2021

The State of Offshore Wind in Massachusetts

REPORT AND RECOMMENDATIONS

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I. Introduction

Massachusetts' Wind Potential

Offshore wind is a large and growing source of energy around the world and is poised for rapid growth in the United States. The technology has improved dramatically, with larger turbines generating much more power and turbines successfully being put much farther from shore and in much deeper water. New announcements promise still better designs, opening up even more area for possible deployment of offshore wind turbines. On top of this, the price of wind energy has plummeted making it competitive with other energy-producing sources[1] and the political climate has changed, opening the possibility that offshore-wind farms could turn the Northeast into America's next energy boom land. Experts in 2020 expected future onshore and offshore wind costs to decline 37–49 percent by 2050, resulting in costs 50 percent lower than predicted in 2015.[2]

Offshore wind is widely used in Europe and China and is being adopted elsewhere in the world. Global offshore wind capacity topped 27 GW by early 2020. Currently, the US. represents less than two-tenths of 1 percent of that capacity. The Biden administration announced a national goal of generating 30 gigawatts of electricity from offshore wind — equivalent to 30 coal-fired power plants — by 2030 as part of efforts to curb greenhouse emissions. If the nation were to reach that goal, it would give the U.S. the same capacity of offshore power over the next nine years that it took Europe 30 years to build.

Massachusetts is uniquely prepared to capitalize on the nation's emerging offshore wind industry and become the "Saudi Arabia of offshore wind." According to DOE's National Renewable Energy Laboratory (NREL), Massachusetts waters have the largest technical offshore wind potential of any state in the contiguous U.S. and has the technical potential to produce more than 1,000 terawatt-hours (TWh) of electricity from offshore wind.[3] The entire Atlantic region – from Maine to Florida – has the technical potential to produce almost 4,600 TWh.[4] The value of the seven initial lease areas awarded to offshore wind developers, representing 11,022 megawatts of potential offshore wind development, started low but rose dramatically over time as Legislatures set statutory targets and industry recognized that a viable U.S. offshore wind pipeline was beginning to take shape. In July 2013, the first two lease areas located in a mutual interest area of Massachusetts and Rhode Island sold for only $3,089,461, representing a potential of 2001 megawatts. The second two lease areas sold for even less in January 2015, selling for $448,171, despite representing over double the amount of potential megawatts at 4,302 megawatts. By the time BOEM auctioned off the third set of leases in December 2018, competition for leases has taken off. The three lease areas, with a potential for 4,719 megawatts, fetched a record price of $405 million. The map below shows the lease areas of Massachusetts, Rhode Island, New York, and Connecticut - located south of Martha's Vineyard – with their selected developers.

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[1] https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-140.pdf
[2] https://www.nature.com/articles/s41560-021-00810-z?utm_medium=affiliate&utm_source=commission_junction&utm_campaign=3_nsn6445_deeplink_PID100072647&utm_content=deeplink
[3] Offshore Wind Energy Resource Assessment for the United States, NREL (2016)
[4] Offshore Wind for America, Environment America (2021)

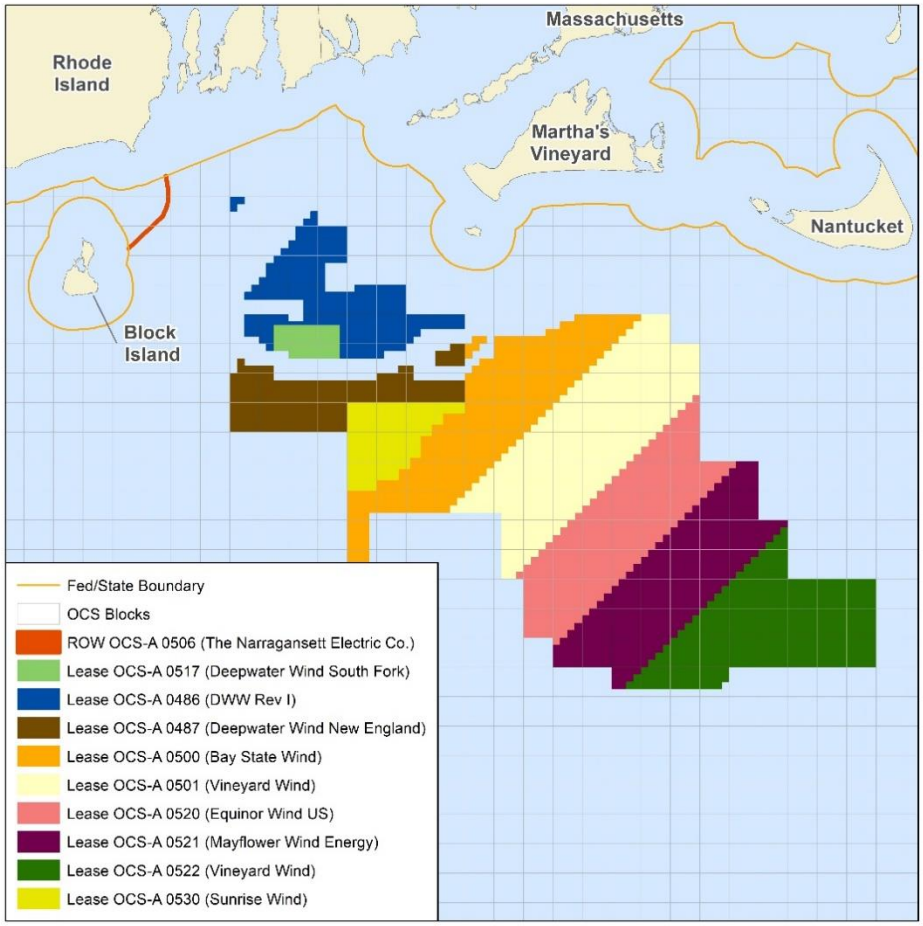


Figure 1. BOEM, 2019.

As a result of legislation passed by the Massachusetts Legislature, Massachusetts utilities will solicit proposals to contract for 5,600 megawatts of cost-effective offshore wind by 2027. The legislation is designed to result in the construction of multiple offshore wind projects off the coast of Massachusetts in the coming years. In addition to helping meet the Commonwealth's GHG emission reduction mandate and powering over one million Massachusetts homes, these first projects will bring significant economic opportunities for Massachusetts businesses while creating thousands of jobs. When Vineyard Wind is operational two years from now, 62 turbines will generate about 800 megawatts of electricity, enough to power 400,000 homes. The amount of carbon dioxide saved would be equivalent to taking 325,000 cars off the road in a year. The project will also generate 3,600 Full Time Equivalent (FTE) job years over the life of the project, including 500 union jobs highlighted at the signing of the nation's first offshore wind Project Labor Agreement on Friday, July 16, 2021 in New Bedford.[5] The Mayflower Wind project, with a commercial operation date in 2025, will reduce emissions that are the equivalent of taking

[5] https://www.wwlp.com/news/state-politics/pols-celebrate-union-labor-for-wind-project/

350,000 cars off the road in one year. It will also create up to 10,000 jobs with both onshore and offshore opportunities.[6]

The graphics below visualize the projected timelines of the Commonwealth's first 3+ offshore wind procurements. Projects from the first three solicitations, totaling 3200 MW, are anticipated to commence operation between 2023 and 2027. An additional 2400 MW has been authorized for procurement.

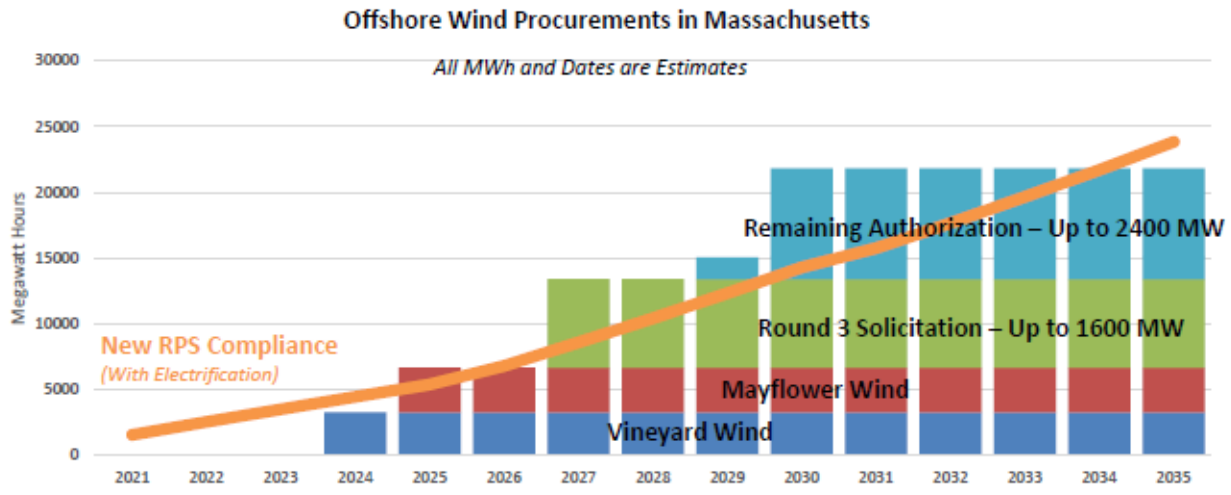


Figure 2: DOER, 2021

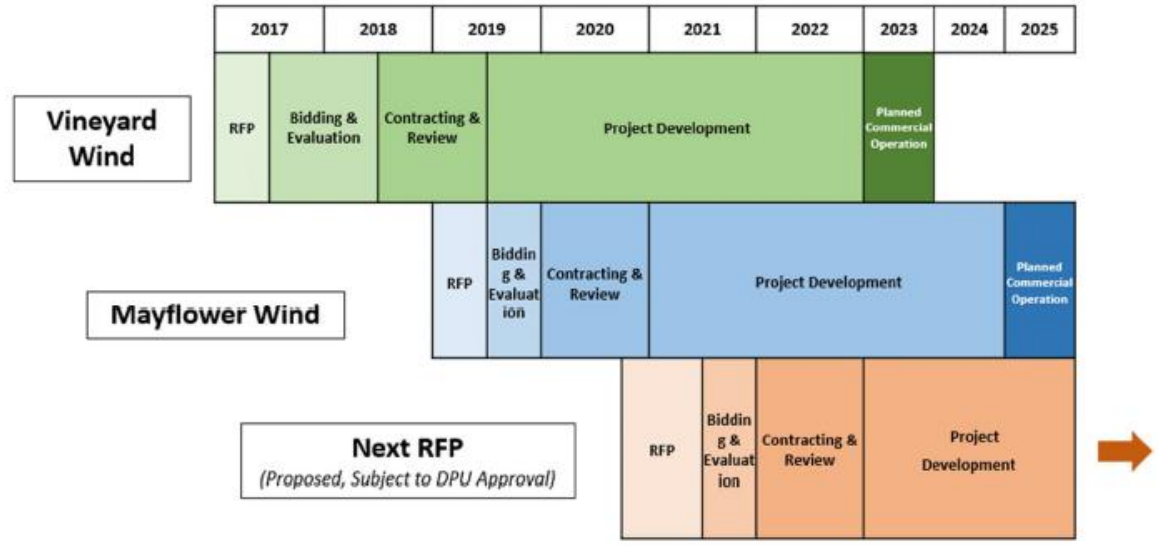


Figure 3: DOER, 2021

[6] Massachusetts selects mayflower wind energy's 804 MW low cost energy proposal | EDP Renováveis

And a new set of surveys is now underway at the Mayflower Wind site offshore Massachusetts, where a joint venture of Shell New Energies US and EDPR Offshore North America plans to build an 804 MW offshore wind farm.[7]

Opportunity

As the technology verges on mass nationwide adoption, the offshore wind industry presents a major economic opportunity for Massachusetts. The industry is both large and growing, with already more than 120,000 workers at over 500 U.S. companies by one estimate. By 2050, employment is seen reaching an estimated 600,000 jobs. Globally, the Global Wind Energy Council estimates that offshore wind today is only 2 percent of what the world needs to get to net zero by 2050.

In 2018, MassCEC released a report on the workforce needs and economic impact of the emerging offshore wind industry, finding that the deployment of the first 1,600 MW of offshore wind alone is estimated to support between 2,300 and 3,100 direct job years over the next ten years and generate a total economic impact in Massachusetts of between $678 to $805 million.

Federal directives are providing a clear lens into the exponential industry growth over the next few decades. In March, the US Departments of Interior (DOI), Energy (DOE), and Commerce (DOC) announced a shared goal to deploy 30 gigawatts of offshore wind by 2030. Meeting this target will trigger more than $12 billion per year in project investment and directly create more than 44,000 good-paying, union jobs by 2030 – with another nearly 33,000 additional jobs created in communities supported by offshore wind activity.

Meeting the target will also catalyze more than $500 million in port upgrade investments; the creation of one to two new U.S. factories for each major windfarm component including wind turbine nacelles, blades, towers, foundations, and subsea cables; and the construction of 4 to 6 specialized turbine installation vessels ($250-500 million each). [8]

Examining multiple scenarios of installation levels and domestic supply chain growth, the American Wind Energy Association anticipates between $28 – $57 billion of total investment in the U.S. economy between now and 2030. They project offshore wind project development, construction, and operations alone will support 45,000 to 83,000 jobs by 2030.[9]

Offshore wind energy has the potential to be the next high-tech industry in Massachusetts: “the new bio-tech.” Currently, the epicenter of wind energy innovation resides in Europe and the economic benefits of offshore wind in the U.S. has primarily focused on blue collar job growth. However, the Commonwealth has the intellectual and institutional resources to become a domestic powerhouse in the professional and engineering sides of the industry as well. Regardless, activity in the next few years

[7] https://www.offshorewind.biz/2021/07/20/subsea-surveys-underway-at-804-mw-wind-farm-site-offshore-massachusetts/

[8] https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/

[9] U.S. Offshore Wind Power Economic Impact Assessment, American Wind Energy Association (2020)

will be critical in determining how much of the economic benefits each state captures over the next few decades.

Commitments and Legislation to Date

Massachusetts has already made substantial strides as a first mover in the burgeoning industry. Over the past few years, the Commonwealth has committed to offshore wind projects and invested tens of millions of dollars into workforce, research, and supply chain development efforts.

Monies allocated or legislatively secured

1) MassCEC, in partnership with Vineyard Wind and Mayflower Wind, has awarded over **$2 million** in grants to Massachusetts institutions, labor unions, non-profit organizations, and businesses to support new offshore wind workforce training and development programs and projects in the Commonwealth. The purpose of these grants is to support the development of a skilled and capable workforce and to address identified gaps and needs for the new offshore wind industry. MassCEC provided $720,000 in awards towards workforce initiatives in 2019; $1.36 million in 2020; and will provide $1.6 million in 2021.
2) The *Next-Generation Roadmap* bill required DPU to direct **$12 million** annually by December 31 from the Mass Save budget to the Massachusetts Clean Energy Center to create a clean energy equity workforce and market development program. This program's purpose is to provide a pathway to working in clean energy for women and minority-owned small businesses, residents of environmental justice communities, and fossil fuel workers.
3) The FY22 budget includes
    - **$13 million** for the Offshore Wind Energy Career Training Trust Fund
    - Minimum **$120,000** to Greentown Labs to support ecosystem acceleration and offshore wind innovation, including pilot studies or prototyping
    - Minimum **$1 million** to EEA for grants to non-profit organizations to support offshore wind innovation and ecosystem acceleration and to support pilot studies or prototyping in offshore wind innovation in partnership with public higher education institutions or marine science non-profit organizations

Monies from Developers through the 83C Power Purchase Agreements

Vineyard Wind's 800-megawatt project plans to provide:

- A Community Benefits Agreement (CBA) to ensure that the economic and job benefits stay local, in Massachusetts
- **$10 million** - Wind Accelerator Fund to attract investment to upgrade and create facilities and infrastructure for developing offshore wind supply chains and businesses
- **$2 million** - Windward Workforce Program to recruit and train MA residents for offshore wind careers
- **$3 million** - Marine Mammals and Wind Fund to research and develop new technologies and methods to protect marine mammals potentially affected by offshore wind development

Mayflower Wind 804-megawatt project plans to provide:

- Mayflower Wind has entered into a Memorandum of Agreement establishing their intent to invest **$77.5 million** total towards economic development, including:
    - The creation of an Offshore Wind Development Fund and
    - $10 million for marine science and fisheries research
    - $7.5 million for port upgrades
    - $5 million for a low-income strategic electrification program

Legislation & Reports

An Act Relative to Green Jobs in the Commonwealth (Chapter 307 of the Acts of 2008)

In 2008, the Legislature passed the *Green Jobs Act*, which established the Massachusetts Clean Energy Center (MassCEC) in Chapter 23J of the General Laws. MassCEC – which began operating in 2009 – is a quasi-public agency funded via the Massachusetts Renewable Energy Trust Fund. The agency is dedicated to accelerating the growth of the clean energy sector across the Commonwealth to spur job creation, deliver statewide environmental benefits and to secure long-term economic growth for the people of Massachusetts. MassCEC – through investments, connections, and funding – works to increase the adoption of clean energy while driving down costs and delivering financial, environmental, and economic development benefits to energy users and utility customers across the state.

An Act to Promote Energy Diversity (Chapter 188 of the Acts of 2016)

In 2016, the Legislature voted to establish the framework for the largest procurement of clean energy in state history, including 1600 megawatts of offshore wind by 2027 and 9,450,000 million megawatt-hours of large-scale hydropower (equivalent: 1200 megawatts) by 2022. Following the precedent set by *An Act Relative to Green Communities* (Chapter 169 of the Acts of 2008) and *An Act Relative to Competitively Priced Electricity* (Chapter 209 of the Acts of 2012), the legislation required a competitive bidding process for these large clean energy projects. As a result, the state's first proposed offshore wind farm, an 800-megawatt project owned by Vineyard Wind, achieved pricing of 6.5 cents per kilowatt-hour. The state's second large-scale project, owned by Mayflower Wind, will deliver pricing of 5.8 cents per kilowatt-hour, subject to a further 10 percent reduction because of its qualification for the new federal Investment Tax Credit. Similarly, the state's large-scale hydropower project, the New England Clean Energy Connect, was secured at 5.9 cents per kilowatt-hour.

An Act to Advance Clean Energy (Chapter 227 of the Acts of 2018)

Building on the success of the *Energy Diversity* legislation, lawmakers again passed legislation in 2018 to further accelerate clean energy growth. In addition to creating a first-in-the-nation Clean Peak Standard and increasing the RPS to 35 percent by 2030, the Legislature authorized the state's energy agency, the Department of Energy Resources (DOER), to double the required amount of offshore wind to 3200 megawatts by 2035, if upon issuing a report to the legislature, it arrived at positive findings. The bill further authorized DOER to require the electric utility companies to solicit and procure proposals for cost-effective independent offshore wind transmission sufficient to support 1600 megawatts of offshore wind generation.

On May 31, 2019, DOER submitted a report to the Legislature and announced they would require the electric utilities to procure an additional 1600 megawatts, bringing the state's total to 3200 megawatts.

As part of the report, DOER stated its intention to convene a technical conference to determine whether they should exercise their newly-granted statutory authority to require the electric utility companies to procure independent offshore wind transmission sufficient to support 1600 megawatts of offshore wind generation. Following a stakeholder process in the winter/spring of 2020, DOER submitted their study results to the Legislature. The agency ultimately concluded that the costs and risks to ratepayers of independent transmission supporting 1600 megawatts outweighed the benefits. DOER did note strong stakeholder support for an independent approach to transmission for a larger capacity than 1600 megawatts and stated that it would support regional efforts to plan for additional transmission. (See *Transmission* for a discussion of the Baker-Polito Administration's engagement with other Governors through the New England Energy Vision regarding the need for a planned, regional approach to efficiently use existing transmission facilities and construct new facilities where necessary "to ensure the transmission grid's reliability, efficiency, and ability to integrate clean energy resources, consistent with certain States' legal requirements and other mandates.")[10]

FY 2020 Budget (Chapter 48 of the Acts of 2019)

Vineyard Wind's low prices vastly exceeded expectations and were over 65 percent lower than the previously proposed Cape Wind prices. This generated discussion among industry stakeholders and the House membership about whether future offshore wind projects could comply with the statutory requirement for the levelized price of energy and associated transmission costs of each procurement to be priced lower than the previous procurement. To address this concern, the Legislature temporarily modified the price cap requirement for proposals considered during the period of July 1, 2019 to July 1, 2020. Statute required DPU to adjust the price of any procurements in this timeframe based on the availability of federal tax credits, inflation, and incentives, and ensured that any mitigation efforts to create and foster employment and economic development in Massachusetts were not counted towards the levelized price.

The offshore wind solicitation during this time period was won by Mayflower Wind. Ultimately, the Mayflower Wind project delivered prices of 5.8 cents per kilowatt-hour, reduced even further by 10 percent because of its qualification for the federal Investment Tax Credit, satisfying the price cap requirement even though legislative action had temporarily suspended this requirement. Although Mayflower Wind was able to submit a project that was less expensive than Vineyard Wind, the price cap issue still warrants revisiting (see pages 40 and 94 in the report). This is partly because the new price to beat is even more stringent at 5.8 cents per megawatt-hour, and partly because of increasing costs as developers face more expensive onshore upgrades to interconnect to the power grid and more frequent use of costly HVDC transmission cables to accommodate longer transmission runs to shore. The pricing achieved in the 83C III RFP will provide helpful information in reevaluating the price cap but shouldn't be relied upon as the ultimate factor in whether the price cap should be kept or repealed. That is because the 83C III RFP, like the RFPs before it, are designed to primarily achieve low prices rather than facilitate robust, local economic development or make longer-term transmission investments feasible.

[10] New England Energy Vision Statement ~ Report to the Governors: Advancing the Vision, p. 10 - 14

FY20, FY21 Budget, and FY22 Budget (Offshore Wind Port Infrastructure Status)

In the FY20, FY21, and FY 22 Budgets, the Legislature has required the Executive Office of Energy & Environmental Affairs in line item 2000-0101 to submit a report detailing the status of the secretariat's efforts to enhance port infrastructure for the development of offshore wind. This report(s) is required to be submitted to the House and Senate Committee on Ways & Means; the House and Senate Committees on Global Warming and Climate Change; the Joint Committee on Transportation; and the Joint Committee on Telecommunications. Although the FY20 budget did not include a submission deadline, the FY21 budget set a deadline of December 30, 2020, and the FY22 budget has set a deadline of December 30, 2021. To date, EEA has failed to submit a report in compliance with the FY20 or FY21 budget.

FY22 Budget

The FY22 Budget contains a number of significant initiatives that propels Massachusetts forward in offshore wind workforce training, supports ecosystem acceleration and innovation, authorizes the Fall River and New Bedford State Piers to be subleased for offshore wind activities, and reaffirms the state's commitment to its bold 5600-megawatt target.

The initiatives include the following:

- $13 million to create an Offshore Wind Energy Career Training Trust Fund to be administered by MassCEC (Outside Sections 11 and 105). These funds will provide:
  - Basic Safety and Technical Training Programs via grants to public higher ed institutions and vocational technical schools
  - Professional Certificate Programs and Courses for offshore wind careers via grants to public higher ed institutions and vocational technical schools
  - Internship Programs to support education and training for offshore wind careers via grants to adult and community service-learning providers, labor organizations, public higher ed institutions, and vocational technical schools
  - Regional Strategy for Workforce Development via grants to regional employment boards
  - Leveraging funds to secure future federal funding support
- Not less than $120,000 to Greentown Labs to support ecosystem acceleration and offshore wind innovation, including pilot studies or prototyping (7008-1116)
- Not less than $1 million to EEA for grants to non-profit organizations to support offshore wind innovation and ecosystem acceleration and to support pilot studies or prototyping in offshore wind innovation in partnership with public higher education institutions or marine science non-profit organizations (2000-0100)
- Authorizes (Outside Section 73) a lessee of the Fall River State Pier to sublease all or a portion of the pier to support offshore wind development and operations and authorizes a lessee of the New Bedford State Pier to sublease up to 20 percent of the pier for the same purposes.
- Clarifying amendment that preserves the legislative intent of procuring 5,600 megawatts of offshore wind, and nothing less (Outside Section 69 and 72).

- The *Next-Generation Roadmap* bill added 2400 megawatts of required offshore wind procurements to previous amounts required in 2016 (1600 megawatts) and authorized in 2018 (an additional 1600 megawatts[11]), for a total of 5600 megawatts. On multiple occasions, however, Governor Baker's Administration summarized the offshore wind provisions in the *Next-Generation Roadmap* bill as having increased the total amount of offshore wind required or authorized in Massachusetts to 4000 megawatts rather than 5600 megawatts.[12] In response to a House TUE inquiry, the Administration stated that the additional 1600 megawatts, authorized by the 2018 law, should be restudied by DOER to determine if it was still beneficial to ratepayers in light of the Climate bill's recent increase to offshore wind.
- As a result, the House included a provision to strike language from *An Act to Advance Clean Energy* to remove ambiguity about whether DOER could reconsider the ratepayer costs and benefits of requiring 1600 megawatts of offshore wind in light of the newly required offshore wind capacity per Chapter 8 of the Acts of 2021.
- The amendment further cements our progress towards achieving this by reinforcing a timeline. It accelerates the requirement for the 1600 megawatts to be contracted from 2035 to 2027 so that all 5,600 megawatts must be contracted for by 2027 – a date that we are on course to meet and cannot afford to delay.

An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy (Chapter 8 of the Acts of 2021)

On March 26, 2021, Governor Baker signed the Next-Generation Roadmap bill into law, preceded by the extraordinary commitment of Speaker Mariano and Senate President Spilka to pass climate legislation after a late-session pocket veto of the conference committee legislation from the previous session. The Next-Generation Roadmap bill advanced key provisions related to offshore wind, including:

- An increase in the amount of offshore wind required by the 83C statute from 1600 to 4000 megawatts, for a total of 5600 megawatts when combined with the 2018 energy law (reaffirmed and clarified by the FY22 budget, outside section numbers 69 and 72)
- An increased emphasis on economic development by adding Secretary of Housing & Economic Development to the process of reviewing offshore wind proposals.
- Authorization for DOER to require distribution companies to competitively solicit for cost-effective offshore wind energy transmission to deliver offshore wind power to shore.

These provisions are significant for providing long-term visibility for the offshore wind industry as Massachusetts takes steps to develop a premier offshore wind workforce and capture significant portions of the offshore wind supply chain. In addition, the authorization for independent offshore wind transmission is significant, because it is now based on 5600 megawatts, rather than only 1600

[11] Subject to a DOER study completed on May 31, 2019 with positive findings, see page 8.

[12] Governor Baker's veto letter from February 7, the Baker-Polito press release on the bill signing day (March 26), and an April 6 presentation by EEA to House TUE members all refer to the *Next-Generation Roadmap* bill as increasing the Commonwealth's total authorization to 4000 megawatts.

megawatts (per *An Act to Advance Clean Energy*). DOER stated in its 2020 offshore wind transmission study that there was significant stakeholder support for long-term and large-scale transmission planning to accommodate the expansion of offshore wind beyond 1600 megawatts. While DOER also stated their preference to work regionally with stakeholders to build out a larger amount of transmission capacity, it also has in its toolkit authorization to build out transmission as a standalone state.

Massachusetts Strengths

In total, **Massachusetts' ports** boast 18 large industrial sites with waterfront access that have the potential to serve as part of a Massachusetts supply chain. They include former coastal power plant properties, former shipyard facilities, and industrial and marine industrial facilities. Located within 100 nautical miles of over 5 GW of potential offshore wind farm development, the ports of Massachusetts represent the ideal place from which to launch the supply chain to serve the industry. A range of supply chain manufacturers interested in participating in the offshore wind industry will want to locate in close proximity to where project staging and deployment will occur.

The **New Bedford Marine Commerce** terminal is the only multi-purpose facility in North America designed to support the construction, assembly, and deployment of offshore wind projects, as well as handle bulk, break-bulk, container shipping and large specialty marine cargo. In August 2020, the Commonwealth signed lease agreements with Vineyard Wind and Mayflower Wind to utilize the New Bedford Marine Commerce Terminal as the primary staging and deployment base for the construction and installation of their offshore wind projects located in federal waters south of Martha's Vineyard. The lease agreements commit the facility to full-time offshore wind work from 2023 into 2027 and are worth more than $32.5 million.

The **Charlestown Testing Facility** in Charlestown offers a full suite of certification tests for turbine blades up to 90 meters in length. The most modern wind turbine, the GE Haliade X, measures 107 meters in length. The testing facility, however, was able to test the Haliade X blade, thanks to a U.S. Department of Energy announcement on October 22, 2019 regarding a slate of awards to support wind energy research, development, and demonstration projects, which included a grant to MassCEC for equipment upgrades at the WTTC to enable structural testing of 85- to 120-meter-long blades.

Massachusetts' **higher education** boasts some of the finest public and private colleges and universities in the world. And higher education, both private and public, is quintessential to Massachusetts. The colleges here are the envy of the world and are tremendous assets for our Commonwealth. The intellectual, economic, social, and civic prosperity of our state is highly dependent upon the existence and expansion of a highly educated citizenry and an excellent system of higher education that will provide our citizens with transformative educational opportunities and also serve as the anchor of a robust workforce development system.

Our higher education institutions have a long track record of leadership in research regarding wind energy, the ocean environment, infrastructure planning, and public policy. The thought leadership, engineering innovation, and workforce education provided by our higher education institutions is

critical, especially because the European offshore wind industry has been well-established from decades of experience.

Our institutions haven't wasted time in forming strategic partnerships to leverage their combined strengths in this sector. Only one month after the *Energy Diversity* Act was signed into law in August 2016, MassCEC awarded a capacity-building grant to the UMass System, Northeastern, Tufts, and the Woods Hole Oceanographic Institution to become the **Massachusetts Research Partnership in Offshore Wind** (MRP). The MRP in turn formed **POWER-US** with the goal of developing cohesive strategies, with support from MassCEC, for national innovation in offshore wind energy. In addition to these partnerships, Bristol Community College, UMass Dartmouth, and Mass Maritime Academy have partnered in **Connect4Wind** to create a vibrant industry that compliments existing fishing and industrial uses of the New Bedford port. Bristol Community College is establishing the **National Offshore Wind Institute (NOWI)**, which will provide internationally recognized GWO (Global Wind Organization) training, required safety training, and other training programs specific to the offshore wind industry. Bristol Community College, UMass Dartmouth, Roger Williams University are participating in the **New Bedford Ocean Cluster**, which aims to "leverage New Bedford's coastal position, marine knowledge base, and landside capacity to drive employment and wealth creation in Greater New Bedford."[13]

The Commonwealth is also fortunate to have several institutions with strengths in innovation and research and development in this sector, including the **UMass Amherst Wind Energy Center**, which conducts multidisciplinary research and education spans the fields of engineering, ecology, public policy, and planning; and **WindSTAR** at UMass Lowell, a wind energy science, technology, and research industry-university cooperative research center.

Our institutions can contribute to strategic development of local labor markets, provide the research to tackle real-life problems, help develop a supply chain that is more suitable for our environment, provide rigorous and disinterested scholarship to both the private and public sectors to think deeply about the decisions they face, and provide assistance on a whole host of other issues.[14]

II. Workforce Development

Background

Workforce Needs

In the 2018 MassCEC Workforce Study, the project team utilized NREL's JEDI OSW model to estimate the number of jobs resulting from the planning, construction, and operation and maintenance of 1,600 MW of OSW.[15] The report estimates that planning and construction activity will generate 2,279 and 3,171 direct job-years, supporting a total of 6,878 to 9,852 job-years when accounting for indirect and induced impacts. The report further estimates a total of 140 to 256 direct jobs will be generated and sustained

[13] https://newbedfordoceancluster.org/the-new-bedford-ocean-cluster-announces-its-incorporation/
[14] https://nebhe.org/journal/new-england-energy-market-and-higher-ed-look-to-catch-a-second-wind/
[15] The team assumed that there would be four 400 MW installations staggered every two years to maintain a manageable number of projects.

annually over the 20- to 25- year life of the wind farms - 964 to 1,748 job-years when accounting for indirect and induced impacts.

