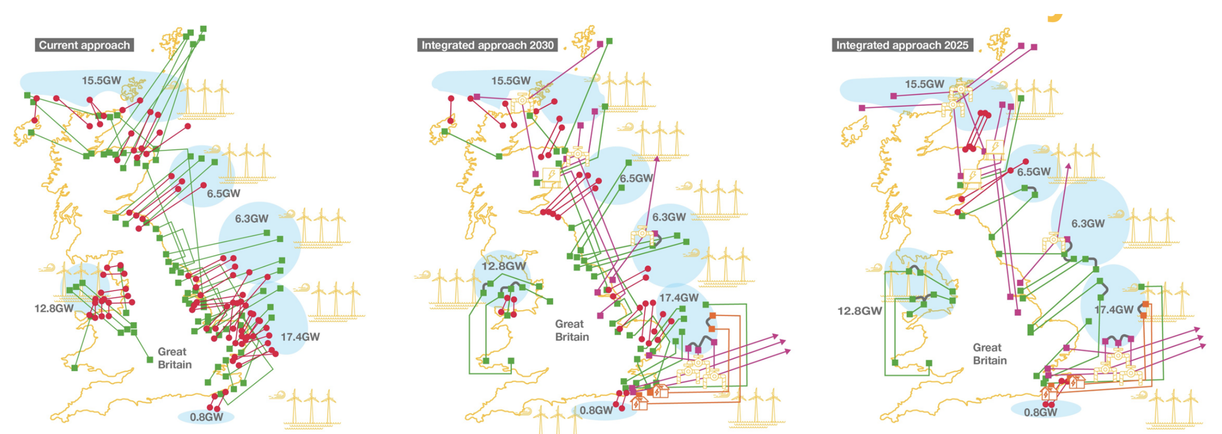
[6] "ISO New England Issues 10-Year Power System Plan for Region." 31 Oct. 2019.

continuing to connect OSW projects to the grid without proper planning. The United States would benefit from an in-depth study on the cost of offshore transmission as well as the cost of inactivity in regards to long-term transmission planning.

Lessons on Networked Planning Abroad

While offshore wind is a relatively new industry in the United States, it is well-established in the North Sea. New England can learn a lot from the experiences of European projects to date. As New England plans for the OSW build-out, we should pay close attention to the U.K. as they seek to implement a networked transmission approach.

We would like to use this opportunity to emphasize the importance of the work that Dr. Biljana Stojkovska and National Grid completed in developing the radial (or project by project) vs networked cost and asset allocation analysis. Figure 3 from Dr. Stojkovska's presentation is a compelling representation of the cost of delaying transmission planning, and the complicated, congested grid that could result. This figure makes two conclusions very clear: 1) the networked approach is more efficient both physically and financially; and 2) the sooner the transition starts, the larger the savings. Thus, the cost of not planning our offshore transmission network is greater than the cost of committing to long-term TEP now.



Capex Cost: £29 billion
Total Assets: 330
Total Landing points: 105

Capex Cost: £27 billion (-8%)
Total Assets: 40% reduction
Total Landing points: 60

Capex Cost: £23 billion (-18%)
Total Assets: 70% reduction
Total Landing points: 30

Figure 3: Radial vs Networked Approach to Offshore Wind in the UK[7]

Additionally, there are surprising geographic parallels between the U.K. and the U.S. East Coast. The scale of the two can be seen below in Figure 4, which shows a striking similarity in scale. This similarity makes it easy to imagine TEP studies for the East Coast that would serve as powerful tools in the discussion of networked U.S. OSW transmission. A study would aid

[7] National Grid ESO, 2020, *Offshore Coordination Phase 1 Final Report*, www.nationalgrideso.com/document/183031/download.

policymakers in understanding the drawbacks of letting OSW projects to continue interconnecting on a project-by-project basis.