A follow-up 2020 MassCEC study, completed by BW Research, identified 119 distinct occupations employed throughout the development of an offshore wind farm. Occupations were organized by phase of the offshore wind farm's lifecycle, as well as by occupational category:

Occupational Category	Number of Occupations
Admin & Finance	11
Construction & Assembly Workers	19
Consultants, Scientists & Researchers	8
Directors and Executives	4
Education	3
Engineers & Technicians	23
Legal & Permitting	3
Management	10
Maritime, Port & Aircraft Workers	5
PR and Marketing	4
Trade Worker	24
Transport & Logistics	5

GWO has estimated projects currently in the pipeline along the East Coast – 9.1 GW by 2025 – will require over 25,000 people to receive entry-level offshore wind training over the next five years.[16]

MassCEC's 2020 study also organized the occupations by phase of the offshore wind cycle:

Planning and Development

- at least two years, typically longer, depending on the project
- two percent of lifetime costs
- 15 percent of the direct workforce addition of a United States offshore wind industry
- MassCEC identifies 47 occupations within this phase, including engineers, financial analysts, and lawyers

Manufacturing and Assembly

- multiple years - though OSW original equipment manufacturers (OEMs) will likely be involved in supplying multiple projects/orders at once
- 44 percent of lifetime costs
- 7 percent of workforce addition
- 75 occupations, including engineers, metal workers, assemblers, and administrative staff

Construction and Installation

- two to five years

[16] https://www.offshorewind.biz/2021/08/26/gwo-us-needs-to-train-25000-offshore-wind-workers-to-build-9-1-gw-by-2025%E2%80%AF%E2%80%AF/

- 12 percent of lifetime costs
- 41 percent of workforce addition
- 68 occupations, including crane operators, electricians, line workers, and welders

Operations and Maintenance

- 20 years or more (depending on lease and energy agreements)
- 40 percent of lifetime costs
- 17 percent of workforce addition
- 59 occupations, including administrative staff, wind turbine technicians, marine operators, and plant managers

Support Services

- occur during all phases, with involvement lasting months or years depending upon the project
- 20 percent of workforce addition
- 39 occupations, including meteorologists, vessel mechanics, lawyers, and policy experts

Educational Needs

The 2020 MassCEC Report examined the state's occupational training programs and current labor levels. Massachusetts' workforce strengths include management and engineering professionals, as well as maritime workers. The state has insufficient availability of construction laborers, transportation workers, and general maintenance workers.

The study then juxtaposed the Commonwealth's available workforce with the needed workforce to fulfill the proposed offshore wind projects.[17] The resulting occupational workforce gaps – the difference between needed and available workforce – were identified as either significant, moderate, or nonexistent. The study found that the Commonwealth is most prepared to meet Science, Engineering, Management, and Maritime needs, while least prepared to meet Construction & Assembly needs. Trades occupations were found to have mostly moderate workforce gaps.

Page 11 of the study identified educational requirements for all offshore wind occupations. The following distribution organizes the occupational requirements by intensity level:[18]

Education Level	Share of Occupations
Entry-Level	52 percent
Mid-Level	38 percent
Advanced-Level	10 percent

For a list of common industry certifications, see Appendix D.

[17] The report examined the available workforce during Q4 of 2019, prior to the onset of the global pandemic.
[18] Entry-Level includes high school diplomas, associate degrees, and apprenticeships; Mid-Level includes bachelor's degrees; and Advanced-Level includes master's and doctoral degrees.

Current Workforce Development Programs

Education institutions and labor organizations – often with support from state funds – have been developing programs to directly prepare workers for the offshore wind industry. These workforce development programs have helped establish Massachusetts as a leader in offshore wind workforce development in the U.S. Between 2019 and 2020, MassCEC – with ongoing financial support from Vineyard Wind and Mayflower Wind – committed to $2.2 million in grants across to support new or expanded offshore wind workforce training and educational programs in the Commonwealth at twelve institutions, organizations, and companies. In July, MassCEC announced an additional $1.6 million in grants to eight Massachusetts organizations, with a focus on reducing barriers to job entry within the industry.

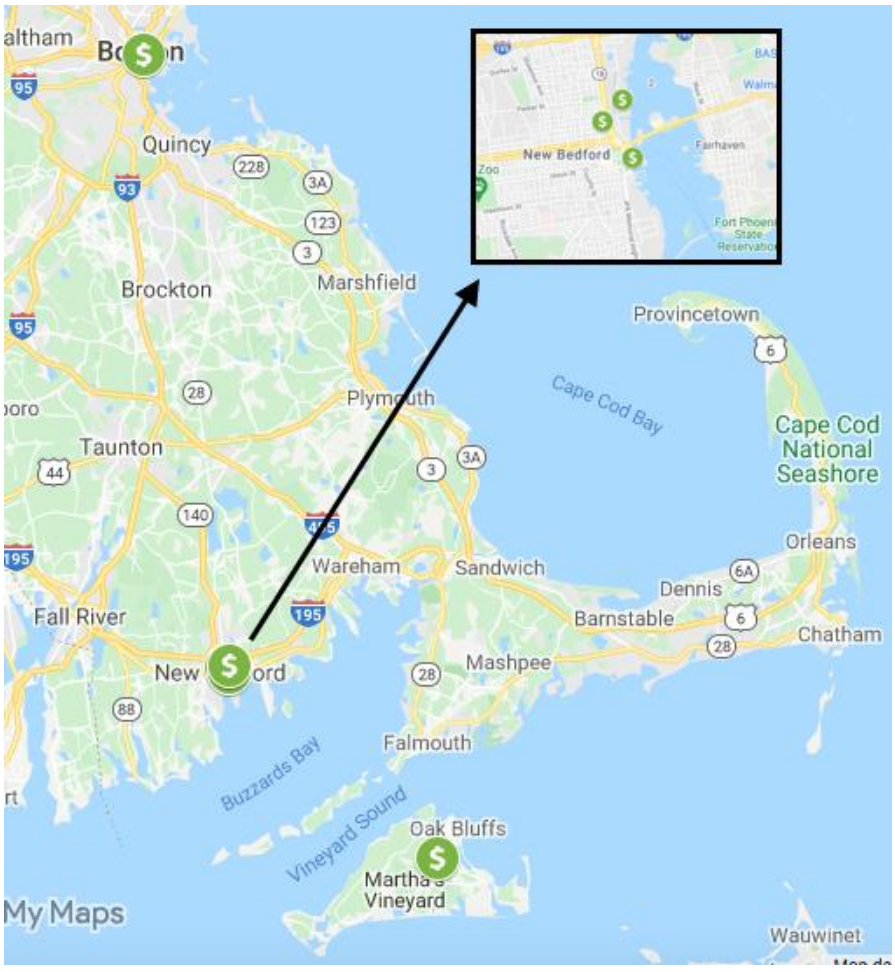


Figure 4: Existing workforce and economic development programs in Massachusetts.

Higher Education

Some higher education institutions across Massachusetts have already begun educating people in fields both directly and indirectly related to the offshore wind industry. As the OSW industry continues to

become more present in Massachusetts over the next few years, these programs will become more important to its successful growth. Below is a brief outline of the programs which currently exist related to the OSW industry. Many of the jobs to be created by the industry – including law, business, and other "soft" fields – are also in high supply in Massachusetts but require less industry focus.

Figure 5: Higher education institutions conducting offshore wind research and/or offering workforce training programs.

Benjamin Franklin Institute of Technology (BFIT)

In partnership with UMass Lowell, BFIT received a MassCEC grant to provide increased levels of financial and academic support to increase diversity in associate and bachelor's degree training programs for technician and engineering level positions in the offshore wind workforce. This project will focus on women, people of color, LGBTQIA+ communities, and recently incarcerated and released individuals convicted of low-level offenses.

Boston University (BU)

BU offers a program in Energy and The Environment and a variety of programs within their College of Engineering related to wind energy. Within the College of Engineering, multiple courses related to wind energy are offered, including Introduction to Clean energy Generation and Storage Technologies and Electric Energy Systems: Adapting to Renewable Resources. There are also some courses in other majors that touch on the topic of wind energy. For example, within the JD Law program, an Energy Law and Policy course is offered.

Bristol Community College (BCC)

Through funding from MassCEC, Bristol Community College offers an Associate in Science in Engineering Technology and Offshore Wind Power Technology. This degree includes multiple courses specifically related to wind energy, such as Wind Power Operations and Maintenance and Wind Industry Safety. BCC also offers its students a 28-credit academic certificate for offshore wind operations and maintenance technicians, as well as basic safety training and basic technical training. The safety training

and technical training are provided through BCC's National Offshore Wind Institute Program (NOWI). Developed as a partnership with Denmark-based Maersk Training, NOWI is currently renovating a former seafood packaging factory into a training facility – complete with house classrooms, obstacle courses, and a deep-water pool. The renovation is expected to cost about $5 million, while fitting it with training equipment will cost an additional $2 million, according to Jo Ann Bentley, the college's Associate Vice President of Administration and Facilities.

In partnership with other community organizations, including Old Bedford Village, BCC has recently received additional state funding to create a communication campaign and neighborhood outreach strategy supported by an asynchronous orientation to offshore wind course focused on entry into the sector to drive access to opportunities in the offshore wind sector. Priority groups for this initiative include residents of New Bedford, black and indigenous people of color, women, veterans, under- and unemployed, and workers seeking to transition into offshore wind from other industries.

Through additional recent funding, the Asian American Civic Association (AACA) will provide recruitment, transportation, and other wraparound services to help qualified individuals complete the Wind Turbine Technician Certificate. AACA will prioritize services to black and indigenous people of color, residents of environmental justice and gateway communities, immigrants, and returning ex-offenders.

Cape Cod Community College (CCCC)

CCCC offers an Associate in Science in Environmental Technology. While their program does not offer courses specifically related to offshore wind energy, the degree is nonetheless important to the development of the industry as a whole. Furthermore, CCCC has a stackable Sustainable Energy Certificate with some wind-related required courses, including, Renewable Energy, Climate & Careers, and Introduction to Wind Energy.

Greenfield Community College (GCC)

Greenfield Community College offers a variety of programs related to the OSW industry, including associate degrees in Renewable Energy/Energy Efficiency and Engineering Science. Within the Renewable Energy/Energy Efficiency program, one course, Fundamentals of Wind Energy, is specifically focused on wind energy. Through their Workforce Development and Community Education programs, GCC also offers a Fundamentals of Wind Energy Workshop.

Harvard University

Harvard offers a variety of degrees related to wind energy including Environmental Science and Public Policy, Sustainability degrees, as well as some engineering programs in partnership with MIT and so they share many of the same classes. Some courses directly relate to wind energy, such as Sustainable Energy; The Technology, Economics, and Public Policy of Renewable Energy; and Addressing the Global Climate Crisis: Challenges for Both Developed and Developing Economies.

Massachusetts Maritime Academy (Mass Maritime)

In partnership with Relyon Nutec and with financial support from the Massachusetts Clean Energy Center, Mass Maritime developed the nation's first 3-day course covering all five modules of Global

Wind Organization (GWO) Basic Safety training. To date, workers from Vineyard Wind, Ørsted, the Iron Workers union, the Pile Drivers and Divers Local 56 union have taken - or have plans to take - the training through Mass Maritime. GWO Basic Safety requires annual recertification, so the first class is due for recertification soon. Mass Maritime plans to expand their program offerings to potentially include examining the feasibility of helicopter transfer, vessel operator, and advanced rescue training.

The Massachusetts Clean Energy Center is sponsoring Local 56 members' participation with a $100,000 Workforce Development Grant. The North Atlantic States Carpenters Training Fund (NASCTF) has co-sponsored training with an addition $50,000. So far, 39 union members have graduated from the course, including three at the instructor level, and an additional 24 individuals are scheduled to participate in October and November.

The Academy is also developing a course designed to introduce cadets to offshore wind and potential careers in the industry. They separately offer an undergraduate degree in Energy Systems Engineering - though it currently does not include specific curricula on OSW.

In August 2021, Mass Maritime unveiled a $50 million renewable energy initiative, including the construction of an energy, engineering, and science laboratory building and a new conference center and hotel. Expected to open in 2024, the Maritime Center for Responsible Energy will contain an aquaculture facility, offshore wind technical training labs, and marine science labs for the academy's studies in fuel cells, tidal power generation, energy storage and offshore wind.

Massachusetts Institute of Technology (MIT)

MIT offers a wide array of Engineering degrees in fields such as Mechanical Engineering, Environmental Engineering, and Civil Engineering. Additionally, they offer a handful of classes directly related to wind energy. Such courses include, but are not limited to, Seakeeping of Ships and Offshore Energy Systems, Atmospheric Boundary Layer Flows and Wind Energy, and Politics of Energy and the Environment. Research on wind energy is also being conducted by various faculty members with the help of students. Finally, MIT is home to the MIT Wind Energy Club, which focuses on providing opportunities for MIT students to learn, educate and discuss advances in wind power through unique interaction with members of industry, government, community groups and academia.

Massasoit Community College (MCC)

MCC offers three Engineering Transfer degrees in the fields of Mechanical, Chemical, and Civil engineering. The program itself is modeled after the first two years of engineering program curriculum at institutions such as Northeastern University, Wentworth Institute of Technology, Worcester Polytechnic Institute (WPI) and the UMass system. No courses in any of these programs are specifically focused on wind energy. MCC is also a partner of Connect4Wind, working to develop training programs and engaging with industry and local stakeholders.

Lastly, MCC offers a one year, online, self-paced, Wind Energy Technician Career Prep course. Some topics in the career prep course include, but are not limited to, wind turbine blades, installing and troubleshooting wind turbines, motors, towers, and electrical coverage.

Mount Wachusett Community College (MWCC)

MWCC offers associate degree programs in both Earth/Environmental Science and Engineering & Physics. Their Energy Management degree includes courses, such as Renewable Energy Sources, related directly to wind energy. MWCC added two 1.65 MW wind turbines to their campus in March 2011 thanks to the Massachusetts Leading by Example Program initiated by Gov. Deval Patrick.

Northeastern University

Northeastern University has programs directly related to OSW, offering a Master of Science in Energy Systems and Master of Science in Environmental Engineering (also offered as a bachelor's degree). Within these programs, courses such as Wind Engineering and Wind Energy Systems relate directly to wind energy and its relevant technology. A Renewable Energy Graduate Certificate is also found under their list of programs, and includes one required course on wind energy, Wind Energy Systems. Approximately 200 graduate students - many of whom are international students - can be found in the Energy Systems program at any given time.

Northeast Maritime Institute

Northeast Maritime Institute offers a variety of online and on-site maritime training programs. Additionally, they received funding from MassCEC through the Gloucester Fishermen's Wives Development Program to work with the Massachusetts Fishermen's Partnership in order to recruit and pre-qualify commercial fishermen for enrollment in dedicated training and certification programs.

Tufts University

Tufts offers programs specifically related to offshore wind energy, including an M.S. program in Offshore Wind Energy Engineering and a Bachelor of Science in Civil and Environmental Engineering. Furthermore, Tufts offers Post-Baccalaureate Certificate in Offshore Wind Energy Engineering. Credits earned in the certificate program may be transferred to the MS and/or PhD program in Offshore Wind Energy Engineering. There are eight members listed as faculty for the Offshore Wind Energy Engineering program.

University of Massachusetts Amherst (UMass Amherst)

UMass Amherst offers an M.S. in Mechanical and Industrial Engineering with a Concentration in Wind Energy. Courses in this program include, but are not limited to, Engineering of Wind Power Systems, Offshore Wind Energy Engineering, and Fluid-Structure Interaction. A PhD program is being newly offered through the Energy Transition Institute. Approximately 15 members of faculty and 20 graduate students are working on topics related to wind energy. Wind energy classes are currently taught to about 120 undergraduate and graduate level students per year.

Though MassCEC funding, UMass Amherst's Clean Energy Extension developed and is now offering an interdisciplinary graduate-level Offshore Wind Professional Certificate program, consisting of three credit-bearing courses. In July, they received additional funding to develop a recruitment program through relationships with multiple university STEM programs. Recruitment will initially focus on black and indigenous people of color/ethnic minorities who are near-term or recent graduates. Subsequent recruitment will include veterans, individuals in Gateway Cities and Environmental Justice Communities, and indigenous populations, and women.

University of Massachusetts Boston (UMass Boston)

UMass Boston offers courses and degrees in topics related to, but not specifically focused on, offshore wind energy. Such courses include a Clean Energy and Sustainability minor and a Clean Energy and Sustainability Graduate Certificate.

University of Massachusetts Dartmouth (UMass Dartmouth)

UMass Dartmouth has multiple programs related to OSW. Such programs include, but are not limited to Civil Engineering BS, Civil and Environmental Engineering MS, Coastal and Ocean Administration, Electrical Engineering BS/MS/PhD, Marine Science and Technology MS/PhD, and Mechanical Engineering BS/MS. Within these programs, some courses related specifically to wind energy include Turbomachinery and Wind Power. Approximately 735 students were enrolled for the Spring 2021 semester in programs related to OSW, as identified by UMass Dartmouth faculty.

University of Massachusetts Lowell (UMass Lowell)

UMass Lowell offers programs in Energy Engineering, including both an MS program and a PhD program. Some courses offered which relate to wind energy include Fundamentals of Wind Energy and Alternative Energy Systems. About 10 graduate students are currently focused specifically on OSW. Additionally, UMass Lowell offers a Wind Energy Graduate Certificate and is planning to develop offshore wind pathways within existing undergraduate majors and graduate programs. The university also has plans to formally recognize student achievement in offshore wind activities.

Along with the BFIT, UMass Lowell recently received additional MassCEC funding to provide increased levels of financial and academic support for women, people of color, LGBTQIA+ communities, and recently incarcerated and released individuals convicted of low-level offenses.

Worcester Polytechnic Institute (WPI)

WPI has multiple engineering programs, including Mechanical Engineering, Civil Engineering, Environmental Engineering, and Environmental & Sustainability Studies. One graduate-level course, Renewable Energy, directly relates to wind energy while other courses are more generally related to the industry.

Additional Programs

Though they may not offer wind-specific curricula, Massachusetts is home to many additional higher education institutions with world-class engineering programs relevant to the offshore wind supply chain. The schools include, but are not limited to:

- Bard College at Simon's Rock
- Berkshire Community College
- Bunker Hill Community College
- Eastern Nazarene College
- Endicott College
- Holyoke Community College
- Merrimack College
- North Shore Community College

- Olin College of Engineering
- Quinsigamond Community College
- Roxbury Community College
- Smith College
- Springfield Technical Community College
- Suffolk University
- Wentworth Institute of Technology
- Western New England University
- Williams College

Non-Higher Education

A.I.S., Inc.

A.I.S., Inc. offers a program for Protected Species Observer training. PSOs are tasked with identifying and protecting species of concern in the world of marine construction; OSW is included in this construction. The registration cost to complete the virtual training is $495 per person. Training is currently being offered remotely due to COVID-19 and is a 3-day program. To qualify for the PSO training, individuals must provide a resume demonstrating an undergraduate degree in science or equivalent and field experience working with protected species.

Adult Continuing Education – Martha's Vineyard (ACE - MV)

Through MassCEC grant funding, ACE-MV offers a 2-year, part-time, 23 college-credit program to earn a Certificate of Recognition as an Offshore Wind Power Technician. This program is offered in partnership with Bristol Community College, who will issue the students' certificates.

Another round of MassCEC funding in July will be used to launch a 24-month diversity outreach project dedicated to increasing the numbers of women and girls in offshore wind training and education. The project scope includes a community-wide, multi-level promotion campaign, financial support for the Wind Technician Certificate, expanded high school science, technology, engineering and math (STEM) programming and listening sessions.

Building Pathways

Recent MassCEC funding will be used to support four 200+ hour Pre-Apprentice General Construction training programs to priority group participants for opportunities in the building trades industry with a focus on opportunities in the offshore wind industry. Target priority groups include women, black and indigenous people of color, veterans, disabled, disconnected or at-risk youth and LGBTQIA community. The organization has an ongoing relationship with IBEW #223.

International Brotherhood of Electrical Workers (Local Union #223)

In partnership with JDR Cables, Local Union #223 is working to establish a high voltage and fiber optic training program for skilled electricians at the IBEW's training facility. The project with JDR was funded by a grant from MassCEC and had a delayed start due to COVID-19. The program is expected to train about 60 people with five trainers. The union also offers other training related to OSW, including high voltage splicing, medium voltage splicing, and fiber optic splicing training. These trainings are available

to all members and there are about 500 members total in the union. GWO certificates are also offered through the union, and at least 20 people are being certified. The GWO certificates are intended for members to learn how to transition from being on a vessel to being on towers.

Self-Reliance

Self-Reliance, using MassCEC funding, is developing a 5-day, 40-hour experiential learning program – centered around the established KidWind curriculum – that introduces the offshore wind industry to K-12 educators and students in Gateway Communities.

VINCI-VR, Inc.

VINCI-VR, Inc. is working with Siemens Gamesa Renewable Energy to develop a virtual reality training wind turbine training simulation called Codex. Codex is the first ever to pass a Global Wind Organization (GWO) audit. Results from Codex's case study show 30 percent improvement in trainee performance, 90 percent reduction in Siemens' cost, and an overall reduction of on-the-job injuries. Also, trainees are able to practice up to three times more training repetitions with this new technology.

Xodus Group and Browning the Green Space

The organization are leveraging MassCEC funding to develop and conduct a workforce program designed to provide Priority Group members with insight on career opportunities in offshore wind. The program will include a targeted community and education engagement campaign that will deliver an overview of the offshore wind industry directed at high schools and community colleges in disadvantaged communities. Target groups include black and indigenous people of color, women, students in Chapter 74 vocational technical education programs, and unemployed and low-income individuals.

Regional Workforce Development Efforts

This section builds upon the findings detailed on pages 14-16 of MassCEC's 2020 Offshore Wind Workforce Assessment.

Rhode Island

Through funds from Ørsted and Eversource, Rhode Island has pledged $4.5 million towards OSW workforce development, including $1.5 million investment into Real Jobs Rhode Island (hosted by the state's Department of Labor and Training) and a $3 million investment to the University of Rhode Island (URI) for a combination of offshore wind workforce development and technical studies.

Real Jobs Rhode Island includes two efforts focused on OSW. The first, Wind Win RI, focuses on high school OSW instruction and provides an Offshore Wind Energy Certificate to students who complete courses on topics such as marine safety and engineering, first aid, and more. The program has already been successfully trialed at North Kingstown High School. Additionally, Real Jobs Rhode Island is offering incentive packages to attract out-of-state businesses to Rhode Island.

URI has also focused on two distinct workforce development efforts. First, the university created The Energy Fellows Program and second, they created a less intensive, interdisciplinary graduate certificate. The Energy Fellows Program is a 2-year program for both undergraduate and graduate students to gain practical experience in the renewable energy industry. All students are assigned to either state

government offices or various renewable energy businesses and complete 600 hours of experience working in the industry. The program has found great success thus far, with an 80 percent employment rate in the renewable energy industry for alumni coming right out of school.

Connecticut

Connecticut's Park City Wind project includes Vineyard Wind commitments to partner with Connecticut workforce development and educational institutions like Building Pathways CT, Career Resources Inc, and Survival Systems USA.

Building Pathways recruits women, veterans, and minorities into apprenticeship programs in the building trades and prepares them for successful apprenticeships. Career Resources Inc. is a pre-apprenticeship support program that focuses on providing basic resources to previously incarcerated individuals looking to reenter the workforce. Survival Systems is currently the only facility in the Northeast able to offer Helicopter Underwater Escape Training, required training for personnel transported to offshore wind farms via helicopter.

New York

As explained in Governor Cuomo's 2021 State of the State, a $20 million Offshore Wind Training Institute is being developed thanks to a joint effort by Stony Brook University and Farmingdale State College. The Institute will offer programs focused on research, professional services, and engineering.

Suffolk County Community College (SCCC) is in the process of developing the National Offshore Wind Training Center with a $10 million grant from the prospective Deepwater Wind Project. The Training Center will be a certified by GWO.

SUNY Maritime College launched the Center of Excellence for Offshore Energy with a $230,000 grant from the New York State Clean Energy Career Initiative, as part of the first phase of the state's Climate Jobs NY program. The Center will offer classroom and online training programs for wind operations, dynamic positioning and offshore vessel operations. It will also serve as a research resource for offshore renewable energy.

New Jersey

New Jersey is developing the Wind Innovation and New Development (WIND) Institute, which aims to be a "center for education, research, innovation, and workforce training for New Jersey and the Northeast/Mid-Atlantic region."[19]

The state has begun offering OSW programs, including the NJ Wind Turbine Training Technician Grant Challenge and the NJ Offshore Wind Safety Training Challenge. The Turbine Training Technician Challenge is a competitive grant program awarding up to $1 million to a New Jersey community college to establish an offshore wind turbine technician training program that includes an industry-recognized, credit-bearing certificate program and pathway to an Associate degree or higher. In July, Atlantic Cape Community College was announced as the winner of the Safety Training Challenge, a grant program

[19] https://www.nj.gov/governor/news/news/562020/20200422a.shtml

administered by the Office of the Secretary of Higher Education (OSHE) and the New Jersey Economic Development Authority. The $3 million prize – funded by the New Jersey Board of Public Utilities' Clean Energy Program – will be used to develop a GWO-certified training program and build a 1,700-square-foot facility to house the program at the college's Atlantic City campus, which will be open by 2022. Atlantic Cape is collaborating the city of Atlantic City, labor unions, chambers of commerce, Stockton University, and the Boys & Girls Club of Atlantic City.

Opportunities in Workforce Development

The 2020 MassCEC Workforce Development Report (p.23) identified three key populations for which in-state workforce training should be developed: "(1) incumbent workers, or those already in the workforce but who may require OSW-specific training; (2) workers in the training/education pipeline, or those that are currently enrolled in existing training programs; and (3) workers not currently employed or actively enrolled in education or training."

The study's recommendations – detailed on pages 23-28 of the report – are abbreviated and presented below.

Training for **incumbent workers** should be focused on upskilling occupations and providing additional safety and technical training/certificates in order for them to participate in the OSW industry.

- **Identify and offer developer and Tier I suppliers' expected workforce qualifications to prospective supply chain firms.** OSW developers and Tier I suppliers reported proper safety training as a key qualification for any potential supplier; however, specific qualifications will likely vary across firms. With industry-wide health and safety training required to be provided by all assembly, construction, and maintenance firms, MassCEC has an opportunity to reduce the burden on potential industry participants by directly connecting them with - and potentially funding - key certificate training programs.
- **Continue support for the creation of standardized professional requirements across the industry and heavily marketing skill expansion opportunities to the Massachusetts fishing community.** Navigation in ports and around wind turbines will require higher precision and thus more training than what has been typically expected of a general vessel worker in the past.
- **Explore the development of on-demand, virtual training facilities.** Developing virtual training facilities is a much cheaper option than building physical training facilities and could potentially reduce the risk of injury which is more common to on-site training centers.
- **Massachusetts should continue to serve as a leader in offering industry-recognized GWO Basic Safety Training programs.** Such programs are essential to the success of the industry's development, as all individuals working directly on the turbines are required to complete them.

Massachusetts has substantial **workers in the education pipeline**; the key will be introducing potential workers to the offshore wind industry and connecting them to employment opportunities.

- **Capitalize on Massachusetts' robust Vocational Technical High School programs by developing and encouraging the use of OSW curricula in key occupation degrees, as well as highlighting the Vocational Technical system in marketing and outreach to potential OSW firms.** With this

two-fold recommendation, workers will be connected to the OSW industry and vice versa while more students become trained and educated in areas of study directly related to OSW.

- **Massachusetts Colleges and universities, particularly the UMass system, should initiate a workforce development collaboration across the members of POWER-US.** The report recognized the current trend seen among institutions of higher education in Massachusetts to establish themselves as national leaders in educating offshore wind engineers and professionals. POWER-US|MA is an academic partnership of Massachusetts institutions seeking to develop cohesive strategies, with support from MassCEC, for national innovation in offshore wind energy. While POWER-US has lacked necessary resources to fully expand their efforts, their actively communicative, in-state research network (and vision for expansion) provides a valuable opportunity to the workforce development space.
- **Market MassCEC's Clean Energy Internship program to prospective workers and suppliers.** Marketing internship opportunities to students and professionals in the OSW industry may attract more professionals by funding paid opportunities for students to work with development, research, and supply chain firms.

For **occupations without the available workforce** to supply the proposed offshore wind industry projects, there are three options: (1) engage long-term unemployed workers, (2) recruit workers from outside of the state, or (3) expand recruitment and education efforts.

- **Work with a workforce board to (1) add initiatives aimed at the provision of transportation, housing, and other basic needs; and (2) expand pre-apprenticeship programming and marketing to provide low-cost, low-stakes apprenticeship exposure to priority communities.** Such recommendations focus on equity and opportunity for predominantly long-term unemployed individuals in priority communities. By supporting such individuals' basic needs and providing the necessary resources for them to reenter the workforce, the state can demonstrate its commitment to removing barriers to employment, particularly in identified priority communities.
- **Convene a regional OSW workforce development task force.** While some occupations may always be competitive geographically, occupations with more significant workforce gaps in various states may be better served being supplied by one or two states. This will not only save each state money compared to the current development of concurrent workforce development strategies but will also help the region as a whole remain competitive for supplier and developer locations.
- **Examine and communicate the long-term, transferable employment opportunities within and outside the OSW industry.** The OSW industry often requires large amounts of workers for relatively short periods of time. Thus, the report highlights the need to ensure that these workers have and know their value beyond the OSW industry. Marketing resources should communicate potential next employment steps to current and future OSW workers.

III. Innovation and Research & Development

UMass Amherst Wind Energy Center

The University of Massachusetts Amherst's Wind Energy Center (WEC) employs 13 faculty members across five different departments. Its multidisciplinary research and education spans the fields of engineering, ecology, public policy, and planning. The WEC has secured over $15 million in research funding since 2008 from institutions, companies, and agencies such as the National Science Foundation, the Bureau of Ocean and Energy Management, General Electric, the Department of Energy, the U.S. Fish and Wildlife Service, and the Massachusetts Clean Energy Center. The WEC's research and development focus areas include:

Turbine design and analysis

WEC faculty and graduate students use modeling software to better understand the behavior and to improve the design and operation of offshore wind turbines. These models include simulations to understand the aerodynamics and wakes of offshore wind farms, and multi-disciplinary wind turbine simulators to understand the reliability of offshore turbines. The goal is to provide insight for industry to develop more reliable and efficient turbines that lower cost of energy. The WEC has received $200K from MassCEC to study the application of offshore wind turbine design standard IEC to Massachusetts conditions, $93K from Convergent Science to create a simulation of wind turbines, and $250K from GE Renewables to study advanced structural damping of wind turbines.

Floating systems engineering

Floating offshore wind has become a focus of the WEC's research activity in the last decade. Areas of active work include the dynamics of platform motions, the behavior of wind turbine wakes in the offshore environment and novel mooring systems for a broad range of water depths that promise to significantly reduce cost and time of construction. The WEC has received $850K from the National Offshore Wind Research & Development Consortium to study innovative deep-water mooring systems for floating wind farms and $300K to study techno-economic mooring configuration and design for floating offshore wind turbines in shallow waters. The WEC is also participating in research funded by the NSF ($500K) to study mooring systems for floating offshore wind turbines.

Structural design and risk assessment/mitigation

The offshore environment poses significant challenges to successful and reliable structural design for wind energy generation, and the WEC is actively engaged in addressing those challenges. For example, the WEC has pioneered, along with collaborators at Northeastern, methods for hurricane and breaking wave risk assessment along the Atlantic Coast as well as adapting successful probabilistic design methods from civil engineering to offshore wind engineering. This research can identify and mitigate risk to offshore wind and provide regulators the tools to manage that risk. The WEC has received $150K in funding from BOEM/BSEE to study breaking wave loads on offshore wind turbines, $125K from MassCEC to study risk and decision-making for the hurricane threat to offshore wind farms. The WEC is also participating in research funded by the National Science Foundation ($325K) to study the reliability-based hurricane risk assessment for offshore wind farms.

Geotechnical and foundation engineering

Research has been conducted on fixed and floating systems including topics such as: the interaction of monopile foundations with the surrounding soil under storm loadings; anchor loads for novel shared anchor systems; new anchor types; and statistical models for offshore geotechnical conditions. WEC capabilities include advanced computational simulation of soil-structure and foundation systems, experimental characterization of soil properties and physical model testing of offshore foundations. The WEC has collaborated on research funded by the National Offshore Wind Research and Development Consortium ($800K) to study innovative anchoring systems for floating offshore wind, and on research funded by the National Science Foundation ($850K) to study novel and efficient seabed ring anchor for omnidirectional loading. The WEC has also received $200K from MassCEC to study geospatial modeling for efficiency and economy in site investigations and foundation design.

Transmission grid and market operations

WEC faculty and students research more efficient and reliable ways of incorporating renewable energy and in particular wind energy into the electricity grid. They study technical, environmental, operational and economic issues relating to the out lay of an ocean grid. The research teams strive to determine market regulations, incentive schemes and trade instruments that ensure economic efficiency, reliability and equitability in any electricity market with heavy penetration of renewable generation sources. The National Science Foundation has awarded the WEC with $2.75 million to study resiliency and equity in the transition to a sustainable energy future, and $3.55 million to study social and economic equity in the science and engineering of a sustainable energy transition.

Environmental and ecological modeling and assessment

WEC faculty and graduate students focus on three primary issues critical for development and operation of ocean energy systems, including: 1) ecological assessment of the positive and negative impacts of ocean energy systems on marine mammals, birds, bats, fish and other marine species; 2) development and evaluation of technologies and protocols for monitoring responses of marine organisms to ocean energy systems; and 3) potential to enhance habitats for marine organisms at ocean energy facilities. Using a unique blend of monitoring equipment, including radar, sonar, and underwater video and audio, combined with at-sea surveys and spatial modeling, the spatial and temporal patterns of marine organisms and their critical habitats are identified. These data are critical for siting ocean energy systems and meeting environmental regulatory review requirements. The WEC has received $2 million in funding from the National Science Foundation to support an interdisciplinary doctoral training program that focuses on engineering, environmental science and policy as they apply to renewable energy. The WEC has also received funding from BOEM/BSEE and the US Fish and Wildlife Service to support the abovementioned research.

Public policy and social acceptance

WEC faculty and graduate students focus their research on understanding the intersection of public acceptance and technological effectiveness for development and operation of ocean energy systems. This research considers how the public is engaged in the wind planning process, and how policy can impact public acceptance.

The WEC has received $6.3 million from the National Science Foundation to fund the Energy Transition and Equity Institute, which now offers a PhD program (the ELEVATE program) that trains students to solve technical, equity, and climate challenges in the energy transition. This innovative graduate STEM program focuses on resilience and social equity, stressing the importance of public, community, and stakeholder engagement to ensure the energy transition benefits everyone.

Greentown Labs

Greentown Labs is the largest climate technology incubator in North America. Its Somerville campus houses prototyping and wet lab space, shared office space, a machine shop, an electronic lab, and a curated suite of programs and resources. It currently provides space to more than 100 start-ups and has supported more than 300 since 2011. Greentown's mission is to provide entrepreneurs with the community, resources, and space they need to grow their climate tech businesses here in Massachusetts.

The entrepreneurs and start-ups that Greentown's resources are geared towards are the ones that will create the jobs of tomorrow. After the construction is done and the maintenance jobs are filled up, Massachusetts will still have the opportunity to continue growing and improving our local offshore wind ecosystem if we stay a step ahead and support technological innovation.

To that end, Greentown Labs is piloting the Offshore Wind Accelerator Program with Vineyard Wind and with the support of the Massachusetts Clean Energy Center. The program's goal is to match young, promising companies with bigger ones that are looking for innovation and have the resources to support it. Most recently, the accelerator program supported three start-ups – Open Ocean Robotics, Night Vision Technology Solutions, and SICDRONE – in re-locating to Massachusetts through the Accelerator's Offshore Wind Challenge. The start-ups worked with Vineyard Wind and Greentown Labs for six months and received mentoring, business training, and access to resources critical for advancing their technology and its commercial development, all the while working towards a clearly defined goal of improving technology for marine mammal monitoring. They were able to test and fine-tune their technologies in Massachusetts waters, and make the necessary business and R&D connections for their businesses to continue growing.

Power US

Power US is a Massachusetts research partnership focused on offshore wind. Participating institutions include UMass Amherst, UMass Boston, UMass Dartmouth, UMass Lowell, Bristol Community College, the Massachusetts Maritime Academy, Northeastern University, Tufts University, and Woods Hole Oceanographic Institution, among others. The group's research and development focus areas include:

Hurricane risk assessment

Mitigating hurricane risks ensures affordable offshore wind energy security. Therefore, Northeastern University, the National Science Foundation, MassCEC, Tufts University, and UMass Amherst are conducting research on improving hurricane risk assessments. This includes modeling impact loads from breaking waves and modeling several scenarios at once to see how a wind turbine is likely to withstand more than one hazard at once.

Structural health monitoring and structural control

UMass Lowell, the National Science Foundation, MassCEC, and WindSTAR are researching new technologies for safe and reliable monitoring of the structural health of wind turbines and turbine blades. UMass Lowell, for example, is developing drones that use digital camera technology to inspect turbine towers and blades. The technology has already been used to inspect bridges and railways.

UMass Amherst, General Electric, Glosten, NREL, MIT, DOE, and Texas Tech University are researching structural control devices that help reduce the cost of energy by absorbing and dissipating energy from the main wind turbine structure.

Design

- Design tools and standards: Northeastern University, Tufts University, and UMass Amherst have produced the design training, standards, and computational tools that enable the construction of offshore wind farms.
- System-level framework: Several POWER-US partner organizations are involved in the design of offshore wind's heavy infrastructure, which must withstand wind, currents, waves, water degradation and other natural hazards.

Testing

- Large scale testing: Northeastern University, UMass Lowell, Tufts University, MassCEC, University of Maine, Clemson University, and UMass Amherst are all involved in the large-scale testing required for infrastructure innovation.
- Ocean test bed: UMass Dartmouth, The National Renewable Energy Laboratory, National Science Foundation, Woods Hole Oceanographic Institution, and Tufts University are working on an Ocean Test Bed that would advance our knowledge of the continental shelf conditions in the very waters undergoing active deployment of offshore wind energy in the U.S., and would provide benchmark datasets for testing local innovations. POWER-US partners think that an offshore extension of the existing Martha's Vineyard Coastal Observatory could serve as a multi-purpose station that supports long-term monitoring and research.

Ocean siting and monitoring

UMass Dartmouth, UMass Boston, and the Woods Hole Oceanographic Institution bring together their world leading ocean expertise to further study:

- Wind sense and ocean modeling: MassCEC-funded observations of the wind resource present off of Martha's Vineyard will be used to estimate expected wind energy production, and BOEM-funded simulations of ocean currents are examining the interactions of off-shore wind infrastructure with fish recruitment.
- Spatial data products and mapping: Advanced mapping and visualization of marine habitats and ecological function in the Northwest Atlantic has provided a comprehensive baseline of information about the conditions on the U.S. Northeast Shelf, which will be useful for fisheries managers and ocean users.

- Acoustic monitoring: BOEM-and MassCEC-funded efforts have provided POWER-US with a better understanding of the noise of construction activities, and have enabled them to test new methods to sense and track whales.
- Advanced bottom habitat mapping: POWER-US has used video technology to create 3D maps that identify the species around a wind turbine/plant and monitor their behavior and ecosystem.
- Understanding wind farm interactions with commercial fisheries: POWER-US produces fine-scale surveys of groundfish overlapping with offshore wind lease areas.
- Environmental monitoring on the outer continental shelf: tracks surface currents, water properties, temperature, and other conditions.

Composites manufacturing

UMass Lowell, the University of New Hampshire, Iowa State University, the University of Delaware, and Rensselaer Polytech Institute, as part of the FIBERS Consortium funded by the National Institute of Standards and Technology and the U.S. Department of Commerce, have produced a roadmap called "Plotting the Road Ahead"(2017) for growing the composites manufacturing industry.

WindSTAR

A wind energy science, technology, and research industry-university cooperative research center at UMass Lowell, WindSTAR focuses on projects that advance the materials, manufacturing, reliability, testing, and monitoring of the blades and turbines at the MassCEC's Wind Technology Testing Center.

NOWRDC

At the federal level, the National Offshore Wind Research and Development Consortium (NOWRDC) was established in 2018 with a $20.5 million DOE investment, matching funds from NYSERDA, and with follow-on contributions from state agencies in Maryland, Virginia, Massachusetts, and Maine—all resulting in a total investment of around $47 million. They recently announced the award of $8 million to 15 offshore wind research and development projects, focused on offshore support structure innovation, supply chain development, electrical systems innovation, and mitigation of use conflicts that will help reduce barriers and costs for offshore wind deployment.

IV. Strategic Partnerships

Power US

Many of the strategic partnerships among POWER-US organizations are discussed in the above section. In addition to these research areas, the academic and research institutions involved in POWER-US are also working on developing a national plan for advancing American innovation in the offshore wind energy industry. Their white paper, "Reaching Convergence in United States Offshore Wind Energy Research: a Multidisciplinary Framework for Innovation" advocates for integrating the offshore wind research and innovation community, establishing public-private partnerships with industry, government funding for testing facilities and staffing, standardized data archives to enable consistent cyber infrastructure, and the development of an open-source modeling platform.

Connect4Wind

Connect4Wind is a memorandum of understanding signed by Bristol Community College, UMass Dartmouth, and Mass Maritime Academy. The MOU represents their commitment to creating a vibrant and sustainable offshore wind industry that compliments the existing fishing and industrial uses of the New Bedford port. The partnership will also develop a better understanding of the workforce requirements of existing models of the offshore wind industry and deepen our knowledge of the new sector and its supply chain model.

The Connect4Wind partners will share research, academic faculty, and educational training facilities to improve their efficiency and use their resources in a fiscally responsible way. They seek to establish partnerships with GE, Siemens, and Vestas to provide students with the technical skills and safety training required by the offshore wind industry. The group is also actively trying to build a marine and environmental testing lab focused on helping the OSW industry on the southern Massachusetts coast. It has established a framework for cooperation that includes:

- Student Participation: Inclusion in degree or non-degree granting offshore wind academic programs at each partner institution.
- Research Collaborations: Each institution will encourage research collaborations in areas of mutual interest.
- Visit of Faculty Members: An institution's faculty members will submit teaching or research proposals for establishing visiting lectures, presentations and services at partner institutions.
- Shared Facility Utilization: Parties will identify specific teaching and research facilities to be made available for the utilization at their respective institutions.

The group has recently welcomed Bridgewater State University, Massasoit Community College and Cape Cod Community College as partners in the initiative.

Community of Practice

MassCEC is piloting a *Community of Practice for Massachusetts Offshore Wind Workforce Training and Development*, which aims to help the offshore wind workforce grantees and other interested partners and stakeholders network, share information and resources, coordinate, and collectively develop training and educational pathways into and through the offshore wind industry. Through this Community of Practice, MassCEC aims to build a cohesive and comprehensive ecosystem of training providers, educational institutions, community development organizations, and support services organizations throughout the Commonwealth that can work collaboratively to build a world-class offshore wind workforce in Massachusetts.

Separately from the Community of Practice, in June 2020, MassCEC announced grant awards to nine Massachusetts institutions and organizations to establish or expand workforce training and development programs that support the state's emerging offshore wind industry. The nine new workforce development programs will further expand the broad-based ecosystem of institutions and organizations throughout the Commonwealth that are helping Massachusetts workers to secure high-quality jobs in offshore wind. Specifically, these awards support health, safety, and technical training

programs; offshore wind vocational education; programs that help members of organized labor unions and commercial fishing interested in offshore wind jobs develop the needed skills; and the build-out of higher education pathways for students interested offshore wind.

Currently MassCEC is assessing how to best proceed with the Community of Practice pilot program. The Center is conducting stakeholder engagement with its grant awardees in order to better understand how they are running their programs, what resources the awardees need going forward, and what kind of networking and best-practice sharing community they would find most helpful. Once MassCEC gathers enough information from awardees and other relevant stakeholders, it will evaluate their needs, gauge what kind of community would be most beneficial, and proceed with the pilot.

NOWI

Bristol Community College's National Offshore Wind Institute, located in New Bedford, is positioning itself to become the one-stop-shop for the offshore wind training industry. It is currently working with GE, Siemens, and Vestas to explore ways in which these companies can support the Institute. BCC offers an offshore wind Associates Degree and certificate program, and NOWI will be offering a summer series on bridges to the offshore wind industry. This program will offer professional development and industry recognized courses focusing on existing industries in order to demonstrate how regional businesses can support the offshore wind industry and become part of its supply chain.

BCC has also announced its partnership with Maersk Training, which will provide the internationally recognized GWO basic health and safety training at NOWI. In addition to the GWO trainings required for all workers on an offshore wind farm, NOWI will also offer other required accreditation, skill development for the workforce pipeline, customized private sector trainings for developers, OEMs and supply chain companies.

NOWI will be modeled after European training centers for offshore wind and provide a complete set of GWO offers in order to ensure easy access to offshore wind sector credentials. The Basic Safety Training will provide participants with the awareness of the hazards encountered when working in the offshore wind industry, and how to control and mitigate these hazards. The Basic Safety Training will be divided into six modules: first aid, manual handling, fire awareness, working at heights, working at heights and manual handling combined, and sea survival. The Basic Technical Training will provide participants with the ability to perform basic hydraulics, mechanical and electrical tasks under the supervision of an experienced electrician, and how to assess, control, and mitigate hazards.

New Bedford Ocean Cluster

The New Bedford Ocean Cluster (NBOC) was established in 2015 as a program of the New Bedford Port Authority, merged with the former New Bedford Wind Energy Center in 2019, and announced its status as a non-profit corporation in August 2021. With a mission "to leverage New Bedford's coastal position, marine knowledge base, and landside capacity to drive employment and wealth creation in Greater New Bedford," the group will focus on combining recruitment of targeted businesses, creation of unique economic infrastructure, workforce development, and support for homegrown ocean economy

companies in the commercial fishing and processing, aquaculture, offshore renewables, and innovation and tech sectors.

The group – organized in part by Xodus' US Vice President of Renewables Alex Thillerup – will be governed by a 10-member board of directors and an executive committee led by president John Bullard (former New Bedford mayor who also served for more than five years as administrator of the National Oceanic and Atmospheric Administration's Greater Atlantic region). Edward Anthes-Washburn (former New Bedford Port Director) will serve as NBOC's vice president, and Jennifer Menard (Bristol Community College) will serve as treasurer and secretary. The remaining board members are: Keith Decker (CEO of Blue Harvest Fisheries), John Quinn (Assistant Dean for Public Interest Law & External Relations: University of Massachusetts Dartmouth), Anthony Sapienza (President, New Bedford Economic Development Council), Chris Rezendes (Professor Emeritus – Marine Biology & Aquaculture Extension Specialist: Roger Williams University), and Michael Quinn (Co-Owner: Quinn Fisheries Inc.). The current New Bedford mayor, Jon Mitchell, is serving on the board in an ex-officio role. The group is actively searching for an Executive Director.

Vineyard Wind is paying the New Bedford Ocean Cluster to design an "Act Local First" program that engages and prepares local companies for supply chain participation.

MassMEP

The Massachusetts Manufacturing Extension Partnership (MassMEP) is a non-profit organization that helps small to mid-sized manufacturers grow in the Commonwealth. MassMEP leverages its partnerships with government, business, and academic institutions to offer their clients three core areas of expertise: operational excellence, workforce strategies, and innovative growth solutions. The organization also helps guide manufacturers through the Massachusetts Workforce Training Fund application process and program implementation.

MassMEP, in partnership with the Clean Energy Center (CEC) and Greentree Consulting, was tasked with identifying manufacturers who could potentially participate in the Massachusetts offshore wind supply chain. MassMEP supported business-to-business supply chain networking, matchmaking and other connections between Massachusetts companies and OEM's and suppliers. This list of manufactures was added to the CEC offshore wind supply chain directory. The table below shows the entire supply chain directory by industry sector, and the number of local organizations and businesses supporting each sector.

Industry Sector	Number of MA Organizations/Businesses
Construction, Installation, and Operations/Maintenance	114
Educational Institution/Training Provider	38
Environmental, Engineering, Geological, and Testing Services	127
Equipment, Supplies, Materials, and Associated Services	131
Government Agencies	26
Manufacturing and Fabrication	77

Marine Facilities, Transport, Logistics, and Safety	94
Offshore Wind Developer	9
Offshore Wind Original Equipment Manufacturer (OEM)	27
Other	72
Professional and Consulting Services	127
Trades, Labor, and Workforce Organizations	33

* Table created based on MassCEC's Offshore Wind Supply Chain Directory.

MassMEP, CEC and the National Offshore Wind Research and Development Consortium, are organizing a Webinar for the Fall of 2021, which will provide manufactures with information and awareness of the emerging wind industry trends and potential opportunities to contribute to the supply chain in the future. The group will also facilitate direct B2B introductions between the small and mid-size enterprises and the major Tier 1 manufacturers.

MassMEP plans on being a resource to the Commonwealth and the State's manufactures as offshore wind develops in the region. This long-term endeavor will require thoughtful communication with the manufacturing community, and MassMEP has made it clear that it is their priority to ensure that Massachusetts manufactures are provided every opportunity to contribute to the Massachusetts offshore wind supply chain.

New England for Offshore Wind

New England for Offshore Wind (NE4OSW) is a coalition that includes partners from a diverse array of organizations and communities across New England committed to combatting climate change by increasing the supply of clean energy to our regional grid through more procurements of responsibly developed offshore wind. The coalition aims to drive New England governors and legislatures to support regional collaboration and make commitments by 2022 to power one third of the region with offshore wind.

Fishing Industry

New Bedford Port Authority

The Bureau of Ocean Energy Management (BOEM) has released federal guidelines which require offshore wind developers to establish a fisheries representative to serve as a point of contact between the developer and the fishing industry. The New Bedford Port has traditionally been a fishing port, which underscores the importance of a mutual understanding and productive relationship between the fishing industry and the offshore wind industry here in Massachusetts. As such, the New Bedford Port Authority will serve as the designated Fisheries Representative of the commercial fishing industry to Vineyard Wind, Deepwater Wind, and Bay State Wind.[20]

[20] New Bedford Port Authority to become fisheries rep to offshore wind; US Offshore Wind Developers Pick Fisheries Representative.

Vineyard Wind has hired two fisheries liaisons dedicated to work with an expanding network of fisheries representatives to communicate throughout southeastern New England and New York. In addition to its work with the New Bedford Port Authority, Vineyard also works with Fisheries Representatives from Martha's Vineyard Fishermen's Preservation Trust, Mass. Lobstermen's Association, New Bedford Seafood Consulting, Coastal Asset Management LLC, Commercial Fisheries Center of RI, and partners with the Responsible Offshore Development Alliance, whose goal is to improve communication between the fishing industry and offshore wind developers.

Vineyard also spends over $2 million a year for fisheries research conducted by a leading university and offers a scholarship for fishermen or families of fishermen to participate in the Offshore Wind Technical Certificate Program at Adult & Continuing Education Martha's Vineyard (ACE-MV).

Vocational Education

Martha's Vineyard High School and ACE-MV

BCC, ACE-MV, and Vineyard Wind have partnered to offer dual enrollment for both Martha's Vineyard High School students and ACEMV adult students in an accelerated offshore wind program that awards them with a BCC certificate. This certificate qualifies the students for a job with Vineyard Wind. The Connect4Wind MOU partners (BCC, Mass Maritime, and UMass Dartmouth) and looking for ways to replicate such partnerships with other area high schools and vocational programs.

Reskilling America

UMass Amherst professors Katherine Newman and Hella Winston authored a book on the vocational education's role in modern education. They determined that for vocational education to be successful, the following factors must be present:

- A unified certification system (such as the international GWO for OSW)
- High levels of funding; it takes a lot of resources to train a high-skill worker
- Companies themselves need to be prepared to offer, or coordinate, training
- Corporate culture must overcome the fear that investing in training is a waste because it will lead other companies to poach their well-trained employees
- Vocational education institutions (whether at the high school or community college level), must work directly with industry partners to create the most relevant and directly applicable training curriculums. The state must be involved in order to standardize these training curriculums (in the case of OSW, we have consistently heard the advice that we should use the existing international standards that the industry already operates under). Unions should also be involved since their fields of expertise will overlap with these industries, and because throughout U.S. history unions have opposed standardized state apprenticeship programs because they saw them as a threat to their own apprenticeships programs.
- State regulations must permit students to spend enough time on the factory floor. The customary two days a week will not be enough, and it's unrealistic to expect that American vocational schools will receive the necessary funding to purchase the extremely expensive advanced manufacturing, IT, robotics, etc., machines that students need to learn on.

- Overcoming the stigma of pursuing a vocational education by redefining what a skilled tradesperson is.

V. National Context

In collaboration with the Bureau of Ocean Energy Management (BOEM), the Northeast Ocean Data Portal now displays the latest maps of Active Renewable Energy Leases and BOEM Wind Planning Areas.

It includes a new priority Wind Energy Area in the New York Bight (indicated in purple in the map below), announced by the Biden-Harris Administration in March 2021 as part of a series of offshore wind commitments made by President Biden. This area of shallow waters between Long Island and the New Jersey coast could support up to 25,000 development and construction jobs from 2022 to 2030, as well as an additional 7,000 jobs in communities supported by this development, according to a Woods Mackenzie study. BOEM intends to auction leases for this area in late 2021 or early 2022.

In addition, in May 2021, California announced its agreement for the federal government to auction off lease areas that could support up to 4,600 megawatts of offshore wind on the West Coast within the next decade.[21] BOEM plans to auction lease areas as early as 2022 within a 399-square-mile area of the Central Coast northwest of Morro Bay as well as an additional area on the North Coast.

To support the Biden-Harris Administration's target of 30,000 megawatts of offshore wind by 2030, BOEM intends to advance new lease sales and complete review of at least 16 Construction and Operations Plans (COPs) by 2025, representing more than 19,000 megawatts.[22]

The $1.2-trillion-dollar federal infrastructure bill – currently awaiting House approval – includes $73 billion for grid infrastructure, and further funding for port climate resilience. These investments are expected to benefit offshore wind, making for easier integration of intermittent renewable generation.

[21] California Announces Historic Agreement with Federal Partners to Advance Offshore Wind Development | California Governor

[22] FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs | The White House

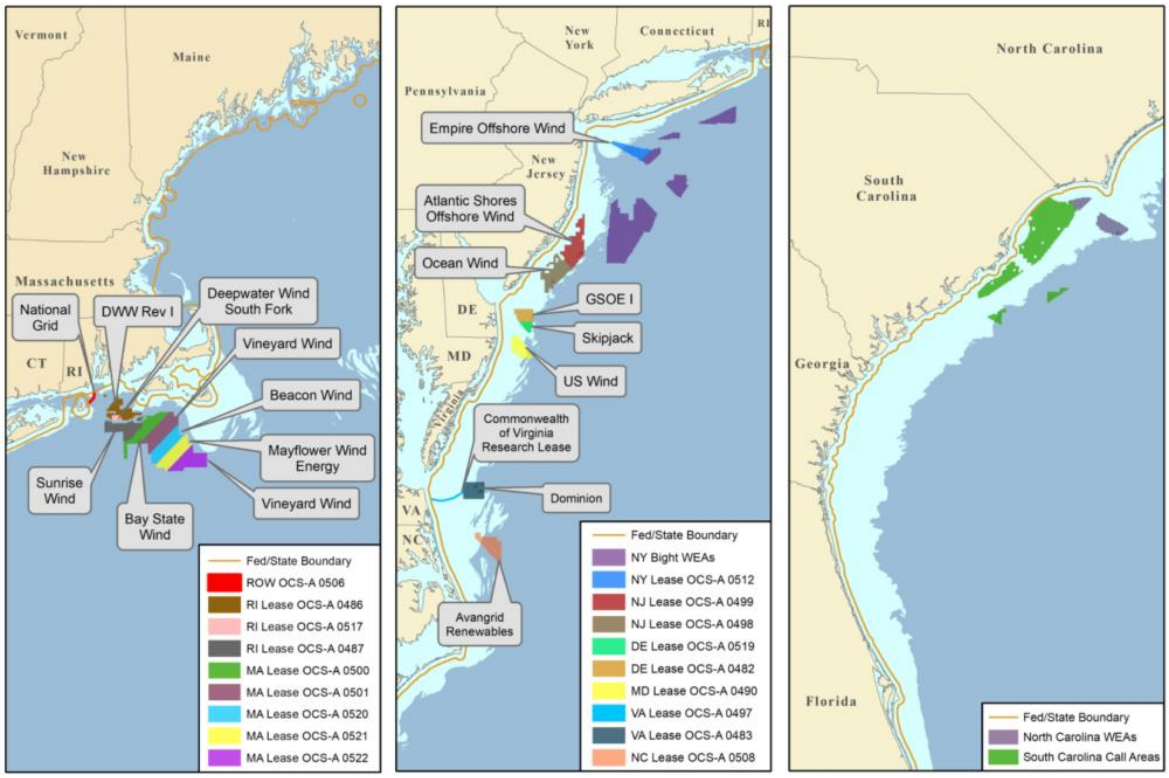


Figure 6. BOEM, 2021.

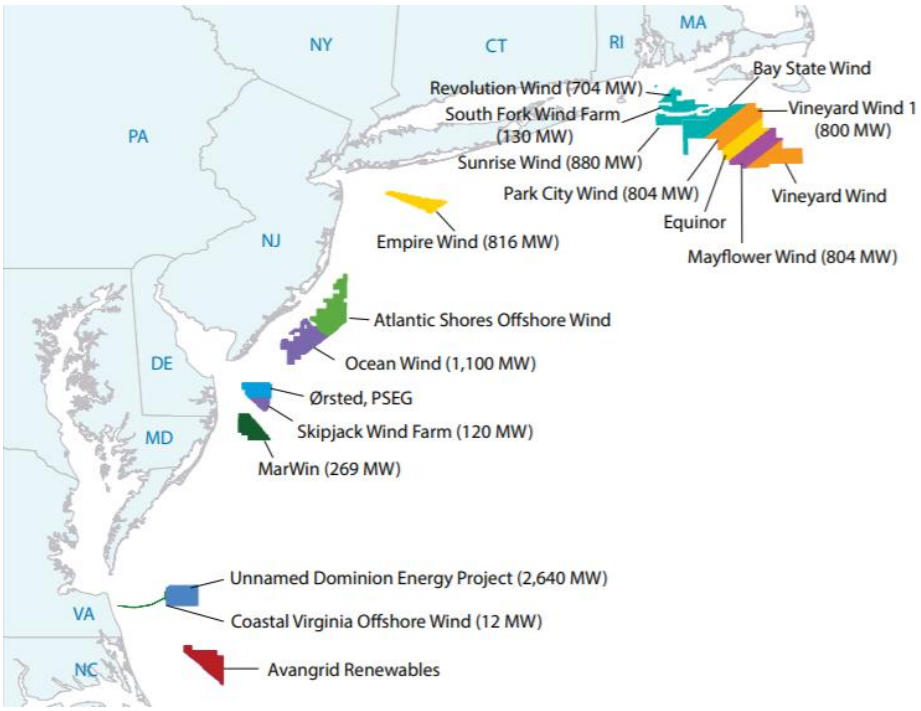


Figure 7. American Wind Energy Association, 2020.

VI. State Conversation

Critiques of Bid Process

Major discussion points around Massachusetts offshore wind solicitation procedures include:

- **Price Cap**: Proposals are currently strictly required to have a lower price point than the previous offshore wind contract. Eliminating the cap could allow for net-beneficial investments into:
    - storage
    - interconnection
    - economic development

  Critics have expressed confidence that the competitive bidding process will yield affordable prices, even without a price cap. Removing the cap, they find, would provide flexibility to choose the most beneficial project to the Commonwealth.
- **Selection**: Many stakeholders are calling for project selection to be conducted by state administration, rather than the local utilities as currently stands. New York and Connecticut both have state agencies administer the selection process.
- **Goals**: The selection criteria could seek to achieve 'cost effective projects that deliver the highest benefit to the Commonwealth.' Such language would allow for greater consideration of economic development, environmental justice, DEI efforts, and other state goals.[23]
- **Remuneration**: Stakeholders have called for consistency, as well as perhaps lowering, of allowed remuneration build-in. As the policy currently stands, remuneration can be "up to 2.75 percent of the contract." There is legislation in support of adopting a static cap of 2.5 percent, though the Attorney General's Office has advocated for significantly lowering – or even removing – remuneration.[24]

State, New Bedford officials and local leaders criticize state's offshore wind bid process

In an April comment letter sent to the Baker administration and the DPU, New Bedford Mayor Jon Mitchell, Fall River Mayor Paul Coogan, state representatives, city councilors, and various New Bedford business leaders said they are concerned the state's approach to procuring offshore wind energy contracts will make it "more difficult for this region to achieve its potential."

The leaders cite the 2019 Mayflower Wind procurement in which one bid had a higher price tag but included investment promises for the region (such as a plan to build a factory at Brayton Point that would have employed as much as 200 people); a different project was selected for the lower price tag despite not promising the same economic investments. The leaders also point out that other states are placing a greater emphasis on economic development investments, cautioning that Massachusetts is losing ground in capturing industry share.

[23] In June, Representative Pat Haddad wrote an article in Commonwealth Magazine supporting increased weight within the procurements for environmental and economic benefits, specifically job creation.
[24] https://commonwealthmagazine.org/energy/dpu-gives-168m-offshore-wind-bonus-to-utilities/

The 2021 procurement process does increase the weighting of qualitative elements from 25 to 30 percent. The new process is also the first to include the Secretary of Housing and Economic Development to assess which of the bids provide the most economic development opportunities.

Ownership of Brayton Point

In a July interview, Governor Baker expressed uncertainty about state ownership of the deep-water pier and 12.5 adjacent acres on the 308-acre Brayton Point property in Somerset, the proposed landing of the Mayflower Wind transmission and the proposed Anbaric Renewable Energy Center. The site is the former location of the Brayton Point Power Plant, a coal-fired power plant which is being decommissioned after shutting down in 2017.

The Somerset Select Board sent a letter to Baker in July asking him to step in and help resolve a dispute between the town and the current owner of the property, Commercial Development Inc. of St. Louis. The Select Board members allege the state Department of Conservation and Recreation owns the pier and the adjacent land, and leased it in the 1950s to the original power plant owner contingent on a power plant being located on the property.

When the Trump administration delayed regulatory approvals of wind farms for close to two years, Commercial Development tried to make some money by leasing space to tenants running scrap metal and road salt operations. The noise and air pollution caused local uproar, flipping seats on the Board of Selectman and calling upon the state to recognize the uses as violation of the state lease.

The Baker Administration has so far avoided addressing the ownership issue head-on, but MassCEC did provide an $18,000 grant this summer to support the "facilitation, mediation, and an assessment of community perceptions and perspectives on future uses of the… property to gauge potential implications for longer-term use of the property by the offshore wind sector."

Diversity

In June 2021, the Boston Globe published an article entitled "Massachusetts has the chance to make offshore wind diverse. Will it?" The article makes the case that the thousands of jobs to be created by the state's OSW industry can – and should – be inclusive so that future industry wealth will spread equitably. The author cites the United States' automobile and other heavy industries' commitments to diversifying their supply chains in the 1980s and 1990s as successful examples.

Massachusetts' Next Generation Roadmap bill has already committed $12 million annually for the Massachusetts Clean Energy Center to create and run a clean energy equity workforce program, as explained in more detail on page 8 of this report. Maryland, Virginia, New Jersey, and New York are codifying minority economic participation into law, or setting goals for diversity, inclusion and environmental justice in their offshore wind projects. Nationally, President Biden's "Build Back Better" plan sets a goal that disadvantaged communities receive 40 percent of the benefits of clean-energy deployment.