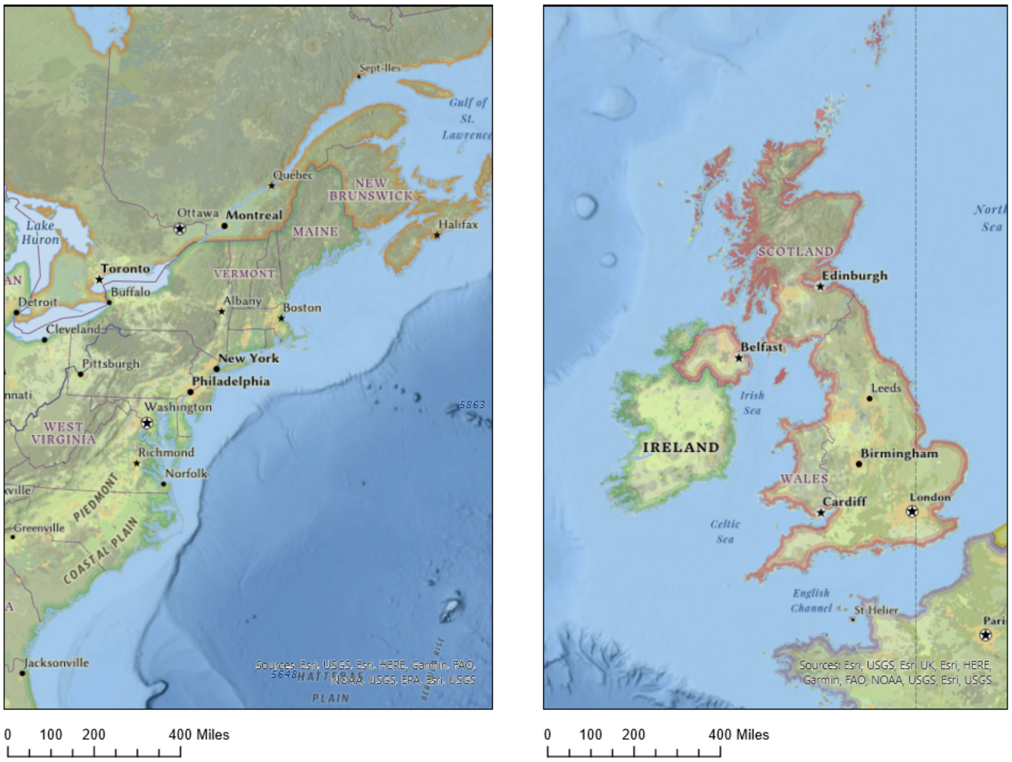


Figure 4: Size comparison of the UK and the East Coast

As we continue to develop tools for communicating the realities of the TEP challenge, we should look to developments across the Atlantic for guidance. Many of the technical challenges the Northeast will face have been studied by other nations around the world. Learning from the research of other countries could be the key to an efficient transmission solution. We believe that studies similar to the National Grid Great Britain study will be helpful to TEP considerations along the East Coast.

Conclusion

With 30 GW of OSW power planned for connection to the East Coast grid by 2035, significant transmission needs are on the horizon. In the absence of strong decision-making based on robust TEP scenario studies, early OSW developments will exhaust the existing POIs and leave later projects with no options but to upgrade our land-based grid significantly behind schedule. In order to support a smooth transition to renewable energy in New England and reach state renewable energy goals, a carefully planned transmission approach is required.

We recommend that New England study networked transmission approaches, which could reveal the potential to save money, reduce coastal impacts, and decrease the number of new substations required. As shown in the National Grid study, the cost savings and avoided infrastructure from pursuing a networked transmission approach are greater if the network is planned earlier. Thus, it is urgent that NESCOE begin working with offshore wind developers to ensure the preservation of coastal resources, on-time project development, and cost savings.

Contributors

Sophie Bredenkamp is in her final semester of an undergraduate degree in electrical engineering and economics at Tufts University. She has focused her undergraduate studies in power electronics and renewable energy, with a recent focus in energy markets and offshore wind.

Emma Edwardson is pursuing a Master's in Offshore Wind Energy Engineering at Tufts University, with an expected completion date of December 2021. Her studies have focused mainly on the status of the transmission grid for OSW development. Prior to her graduate studies, Emma received a B.S., with high distinction, in civil engineering from Worcester Polytechnic Institute. Emma has previous experience in the field of transmission, working as power delivery engineer at Black and Veatch and a transmission line engineer at Leidos.

Lauren Quickel is pursuing a Master's in Offshore Wind Energy Engineering at Tufts University, with an expected completion date of December 2021. She has worked with Emma, Rebecca, and Sophie on evaluating the transmission grid for OSW development since September 2020. Lauren is a consultant at Ramboll, working mainly on offshore wind ports, infrastructure, and supply chain assessments, and contributed to writing the New Jersey Offshore Wind Strategic Plan. She graduated summa cum laude from Tufts University in 2019 with a B.S. in Environmental Engineering.

Rebecca Wolf is pursuing a Master's in Offshore Wind Energy Engineering at Tufts University, with an expected completion date of December 2021. She received her B.S. in Engineering from Smith College in May of 2020 (virtually). Her focus is the integration of offshore wind energy into the grid, and has been working with Emma, Sophie, and Lauren on this project since last semester. She is passionate about decarbonizing the energy sector and diversifying the world's energy portfolio. She is currently a Programs Intern at the Tufts Institute of the Environment.

Eric Hines, Ph.D., P.E., directs the offshore wind energy graduate program at Tufts University, where he leads the Power Systems & Markets Research Group, with members from civil engineering, electrical engineering, and public policy. Dr. Hines has over 20 years of experience engineering innovative infrastructure. Major offshore wind related projects include the Wind Technology Testing Center in Charlestown, MA, the New Bedford Marine Commerce Terminal, the Partnership for Offshore Wind Energy Research (POWER-US), and the digital twinning work for the Block Island Wind Farm. He works at the technology/policy interface to develop systems-level design concepts and has received numerous awards for his work in industry-driven research. He studied engineering and public policy as an undergraduate at Princeton University and as a

Fulbright Fellow in Germany. He holds an M.S. in applied mechanics and a Ph.D. in structural engineering from the University of California, San Diego.

Barbara Kates-Garnick, Ph.D. is a professor of the 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.