Elizabeth Turnbull Henry – president of the Environmental League of Massachusetts – has called upon the state to reapportion some project selection points currently awarded for price and to create a new

standalone category for diversity and inclusion. “Give it enough points to really matter — so it could determine the difference between winning and losing the bid,” Henry says in an April 2021 op-ed, “Offshore wind procurement should use 'Massport model'.” The ‘Massport model’ being called to mirror regards procedures for developing properties owned by Massport, including a recent RFP which 25 percent of points on the strength of the bidder’s diversity and inclusion plans.

VII. Supply Chain

A project developer will typically procure the design, supply and installation of turbines from the turbine OEM and one or more prime equipment and installation contractors (or **Tier I suppliers**). In other cases, some developers choose to multi-contract, using in-house or contracted-in expertise to manage up to 100 direct contracts.

Contracts for manufacture and construction are often signed two years before construction although in some cases, large supply contracts are sourced earlier via strategic framework agreements or strategic company alliances. Contracts for the manufacture of balance of plant equipment and installation services may be signed later than turbines but designs are finalized early on in this process.

The offshore wind supply chain has a strong cohort of major component suppliers which contract directly with project developers. This top level of supply chain typically supply Wind Turbine Generators (WTGs), Foundations, Substations (onshore & offshore), and Export & Array Cables. These major component suppliers contract their components from principal (or **Tier II**) suppliers. Additional specialist suppliers are referred to as **Tier III** suppliers.

2021 MassCEC OSW Supply Chain Assessment

In 2020, MassCEC contracted out a study assessing the strengths, weaknesses, and opportunities of the Commonwealth’s offshore wind supply chain. The study – produced by Xodus and BW Research – conducted a survey of potential offshore wind companies in Massachusetts and contrasted the findings to industry knowledge of the offshore wind supply chain needs. The final findings and recommendations are yet to published, as they currently await EEA approval.

VIII. Technical Considerations

Transmission

The installation of individual wind turbines and wind farms requires a significant amount of planning, coordination, and design work. Mistakes can be very costly. As more and more wind turbines are added to conventional networks, attention must be given to the type of transmission to use and how that process should be conducted. Massachusetts currently has Vineyard Wind scheduled to deliver 800 MW to West Barnstable using an AC transmission, while Mayflower Wind is also connecting 800 MW to Cape Cod through Falmouth using a DC transmission. Understanding the rationale behind this decision requires knowledge of the transmission procurement process and how the two systems differ.

Around the country, tensions are cropping up over a planned acceleration of renewable energy projects that some local residents say are being forced upon them. New Jersey passed a law in July stripping local

communities of authority over placement of transmission lines, removing a key barrier for offshore wind in the state. Under the new law, developers can appeal blocked approvals at the local level to the New Jersey Board of Public Utilities. The board would be able to override local government opposition if it deemed that a project's request to land a transmission cable was just and had followed state requirements.

To note, the Japanese company PowerX has recently announced plans to construct their first electric boat which will be able to store and transfer offshore wind power to shore. The power transfer vessel, which will feature 200 megawatt-hours of energy storage capacity, is expected to be constructed by 2025. PowerX's vision is to develop a fleet of similar ships to forgo the need for offshore transmission altogether.[25]

AC vs. DC Transmission

The two transmission systems differ both in cost and technical capabilities. DC transmission cables experience less energy loss and are thus more cost-effective when long export cables are required. By enabling longer cable runs, DC also facilitates more cost-effective interconnection by increasing access to robust points of interconnection (e.g. Brayton Point) or delivery directly to load centers (e.g. Boston or SW CT).

Delivering directly to load centers reduces the need for onshore upgrades, a finding of Brattle Group and ISO-NE's Economic Study of offshore wind integration for NESCOE (see below), which can often be the largest expense of AC transmission.

Regional ISOs and FERC policy currently place additional project costs onto companies that trigger grid upgrades. Connecticut's Park City Wind, for example, opted to connect to the closest point (West Barnstable) using AC cables, triggering responsibility for over $200 million in grid upgrades on Cape Cod.

[25] https://www.powermag.com/japanese-firm-unveils-ship-dedicated-to-storing-and-transmitting-offshore-wind-power/?mc_cid=b8b6c3dbf7&mc_eid=7c88fec79c

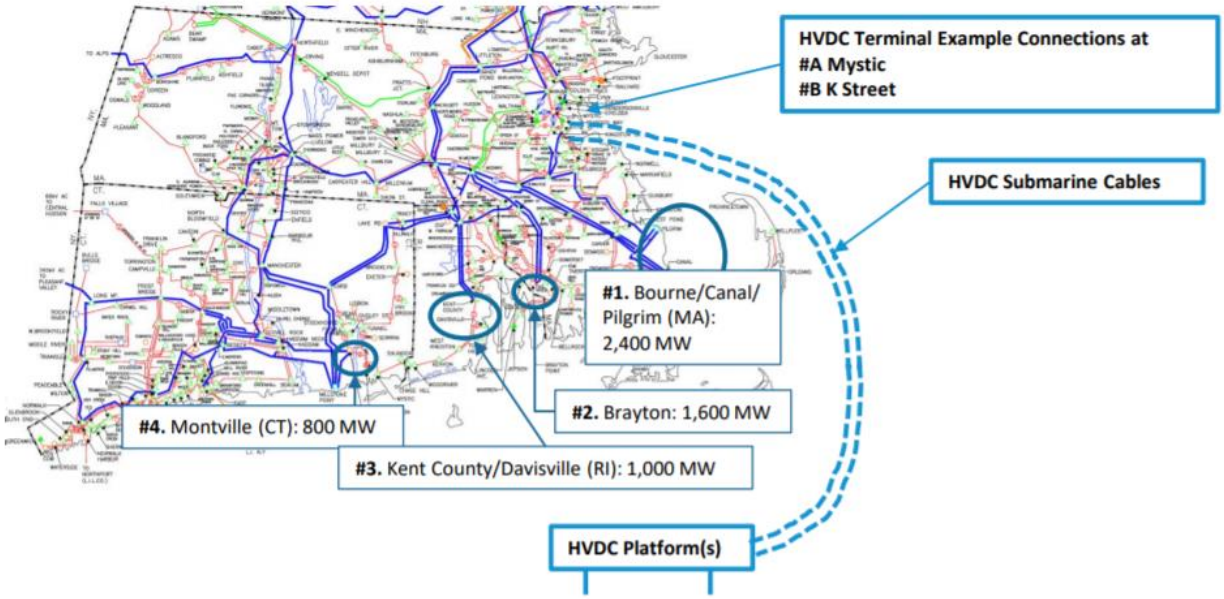


Figure 8. ISO-NE, 2020.

A main benefit of AC is that the grid operates in AC, avoiding the need for high-cost DC converter stations. AC transmission is also a more mature technology that requires less equipment and is faster to manufacture than DC hardware. AC cables, however, carry less power than DC and experience greater energy losses. The cost savings are typically only realized if AC can be used to connect to a strong POI that is under 50-60 miles away. AC can account for energy losses through strategically placed compensation stations that add voltage to the line, but these compensation stations – as large as offshore oil rigs - can often be just as expensive as DC converter stations.

Transmission developers are increasingly looking towards DC to minimize onshore upgrades. Onshore reconstruction of lines from Cape Cod to Boston is estimated at $1 billion; it may be more feasible to deliver wind energy to the interior parts of Massachusetts by using HVDC cables to go around or under the Cape.

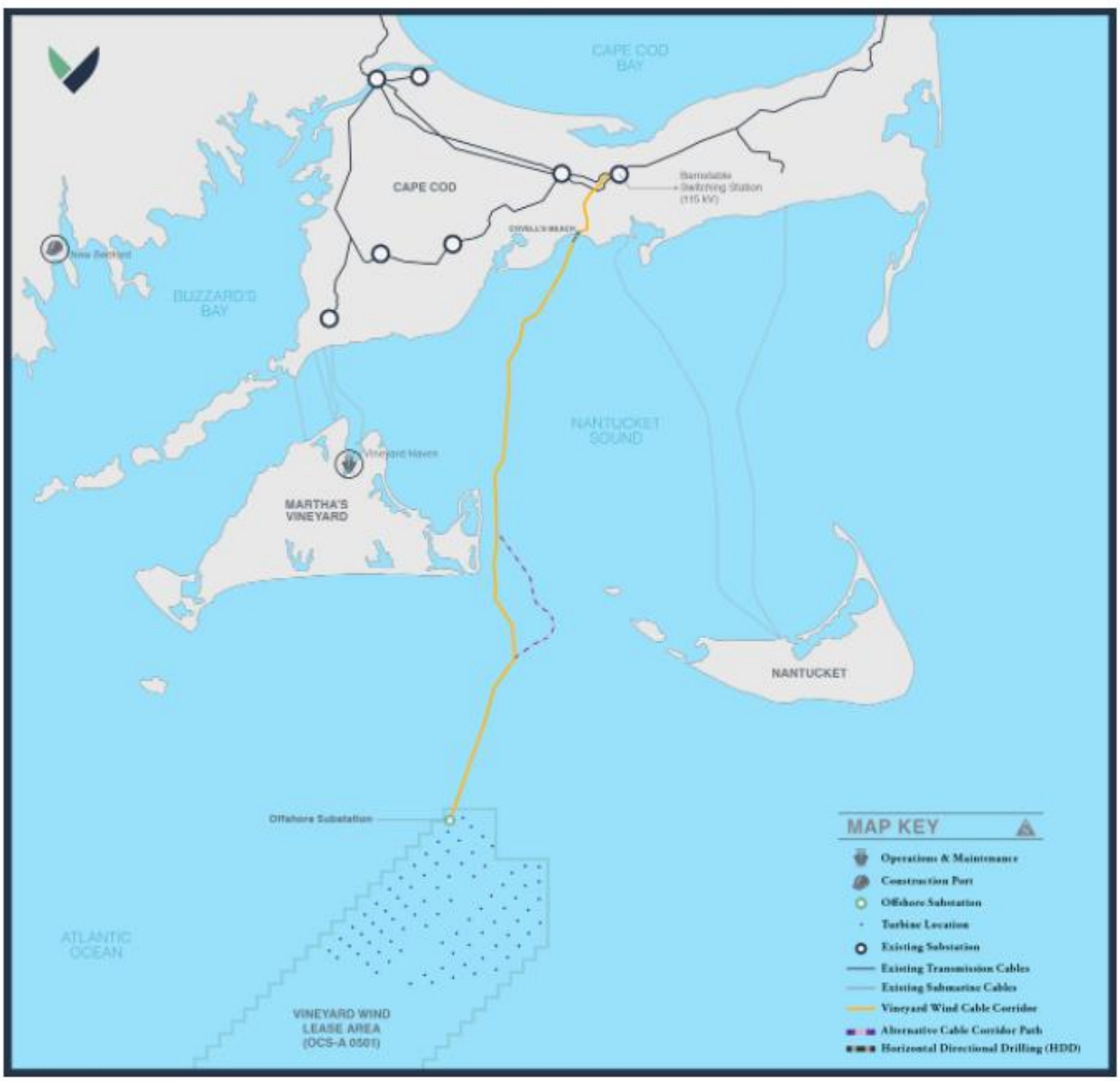


Figure 9. Vineyard Wind, 2020.

AC transmissions have lower maintenance and repair costs and employ fewer workers. DC converter stations, meanwhile, generate hundreds of jobs while the platforms are being constructed. The materials for the converters have traditionally been supplied from Europe but are increasingly being sourced from the Gulf of Mexico. Environmentally, AC and DC transmission systems have similar effects. Both produce electromagnetic frequencies (EMF) that are negligible to human activity and animal life.

Planned Transmission and Competitive Investment

Independent Service Operators (ISOs) were created by FERC in 1998 to function as regional grid operators; they select the location for projects and decide upon the best manner to implement them. In the status quo, developers of new generation projects are tasked with securing connectivity into the grid and held responsible for all grid upgrade costs. After the next offshore wind project selection, the

next grid upgrades will pose a significant, possibly inhibiting, cost – over $1 billion according to one estimate.

New Jersey's last RFP instituted a policy in which the first $200 million of grid upgrades would be borne by the developer, while any remaining costs would be split amongst projects.

Some states have also considered implementing a competitive process in which transmission developers could bid independently for grid infrastructure projects based on an estimated need for generation, minimizing ambiguity around potential upgrade costs that wind developers face when connecting to the grid and thus reducing the need for risk premiums in developer bids.

Advancing competition in transmission can help increase the value of the investments and provide more transparency into transmission costs. This ultimately increases the attractiveness of strengthening the regional transmission grid to create a more robust and cost-effective electricity system. Prior models demonstrate that competitive processes are more successful in reducing transmission project costs than those typically posed by ISOs. Competitive transmission development can yield innovation and increased cost discipline on the industry, thereby benefitting electricity consumers.

Figure 10. Possible offshore wind transmission systems

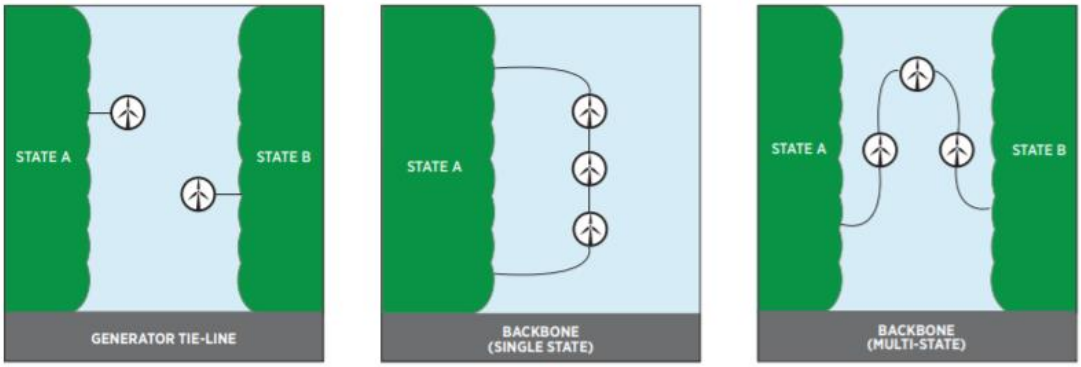


Figure 11. Business Network for Offshore Wind, 2020.

The Brattle Group recently found that a planned offshore transmission network and supporting onshore grid upgrades in New England would cost $500 million less upfront than the current unplanned

transmission approach involving the sequential evaluation of individual proposed generator interconnections, with ongoing savings of $55 million per year from reduced power losses.[26] In addition, customers could see over $300 million in annual savings because the offshore network would deliver power to higher-priced locations on the grid, triggering larger reductions in wholesale power prices. A planned approach could reduce the need for onshore transmission upgrades by delivering greater quantities of power to more optimal interconnection points on the grid. In January 2020, the National Renewable Energy Laboratory released a high-level study considering the future grid integration of 2 and 7 GW of OSW generation into the combined ISO- NE and NYISO control areas.[27] The study concluded that the delivery of 7 GW of OSW to certain locations in the Northeast could trigger costly OSW curtailments – of nearly 6 percent – due to onshore transmission congestion.

In August 2019, the New York Power Authority conducted a study which identified four key lessons from European OSW experiences:

- The most effective path to low-cost wind power is through scale and healthy competition.
- The offshore transmission model used is dependent on a variety of physical and non-physical factors including geography. Regardless of model chosen, the coordination and incentive alignment between all parties is critical and needs to match their levels of respective capabilities.
- Visible, long-term grid planning on and offshore removes barriers to entry, improves coordination, and lowers costs.
- Cross-border coordination helps countries leverage planned transmission infrastructure, achieve resource flexibility and gain economies of scale. [28]

There are two main mechanisms for how competitive transmission can function. Following President Biden's climate-related executive order in January 2021, FERC has provided the Department of Energy Resources (DOER) a larger scope in which to examine independent transmission systems. If the scale of transmission is large enough, DOER can "unbundle" transmission from wind generation and set up a single state procurement for the transmission piece. FERC has also recently allowed for states to go into "voluntary agreements" with ISOs to work together on transmission procurement. The move is part of a larger effort by FERC to allow states to be more involved in the transmission process, inspired by the success of similar models in Europe.

Local Grid Technology Innovation & Expertise

In looking at transmission issues, we call your attention to American Superconductor Corporation, a Massachusetts-based manufacturer of systems that provide MW-scale power resiliency solutions. AMSC has a manufacturing facility in Ayer, MA, where they produce components for high temperature superconductor cables. More than ten years ago, the Department of Homeland Security initiated its Resilient Electric Grid (REG) Program in partnership with AMSC primarily to enhance protections of

[26] https://brattlefiles.blob.core.windows.net/files/18939_offshore_transmission_in_new_england_-the_benefits_of_a_better-planned_grid_brattle.pdf
[27] https://www.nrel.gov/docs/fy20osti/74191.pdf
[28] https://www.nypa.gov/-/media/nypa/documents/document-library/news/offshore-wind.pdf

urban core transmission systems against extreme weather, man-made attacks, cyber security and other catastrophic events. Through its Gridtec Solutions, ASMC also provides engineering planning services and advanced grid systems that optimize network reliability and efficiency. Through its Windtec Solutions, ASMC provides wind turbine electronic controls and systems, designs and engineering services that reduce the cost of wind energy.

AMSC is a local company well poised to enter the growing offshore wind industry, and the grid changes its likely to bring along, here in Massachusetts and in the New England region as a whole. It has completed Phase I of a Superconductor Cable Development Project in Chicago, which increases the reliability of the substations in that urban setting and allows ComEd to gain experience with the technology before moving on to phase II. Phase II is a larger project in Chicago's Central Business District that connects three area substations with two HTS cables, looping the substation infrastructure together. ComEd and AMSC hope that this project, the first in North America and third in the world, will serve as a demonstration for other utilities in the U.S. to model. A REG project similar to this was proposed for Boston's Back Bay but was aborted after the Eversource merger with NSTAR.

2021 New England Energy Vision Statement

In June, the New England States Committee on Electricity submitted a report to New England Governors with a vision for a clean, affordable, and reliable 21st century regional electric grid. This vision aimed to provide a regionally based market for electricity while staying committed to the Commonwealth's clean energy laws. Major sections of the report focused on improvements to the wholesale electricity market, transmission planning, and the governance of ISO-NE. Areas of transmission needing improvement included ISO-NE's role in the long-term process for transmission planning specifically in allowing greater participation by the States. Increased participation would allow for more individualized approaches to meeting each States' energy transition goals. The statement discouraged ISO-NE from doing their own research and encouraged cooperation with States to conduct joint ventures using regional universities and interested developers. The general purpose was to shift more responsibility onto each State's institutions throughout the transmission process in order for each development to be individualized.

The Governors, in turn, drafted a letter affirming the findings and recommendations.

2020 DOER Offshore Wind Study

In 2018, Massachusetts passed An Act to Advance Clean Energy which required DOER, by July 31, 2019, to investigate the necessity, benefits and costs of requiring the Electrical Distribution Companies to conduct solicitations and procurements for up to 1,600 MW of additional offshore wind. DOER first analyzed the cost-effectiveness of an additional 1,600 MW of offshore wind, the optimal timing of any future procurements, and other impacts on the environment and economy from the growth of offshore wind in Massachusetts. DOER solicited input from the public and key stakeholders, including environmental groups, developers, industry groups, EDCs, fisheries, and academia. An additional 1,600 MW procurement of offshore wind energy will result in over 6,000,000 MWh of annual clean energy when fully online. The study modeled three scenarios that varied the amount of power that transmissions could handle ranging from an additional 800 MW to the full 1600 MW. DOER explored whether these transmission systems should be planned and constructed in advance.

DOER's findings were that the Act limited the size of a potential independent offshore wind transmission solicitation to 1,600 MW and at this size, there would likely be similar benefits from reduced cabling and/or improved interconnection from a transmission solicitation alone as from a bundled solicitation for generation and transmission at the same capacity. There was significant support for the potential benefits of a "networked" or "backbone" independent transmission, which could be achieved more effectively at a larger scale of offshore wind build-out and with regional coordination among New England states (rather than through a single state procurement with limited size). A separate solicitation for 1,600 MW transmission capacity is "too limiting to yield an offshore transmission grid that could be used as a platform for future offshore wind development for Massachusetts or the region," concluded DOER. A larger solicitation would give developers maximum flexibility to use transmission infrastructure efficiently, thereby helping the Commonwealth receive the best bids that minimize the environmental and socioeconomic impacts of siting offshore wind structures in the ocean and achieve many of the potential benefits of the independent transmission solicitation without the added costs and risks. DOER found that undertaking a separate transmission solicitation would "likely introduce certain risks such as: delaying upcoming offshore wind generation procurements; coordination issues between separate transmission and generation projects; and contracting and permitting hurdles that may increase costs and delay the successful development of future selected offshore wind projects."

Specifically, there is a need for long-term and large-scale planning for the transmission system in New England to accommodate a future expansion of offshore wind energy, including beyond the next 1,600 MW. DOER agreed and recognized the need for transmission upgrades and planning to accelerate clean energy goals. In April 2019, the New England States Committee on Electricity (NESCOE) requested that ISO-NE conduct an economic study regarding the impacts on the regional transmission system and wholesale market of increasing penetration of offshore wind resources and the report was released last month. According to DOER, "Massachusetts will work with other states and the ISO-New England to build on the regional study to assess cost-effective transmission upgrades that may be needed to accommodate offshore wind and other clean energy resources."

In the 2021 Roadmap Bill, the state authorized DOER to solicit and procure proposals for independent transmission for the now 5600 MW of offshore wind energy authorized by the bill.

New Jersey Competitive Solicitation

Concerned that the current approach of building individual transmission lines is short-sighted - with not enough interconnection points to meet OSW goal and significant transmissions-induced project risks, costs, and delays – and seeking to learn lessons from Europe, New Jersey recently set an example of a possible policy solution.

New Jersey's 2019 Offshore Wind Strategic Plan found that a unified, well-coordinated approach to transmission planning is necessary. The report recommended collaborative effort amongst DPU, the utilities, and the regional transmission operator to seek possible policy solutions, including working with regional states. The study also found that immediate offshore wind projects should move forward, but future projects should wait for a comprehensive transmission plan.

As a result, in April, New Jersey's regional grid operator PJM opened a 120-day solicitation window (on behalf of their "DPU") for qualified developers to submit potential transmission solutions that would help deliver OSW to the existing grid. The solicitation sought potential options for four interrelated components:

- upgrades to the existing grid
- extension of the grid closer to offshore wind locations
- optimal landfall approaches (considering environmental impacts and need for substations)
- interconnections between offshore substations to provide benefits of a networked offshore grid

It contained extensive consumer protections (inc. ability to phase-in upgrades) and allows NJBPU and PJM to select multiple proposals, select no proposals, and terminate the implementation process at any time.

Ports

Needs

As offshore wind energy develops in the United States, port facilities will become strategic hubs if they meet specific requirements of the offshore wind industry. Today's ports generally require additional investment before they can serve as marshalling ports for offshore wind projects.

States have already committed more than $692 million and offshore wind developers have committed over $729.5 million into port infrastructure nationwide. Private and state funds could be further leveraged with federal programs such as the Maritime Administration's Port Improvement Development Program (PIDP), the Department of Transportation's Better Utilizing Investments to Leverage Development (BUILD) Grant Program, and the Water Resources Development Act (WRDA).

Areas for investment include:

- **Heavy-Duty Wharves**: must be made out of materials (such as iron or concrete) capable of withstanding the weight of turbine components – such as a four-tower rack weighing 750 tons
- **Lay-Down Areas**: heavy components- including turbine blades, foundations, and nacelles – require areas for staging and assembly capable of withstanding their weight (over 2800 tons) and length (longer than a football field)
- **Dredging**: will be necessary in some ports to ensure port access to a variety of vessels
- **Manufacturing Facilities**

There are a few key Tier I manufacturing needs that will require a US supplier. Only turbines will likely need more than one domestic supplier for the near future, others will likely supply all projects on the Eastern seaboard.

- **Turbines**: Virginia will likely receive one, New Jersey is trying to capture another
- **Monopiles**: captured by New Jersey
- **Towers**: New York is seeking to capture

- **Export & Array Cables**: identified by Vineyard Wind as an area Massachusetts may want to capture, also potentially being sought by New Jersey
- **Substations**

Vineyard Wind representatives estimate that states have roughly 2.5 years to build out their ports, which will then last for 50 years. They indicate that past success has been found in utilizing public investment to build the platform and then allowing private investment to build on top of it. They also cite port infrastructure commitments as critical in developers' ability to offer more favorable bids, especially when port redevelopment proposals are not weighed as heavily in the selection process.

2017 Port Infrastructure Assessment

In 2017, MassCEC conducted a two-phase Port Infrastructure Assessment to identify waterfront properties that could support additional construction and operation activities for offshore wind facilities

Volume 1: Intro to the Existing Conditions concluded that the proximity and volume of waterfront industrial sites make the ports of Massachusetts an ideal place from which to launch an offshore wind supply chain. Numerous under-utilized waterside facilities exist within Massachusetts ports that may be available for redevelopment to meet the needs of the new offshore wind industry, including former coastal power plant properties, former shipyard facilities, and industrial and marine industrial facilities.

Volume Two: Engineering Assessment of Potential Site Redevelopment and Reuse Scenarios, guided by offshore wind industry leaders worldwide, established current and future trends to develop a set of offshore wind facility requirements for component manufacturing, staging, and operations and maintenance. Completed in October 2017, the Engineering Assessment overlays the facility requirements for each of the above-listed offshore wind activities with the existing conditions at each Massachusetts waterfront property and evaluate which locations could best support various activities. For each property, MassCEC performed an engineering analysis to create conceptual redevelopment designs, high-level cost estimates and permitting pathways required for the sites to be able to support offshore wind activities.

Massachusetts Ports

The New Bedford Marine Commerce Terminal (NBMCT) is a major strength of the MA offshore wind supply chain, as it is currently the only facility in the US that is designed specifically for the staging of offshore wind projects and is under agreement to serve as the primary staging and deployment base of the construction and installation phase for the Vineyard Wind and Mayflower Wind projects.

In addition to this major piece of infrastructure in New Bedford, other port facilities and waterfront spaces around the state have been identified and could potentially be acquired or leased and improved upon through industry- led investment to become suitable facilities for a number of offshore wind activities. These include options in Quincy (which likely has too many issues, including bridges), Fall River, Somerset, New Bedford, and Boston – totaling 18 facilities in all. For the complete list and viable redevelopment scenarios, see MassCEC's virtual Port Assessment Site Tour.

Other Northeast ports will likely compete for contracts related to staging and marshalling, including two in Connecticut:

- Bridgeport, which will act as the staging port for the Park City Wind project
- New London, which has entered into a partnership with Ørsted and Eversource for port improvements needed for the Revolution Wind project

In addition to the MA port infrastructure to support offshore wind projects, there comes significant opportunity for local companies to provide port and logistics services including security, utilities, fuel bunkering, stevedoring, cranes, handling, forklifts, SPMTs, trailers, vessel maintenance, ships agent, towage, and waste removal. Provision of these services is not limited to the project installation phase, where smaller ports in MA may aid in these logistical services to support the development surveys and wind farm O&M stages.

Vineyard Wind is currently considering Tisbury Marine Terminal as a base for its operations and maintenance activities. The site plan – expected to be operational by June 2023 – includes three vessel berthing spaces and a pile-supported pier designed to transfer spare parts, general maintenance equipment, tools, and wind farm technicians to the offshore sites. The terminal is designed to initially service wind farms of up to 1,600 MW.

Governor Baker is proposing the Commonwealth spend $100 million of American Rescue Plan Act federal money on marine port infrastructure to support the offshore wind industry. The Governor specifically named New Bedford, Somerset, Fall River, and Salem as priorities for port infrastructure improvement.

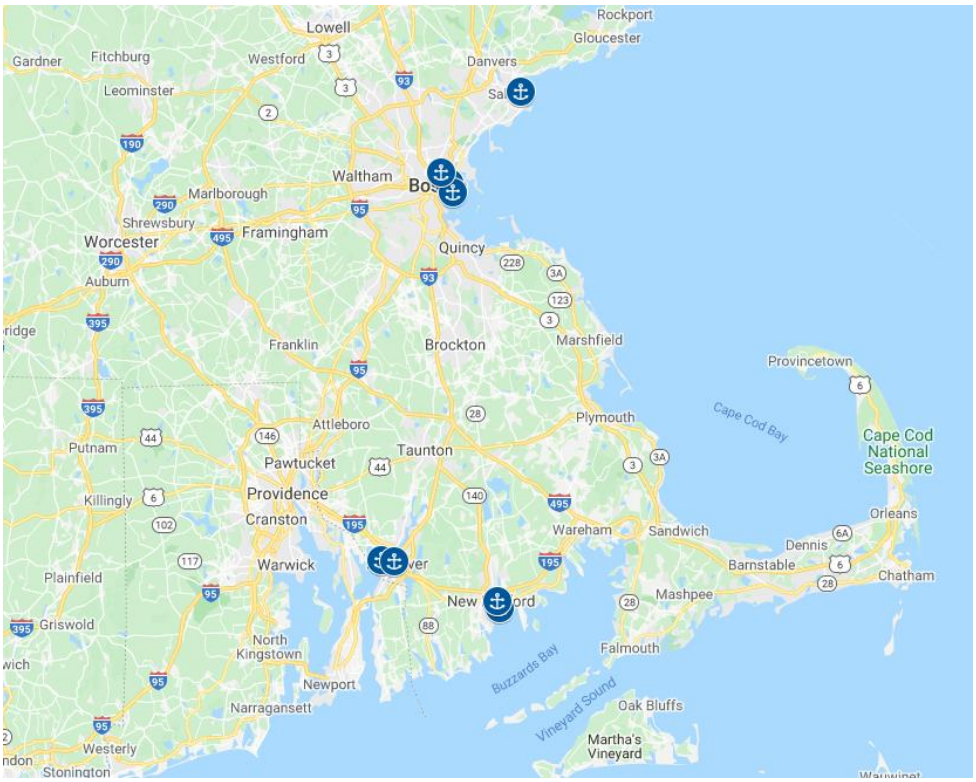


Figure 12: Existing port infrastructure in Massachusetts.

New Bedford

The Port of New Bedford has leveraged federal, state, and private funding to build infrastructure for offshore wind staging areas. Vineyard Wind signed a $6 million annual lease to use the New Bedford Marine Commerce Terminal for at least 18 months, for a total of $9 million.

In 2018, the Department of Transportation awarded the Port a $15.4 million BUILD grant to build areas for offshore wind staging, to create more room for fishing and other commercial vessels, and to remove contaminated materials. Industry, state, and federal funds are needed for port infrastructure to advance the full deployment of offshore wind, though the Port does face a long-term restriction posed by a hurricane barrier which limits port access for larger vessels. Large pieces will rely on feeder barges for transport out of the port and onto a larger ship.

In 2019, Vineyard Wind granted the Port Authority an additional $50,000 to develop their facilities. This year, New Bedford announced plans to demolish the Cannon Street Power Station and develop a 30-acre staging area, doubling the city's capacity for offshore wind staging.

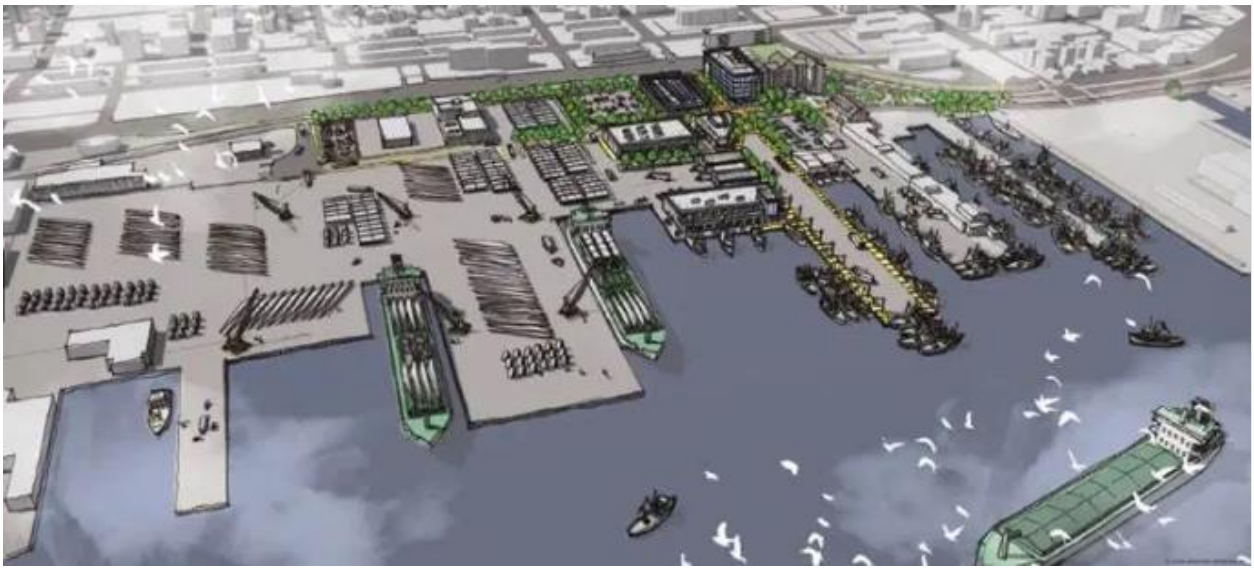


Figure 13. City of New Bedford, 2021.

Over the past 40 years, the Environmental Protection Agency – through their Superfund program – has been cleaning up New Bedford's port. With clean-up nearly complete, the port is being dredged for the first time since the 1950s using a $24 million MassWorks grant. In 2020, the EPA turned over their terminal to the city. With capital investment, the EDA Pier, North Terminal, State Pier (of which 20 percent can be used for offshore wind), and other New Bedford port terminals can be transformed to further support the offshore wind industry. There is even an opportunity for a "Deep South" terminal to be constructed outside the hurricane barrier (roughly estimated to cost $200 million).

Somerset

In 2019, Anbaric announced a $650 million investment to convert the former Brayton Point coal plant into the Anbaric Renewable Energy Center, featuring 400 megawatts of on-site battery storage and a

1,200 megawatt high-voltage direct current converter to serve the offshore wind industry as part of the company's vision for its Massachusetts OceanGrid project, a shared interconnection point for the multiple companies competing to build wind turbine installations off the Massachusetts coastline. The space will also house manufacturing and storage space for large turbine components. Vineyard Wind estimates a manufacturing facility in Somerset to cost roughly $200 million.

Fall River

The 10-acre Fall River State Pier is located along the east bank of the Taunton River. It is operated by Fall River Line Pier, Inc. as a marine terminal for general cargo and breakbulk industry, as well as commercial fishing vessels, ferry service, and the cruise ship industry.

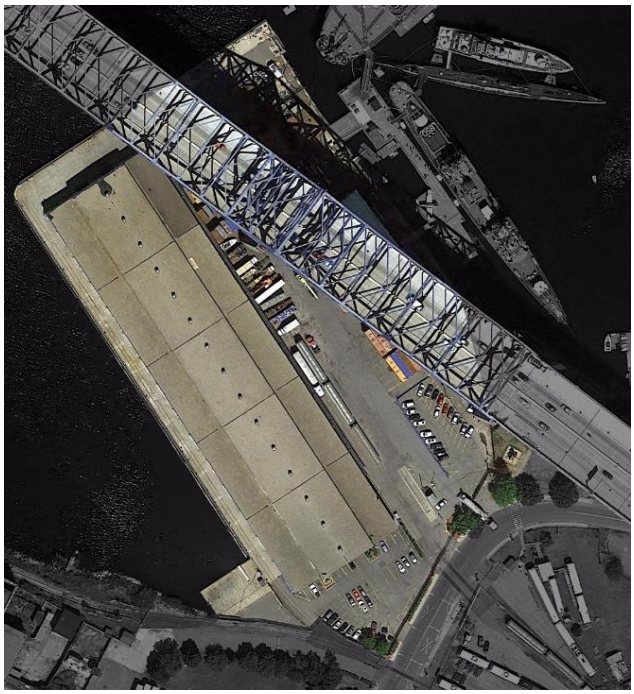


Figure 14. MassCEC, 2017.

The Pier is located approximately 37 nautical miles from the leading edge of the offshore wind energy areas located south of Martha's Vineyard, but it lies partially under the Charles M. Braga Jr. Memorial Bridge. The site is accessible by two deep water berths, on-site rail, and a trucking fleet in close proximity to the interstate highway system.

In 2019, Vineyard Wind provided $50,000 toward a study to analyze potential future use of approximately 3.5 acres of a 6-acre parcel owned by the Fall River Redevelopment Authority (FRRDA) that lies within the Fall River Waterfront Urban Renewal Plan area.

One of Mayflower Wind's multiple bids on 83C III includes setting up an operations and maintenance base at the Borden & Remington complex in Fall River.[29]

Salem

According to Mayor Kim Driscoll, Salem's harbor is ideally suited for offshore wind projects because it has a deep-water channel and no bridges, power lines, or breakwaters that could restrict large vessels from coming and going. A former coal-fired power plant on the waterfront in Salem has been replaced by a much smaller natural-gas fired facility, freeing up an estimated 42 acres of cleared land – 13.7 acres on the north side of the property and 29 acres on the south side.

The investors behind Footprint Power, the developer of the new plant, have floated the idea of repurposing the southern side of the property for mixed-use development. With the Biden

[29] https://www.statehousenews.com/email/a/20211774?key=558f70

administration aggressively pursuing the development of offshore wind, however, they put out a request for expressions of interest and received six to eight submissions related to offshore wind.

Four times further from the lease areas than New Bedford, use of Salem's port would likely require a Jones Act vessel – estimated at north of $500 million alone. Salem could also cater to offshore wind development in the Gulf of Maine, where the federal government has yet to auction any offshore wind leases.

Figure 15. Footprint Power, 2021.

Vineyard Wind's 83C III bid, Commonwealth Wind, includes the creation of a public-private partnership for a turbine assembly and staging site in the Port of Salem.[30]

Boston

The Massachusetts Port Authority (Massport) – in addition to owning and operating three airports, including Logan International – owns and operates public terminals in the Port of Boston, including three with potential offshore wind usage. Massport hosts additional office space and real estate, which can serve the professional and workforce development aspects of the industry as well.

1. **Medford Street Terminal and Boston Autoport**, Charlestown

[30] https://www.salem.com/home/news/vineyard-wind-partnership-salem-harbor-port

The space is currently home to a cock, office, warehouse areas, automobile shipping, and the MassCEC Wind Blade Test Facility. While the bulk of available space is behind the Tobin Bridge, there are two portions that lay outside the bridge. The privately-operated Autoport is open to collaboration with the wind industry that could include a new multi-floor deck facility to free up more room.

2. **East Boston Shipyard and Marina**, East Boston

This space is currently home to a variety of marine facilities, including ship repair equipment. The facility lies within the Ted Williams Tunnel which limits ship berths to 40 feet and has limitations in accessibility by land. However, it could function in industry support roles, with two companies currently seeking to build a large vessel maintenance facility.

Figure 16. Massport, 2020.

3. **Massport Marine Terminal (MMT)/North Jetty**, South Boston

This space has been continuously developed to support a dynamic seafood industry. A 12-acre parcel (which includes the North Jetty) – which features a deepwater port with a hardened head and a bulkhead berth, and can be dredged as deep as needed – cannot be a main assembly facility due to size but could be the site of specialized operations, especially for projects north of Cape. The Eastern Salt Company is contemplating substantial investment into the property for a multi-use site that could operate as a satellite facility and support the OSW industry. They recently applied for $20 million federal grant to dredging and bulkhead/jetty repair.

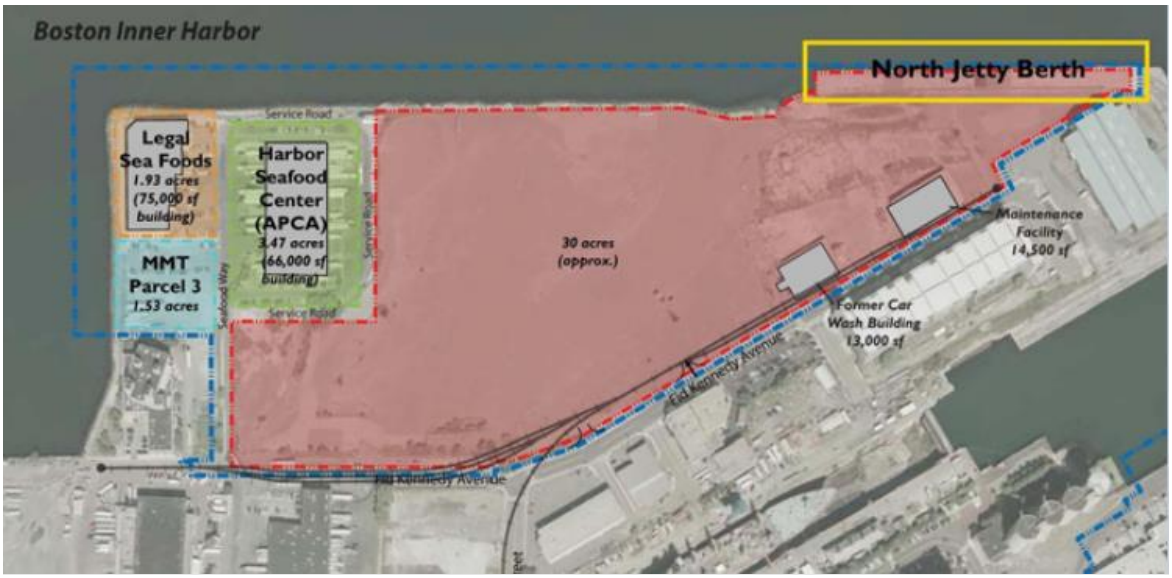


Figure 17. Massport, 2015.

Fixed v Floating Turbines

All offshore wind generation actively being pursued in the United States is through fixed-bottom turbines, meaning they use some structure – often a pile-driven monopile, metal jacket foundation, or gravity-based concrete foundation – to secure themselves to the ocean floor dependent on seafloor conditions. Capturing strong generation potential further into the ocean, however, will require deep-water solutions like floating wind farms, which can operate at depths of over 3,000 feet.[31]

From left to right: a monopile, jacket, twisted tripod, floating semi-submersible, floating tension leg platform and floating spar.

Figure 18. NREL, 2020.

[31] https://environmentamerica.org/sites/environment/files/reports/AME_Offshore-Wind-For-America_2021.pdf

There are three main styles of floating wind farms. *Spar* structures are made of steel or concrete with added ballast to create a low center of gravity and stabilize the structure in the sea. *Semisubmersible* structures have the advantage of easier assembly, but they have a higher mass and can lead to increased corrosion of the structure. These achieve stability from their buoyancy in combination with a large area in contact with water. *Tension Leg Platforms* create stability from mooring lines that fix them in place. However, they are more difficult to install and are vulnerable to earthquakes and tsunamis.

Massachusetts, Maine, and New Hampshire all have massive floating offshore wind potential, providing an opportunity for the Commonwealth to emerge as a unique leader in this cutting-edge technology.

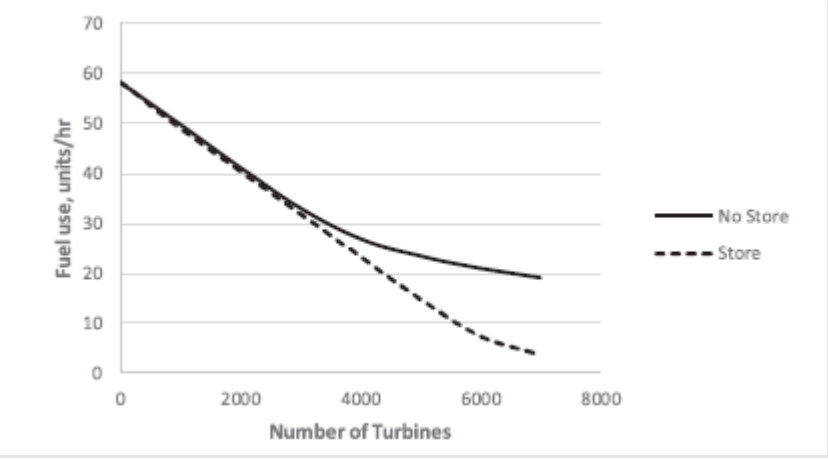
Storage

Effective long-term storage is critical component of the clean energy transition, as solar and wind resources are more variable and cannot be as responsive to grid demand. UMass Amherst's Clean Energy Extension developed a time series simulation model ("Hybrid2Grid") – using simplified but plausible sub-models of the various components – to predict how effectively a mixture of generators, some conventional and others non-conventionally dispatchable (e.g. wind turbines and solar PV panels), together with realistic energy storage technologies can supply a real electricity demand. The project grew out of an investigation into the possible applicability of larger scale energy storage to the New England electric grid in the event that large amounts of offshore wind energy might be developed there in the near future.

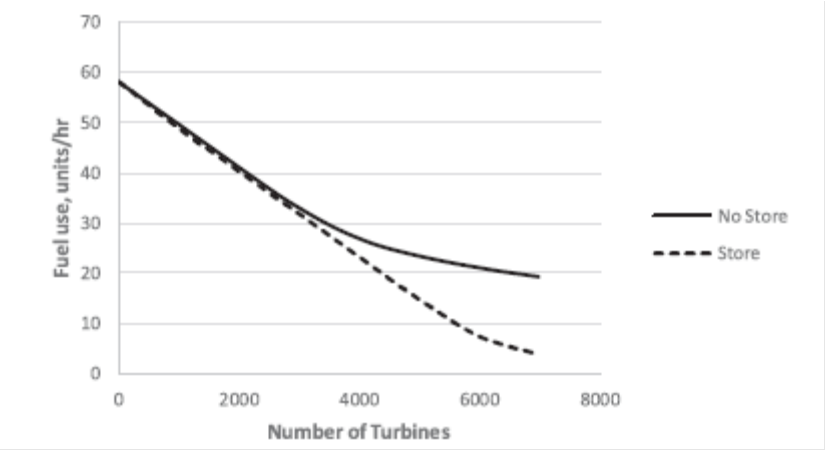
Hybrid2Grid is limited in that it currently does not consider:

- economics (except fuel cost),
- forecasting,
- generator start-up times,
- dispatch strategies,
- generator flexibility

The study concluded that with an *ideal generator*, wind energy could supply about half of the load (saving a corresponding amount of fuel) without the need for storage and without significant energy curtailment. Storage becomes progressively more useful as penetration levels increase.



With a *non-ideal generator*, significant fuel savings are impossible without storage, but even just a little storage makes a big difference. Energy storage may only need to be capable of storing one day's energy consumption to become quite useful. The greatest challenge, then, is ensuring that energy is able to be stored with little to no loss in efficiency.



Actual utility systems consist of multiple generators of different types so the combination would actually result in a fuel vs. power curve similar to that of an ideal generator with some caveats.

- Suggests that the total amount of storage need not actually be very large (roughly a day's energy consumption) to be useful

A hybrid grid including wind turbines plus solar photovoltaics and storage could be preferable to a system using just one of the technologies (subject to an evaluation of the comparative costs). The beneficial effect of partial correlation of wind speeds from spatially separated sites can reduce the amount of storage needed compared to what would be predicted if that partial correlation were not considered. Supplying 100 percent of the electrical supply with only wind, solar and storage remains a challenge.

The overarching conclusions are that:

- energy storage will become progressively more important when supplying very large fractions of electrical networks' loads with wind and solar PV, but that
- there are many issues to consider in ensuring that the storage is integrated most effectively. Models such as the one described here can be useful in undertaking such assessments.

Hydrogen

One of the drawbacks to wind energy is the variability that comes with its energy production. In times when excess energy is being produced by wind turbines, the surplus energy is commonly curtailed so energy potential is being lost. One solution to rectify this problem and capture more energy from turbines is to use excess energy generated by turbines to produce hydrogen. Hydrogen can be used in fuel cells to generate power using a chemical reaction rather than combustion, producing only water and heat as byproducts. It can be used in cars, in houses, for portable power, and in many more applications.

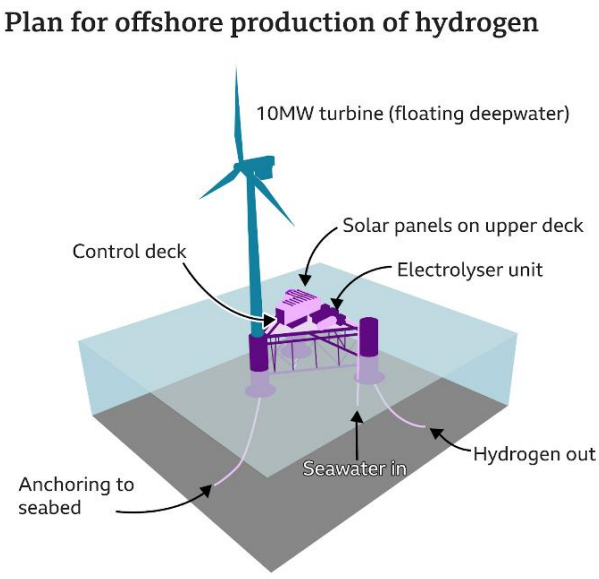


Figure 19. ERM, 2021.

In order to create hydrogen that can be used for fuel, water molecules must be split with electricity through a process called electrolysis. The electrolysis reaction takes place in a unit called an electrolyzer. Three different types of electrolyzers can be used in the reaction, and can result in zero greenhouse gas emissions, depending on the source of the electricity used. If hydrogen fuel and electric power generation were integrated at a wind farm, it would allow flexibility to shift production to best match resource availability with system operational needs and market factors.

Companies in Europe have started sketching plans to incorporate hydrogen production into their wind turbines. In Europe, Siemens Gamesa and energy firm Siemens Energy are ploughing €120m ($145m) into the development of an offshore turbine with a built-in electrolyzer. Global engineering company Tractebel is exploring the possibility of building a large-scale, offshore hydrogen production plant powered by nearby wind turbines. The Company ERM is also looking into hydrogen production and has drafted plans to fit floating wind turbines with desalination equipment to remove salt from seawater, and electrolyzers to split the resulting freshwater into oxygen and the sought-after hydrogen. British company ITM Power designs and manufactures electrolyzers, and has the largest electrolyzer manufacturing facility in the world. Their technology uses electricity and water to generate hydrogen gas on site and can be scaled to 100MW+.

Wildlife Impacts

Mass Audubon, the Nature Conservancy, the National Wildlife Foundation, and the Conservation Law Foundation have been collaborating for the last decade to protect wildlife through offshore wind industry development. The group supports industry development but, citing large knowledge gaps, seeks greater environmental monitoring and more organized stakeholder groups.

Fish

The largest impact on fish from offshore wind is from the sounds of construction. Pile-drivers, used to dig holes during construction, can create noise that is heard up to 80 km away.[32] This noise disrupts the fish and causes increased stress levels. Commonly fished species in the Cape like the common dab, Atlantic salmon, and Atlantic cod are often affected. Other adverse conditions include the pollution of passing vessels, collision risks, and loss of prey due to ecosystem changes.

[32] Effects of Offshore Wind Farm Noise on Marine Mammals and Fish, COWRIE (2006)

Industry Concerns

Fishing industry stakeholders often oppose offshore wind development. Adverse effects on fish and limitations caused by the position of the turbines limit catches. Industry officials should be included in the development of future plans, as they were in the Vineyard Wind project. Vineyard Wind agreed to move the farm south of Martha's Vineyard to protect scallop fishing, which would have been heavily damaged if the farm was built in the previous area. Additionally, compensation for fisheries is often recommended to compensate for lost revenue; Vineyard Wind paid over $16 million in trust to Rhode Island fishing associations.[33] Fishermen have also been offered scholarships for continuing education courses to become offshore wind technicians.

In 2019, the five New England offshore wind leaseholders – including Vineyard and Mayflower Wind – proposed a 1x1 nautical mile layout throughout all five adjoining lease areas to address commercial fishing industry concerns. This layout removes 30 percent of the total potential energy production to create over 200 transit lanes.[34]

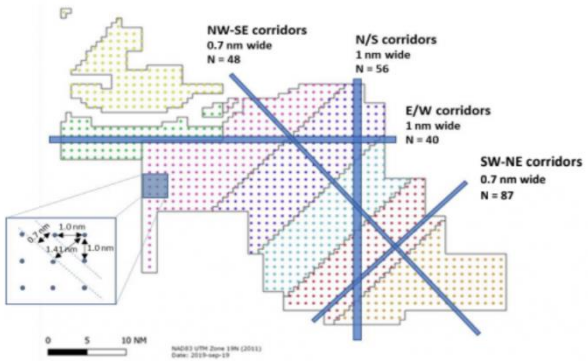


Figure 20. W.F. Baird & Associates, 2019.

This summer, BOEM held virtual meetings with fisherman regarding the proposed sale of more than 600,000 acres of a New York bight for offshore wind development. In April, New Bedford Mayor Jon Mitchell cautioned that the areas were established on "significant" scallop fishing grounds and proposed the removal of a five-mile strip along the eastern boundary of Hudson South to minimize fishery impacts. While willing to comply, the Port of New Bedford have expressed frustration that BOEM officials seemed to place greater burden of proof on the city to provide scientific evidence. Anecdotes from New Bedford fishermen suggest that the bight accounts for a significant portion of their annual scallop yield and warn that turbines would impact fishery survey vessels as well.

In September 2021, the Nature Conservancy unveiled a marine mapping tool which aims to cover the coast from Maine through North Carolina and include information about the makeup of the seafloor, the fish and invertebrates that live near the bottom of the ocean in a given area, the marine mammals that frequent a chosen swath of ocean, the bird species that are known to be in the area and more. The tool will also allow a user to compare data from different times of the year, including historical data.[35]

Coastal Habitats

Offshore wind development can lead to changes in coastal sedimentation due to unusual wave action, damaging the habitats of many species that live on the coast. Coastal erosion from wave activity can

[33] http://www.crmc.ri.gov/windenergy/vineyardwind/Agreement_RIFFVT.pdf
[34] https://cleanpower.org/wp-content/uploads/2021/06/ACP-OSW-Factsheet-MA-Casestudy-Fishery-Maritime-Input.pdf
[35] https://www.statehousenews.com/email/a/20211758?key=13e6860

also lead to accelerated sea level rise. Invasive species may be introduced to coastal areas through industry operations, pushing out endemic species.

Benthos

Wind farms can disrupt the natural process of sedimentation of nutrients to the sea floor, where it can be reabsorbed into the food chain by bottom-dwelling organisms. This process harms organisms like plankton, which rely on this source of energy, and animals that feed off these organisms, including baleen whales and some species of fish, further harming the fishing industry. However, offshore wind can also be beneficial to the sea floor, as it acts as an artificial reef for bottom dwelling organisms to latch onto.

Marine Mammals & Sea Turtles

The sounds from piledrivers during construction have the largest impact. Atlantic right whales, harbor porpoises, and Atlantic white-sided dolphins are commonly affected marine mammals because their calls, used for mating, feeding, and other social interactions, are in the same pitch range as the noises made by pile-drivers. Harbor porpoises in Germany were affected by noises up to 25km away.[36] Vineyard Wind encountered resistance – from the Natural Resources Defense Council, the National Wildlife Federation, and Conservation Law Foundation – when planning OSW because of the harm to endangered right whales and agreed to modify their plans to protect the species (see below). Similar negative effects have been seen among sea turtles.

In August, a group called Nantucket Residents Against Turbines announced a federal lawsuit aimed at stopping the construction of offshore wind farms in the MA/RI lease areas, based on efforts to protect the Northern Atlantic right whale. NOAA describes the right whale as "one of the world's most endangered large whale species, with less than 400 individuals remaining." The group contends with NOAA's previous determination that the Vineyard Wind project will not jeopardize the species and is attempting to sway future findings in the area.

Birds and Bats

Birds are less affected by the construction of offshore wind and are more affected by their operation. The main adverse effect on birds and bats comes from collisions. While it is known that offshore wind can be detrimental to bird populations, statistics on the number of collisions are difficult to find as the carcasses of birds cannot be easily recovered over the ocean. Birds and bats may also be affected by loss of feeding area and erosion destroying their coastal habitats. Species like the great black-backed gull and the storm petrel are at high risk in the Cape.

Opportunities for Mitigation

Marine mammal impact can be minimized by focusing on building the wind farm in the Fall when marine mammals will migrate. This has been agreed to by Vineyard Wind, who will curtail building in the winter and early spring, when Right Whales are most present. To protect fish species, developers can create exclusion zones around the turbines – during construction and/or during operation – to allow marine

[36] https://tos.org/oceanography/article/offshore-wind-farm-artificial-reefs-affect-ecosystem-structure-and-functioning-a-synthesis

species to replenish. Throughout the wind farm lifecycle, protected species observers are employed on vessels to minimize direct damage to marine species in the area closest to the turbine. Vineyard Wind has also agreed to limit construction noise from pile drivers.

IX. Other States

Up and down the Eastern Seaboard, states are in an arms race to set ambitious offshore wind energy targets, capture as much of the supply chain as possible, and reap the economic benefits from a rapidly growing industry. This flurry of activity is beginning to extend to the West Coast as all states look to collaborate with a strong partner in the Biden-Harris Administration and play a key role in achieving the President's 30,000-megawatt target by 2030.[37] [38] Industry analysts view the 2030 target as incredibly challenging and even aspirational and posit that California would need to join East Coast states in setting a strong 2030 target if the Biden-Harris target is to be reached.[39]

East Coast states have established 36,530 megawatts[40] of offshore wind procurement targets by 2035.[41] In California, which reached an agreement with the federal government in May 2021 to auction lease areas supporting up to 4600 megawatts, recent legislation AB525 requires the state to set planning goals for 2030 and 2045.[42]

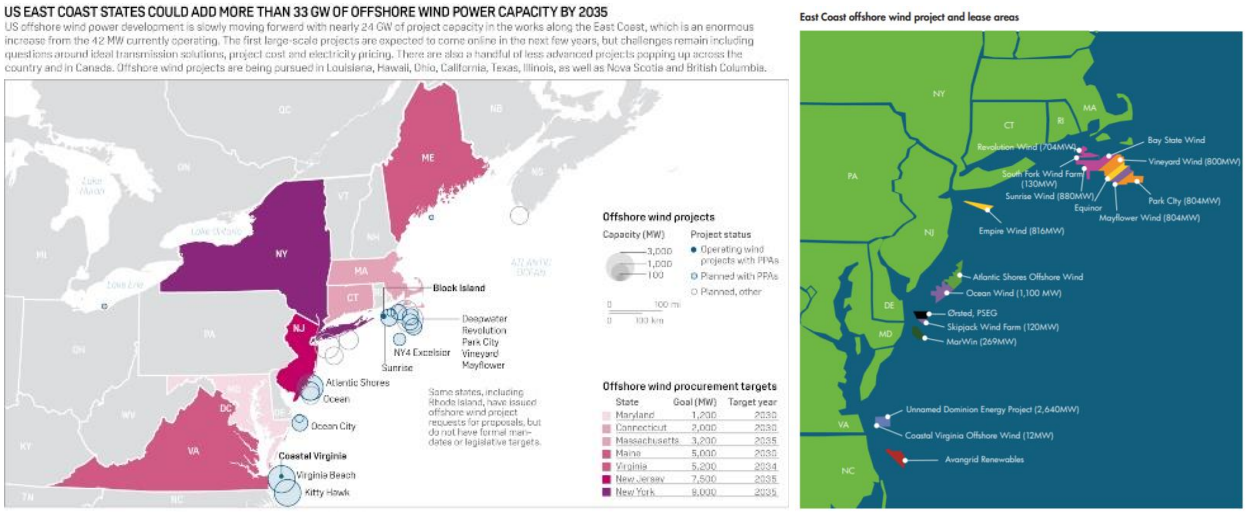


Figure 21. S&P Global Platts Analytics (left) and GWEC (right), 2021.

[37] FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs | The White House
[38] California Announces Historic Agreement with Federal Partners to Advance Offshore Wind Development | California Governor
[39] A supportive offshore wind industry sees Biden's 2030 goal as ambitious, SPG Global
[40] Analysis from SGP Global Platts Analytics, SGP Global Market Intelligence, BOEM, and NYSERDA show 33,100 megawatts in offshore wind targets as of May 7, 2021. The accounting leaves out Rhode Island's goal of 1,030 megawatts. It further credits Massachusetts with 3200 megawatts, rather than the 5600 megawatts secured by the FY22 state budget.
[41] Offshore Wind Power Facts | ACP (cleanpower.org)
[42] https://leginfo.legislature.ca.gov/faces/billAnalysisClient.xhtml?bill_id=202120220AB525#

State targets should be evaluated in proportion to their total retail electricity sales, as some states such as New York, Virginia, and New Jersey have a higher load than others, and in that sense more buying power. States that have higher load will also be able to require more megawatts than states with smaller loads while being less disruptive to price formation in the electricity markets of the respective Regional Transmission Organization (RTO) in which they participate. Massachusetts' load by itself isn't sufficient to match the consumption of these states, however, when combining the Southern New England states (MA, CT, RI), their total retail electricity sales equal 86,586,509 megawatt-hours, which places them ahead of New Jersey, while still behind Virginia and New York.

State	Target (MW)	Total Retail Electricity Sales (MWh)[14]
New York	9,000 MW	145,600,345
New Jersey	7,500 MW	73,916,704
Massachusetts	5,600 MW	51,336,598
Virginia	5,200 MW	118,435,380
Maine	5,000 MW	11,732,040
Connecticut	2,000 MW	27,899,996
Maryland	1,200 MW	60,720,658
Rhode Island	1,030 MW	7,349,915

Table 1: U.S. Energy Information Administration, 2019

The offshore wind industry has further proposed at least $2.9 billion in investments for manufacturing, ports, vessels, workforce development, and research. This includes $1.47 billion for 12 manufacturing investments, $965.6 million for 15 ports investments, $580 million for 8 vessel investments, $57 million for 11 workforce development initiatives, and $50.5 million for research. (Interactive infographic/map available)

With industry estimates of 86,000 megawatts of projects by 2050,[43] and projections from the Biden-Harris Administration for 110,000 megawatts by

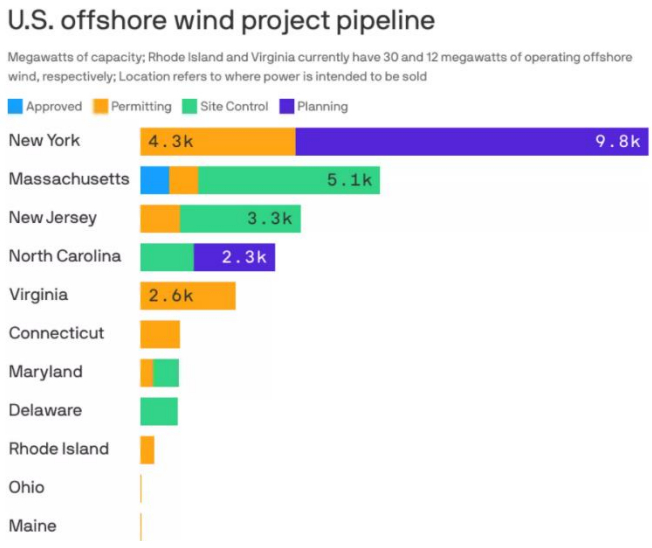


Figure 22. Axios, 2021.

[43] Offshore Wind Power Facts | ACP (cleanpower.org)

2050,[44] the offshore wind industry will only continue to grow as states compete to be on the leading edge.

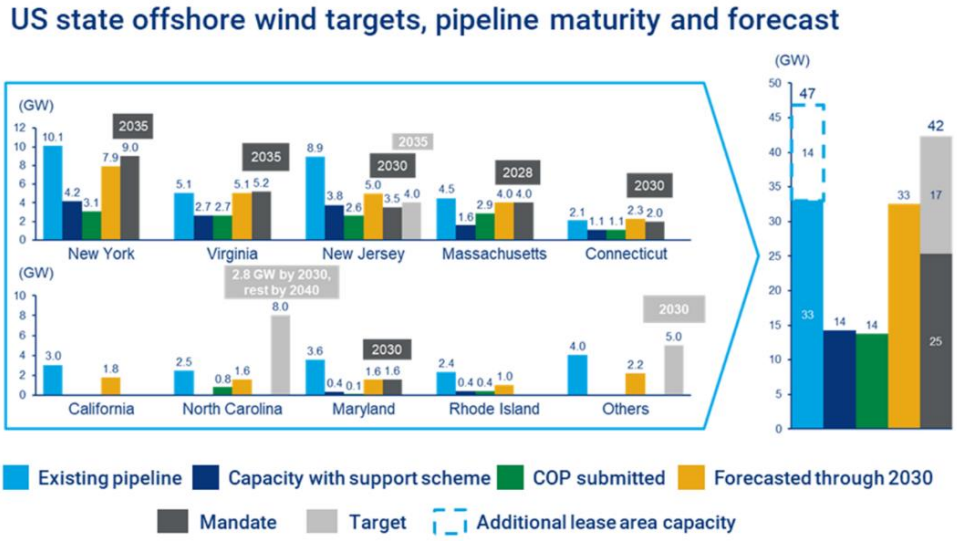


Figure 23. Wood Mackenzie, 2021.

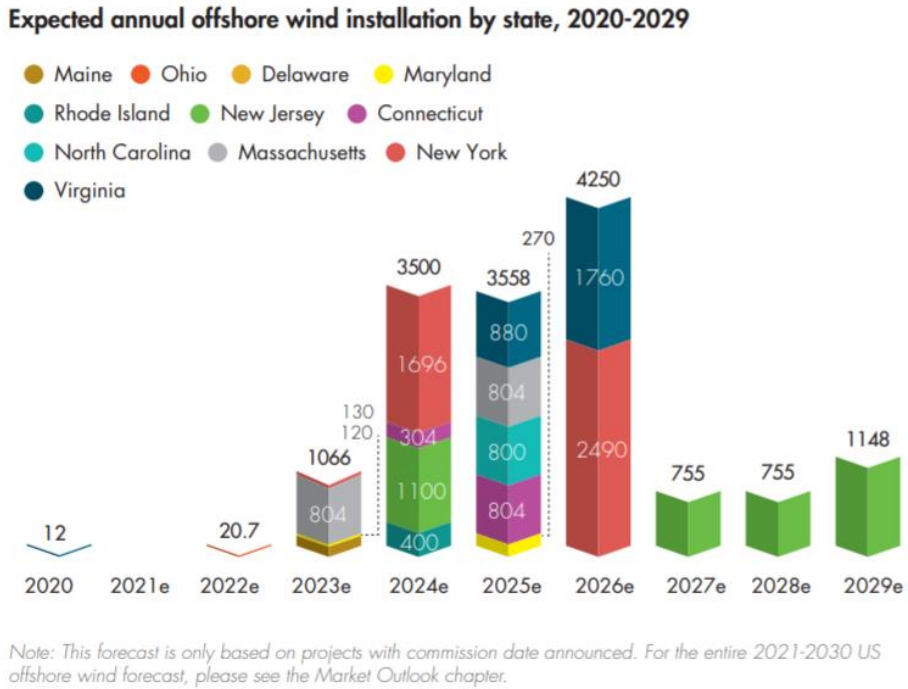


Figure 24. GWEC, 2021.

[44] FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs | The White House

New York

Despite initially trailing other states in the race for offshore wind dominance, New York has arguably surpassed other contenders to position itself as the "center of gravity" for the industry.[45]

In 2017, Governor Cuomo announced a 2,400-megawatt offshore wind target by 2030, which would soon be surpassed by clean energy legislation passed in July 2019, which increased New York's goal to 9,000 megawatts by 2035, as well as a 100 percent zero-emissions electricity requirement by 2040.[46] In 2018, NYSERDA issued its first large-scale solicitation,[47] resulting a combined 1,696 megawatts in 2019 (Empire Wind 1 and Sunrise Wind).

Through this first solicitation, project developers are making $287 million in investments in multiple regions of the state, including the Capital Region, Brooklyn, Staten Island and Long Island. Investments will also include a new $20 million Offshore Wind Training Institute (OWTI) and a $3 million Community and Workforce Benefits Fund (CWB Fund) to establish the institutional infrastructure to educate, train and employ New Yorkers. The solicitation also established the New York State Advisory Council on Offshore Wind Economic and Workforce Development. The Equinor-backed Empire State project will result in investments in three port areas, including support for the fabrication of gravity-based foundations at the Port of Coeymans: the use of the South Brooklyn Marine Terminal as a long-term operations and maintenance base, and the use of the Homeport Pier for the final foundation staging. The Sunrise project, a joint Eversource/Ørsted venture, proposed to make its operations headquarters for North America and its regional operations and maintenance hub at Port Jefferson, a facility for foundation fabrication and transition pieces in the Capital Region, and the Arthur Kill Terminal as a dedicated marshalling port.[48] These first solicitation investments build off of the $1.5 million announced by Governor Cuomo in his 2019 State of the State address.[49]

In 2019, the agency, in conjunction with the New York State Department of Transportation, and Empire State Development started Phase 1 of a two-part process designed to result in competitive public-private investments in port infrastructure. The agency issued a Request for Qualifications (RFQL) to pre-qualify proposers and resulted in 11 pre-qualified ports. In Phase 2, offshore wind developers were required to partner with a pre-qualified port and propose investments as part of their competitive bids

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[45] https://www.greentechmedia.com/articles/read/inside-new-yorks-push-to-be-center-of-gravity-for-us-offshore-wind

[46] https://www.nyserda.ny.gov/-/media/Files/Programs/offshore-wind/2021-02-10-OSW-Public-Webinar.pdf

[47] New York had one smaller-scale solicitation in 2017, when the Long Island Power Authority awarded a contract to the 130 MW South Fork Wind Farm following a competitive solicitation. https://www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Focus-Areas/NY-Offshore-Wind-Projects

[48] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjwheai5KnyAhW9EFkFHe-pBlMQFnoECAIQAQ&url=https%3A%2F%2Fwww.nyserda.ny.gov%2F-v%2Fmedia%2FFiles%2FPrograms%2Foffshore-wind%2FOffshore-Wind-Solication-Fact-Sheet.pdf&usg=AOvVaw03jjQa49V-dZRgK55S-KkC

[49] https://www.governor.ny.gov/news/video-audio-photos-rush-transcript-governor-cuomo-outlines-2019-justice-agenda-time-now

in the second large-scale OREC solicitation. The state provided up to $200 million in state money that could be leveraged in Phase 2.

In 2020, NYSERDA issued a second solicitation, and in 2021, issued awards to Empire Wind 2 and Beacon Wind, resulting in a total of 2,490 megawatts. This second solicitation will leverage almost $3 of private funding for every $1 of public funding for a combined investment of $644 million for resilient port facilities in the Capital Region and Brooklyn. These investments will establish the nation's first offshore wind tower manufacturing facility ready to service both offshore and onshore wind farms in the region at the Port of Albany and a cutting-edge staging facility and operations and maintenance hub at the South Brooklyn Marine Terminal.[50] The Port of Albany project is projected to create 500 construction jobs and will employ 300 full time workers who will build 150 of the wind turbine towers each year.

The $20 million Offshore Wind Training Institute (OWTI), originating from Sunrise Wind's bid in the first solicitation, launched in January 2021 with plans to train 2,500 individuals beginning this year.[51] Ultimately, the state plans to train approximately 10,000 workers to supports is goal of 9,000 megawatts.[52] The OWTI will work closely with the National Offshore Wind Training Center (NOWTC) located at Suffolk County Community College on Long Island, a joint $10 million partnership also created by Ørsted and Eversource Energy through the Sunrise Wind project. The OWTI issued a $3 million solicitation with awards expected in summer/fall 2021 to support training and educational organizations focusing on early training and skills development for disadvantaged communities and workforce training initiatives that build partnerships between workforce development, training, labor, and business institutions to support local supply chains and manufacturing in New York State.

In September 2021, Mayor de Blasio and New York City Economic Development Corporation (NYCEDC) announced a $191 million, 15-year plan to make New York City a major hub for offshore wind. The investments will be focused on sites and infrastructure, business and workforce, and research and innovation. The plan is expected to create 13,000 jobs, direct 40 percent of jobs and investment benefits to women, minorities, and environmental justice communities, reduce emissions by 34.5 million tons of CO2, and invest in the South Brooklyn Marine Terminal to help turn it into a premier offshore wind port.[53]

As a result of these strategic actions, not only does the state have the largest megawatt target of any states (9,000 megawatts), it also now has five projects (over 4300 megawatts) as well as five ports under active development -- more than any other state in both respects.[54]

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[50] https://www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Focus-Areas/Offshore-Wind-Solicitations/2020-Solicitation

[51] https://www.suny.edu/suny-news/press-releases/01-21/1-13-21/wind.html

[52] https://portal.nyserda.ny.gov/servlet/servlet.FileDownload?file=00Pt000000RdXfxEAF

[53] Offshore Wind NYC Plan (edc.nyc)

[54] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiix7-jpqfyAhWimOAKHf_tDo8QFnoECC4QAQ&url=https%3A%2F%2Fwww.nyserda.ny.gov%2F-

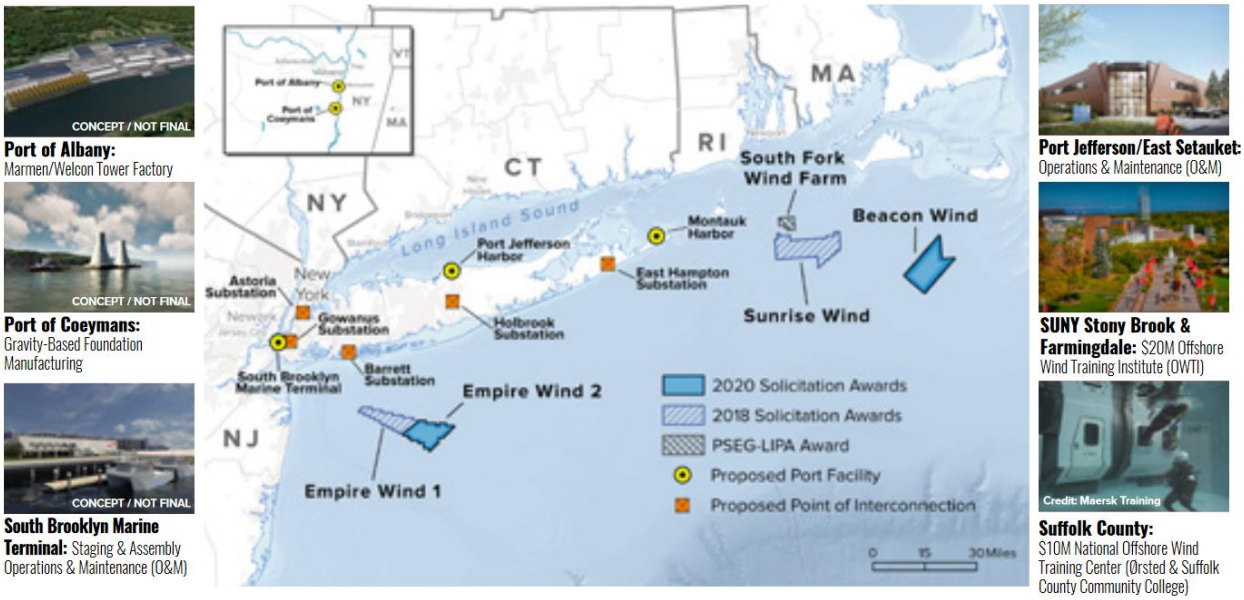

Figure 25: NYSERDA, 2020

As part of the New York 2020-2021 budget, the state announced the passage of Accelerated Renewable Energy Growth and Community Benefit Act. This legislation required the state to conduct a Power Grid study regarding transmission system investments to support clean energy growth. The study focuses on three areas: 1) utility infrastructure needs; 2) zero emission electricity scenario planning; and 3) an offshore wind study. The wind study focuses on offshore and onshore bulk transmission scenarios to identify possible solutions to integrating 9,000 megawatts of offshore wind. The study's results found that possibly no major onshore bulk transmission upgrades will be needed to integrate 9,000 MW of offshore wind generation by 2035 other than expanding Long Island bulk transmission links and likely local upgrades in New York City. However, it did state that additional actions will likely be needed to "implement carefully-planned storage deployment that is closely coordinated with OSW and land-based renewable generation interconnection needs." In addition, because of New York Harbor cable routing limitations, Manhattan substation space constraints, and Harbor and Long Island permitting complexities, the study recommended that offshore wind projects with radial connections be capable of being integrated into a meshed offshore wind network (by linking offshore substations of different projects together) to allow the possibility of transition to a more resilient and reliable delivery system.[55]

%2Fmedia%2FFiles%2FPrograms%2Foffshore-wind%2F2021-02-10-OSW-Public-Webinar.pdf&usg=AOvVaw0ITJ2I3jMWwq5nTYoVGuYV

[55] https://www.nyserda.ny.gov/-/media/Files/Publications/NY-Power-Grid/Executive-Summary.pdf

New Jersey

Forthcoming EWW Monopile Manufacturing Facility, Paulsboro, NJ

In August 2010, Governor Chris Christie held a bill signing at the Paulsboro Marine Terminal to sign the Offshore Wind Economic Development Act, which directed the New Jersey Board of Public Utilities (NJBPU) to establish a program for Offshore Wind Renewable Energy Certificates (ORECs).[56] After years of subsequent delay by the Christie Administration,[57] Governor Murphy issued Executive Order 3 on January 31, 2018 and directed all New Jersey state agencies with responsibilities under the Offshore Wind Economic Development Act to fully implement the act.[58] Following this order, New Jersey undertook a series of actions to bolster offshore wind, including passing the Clean Energy Act in May 2018 to require 3,500 megawatts of offshore wind by 2030,[59] establishing the OREC financing mechanism in July 2018,[60] opening the Offshore Wind Tax Credit program in January 2019,[61] increasing the offshore wind target by Executive Order 92 to 7,500 megawatts by 2035 in November 2019,[62] announcing a decade-long offshore wind solicitation schedule in February 2020,[63] and releasing the New Jersey Offshore Wind Strategic Plan in September 2020.[64]

The New Jersey Offshore Wind Strategic Plan (NJ OWSP) was responsible for making strategic recommendations for development of OSW in New Jersey. A series of 6 OSW solicitations associated with this plan are being overseen by the NJ Board of Public Utilities. The figure below shows New Jersey's planned solicitation schedule with solicitations divided into six tranches. These solicitations are

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[56] Gov. Chris Christie signs offshore wind power bill - nj.com
[57] New York leading offshore wind push while New Jersey lagsPOLITICOSearchSearchClose
[58] NJDEP-Air Quality, Energy & Sustainability
[59] NJDEP-Air Quality, Energy & Sustainability
[60] 20180725_OREC.pdf (nj.gov)
[61] New Jersey Opens Offshore Wind Tax Credit (oedigital.com)
New Jersey Offshore Wind Tax Credit Program: a tax credit program provides reimbursement for capital investment in industry-specific facilities located in the seven southern counties of New Jersey
Eligibility: A company making a capital investment in an offshore wind related facility of $50M ($17.5M if a tenant) in the seven southern counties of New Jersey and will be employing at least 300 new, full-time employees at the qualified wind energy facility or through an equipment supply coordination agreement
Benefit: Tax credits equal up to 100 percent of the qualified capital investments made, except as limited by a 110 percent net positive economic benefit to the State
[62] Office of the Governor | Governor Murphy Signs Executive Order to Increase Offshore Wind Goal to 7,500 Megawatts by 2035 (nj.gov)
[63] Office of the Governor | Governor Murphy Announces Offshore Wind Solicitation Schedule of 7,500 MW through 2035 (nj.gov)
[64] https://www.nj.gov/bpu/pdf/Final_NJ_OWSP_9-9-20.pdf

spaced every two years from 2018 - 2028, starting at 1,100 megawatts and progressing to larger solicitations of 1,400 megawatts. The NJ OSWP states: "As each solicitation approaches, capacity targets and schedule will be evaluated based on conditions existing at that time, including availability of tax credits or grants, establishment of supply chain, transmission solutions, technology advancements, and levelized cost of energy (LCOE) trends."

The first solicitation award was announced on June 19, 2019 by the New Jersey Board of Public Utilities and given to Ørsted's Ocean Wind 1,100 megawatts project. The second solicitation, commenced in September 2020, showcases the flexibility of the New Jersey solicitation model. Instead of only issuing solicitations for 1,200 megawatts, as was initially planned, the second solicitation sought between 1,200 megawatts to 2,400 megawatts. On June 30, 2021, NJBPU issued awards to two projects that totaled 2,658 megawatts, surpassing the solicitation's upper limit and bringing the state nearly halfway to their 7,500 megawatts project.[65] The NJBPU issued an award of 1,510 megawatts of capacity to Atlantic Shores and 1,148 megawatts to Ørsted's Ocean Wind II.

FIGURE 1-8: PROPOSED OFFSHORE WIND SOLICITATION SCHEDULE THROUGH 2035

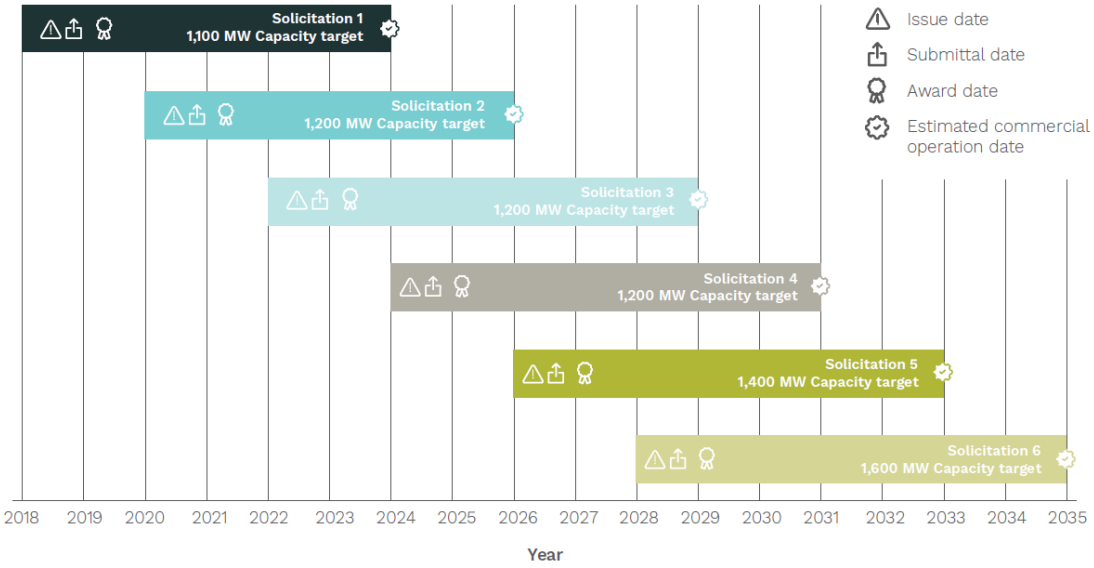

Figure 26: New Jersey Offshore Wind Strategic Plan, 2020

Over 10 years after Governor Christie signed offshore wind legislation at the Paulsboro Marine Terminal, Governor Murphy announced in December 2020 a $250 million investment (pledged by Ørsted and EEW Group, a German large-scale pipe manufacturer) to build a state-of-the-art Tier 1 monopile manufacturing facility.[66] The facility, expected to begin production in 2023, is designed to supply the entire U.S. offshore wind industry and is projected to yield 500 high-paying jobs at full buildout. On June 29, 2021, Governor Phil Murphy built upon this significant investment by signing the state's FY22 budget

[65] NJ awards 2 more offshore wind projects, tripling capacity (apnews.com)
[66] Office of the Governor | Governor Murphy Announces $250 Million Total Investment in State-of-the-Art Manufacturing Facility to Build Wind Turbine Components to Serve Entire U.S. Offshore Wind Industry (nj.gov)

into law, securing a $200 million investment which he had championed to construct an offshore wind port in Salem County Wind Port.[67] This latest investment by New Jersey matches New York's $200 million commitment to investment in offshore wind port infrastructure.[68] The State currently estimates the Wind Port will cost between $300-400 million at full build and the New Jersey Economic Development Authority (NJEDA), which is leading development, is currently considering a range of public, private, and public-private partnership (P3) financing options. The Salem County site will be designed to marshal and manufacture offshore wind turbines, including the making, staging, assembly, and transport of towers, nacelles, rotors, and blades to the offshore wind farm sites. State officials believe that this site will offer significant logistical and economic advantages for offshore wind companies by co-locating manufacturing, final assembly, and testing activities with the planned marshalling activities of the Salem County port. The Wind Port has the potential to create up to 1,500 manufacturing, assembly, and operations jobs, as well as hundreds of construction jobs in New Jersey. New Jersey officials envision the Salem County Wind Port as complementary to the Paulsboro manufacturing facility to "make New Jersey a one-stop shop for the U.S. offshore wind supply chain."[69] The state claims that there are currently no equivalent sites or ports like the Salem County Wind Port in New York, Delaware, or Maryland.

Finally, the Office of the Secretary of Higher Education, in conjunction with the New Jersey Economic Development Authority, implemented an Offshore Wind Safety Training Challenge in February 2021[70] to provide up to $3 million to help establish an industry-recognized offshore wind training program and facility. This program was funded by the New Jersey's Clean Energy Program™ (NJCEP). In July 2021, the Atlantic Cape Community College won a competitive $3 million grant in July 2021 to develop a GWO certified training program and facility that will be operation in 2022.[71] Atlantic Cape's proposal featured extensive stakeholder support, prioritized diversity and inclusion, and partnered with GWO-certified companies, including a women-owned business and two UK-based companies. Atlantic Cape plans to use the funds to build a 1,700-square- foot addition at their Atlantic City campus for Basic Safety Training modules and use a rehabilitated section at Gardner's Basin for the Sea Survival module. Overall, the Garden State has the goal of at least 1,825 workers completing GWO Basic Safety and Sea Survival Training between 2023 and 2035.[72]

Virginia

On June 29, 2020, Virginia Governor Ralph Northam built off his executive order a year prior[73] and signed legislation requiring 5,200 megawatts of offshore wind by 2034. On this same date, Virginia's first project, Coastal Virginia Demonstration Project, finished construction on its two 6 megawatt turbines. These actions paved the way for the Coastal Virginia Offshore Wind Commercial Project, the state's 2,640 megawatt project that is slated for commercial operation in 2024/2025, and which will be

[67] Office of the Governor | Governor Murphy Signs Fiscal Year 2022 Appropriations Act into Law (nj.gov)
[68] More NJ state money for offshore wind industry? | NJ Spotlight News
[69] 20210224-economic-PaulsboroMarine.pdf (nj.gov)
[70] https://www.njeda.com/windsafetytrainingchallenge/
[71] https://www.njeda.com/atlantic-cape-community-college-wins-nj-offshore-wind-safety-training-challenge/
[72] https://www.njeda.com/atlantic-cape-community-college-wins-nj-offshore-wind-safety-training-challenge/
[73] Governor Northam's executive order required 2,600 megawatts by 2026.

the first U.S. offshore wind farm owned by a utility. In July 2021, the Bureau of Ocean Management (BOEM) announced it would begin the process of preparing an environmental impact statement for the project, a key step along the way to receiving a record of decision to allow construction.[74]

Siemens Gamesa has been actively considering opening a U.S. turbine blade factory in Virginia in partnership with Dominion Energy to coincide with the state's first large scale offshore wind farm.[75] The company's chief executive Andreas Nauen said: "A final decision is not taken, but linked to projects in 2024/25 – if we go for the investment it [the opening of the new facility] will be in that timeline."[76]

In addition, Dominion Energy announced in June 2021 that the nation's first Jones Act compliant offshore wind installation vessel (the *Charybdis*), once operational, will be chartered by Eversource and Ørsted to support the construction of the Revolution Wind and Sunrise Wind farms. The approximately $500 million vessel, which is being constructed in a Texas shipyard, is expected to begin commercial operation by late 2023.[77]

Maine

In 2019, Governor Mills signed legislation establishing a 5,000 megawatt, legally binding target for offshore wind by 2030. As a result of deliberations with Maine's established fishing industry, the state will prohibit offshore wind development in state territorial waters (other than a 12-megawatt demonstration project). The state will also not be allowed to issue permits for cables or new transmission for projects in federal waters unless it can comply by April 2023 with three action points raised by the fishing industry.[78] Maine is constructing a 12 megawatt floating wind turbine demonstration project, which could begin commercial operation in 2023, and intends to exclusively use this technology for its projects.[79] As such, its projects will serve as a test bed for the rest of the nation to determine the viability of floating wind in the U.S.

Connecticut

In June 2019, Connecticut passed legislation requiring 2,000 megawatts of offshore wind by 2030, and in August 2019, the state's Department of Energy and Environmental Protection issued an RFP to solicit

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[74] https://www.reuters.com/business/energy/us-review-proposed-dominion-energy-wind-farm-off-virginia-2021-07-01/

[75] https://www.greentechmedia.com/articles/read/siemens-gamesa-may-build-first-factory-for-its-14mw-offshore-turbine-in-the-us

[76] https://renews.biz/66127/siemens-gamesa-considers-us-blade-factory/

[77] https://www.workboat.com/wind/dominion-to-charter-first-jones-act-offshore-wtiv-in-the-u-s

[78] Maine state officials must 1) complete Maine's offshore wind strategic planning project; 2) conduct a comprehensive review of state laws and regulations to ensure adequate protection of Maine's coastal resources; and 3) require the Offshore Wind Research Consortium to identify research questions regarding offshore wind development that need to be answered. https://www.nationalfisherman.com/northeast/maine-compromise-prohibits-new-offshore-wind-development-in-state-waters

[79] https://energynews.us/2020/08/07/why-floating-turbines-are-so-important-to-maines-offshore-wind-prospects/

bids for this amount.[80] In September 2019, Governor Lemont issued Executive Order No. 3 calling for Connecticut to transition to 100 percent zero-carbon energy by 2040, requiring the Department of Energy and Environmental Protection (DEEP) to analyze pathways and recommend strategies to achieve a zero-carbon target by 2040.[81] In March 2021, DEEP Commissioner Katie Dykes recommended that the state increase its target by 150 percent to 5,000 megawatts of offshore wind in order to meet its 2040 zero-carbon goals.[82] Currently, Connecticut has two offshore wind projects actively being developed. The 704-megawatt Revolution Wind project (a joint procurement with Rhode Island) will be staged at the New London Harbor and the 804-megawatt Park City Wind project will be developed in Bridgeport, Connecticut.

Approximately 22 months prior to passage of offshore wind legislation in June 2019, negotiations regarding the redevelopment of the State Pier in the New London Harbor for offshore wind purposes commenced between the state, the city of New London, the State Pier lessor Gateway, and lessees Ørsted and Eversource. These talks culminated 18 months later in February 2019 with a cumulative $157 million public-private investment to be made at the State Pier in the New London Harbor to transform it to handle larger vessels and heavy lift cargo and serve as a staging area for the offshore wind industry.[83] Although this process was temporarily delayed due to controversy around the spending practices and operations of the Connecticut Port Authority, and although it suffered from price increases from $93 million to $137 million due to the need to relocate a large installation vessel to another area of the pier, the state secured a 10 year lease with Ørsted and Eversource for the pre-assembly of wind turbine generators used for the Revolution Wind, South Fork Wind, and Sunrise Wind projects, among possible others.[84] This project is expected to create over 400 construction jobs and sustain 100 jobs thereafter. Construction on the pier will start in 2021.[85]

In addition to the offshore wind package for New London, Connecticut will also benefit from offshore wind investments in Bridgeport. Vineyard Wind plans to set up its headquarters for the Park City Wind project in downtown Bridgeport and will also lease the 15-acre Barnum Landing site to store and assemble transition pieces, which are the parts of the turbine that anchor the body of the machine to the steel foundation. After construction of the Park City project, a portion of the site will serve as an operations and maintenance area for the project's 20-year lifespan.[86]

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[80] DEEP Releases Offshore Wind RFP (ct.gov)
[81] Governor Lamont Signs Executive Order Strengthening Connecticut's Efforts to Mitigate Climate Change
[82] Connecticut Expected to Increase Off-Shore Wind Contracts (governing.com)
[83] The Day - Connecticut Port Authority board to vote on $157 million redevelopment plan - News from southeastern Connecticut
This included $22.5 million committed by the parties for State Pier infrastructure improvements.
[84] Governor Lamont Announces Major Development Plan That Will Establish New London as a Central Hub of the Offshore Wind Industry (ct.gov);
Governor Lamont Announces Host Community Agreement Signed by New London and Ørsted/Eversource Joint Venture (ct.gov)
[85] Connecticut Expected to Increase Off-Shore Wind Contracts (governing.com)
[86] Vineyard Wind Announces Connecticut Headquarters, Signs Lease for Construction and Staging at Barnum Landing — Vineyard Wind

Maryland

Maryland passed the *Clean Energy Jobs Act* in 2019, establishing an RPS-carveout for offshore wind through ORECs which will result in 1200 megawatts by 2030. The state has approved two projects, the 248-megawatt MarWin farm and the 120-megawatt Skipjack farm.[87] In October 2020, Maryland and joined Virginia and North Carolina in agreement to share resources to advance offshore wind in the region. This summer, US Wind – developers of the MarWin project – submitted a bid for a new 1,200 MW offshore wind farm, Momentum Wind, and proposed to build a new steel fabrication facility to supply both Maryland projects.

Trade Point Atlantic and Ørsted U.S. Offshore Wind have begun to develop a 50-acre staging site at Baltimore's Sparrows Point.[88]

Rhode Island

Rhode Island made national headlines in December 2016 when the 30-megawatt Block Island wind farm began generating electricity. The state later collaborated with Massachusetts when the Bay State was issuing its first large-scale RFP, and as a result, procured the 400-megawatt Revolution Wind project in 2018.[89] In October 2020, Governor Raimondo's administration announced that the state is seeking to procure an additional 600 megawatts. If approved by the state's Public Utilities Commission, the state will have 1,030 megawatts of offshore wind.[90]

Pacific

Since May 2021, President Biden has opened California's coast up to wind development, with an agreement to auction lease areas supporting up to 4600 megawatts. Recent legislation in the state, AB525, requires by March 1, 2022 that offshore wind planning goals for 2030 and 2045 are set for California, and that a process is undertaken to evaluate and quantify the maximum feasible amount of offshore wind to achieve emission reductions, reliability, employment, and ratepayer benefits.[91] The bill was signed into law on September 23, 2021.[92]

As the Pacific Ocean reaches greater depths more quickly than the Atlantic, monopile structures cannot reach the seafloor. Because of this, the Pacific's greatest wind resources can be more efficiently utilized through floating structures.

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[87] https://blogs.constellation.com/energy-policy/maryland-rps-requirements-a-focus-on-offshore-renewable-energy-certificates/

[88] https://www.wmar2news.com/news/region/baltimore-county/old-sparrows-point-steel-mill-to-become-states-first-offshore-wind-energy-staging-center

[89] https://www.windpowermonthly.com/article/1465766/deepwater-vineyard-win-capacity-first-rfps

[90] https://www.ri.gov/press/view/39674

[91] https://leginfo.legislature.ca.gov/faces/billAnalysisClient.xhtml?bill_id=202120220AB525#

[92] https://www.gov.ca.gov/2021/09/23/governor-newsom-signs-climate-action-bills-outlines-historic-15-billion-package-to-tackle-the-climate-crisis-and-protect-vulnerable-communities/

Great Lakes

In October, the Ohio Power Siting Board approved the Icebreaker Windpower project, putting it on track to become the first freshwater offshore wind project in North America. However, the project – consisting of six turbines sitting 8 to 10 miles northwest of Cleveland and producing 21 megawatts of electricity per year – still needs its wildlife impact monitoring plan approved by the Ohio Power Siting Board before construction can begin, which is a process with no set timeline. Additionally, it faces a legal challenge from lakeview condo dwellers.[93] The Ohio Supreme Court will likely announce their decision in early 2022.[94]

The decision has massive ramifications on the future of the region's industry; winds off the Great Lakes are estimated to be able to supply up to one-fifth of the combined 2050 electricity needs for Ohio, Michigan, Wisconsin, Minnesota, Illinois, Indiana, and Pennsylvania.[95] The region, however, is limited in usable area and hampered by winter ice that could damage turbines.

X. Legislative Action

Stakeholder Asks

Throughout the spring and summer of 2021, the TUE Committee held a series of stakeholder conversations to gain a deeper understanding of the opportunities and needs of the industry. The following are some of the legislative requests that arose from those conversations.

Tufts: Higher Ed Funding

Professor Eric Hines, of Tufts University, spoke to the potential of $10 million from MassCEC to higher education institutions. He reported that all UMass campuses (except UMass Medical) are ready to work on offshore wind efforts. Before 2016, the institutions were fighting each other for small amounts of money; they formed POWER-US in an attempt to work together to go after larger sums of money. The expectation was that the UMass system would lead, while maintaining partnership with Tufts and WHOI.

Professor Hines recommends the funds be provided over three to four years, rather than competed over in small tranches, with a fixed amount of money per year provided to each institution. The idea would be to give a charge to institutions to leverage federal dollars. This would create stability and platform for significant federal initiatives and would bring together universities. It would also allow them to win federal dollars on the scale of hundreds of millions. While a direct line item had been considered for this type of venture, UMass ultimately decided against this approach because of other university-wide spending priorities that took precedence.

Bristol Community College: NOWI Training Facility and Innovation & Entrepreneurship Program

BCC plans to launch the National Offshore Wind Institute (NOWI) in 2022 in a renovated 30,000 square foot facility. It will have the capacity to train 200 delegates per week in short-term, days-long or weeks-

[93] https://insideclimatenews.org/news/26102020/icebreaker-project-lake-erie-cleveland-wind-energy/
[94] https://www.4coffshore.com/windfarms/united-states/icebreaker-united-states-us82.html
[95] https://environmentamerica.org/feature/ame/offshore-wind-america

long trainings. BCC will utilize its partnership with Maersk Training for the facility and the specific fit-out and equipping of training labs to align it with GWO certification requirements.

Additionally, NOWI will offer the Innovation & Entrepreneurship (I&E) program in the first quarter of 2023 to foster new businesses and job creation. The I&E program will offer a pathway for those with new ideas or existing intellectual property to refine, develop, and protect them for application in the offshore wind sector.

Bristol Community College has said that state financial support would be beneficial for NOWI because it will be difficult to turn a profit in the early years. NOWI received initial seed money from MassCEC but now requires $7 million in capital investments in the facility renovations as well as equipment investments, as detailed below:

- *NOWI Renovations:* The NOWI facility will require a $5 million renovation to develop this essential offshore wind training center, including a Blade Repair lab. The 30,000 sq. ft. building will need this investment into industry/certification specific building--providing Bristol an opportunity to compete against other states' facilities that have had state investment.
- *Equipment:* The NOWI will require $2 million that is critical to be able to first achieve accreditation as a GWO training facility as well as to offer GWO and other training programs.

UMass Dartmouth: Workforce Pipeline

The Committee held multiple stakeholder meetings with UMass Dartmouth and other higher ed institutions in preparing this report. Dr. Michael Goodman, Acting Provost & Vice Chancellor for Academic Affairs, and Dr. Ramprasad Balasubramanian, Vice Provost for Research and Academic Affairs provided recommendations.

UMass Dartmouth is located in the heart of the Southcoast and is ideally positioned to provide scientific and technical support to both the emerging offshore wind sector and other Blue Economy industries. With our proximity to several industrial ports capable of supporting the offshore wind industry, scientists and engineers at UMass Dartmouth are ideally situated to advise, consult, and engage with the development of this major emerging industry. The following is a list of some areas relevant to the offshore wind industry where UMass Dartmouth faculty already have deep expertise.

- Meteorological and oceanographic information and analysis
- Assessing and mitigating impacts on environmental, coastal, and marine assets
- Offshore wind component research, design, testing and engineering (including fluid and solid mechanics)
- Marine geotechnical engineering, especially wind turbine foundations and offshore structures
- BlueTech peripherals for operations support
- Offshore wind policy, law and economics, including community needs and impacts studies

UMass Dartmouth is actively seeking opportunities to enhance the alignment of our educational programming and research activities with the needs of the offshore wind industry. A survey of UMass Dartmouth faculty revealed extensive offshore wind-related research and educational interests and

capabilities and close communication is being maintained with offshore wind companies such Vineyard Wind, Mayflower Wind, Ørsted, and Anbaric, as well as offshore civil engineering firms such as WSP, Haley and Aldrich, and CDM Smith. The following capabilities were identified as being absent in the Northeast United States and critical to the development of a local system of research and development support for the growing offshore wind sector. In addition, we have identified several external research partners who have a stated a strong interest in having access to these facilities, such as at UMass Amherst, UMass Lowell, UMass Boston, Northeastern University, Tufts University, Alden Laboratories, HR Wallingford, and the Norwegian Geotechnical Institute.

UMass Dartmouth is currently in the process of preparing a proposal to the Massachusetts Technology Collaborative seeking support for the development of a Marine and Environmental Testing Laboratory (METL) that would be available to external users on a fee-for-service basis. If funded, it will support the development of biodegradable and ocean-safe plastics and other materials by accelerating their path to market. Plastic pollution and waste disposal and recycling costs are growing problems for ecosystems, human health, and local governments all over the world, and many states across the country are cracking down on the plastics industry through Extended Producer Responsibility programs. If funded, this proposal will help Massachusetts manufacturers increase their competitiveness in an increasingly eco-conscious consumer market and reduce negative externalities on regional industries such as fishing and tourism.

The facilities proposed below would build on the MTC investment and become a part of the METL, and would thus benefit from the organizational structure we are creating to ensure that these facilities are responsive to industry needs. For example, all of these facilities would be established as University of Massachusetts “Core Facilities” to enable ease of access by outside users and the use, management, and further development of the facilities would be guided by both an advisory board and a user group. The identified research facilities are as follows:

<u>Recirculating Saltwater Flume Tank:</u>

The proposed recirculating racetrack flume for the University of Massachusetts Dartmouth will provide unique research and testing capabilities by allowing hydrodynamics testing in seawater with a sediment boundary. The flume will utilize treated seawater from Buzzards Bay and will have wave generation capabilities and a sediment pit which can be filled with site specific or standard soils. This will allow for hydrodynamic testing of the nature – infrastructure nexus where seawater and soil chemistry are critical. Proposed research topics include:

- Addressing challenges like scour and sediment transport around the offshore foundations by combining hydrodynamic and geotechnical process involved in fluid-structure-soil interaction systems;
- Testing small-scale physical models of novel floating foundations designed for offshore wind turbines; and
- Testing and optimization of submarine cable protection devices.

<u>Geotechnical Centrifuge for Offshore Engineering</u>

The geotechnical centrifuge is a tool for high-gravity scale modeling of foundations and geosystems. Centrifuge modeling is popular in the offshore industry because of the size of the infrastructure and the high cost of offshore wind field testing. The geotechnical centrifuge will be specifically set-up with technical and administrative capabilities to best support the growth of the offshore wind industry. It will include a two-dimensional actuator system for simulating wind and wave loading and will include tools for modeling silent pile installation that are currently in development to protect marine mammals. Related research topics include the design and testing of novel offshore wind foundations for difficult soil conditions as well as anchor systems for floating offshore wind.

Closed-Loop Subsonic Wind Tunnel

A closed-loop subsonic wind tunnel with a 2-meter square test section to test the aerodynamics of full, scale-model wind turbines. The wind tunnel would have temperature controls for simulating ice and cold weather conditions and the ability to generate active turbulence.

Budget Request Summary

The requested budget items will significantly advance our region's competitiveness as a destination of choice for the offshore wind industry and help provide additional employment opportunities, both short term and long term, in our economically challenges region. Total budget needed for all items would be $6.5 million, not including the Biodegradation Lab.

Need	**Budget**
Recirculating Saltwater Flume Tank	$2.75 million
Geotechnical Centrifuge for Offshore Engineering	$3 million
Closed-Loop Subsonic Wind Tunnel	$750,000

UMass Amherst: Research Funding

A group of wind energy professors at UMass Amherst identified enormous untapped demand from students to gain experience and expertise in wind energy. They report that sustained funding of institutions of higher education in Massachusetts is needed to grow the pipeline of highly trained students at the undergraduate, MS, Ph.D. and certificate levels in wind energy. At UMass Amherst, demand for research positions and internships far exceeds our capacity to support students. For example, sustained $1 million annual support would allow the following initiatives:

- 20 undergraduate independent research opportunities
- 20 internship placements in OSW industry (undergraduate and graduate)
- 15 graduate students engaged in research targeted at industry needs
- Significant outreach and communication to publicize the vibrancy of the Massachusetts offshore wind ecosystem

The group proposes sustained funding of the member institutions of POWER-US (see above). POWER-US would collaborate directly with industry and government to target areas of high impact research that will accelerate offshore wind energy development and will produce innovative new technologies.

The group provided possible models for the management of this funding arrangement:

- One percent of project cost, set-aside by developers, could fund the initiatives described above and give Massachusetts the most comprehensive workforce development ecosystem in the nation; one rivaled worldwide only by Denmark and the UK. A variety of mechanisms exist (authorizing legislation, developer RFP process) available to incentivize or require such investment. This concept is currently included in H.3302.
- In the 1990s, the Legislature established the Strategic EnviroTechnology Partnership (STEP), creating a funded partnership including UMass Amherst, Lowell, Boston and Dartmouth and the state government (EOEA and DOER) to conduct targeted research focused on environmental technology and renewable energy growth.
- In the Oil and Gas industry, it is common for developers to contribute a portion of profits to local research institutions to develop the local workforce.

GE: Wind Training Center

In a stakeholder meeting with GE, Jim McGaugh, Executive Director & Counsel and Head of US State Government Affairs & Policy, spoke to the need for the U.S. to create a wind training hub, similar to what been done in Germany and France. He noted New York and New Jersey's efforts to establish premier offshore wind training programs and facilities. New York has invested $20 million in its Offshore Wind Training Institute, which launched in January 2021, with plans to train 2,500 individuals in its first year and 10,000 workers overall.[96] The institute is partnering with the $10 million National Offshore Wind Training Center at Suffolk County Community College in Long Island. New Jersey awarded $3 million to the Atlantic Cape Community College to establish a training program and a training facility to be operational in 2022. The Garden State has the goal of at least 1,825 workers completing GWO Basic Safety and Sea Survival Training between 2023 and 2035.

Mr. McGaugh noted that industry stakeholders would be interested in supporting the Commonwealth's efforts to establish a central training center in Massachusetts. Mr. McGaugh also indicated that New York and New Jersey's earlier aggressive actions in establishing training programs and facilities may result in one of those states serving as the training epicenter for the U.S. offshore wind industry and obviating the need for such a training center in Massachusetts. Other stakeholders, such as Bristol Community College, hold the view that the Eastern Seaboard will need multiple training centers to provide a whole host of trainings and certifications, similar to Europe, which has facilities across the continent near wind farms.

[96] https://portal.nyserda.ny.gov/servlet/servlet.FileDownload?file=00Pt000000RdXfxEAF

NOWRDC

Carrie Cullen-Hitt of provided a series of recommendations. NOWRDC spoke to the challenge of transmission and interconnection constraints and recommended Massachusetts

The National Offshore Wind Research and Development Consortium (NOWRDC), with its role as national non-profit providing services to numerous states, takes no formal role in promoting Massachusetts-specific offshore wind policies. However, in response to questions of what actions the state could undertake to strengthen its offshore wind leadership, NOWRDC offered the following responses. The organization suggested that Massachusetts could play a role in urging ISO-New England to address transmission and interconnection constraints that will limit future offshore wind deployment. It further noted that industry stakeholders had raised the importance of a study on the use of Power Purchase Agreements (PPAs) or other means to drive economic development, although such a study has not been conducted. Further, NOWRDC stressed the importance in a standardized certification to avoid having different schools produce different certificates and suggested spreading awareness and advocating usage of the GWO certification that schools such as Bristol Community College and Mass Maritime are employing. Finally, NOWRDC recommended leveraging federal funding to make strategic recommendations.

Successful Models

Life Sciences Initiative

Chapter 130 of the Acts of 2008 established the 10-year, $1 billion life sciences Initiative to develop and sustain the Massachusetts' life science industry cluster, including pharmaceutical, biotechnology, medical devices, bioinformatic, and diagnostic companies. The initiative addresses the cluster's physical, human, and financial capital needs.

Managed by the quasi-public, Massachusetts Life Sciences Center (MLSC), an economic development and investment agency, the programs are available to certified companies. The criteria requires that companies project the state tax revenue they expect to generate and the number of permanent full-time jobs they expect to create or retain. The MLSC can revoke a certification and funding if actual revenue is less than 70 percent of the projected revenue.

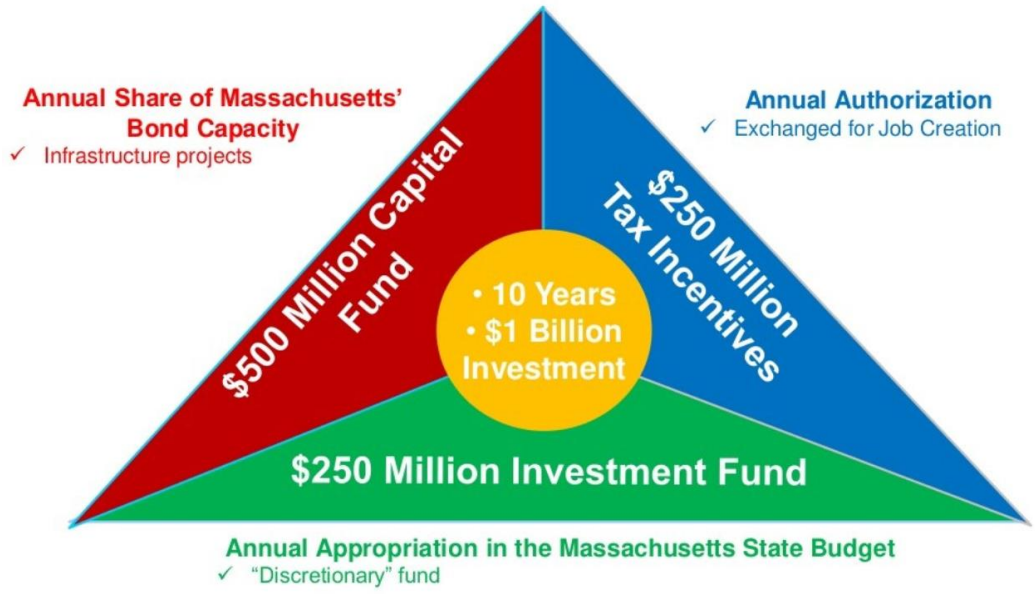

Figure 27: Biomedical Growth Strategies LLC, 2016

The Life Sciences initiative includes several economic development programs targeted exclusively at the life sciences cluster. These address the cluster's workforce development, long- and short-term physical infrastructure, and financial needs. The initiative's price tag includes up to $500 million in bonds for specified capital projects, $250 million in appropriations for grants and loans, and $250 million in personal and corporate business tax credits and sales tax exemptions. The tax credits are capped at $25 million annually.

Other Countries

A review of countries successfully establishing offshore wind industries finds that industry expansion generally relies on supportive government policies, technological progress, and falling costs.

Denmark

While Massachusetts' comprehensive OSW ecosystem would be the first of its kind in the US, it is a model with a proven track record. Denmark mirrors Massachusetts with a similar population, land area, coastline, and GDP. But, they have over 80,000 jobs in the wind energy industry, many focused on high-tech innovation and engineering, contributing to 5 percent of the GDP. International firms from around the globe set up shop in Denmark to learn from their expertise and hire their workers. And Denmark now produces over 50 percent of their electricity from wind energy.

The oil crises of the 1970s served as the spark for Denmark's transition to a new form of energy. At the time of the first oil crisis in 1973, 95 percent of Denmark's energy came from imported oil. Initially, Denmark responded to the crises by turning to coal, but later realized the potential to start a new industry. Wind energy became a national priority, as a combination of national policies and subsidies – along with support from local communities and utilities – allowed the industry to take off. In 1993, a fixed feed-in tariff was established to make installation of wind power competitive. Danish wind projects

then received a refund from the Danish carbon tax, and a partial refund on the nation's energy tax. The cumulative effect of these refunds doubled the payment to wind projects for the first five years of their operations. In 2009, Denmark introduced an environmental premium of $0.05/kWh to electricity prices and provided a $0.004/kWh compensation to new wind energy projects.

Taxes are the primary constituent of Denmark's electricity costs - 56 percent of the consumer cost of electricity goes towards taxes to support the welfare state. Danes pay more in taxes than they do for the production, transmission, and distribution of electricity. A Public Service Obligation funds the development of renewable energy, supports decentralized combined heat and power production, and helps pay for energy research and development.

A key factor to the Danish concept working well is the Danish population's willingness to the industry. Energy and environment politicians used attractive participation schemes to encourage local residents affected by the wind farm projects to get involved rather than driving them to engage in endless legal disputes. Residents and communities have a legally guaranteed share in the profits generated by wind or solar energy farms. They also receive compensation if wind farms cause their properties to depreciate. Meanwhile, state guarantees are available to support independent projects that produce sustainable energy.

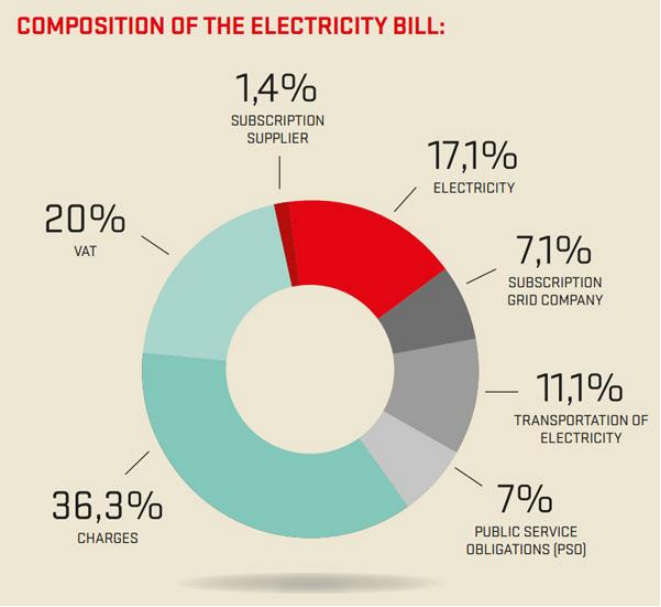

Figure 28: Keane Gruending, 2016

UK

With 11 GW of offshore wind, the United Kingdom currently has the world's biggest offshore wind market. The country produces enough to power 7.5 million UK homes a year. Today, 44 percent of the UK's electricity comes from renewables. They aim to reach net-zero emissions by 2050 and produce 40 GW of offshore wind by 2030.

The UK's 2008 Climate Change Act set a target of lowering GHG emissions to be at least 80 percent below 1990 levels by 2050. The government decided that the best way to reach that target was by focusing on offshore wind. Their strategies included: offshore wind research funding, a giant blade-testing facility in Northumberland, and large subsidies. Government subsidies for offshore wind were greater than for onshore wind or solar.

In 2013, the government authorized competitive auctions for low-carbon power. Companies bid to supply electricity in 15-year contracts. The government pays the difference between the bid price and the market price. Since 2015, these auctions have excluded onshore wind and solar. The fact that the contracts were long-term brought on investor confidence. As more investments were made, the

industry grew and matured, allowing for technological advancements. The government's reliance on offshore wind to reach its decarbonization efforts motivated it to pursue a deal with the offshore wind sector to facilitate the energy transition and spur economic development.

The UK's strategy for economic development was to incentivize growth clusters around ports. The goal was, and continues to be, to build related industries together in order to achieve economies of scale. The clusters are thoughtfully coordinated by a local lead, such as an economic development agency that identifies what is strong and already happening in a given area, and then actively brings in suitable companies that will support each other to create an industry cluster. Some clusters can be maintenance focused, other operations focused, and others can be manufacturing focused, depending on what resources are already present in the area. The actual companies and organizations themselves are not associated with each other, but their presence in proximity to each other anchors the area as an industry stronghold that attracts more investment and development.

In 2019, the UK government and offshore wind industry formed **the Offshore Wind Sector Deal**. The agreement ensured that the government will hold auctions every two years, and in return expects the OSW industry to continue cutting costs, committing to lower their impact on bill-payers, and investing in and driving growth in the UK's manufacturing base. Some of the major components include:

- Government will invest £557 million into clean power auctions
- Setting a goal of generating 30GW of offshore wind by 2030
- The OSW sector will invest up to £250 million into the UK's supply chain, establishing the Offshore Wind Growth Partnership (OWGP) to support the growth of manufacturing jobs
    - The goal of providing UK businesses with this kind of support is to increase UK exports fivefold to £2.6 billion by 2030
- The OSW sector will invest $48 billion into the UK's energy infrastructure in order to help it transition into a smart grid

The agreement enabled closer collaboration between government and the OSW industry, and the long-term contracts reinforced effective and stable regulatory regime for OSW. Developers, supply chain companies, and investors were given the confidence necessary to invest in the industry, which has helped support innovation that has driven down prices of the technology. A common critique is that growing the UK's manufacturing base does not pair well with cutting down the cost of offshore wind power, since Britain's labor costs are relatively high.

The UK has recently attempted to better organize industry stakeholders. Their OSW Evidence and Change Program – organized by the Crown Estate – brings environmentalists, fishing representatives, and developers together to advise academic research and find common solutions to help inform policy.

China

China, meanwhile, has the world's fastest growing offshore wind market, leading the globe in new OSW construction. In 2018, the country installed 1,800 MW and currently has about 3,700 MW[97] of projects under construction. The country has focused on supporting local developers and building a local value chain.

In 2014, China implemented a high subsidy for wind power, which helped the domestic sector grow quickly. Their 2016 Five Year Plan included a plan for wind power development and set a target of 10 GW of offshore wind power by 2020. Four of China's coastal provinces were tasked with constructing 1,000 MW each, while 11 coastal provinces in total started preparing for offshore wind expansion. Developers had a clear signal and started preparing projects – aided by improving technology and competitive subsidies. The government has announced, however, that starting in 2022, new wind projects will not receive government subsidies; this announcement rapidly grew the nation's OSW as developers rushed to get their projects connected before the cut-off but threatens to slow the growth moving forward.

Pending and Prior Legislation

An Act to provide for the investment in and expansion of the offshore wind industry in the Commonwealth (H.3310)

This session, Leader Golden filed an offshore wind bond bill that creates the Offshore Wind Industry Investment Fund and authorized $500 million therein, with $50 million specifically earmarked for port infrastructure development. It further requires MassCEC to create an offshore wind industry tax incentive program and authorizes them to provide up to $30 million in incentives annually to certified offshore wind companies. The bond bill aims to emulate the highly successful $1 billion life sciences initiative which developed and sustained the life science cluster.[1]

Similar to the life sciences bill, H.3310 creates a certification and revocation process for offshore wind companies (if a company's representations are materially at variance with the company's conduct).

The monies can be used for

- investments, grants, research, and loans;
- promoting manufacturing activities for new and existing advanced technologies and offshore wind research;
- providing funds for revitalization and infrastructure for ports in the commonwealth;
- providing workforce training grants to prepare individuals for offshore wind careers;
- providing funding for development, coordination and marketing of higher ed programs; providing site remediation, preparation and ancillary infrastructure improvement projects

In addition, offshore wind companies shall be eligible for tax incentives (created by this Act); assistance from the MassCEC in accessing economic incentive programs within the MA office of business

[97] Fortune Business Insights: OSW Power Market Size, Share and Industry Analysis
China Daily: China set to be the world leader in OSW market this decade

development, including resources to locate or expand in the state; assistance from the MassCEC in obtaining federal grants; preference for funding for offshore wind industry job training programs; and preference for pre-permitted industrial land.

The bill further strikes the offshore wind price cap requirement from the *Energy Diversity* Act of 2016 which required each successive offshore wind procurement and associated offshore wind transmission costs to be less expensive than the previous procurement. (See Section X: Legislation and Reports to Date for a discussion on the offshore wind price cap)

It further requires that the Department of Public Utilities give preference to proposals that demonstrate economic development contributions to the Commonwealth and requires the winning bid for 83C offshore wind solicitations to be chosen by a selection committee that consists of the EOEEA Secretary (Chair), the EOHED Secretary, the Attorney General, an appointee made by the Speaker, and an appointee made by the Senate President.

An Act to support innovation and local investment in the green economy (H.3294)

Representative Carolyn Dykema has sponsored legislation to provides a potential funding source to grow MassCEC.

Section 1 of the bill establishes a program managed by the Massachusetts Clean Energy Center to support public entities, municipalities, and their residents in partnering with private entities to develop, pilot, and deploy solutions to decarbonize communities, buildings, homes, businesses, and vehicles. The program may provide resources that include, but are not limited to:

- feasibility studies
- consulting services
- direct grants for pilot and demonstration projects
- technical assistance for energy planning
- consumer engagement and education initiatives
- direct financial support to municipalities or NGOs for local staffing to support these efforts

The public interests to be advanced through this program will include, but not be limited to:

- strategic clean energy planning
- fleet electrification
- grid modernization and resilience
- deploying EV charging infrastructure
- building decarbonization transitions
- distributed energy resources

The program will prioritize projects in EJ communities, Gateway Cities, Green Communities, MVP Communities, and projects that pilot and deploy innovative technologies by MA based companies.

Section 2 adds language to the goals and allowable uses of the Renewable Energy Trust Fund to include:

- Assisting the Commonwealth in meeting net-zero goals
- Facilitating energy supply chain procurement including offshore wind supply chain activity

- Advancing building decarbonization, advancing clean transportation technologies
- Grid modernization development

Section 3 increases the charge on electricity customers from 0.5 mill per kilowatt-hour to 1.5 mill per kilowatt hour and creates a charge of 14.65 mill per them for all natural gas customers.

An Act powering Cape & Island homes with offshore wind energy (H.3301)

Representative Dylan Fernandes is seeking to create a mechanism by which municipalities can benefit directly from local renewable energy projects.

The bill would allow a municipality to enter a "community empowerment contract" with a company proposing to construct a renewable energy project. The bill allows for contracts of this type to be formed until December 31, 2031.

Stipulations for a community empowerment contract include:

- The municipality cannot utilize its collateral, credit or assets as collateral or credit support.
- The contact must be entered prior to project construction.
- The contract must be a "contract of differences," stabilizing electricity prices for participants and specifying a fixed price for the energy and renewable energy certificates (RECs).
- The contract must specify:
    - how a project's contracted energy and RECs can be sold to a third party – at a price established by the wholesale market or an index and as agreed by the parties to the contract – and
    - how the proceeds from a sale can be credited to the amount owed from the project participants.
- If the amount earned in a sale exceeds the fixed price, the participants must be credited for the difference.
- A contract cannot agree to physically deliver electric energy to participants.
    - It can require delivery of RECs.
- The contract must specify whether RECs are to be provided and, if so, how the RECs are to be transmitted and disposed of or retired.
    - The RECs may be (a) assigned to the load of each participant or subset or participants; or (b) sold in a transparent, competitive process, the proceeds from which would be applied to the contract for differences mechanism.
- A REC cannot be used by a supplier (basic service or competitive) to meet its requirements under the renewable energy portfolio standard (RPS) unless it is first sold in a competitive, transparent process.
- The contract must last at least 10 years from when the project commences operation.
- The contract must describe how a charge or credit is calculated based on the contract for differences mechanism.
    - The calculations must ensure full payment or credit to the project even if a resident does not fully pay their distribution utility bill.

    - If there is a nonpayment of all or a portion of a distribution utility bill, an increase in charges to the residents may be used.
    - The contract must specify a contract administrator to perform the calculations.
- The contract can exempt residents who receive low-income electric rates.
- Municipalities can enter a contract through a majority vote of their legislative body.
    - Cities must also gain approval from their mayor or city manager.
- Two or more municipalities may join a contract together.
- A public hearing must be held prior to joining a contract.
    - The hearing must specify the proposed project under the contract and the length of the contract.
    - The hearing must present estimated rate impacts under reasonable scenarios for future energy price, calculated by a third party.
- A mailing must be delivered to residents 30 days prior to the hearing, with:
    - the proposed project and contract information
    - estimated rate impact on constituents
    - procedure for customers to opt out of the proposed contract, and
    - information regarding the public hearing.
- Residents will be automatically opted into the contract, unless they provide notice to the municipality within 90 days of the contract's authorization.
    - Residents receiving a low-income electric rate can opt out at any time.
- Customers cannot participate if they use more than 5 percent of the region's total annual electricity usage.
- Residential and small commercial customers that start after the municipality enters into the contract will be automatically opted in.
    - Large commercial customers can opt in (unless otherwise prohibited) but cannot opt out later.
- The contract cannot require participants to change their electricity supplier.
- The contract must be indicated in a line item on a resident's distribution utility bill
    - A distribution utility may recover verifiable and reasonable costs for the implementation from the municipality or residents.
    - If implementation requires changes to the distribution utility company's billing system, ACP funds or the Massachusetts Renewable Energy Trust Fund can be used to cover costs (with DPU approval).

DPU shall promulgate regulations, guidelines or orders, within 6 months of the effective date of this act, that establishes:

- A process for municipalities to request the summary historic load and payment information of the electricity customers from the distribution utility
    - The utility can charge for verifiable, reasonable and direct costs associated with providing the information as approved by the DPU
- A procedure for municipalities to have a contract approved by the department DPU

    - The DPU should minimize the administrative and legal costs to the maximum extent possible
- guidelines or standards by which the contract administrator must:
    - provide utility adjustments to charges to the distribution or credits to participants via a line item on the distribution utility bill
    - provide necessary information for the distribution utility to make or receive payments to or from the project

DOER shall promulgate regulations, guidelines or orders, within 6 months of the effective date of this act, that detail:

- how RECs may be transmitted and retired appropriately, and the energy source disclosure information accurately provided to participants
- recommended practices for municipalities to ensure transparency and accountability

DOER must provide technical assistance to municipalities upon request.

The community empowerment contract is separate from an electricity supply contract, and municipalities that enter community empowerment contracts should not be considered electricity suppliers.

The legislation includes a pilot program available to municipalities in Barnstable, Dukes, and Nantucket Counties. Within 1 year of the pilot program (annually thereafter for 5 years), the EEA Secretary must submit a report to the TUE Committee that details the results of the pilot program, including:

- renewable energy projects funded
- stabilization of prices for electricity customers
- enhancement of local energy security and reliability
- fostering of economic development
- reduction of electric system carbon emissions

An Act to promote offshore wind energy and renewables (H.3302)

Rep. Fernandes has also sponsored legislation to particularly bolster the environmental, economic, and equity components of offshore wind industry development. The bill has eight key sections, each differing in scope:

Section 1. Additional Offshore Wind Solicitations

The DOER must investigate the necessity, benefits, and costs of requiring distribution companies to conduct at least 2,800 megawatts in additional offshore wind generation solicitations and procurements.

Section 2. Removing Cost Limitations

The DPU no longer needs to ensure that a procurement's price (levelized price per megawatt hour plus transmission costs) is greater than or equal to that of the previous procurement.

Section 3. Removing Remuneration for Distribution Company
The DPU no longer needs to provide for an annual remuneration for the contracting distribution company up to 2.75 percent of the annual payments to compensate the company for accepting the financial obligation of the contract.

Section 4. Environmental and Fisheries Mitigation
Contracts must include an environmental and fisheries mitigation plan, with:

- an explicit description of the best management practices and any mitigation the developer will employ for impacts to:
    - wildlife (including threatened or endangered species such as North Atlantic right whales)
    - coastal and marine habitats
    - natural resources
    - ecosystems
    - traditional or existing water-dependent uses (including commercial and recreational fishing)
- pre- and post-construction monitoring to understand the effects of facilities on marine and avian species.

DOER must establish an environmental working group and a fisheries working group to provide input on best practices, conduct ongoing review of implemented monitoring and mitigation programs, and provide feedback and recommendations on an as-needed basis.

Proposals must include a minimum $10,000 per MW contribution to regional research into strategies to avoid and mitigate impacts to the marine environment. (DOER will determine how best to use the funds.)

Section 5. MassCEC Contributions
Proposals must allocate at least 1 percent of project costs to a fund in support of Massachusetts-based offshore wind power research and workforce development to be administered by MassCEC (allowing a portion of funds to cover reasonable administrative costs).

Section 6. Economic and Workforce Development Commitments
Proposals must include a variety of specified certification and disclosure requirements, regarding the developer's past and future commitment to:

- workforce development
- economic development
- diversity, equity, and inclusion
- organized labor
- apprenticeships
- anti-discrimination
- labor harmony during all project phases

Failure to provide the documentation will result in a 30-day project suspension. If documentation is still not provided, the project will be terminated, and all awarded funds will be returned. The Attorney General will enforce the provisions and can enact consistent regulations.

Section 7. Preference for Entities with Commitments to Purchase Offshore Wind Energy
Where feasible, DOER should give preference to proposals that include commitments to enter long-term contracts with businesses, nonprofit organizations, municipalities, or other government entities directly to purchase offshore wind energy.

Section 8. Minority-Owned Business Commitments
In evaluating a proposal, the DPU shall consider whether the respondent and its subcontractors are likely to meet specific identified goals for:

- the utilization of minority-owned businesses as contractors and vendors
- the hiring of members of socially- or economically- disadvantaged communities

Proposal must include specified evidence that the developer has made serious good faith effort to solicit and interview a reasonable number of minority investors. DOER will consult the Supplier Diversity Office (SDO) in drafting those sections of a solicitation.

SDO can participate in the DPU hearing processes and must prepare guidance to developers regarding best practices. DOER and SDO must consult with MassCEC and the Massachusetts Environmental Justice Advisory Committee in drafting sections of a solicitation or regulations.

DOER shall (within 120 days):

- require developers to make quarterly reports describing the number and dollar amount of contracts and subcontracts to minority-, women- , and veteran- owned businesses
- Developers must submit information regarding any failure to meet the goals, identify efforts that have been undertaken, and provide a plan to meet the goals
- describe a process by which DOER will publicly review and post such reports

An Act relative to Fall River offshore wind opportunity (H.3303)

Rep. Carole Fiola's bill seeks to authorize the Fall River State Pier to be used to support facilities for offshore energy exploration or development; prohibits the use of the Fall River State Pier to support facilities for offshore oil and gas exploration or development; and authorizes the pier to be used to support offshore wind development and operations.

The objective of this bill was already accomplished through Outside Section 73 of the FY22 budget.

An Act relative to clean energy resources (H.3315)

Leader Golden's bill requires competitive procurements for clean energy generation.

SECTION 1: Adds Section 83E to the procurement statute that includes procurements requirements for offshore wind (Section 83C) and clean energy resources, including large-scale hydropower (Section 83D).

SECTION 2: Amends eligibility criteria in the definition of "clean energy generation" related to the Section 83D procurement. It removes the requirement for eligible new Class I RPS resources to be firmed by hydroelectric generation and clarifies that new Class I RPS resources includes offshore wind. It further removes the requirement that eligible hydroelectric generation be "firm service," and also allows any combination of new Class I RPS resources, hydroelectric generation, or energy storage as an eligible resource.

SECTION 3: Similar to the Section 83C and 83D contracts, the length of the 83E contracts shall be for 15-20 years.

SECTION 4: Requires the contracting electric distribution companies to consider terms that would require all clean energy certificates from any future offshore wind projects required under Section 83C to be delivered to said distribution companies for the project's lifetime.

SECTION 5: The contracting electric distribution companies are prohibited from seeking remuneration for the delivery of clean energy certificates to said companies that exceed the term length of the long-term contract.

SECTION 6: For the new Section 83E procurement (to be created by this legislation), "clean energy generation" shall have the following definition (consistent with this legislation's proposed changes to the term "clean energy generation" in Section 83D):

(i) new Class I renewable portfolio standard eligible resources, including but not limited to offshore wind energy generation;
(ii) hydroelectric generation; or
(iii) any combination of new Class I RPS eligible resources, hydroelectric generation, or energy storage.

Requires electric distribution companies to jointly solicit proposals for clean energy generation for up to approximately 9,450,000 megawatt-hours by December 30, 2030. The procurement schedule shall ensure that, as needed in conjunction with any regional or multi-state competitive market procurements for clean energy generation resources that are authorized pursuant to said chapter 169, the companies enter into cost-effective contracts by December 31, 2035.

The DPU shall promulgate regulations that allow for remuneration of 2.5 percent.

Requires the department of energy resources (DOER) and the attorney general to select the independent evaluator to assist the department of public utilities (DPU) in determining whether the procurement process is open, fair, and transparent. DOER, in consultation with the distribution companies and the independent evaluator, may terminate solicitations if it determines no reasonable proposals were received. DPU may reject a contract if the independent evaluator determines the solicitation and bid selection is not fair and objective.

DPU shall consider the attorney general's recommendations prior to approving contracts.

The distribution companies may decline contract proposals that would negatively affect their balance sheets. DOER and DPU may jointly develop requirements for a bond or other security to comply with the procurement requirements.

For both procurements, requires a unit-specific tracking system to ensure the Commonwealth receives the full environmental benefits of the clean energy generation. Includes severability clause to allow all sections not under challenge to be implemented expeditiously.

An Act relative to a competitive market for clean energy (H.3316)

Leader Golden's bill authorizes EEA to evaluate if it would be feasible for the Commonwealth to participate in a regional clean energy market and to further replace any remaining competitive procurements with this regional market.

SECTION 1: Adds Section 83F to the procurement statute that includes procurements requirements for offshore wind (Section 83C) and clean energy resources, including large-scale hydropower (Section 83D).

SECTION 2: Amends eligibility criteria in the definition of "clean energy generation" related to the Section 83D procurement. It removes the requirement for eligible new Class I RPS resources to be firmed by hydroelectric generation and clarifies that new Class I RPS resources includes offshore wind. It further removes the requirement that eligible hydroelectric generation be "firm service," and also allows any combination of new Class I RPS resources, hydroelectric generation, or energy storage as an eligible resource.

SECTION 3: Inserts Section 83F, which requires the EEA secretary, in consultation with DOER and DPU, to investigate the potential of using or participating in regional or multi-state clean energy market mechanisms or structures to facilitate financing of clean energy generation, including offshore wind, in order to meet the Commonwealth's clean energy needs and comply with Chapter 21N statewide emissions limits and sublimits, while providing benefits to the state.

After review, EEA, in consultation with DOER and DPU, is authorized to determine whether multi-state clean energy market mechanisms or structures are capable of meeting the Commonwealth's clean energy needs, including portfolio requirements, while providing benefits to the state. They may further set regional market targets to meet the state's clean energy needs and further determine that competitive solicitations, including offshore wind solicitations under Section 83C, are no longer necessary. The EEA secretary may require the electric distribution companies to enter into agreements, obligations, contracts, or otherwise participate in the regional markets to facilitate the financing of an equivalent amount of clean energy generation as required under Section 83C.

An Act relative to accountability of public funds used for wind turbines (H.3370)

Rep. Todd Smola's legislation requires that expenditures of money for wind turbines from the Massachusetts Renewable Energy Trust shall be posted on a website which will contain the name, program, date of award, amount, and project name and location maintained by the CEC for that purpose and updated monthly.

An Act promoting transparency in wind generated electricity production (H.3371)

Rep. Todd Smola has also sponsored legislation to require wind turbine projects that receive grants, loans, or federal funds through the Fund to report production statistics to the Department of Energy Resources who will verify the data with a third-party auditor and post it to its public website.

An Act relieving the adverse effects of wind energy (H.3373)

Titled the "Wind Energy Relief Act," Rep. David Viera's legislation establishes a new fund, the Wind Energy Relief Fund, to provide compensation for losses incurred as a result of detrimental health effects, property loss or any other adverse impacts resulting from the siting of a wind turbine that was developed with any assistance from the Massachusetts Clean Energy Center.

$15 million from the Massachusetts Renewable Energy Trust Fund shall be transferred to the Energy Relief Fund every year. This transfer is given priority over any other uses of the funds.

The legislation also sets up a second fund, the Wind Turbine Decommissioning or Relocation Fund, to provide municipalities compensation for the decommissioning or relocation of a wind turbine that was developed upon false, misleading, or inaccurate information, reasonably relied upon by a municipality, in its final determination to allow construction of the wind turbine.

$7.5 million from the Massachusetts Renewable Energy Trust Fund shall be transferred to the Decommissioning Fund every year. This transfer is given priority over any other uses of the funds, except for funds dedicated to the Wind Energy Relief Fund.

The Act further repurposes the mandatory renewable energy surcharge on electric bills to provide assistance to consumers, businesses, and municipalities seeking relief from the effects of wind energy development, in addition to supporting renewable energy projects.

An Act Relative to Immediate COVID Recovery Needs (H.3922)

This legislation filed by Governor Baker proposes to spend $100 million in federal money from the American Rescue Plan Act on marine port infrastructure to support the emerging offshore wind industry. The funds would support public and private investments in communities like New Bedford, Salem, and Somerset (Brayton Point), and others (including Boston Harbor) to enable the Commonwealth to realize the promise of short-term and long-term economic growth associated with burgeoning offshore wind development. Monies can be spent on design, construction, reconstruction, improvement, rehabilitation or expansion of port areas.

An Act relative to transmission for offshore wind energy (H.2814, 191st Session)

This bill – filed by former Representative Brodeur – would have required the solicitation and procurement of expandable transmission for offshore wind, which is defined as a system that can deliver offshore wind power from one or more sources, deliver the electricity into the regional power grid, and be expanded incrementally to deliver additional offshore wind generation. It further authorizes Massachusetts to coordinate a joint solicitation with other states.

Upon receiving reasonable proposals, DOER, in consultation with distribution companies and the Attorney General, must select a proposal.

The developer is prohibited from constructing the project until directed by DOER and may only construct the portion of the project needed to reliably and cost-effectively deliver offshore wind power that is produced under contracts approved by DOER and the department of public utilities.

The bill was passed favorably by both the TUE and Ways and Means Committees but never received a House vote. No representative refiled the legislation after the Representative left his seat for a new position.

TUE Recommendations

In consideration of all of the issues raised in this memorandum, it is my recommendation that the House propose an omnibus piece of legislation which incorporates the following items.

Eliminate Price Cap from the Energy Diversity Act of 2016

The price of wind energy has plummeted making it competitive with other energy-producing sources, and the political climate has changed, opening the possibility that offshore-wind farms could turn the Northeast into America's next energy boom land. Experts in 2020 expect future onshore and offshore wind costs to decline 37–49 percent by 2050, resulting in costs 50 percent lower than predicted in 2015. Given these circumstances, there is less concern that we will get extreme bids without the offshore wind price cap contained in the Energy Diversity Act of 2016 which requires each successive offshore wind procurement and associated offshore wind transmission costs to be less expensive than the previous procurement. The Commonwealth can always choose to not take bids if the pricing is egregious. And removing the price cap will likely bring additional value to Massachusetts in terms of storage solutions, interconnection, and economic development opportunities.

H. 3310 contains language striking the cap and we recommend including that language in the omnibus bill.

Create an OSW Industry Investment Fund ($500 Million with $200 million for ports)

We should adopt portions of Leader Golden's H.3310 which creates the Offshore Wind Industry Investment Fund and authorizes $500 million therein, but we should increase funds earmarked for port infrastructure development to $200 million, to bring the legislation to $700 million total. The bill further requires MassCEC to create an offshore wind industry tax incentive program and authorizes it to provide up to $30 million in incentives annually to certified offshore wind companies. The bill aims to emulate the highly successful $1 billion life sciences initiative which developed and sustained the life science cluster. It also creates a certification and revocation process for offshore wind companies.[98]

[98] Decertification is allowed if the return on investment is realized as less than 70% of what was submitted in the certification process.

The bill further requires that the Department of Public Utilities give preference to proposals that demonstrate economic development contributions to the Commonwealth and requires the winning bid for 83C offshore wind solicitations to be chosen by a selection committee that consists of the EOEEA Secretary (Chair), the EOHED Secretary, the Attorney General, an appointee made by the Speaker, and an appointee made by the Senate President. We should adopt language that increases the preference for proposals that demonstrate economic development contribution. In that regard, a 50-50 split has been adopted by other states to encourage more economic development.

We should also consider the following additions to H.3310:

- Consider expanding definition of "offshore wind company" to allow non-profits and higher education institutions to qualify for funds dispersed the Massachusetts Offshore Wind Industry Investment Fund – OR provide separate funding for non-profits and higher-ed institutions outside of the $500 million authorization
    - Current definition: "Offshore wind company", a business corporation, partnership, firm, unincorporated association or other entity engaged in offshore wind development, manufacturing or commercialization in the commonwealth and any affiliate thereof, which is, or the members of which are, subject to taxation under chapter 62, 63, 64H or 64I."
- Require MassCEC to spend money from the fund every year, similar to the GreenWorks bond bill from last session
    - "There shall be at least 1 open solicitation period each year to accept and consider new applications."
    - Consider extending the date that funds can be dispersed (2023 deadline)
        - Perhaps an initial deadline
        - With further money being available for future procurements, subject to matching requirements
- Funding amounts/mechanisms
    - Increase earmarks for Ports infrastructure from $50 million to $200 million to match state commitments made in New York and New Jersey
        - Offset this increase to ports by increasing overall bill to $700 million
        - If the Massachusetts Offshore Wind Industry Investment Fund is funded fully or in part by bond monies, as this bill allows, the bill could be exempted from the bond cap to ensure the Administration can't prevent or downsize spending, similar to what was done with the GreenWorks bond bill (bond monies don't typically pay salaries and aren't typically used for private property [Gov. Baker's criticisms of GreenWorks last session])
    - Consider an earmark for a tiered level of cost-sharing for interconnection costs with private developers, subject to a matching requirement, similar to what New Jersey did
    - Consider requiring future offshore wind solicitations (83C IV and beyond) to submit proposals with partnerships and investments in ports or training facilities certified by

this bill, similar to what New York did in their own pre-certification process and OSW solicitations with its 11 pre-certified ports.

- Encourage research on how to produce hydrogen w/ OSW

Coordination Role and Funding increase for MassCEC

We should consider adding language to the bill that designates MassCEC as the coordinating authority for ongoing OSW development efforts and addresses unmet needs in the industry. We also need a center for education, research, innovation, and workforce training related to the development of offshore wind in Massachusetts.[99] NOWI could fulfill that role in the future, but we need a centralized office to coordinate all of the efforts underway at this time. As we have shown in this report, there is a lot of activity in the OSW space and coordination could help build a robust industry here.

We should also consider language from Rep. Dykema's Bill (H.3294) calling for additional funding for MassCEC with specifications that call for better coordination among the different offshore wind players in the state. MassCEC is well poised to be the lead on this effort and we should provide it with additional funding to expand its offshore wind division. On the coordination piece, we learned that some of the Power-US members were left out of MassCEC's work on its offshore wind report, even though they had contributed to past reports. In our meetings, these members expressed surprise and even a bit of frustration. Power-US's expertise in this area makes it a valuable asset in this field, and cooperation between Power-US and MassCEC is critical. In order to ensure that MassCEC is leading, coordinating, and working with all of the Commonwealth's key stakeholders, the funding allocation should stipulate collaboration, perhaps by requiring Power-US to be a part of the Community of Practice, or specify that a minimum of the funds has to go to Power-US and specify that a minimum of the funds has to go to NOWI.

Section 3 of Rep. Dykema's bill would provide additional funding for MassCEC by increasing the charge on electricity customers from 0.5 mill per kilowatt-hour to 1.5 mill per kilowatt hour and creates a charge of 14.65 mill per therm for all natural gas customers. We have heard concerns about increasing charges for electric customers, and have been urged to consider a rate base increase to the gas side rather than electric. With decreased fossil fuel usage, that could propose a problem in the future.

Section 5 of Rep. Fernandes bill (H.3302) would require proposals to allocate at least 1 percent of project costs to a fund support of Massachusetts-based offshore wind power research and workforce development to be administered by MassCEC (allowing a portion of funds to cover reasonable administrative costs). This is another alternative source for funding.

[99] New Jersey created the WIND Institute to coordinate and galvanize cross-organizational workforce, education, research, and innovation efforts to support New Jersey as a leader in offshore wind. https://www.njeda.com/wind-institute/

Remuneration

We should adopt legislation directing the DPU to promulgate regulations that consistently sets remuneration for all project bids and ties the funding to grid improvements. We should have further discussion about remuneration in general given the concerns raised by the Attorney General.

Environmental and Fisheries Mitigation

We should adopt the legislative intent of Section 4 of H.3302 by amending 83C (Chapter 188 of the Acts of 2016) to provide consistency across developer's environmental and fisheries mitigation plans. New contracts must include an environmental and fisheries mitigation plan, with (a) an explicit description of the best management practices and any mitigation the developer will employ for impacts to wildlife (including threatened or endangered species such as North Atlantic right whales), coastal and marine habitats, natural resources, ecosystems, and traditional or existing water-dependent uses (including commercial and recreational fishing); and (b) pre- and post-construction monitoring to understand the effects of facilities on marine and avian species.

We should also direct DOER to establish both an environmental working group and a fisheries working group to provide input on best practices, conduct ongoing review of implemented monitoring and mitigation programs, and provide feedback and recommendations on an as-needed basis.

Finally, we should ensure that proposals include a minimum financial contribution to regional research into strategies to avoid and mitigate impacts to the marine environment.

Workforce Development/ Innovation and Entrepreneurship Center

We should provide funding to BCC's NOWI which is poised to be a much-needed training center as well as feature Innovation and Entrepreneurship programs. NOWI already has the personnel and necessary know-how to provide internationally recognized training and certifications; helping the program grow would elevate the local institution as one of the first in the nation to provide such training. The funding would efficiently support something that already exists and is well equipped to do the job, rather than "reinventing the wheel" and creating new training standards just for MA, while making MassCEC the funding source would reassert the agency's role in coordinating workforce development efforts. As set forth on pages 75-76, NOWI is looking for $7 million in funding.

Grid Modernization and Independent Transmission Planning

Phase I: We should commission a study, which shall be completed by June 1, 2022, that provides a technical foundation to understand the physical and electrical state of current grid infrastructure relative to the Commonwealth's newly increased offshore wind goals as well as identify pathways to upgrade the power grid to accommodate 5600 megawatts of offshore wind by 2027. Such a study

would be similar to the power grid study required by New York regarding its 9,000-megawatt target, described on page 68.[100] After the study is completed, we should proceed to Phase II.

Phase II: We should direct the DOER to coordinate with ISO-NE, DPU, and the utilities in soliciting potential transmission solutions, based on the findings of the Phase I study, that would help deliver offshore wind to the existing grid. As in the recent New Jersey solicitation (discussed on page 49), the proposals should include potential options for any or all of the following components:

- upgrades to the existing grid
- extension of the grid closer to offshore wind locations
- optimal landfall approaches (considering environmental impacts and need for substations)
- interconnections between offshore substations to provide benefits of a networked offshore grid

DOER should be authorized to conduct the solicitation in coordination with other states. The solicitation should include consumer protections, including allowing ISO-NE and the DPU to (a) select multiple proposals, (b) select no proposals, and (c) terminate the process at any time.

This approach recognizes the need for transmission planning and provides greater flexibility in solutions. In addition to the Phase I study, the solicitation builds upon the learned experiences and study findings from Europe, New Jersey, New York, and DOER discussed on page 45.

College in High School

We should consider enhancing college in high school programs, including the credentialing and certification provisions contained in H.693 filed by Representative Roy and Representative Lipper-Garabedian. This would allow us to introduce OSW to students at an earlier age and help bolster the workforce.

As mentioned on page 24, Rhode Island is expanding its Offshore Wind Energy Certificate program in high schools, having already successfully piloted the initiative at North Kingstown High School.

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[100] This study is the result of legislative language. As part of the New York 2020-2021 budget, the state announced the passage of Accelerated Renewable Energy Growth and Community Benefit Act. This legislation required the state to conduct a Power Grid study regarding transmission system investments to support clean energy growth. The study focuses on three areas: 1) utility infrastructure needs; 2) zero emission electricity scenario planning; and 3) an offshore wind study. The wind study focuses on offshore and onshore bulk transmission scenarios to identify possible solutions to integrating 9,000 megawatts of offshore wind.
Click this link for specific bill language:
P. 2, lines 22 – 28, P. 3, lines 1 - 5 [Legislative Findings & Statement of Purpose, § 2 of bill]
P. 28, lines 20 – 28; P. 29 lines 1 – 28; P. 30 lines 1- 27; P. 31, lines 1 – 28, P. 32, lines 1- 28, P.33, lines 1 – 16 [Power Grid Study Language, § 19 of bill]

Further Funding

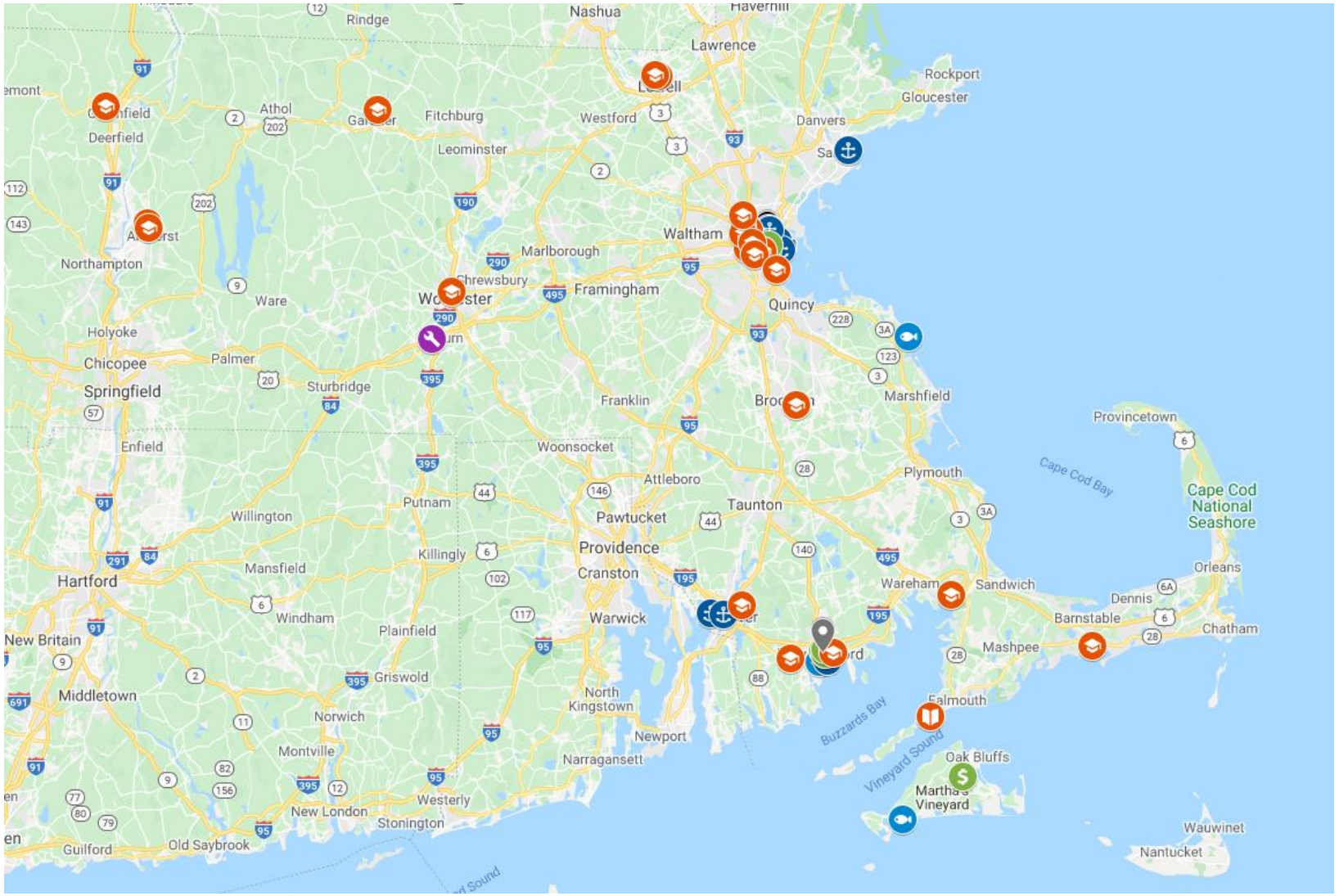
- UMass Amherst: $1 million annually, as described on page 78-79, for research positions and internships.
- UMass Dartmouth: $6.5 million to address the equipment needs outlined on pages 76-78.
- Power-US (BCC, UMD, MMA, Tufts University, UMass Boston): $10 million as described on page 75.

Appendix A. Key Reports

- Cost Savings Offered by Competition in Electric Transmission: Experience to Date and the Potential for Additional Customer Value, The Brattle Group (2019)
- Global Offshore Wind Report, Global Wind Energy Council (2021)
- Grand challenges in the science of wind energy, National Renewable Energy Laboratory (2019)
- Massachusetts Offshore Wind Workforce Assessment, Massachusetts Clean Energy Center (2018)
- New York State Offshore Wind Master Plan, New York State Energy Research and Development Authority (2018)
- New Jersey Offshore Wind Strategic Plan, New Jersey Board of Public Utilities (2020)
- Offshore Transmission in New England: The Benefits of a Better-Planned Grid, The Brattle Group (2020)
- Offshore Wind for America: The promise and potential of clean energy off our coasts, Environment America (2021)
- U.S. Offshore Wind Power Economic Impact Assessment, American Wind Energy Association (2020)
- Offshore Wind Energy Resource Assessment for the United States, National Renewable Energy Laboratory (2016)
- Offshore Wind: Generating Economic Benefits on the East Coast, Environmental Entrepreneurs (2018)
- Offshore Wind Transmission White Paper, Business Network for Offshore Wind (2020)
- Offshore Wind Workforce Training in Massachusetts: Gap Analysis and Strategic Recommendations, Massachusetts Clean Energy Center (2020)
- Research & Development Roadmap 3.0, National Offshore Wind Research and Development Consortium (2021)
- Transmission Options for Offshore Wind Farms in The United States, UMass Amherst (2002)
- The UK Offshore Wind Industry: Supply Chain Review, Offshore Wind Industry Council (2019)
- The Virginia advantage: The roadmap for the offshore wind supply chain in Virginia, BVG Associates (2018)

Appendix B. Massachusetts Offshore Wind Clusters

For an interactive version of the map, visit: https://www.google.com/maps/d/edit?mid=1QrTOIbqn4_eF3wy0MkYjucqq5vJPXXVI&usp=sharing



Appendix C. Massachusetts Offshore Wind Workforce Gaps

The following table includes all occupations identified in Appendix B of MassCEC's 2020 Offshore Wind Workforce Assessment as participatory in the life cycle of offshore wind farm, ordered by the annual full-time equivalent jobs (FTEs) needed to supply all phases of the first 1600 MW of proposed projects in-state. While the study assumes a complete in-state supply chain, many of the tasks will likely be completed outside Massachusetts.

Workforce gaps are the difference between *available* workers (the annual surplus of educational completions and short-term unemployed workers over the number of annual job openings) and *needed* workers (the estimated the annual number of FTEs that would be needed to fulfill the state's proposed OSW projects). Red indicates a significant gap, yellow indicates a moderate gap, and green indicated no gap.

Location quotients – the ratio of talent concentration in a defined geography to that of the national average – were calculated at the state-level. For instance, a location quotient of 4.0 means that the concentration of the occupation in Massachusetts is four times higher than the concentration of the occupation across the United States.

The study, conducted in late 2020, used data from the fourth quarter of 2019 to estimate post-COVID employment levels.

Description	2019 Location Quotient	2019 Jobs	MA OSW Workforce Gap
Miscellaneous Assemblers and Fabricators	0.5	16,796	
Structural Metal Fabricators and Fitters	0.54	1,056	
Inspectors, Testers, Sorters, Samplers, and Weighers	0.72	10,566	
Maintenance and Repair Workers, General	0.79	30,637	
Helpers--Installation, Maintenance, and Repair Workers	0.66	1,653	
Stockers and Order Fillers	0.84	43,841	
Electricians	0.97	18,288	
Plant and System Operators, All Other	1.31	458	
Welders, Cutters, Solderers, and Brazers	0.36	3,832	
Industrial Machinery Mechanics	0.48	4,687	
Shipping, Receiving, and Inventory Clerks	0.83	14,621	
Plating Machine Setters, Operators, and Tenders, Metal and Plastic	0.9	947	
Engine and Other Machine Assemblers	0.17	214	
Metal-Refining Furnace Operators and Tenders	0.25	107	

Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	1.45	10,459	
Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	0.53	2,229	
Construction Laborers	0.85	31,137	
Transportation, Storage, and Distribution Managers	0.99	3,433	
Logisticians	0.67	4,383	
Excavating and Loading Machine and Dragline Operators, Surface Mining	0.89	1,190	
Industrial Production Managers	1.23	5,679	
First-Line Supervisors of Mechanics, Installers, and Repairers	0.9	11,133	
Laborers and Freight, Stock, and Material Movers, Hand	0.59	43,550	
Material Moving Workers, All Other	0.65	555	
General and Operations Managers	1.37	83,422	
Metal Workers and Plastic Workers, All Other	0.42	267	
Captains, Mates, and Pilots of Water Vessels	0.62	742	
Wind Turbine Service Technicians	0.33	77	
Crane and Tower Operators	0.42	490	
Computer Numerically Controlled Tool Operators	0.64	2,385	
Continuous Mining Machine Operators	0.01	4	
Sailors and Marine Oilers	0.36	378	
Riggers	0.88	530	
Hoist and Winch Operators	4.74	668	
Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	0.67	2,536	
First-Line Supervisors of Production and Operating Workers	0.75	11,827	
Heavy and Tractor-Trailer Truck Drivers	0.6	30,944	
Aircraft Service Attendants and Transportation Workers, All Other	0.43	397	
Architectural and Engineering Managers	1.71	8,290	
Structural Iron and Steel Workers	1.29	2,516	
Cement Masons and Concrete Finishers	0.42	2,143	
Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	1.03	846	
Machinists	0.85	8,064	

Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	0.47	2,235	
Chemical Equipment Operators and Tenders	0.27	576	
Financial and Investment Analysts, Financial Risk Specialists, and Financial Specialists, All Other	1.6	18,767	
Financial Managers	2.05	34,592	
Operating Engineers and Other Construction Equipment Operators	0.76	7,929	
Engineers, All Other	0.85	3,638	
Human Resources Managers	1.6	7,217	
Administrative Services and Facilities Managers	1.56	12,138	
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	1.16	731	
Electronics Engineers, Except Computer	1.17	3,891	
Industrial Engineers	1.64	11,807	
Elevator and Escalator Installers and Repairers	1.42	1,014	
Production Workers, All Other	0.68	4,094	
Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	0.64	839	
Commercial Pilots	0.39	521	
Electrical Power-Line Installers and Repairers	0.75	2,109	
Stationary Engineers and Boiler Operators	0.93	885	
Purchasing Managers	1.67	3,110	
Office Clerks, General	0.89	73,280	
Computer Numerically Controlled Tool Programmers	0.76	487	
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	0.98	59,237	
Ship Engineers	0.34	118	
Commercial Divers	1.34	152	
Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	0.73	221	
Electrical and Electronic Engineering Technologists and Technicians	1.18	3,697	
Computer Occupations, All Other	1.12	12,400	
Drafters, All Other	0.55	211	
Bookkeeping, Accounting, and Auditing Clerks	1.19	49,318	

Calibration Technologists and Technicians and Engineering Technologists and Technicians, Except Drafters, All Other	0.96	2,196	
Public Relations Specialists	1.11	7,228	
Mechanical Engineers	1.26	9,645	
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	1.97	15,954	
Reinforcing Iron and Rebar Workers	0.72	450	
Compliance Officers	1	7,959	
Market Research Analysts and Marketing Specialists	1.27	22,487	
Accountants and Auditors	1.09	38,558	
Marine Engineers and Naval Architects	1.42	479	
Computer and Information Systems Managers	1.83	20,212	
Geological and Hydrologic Technicians	0.22	98	
Human Resources Assistants, Except Payroll and Timekeeping	0.84	2,608	
Human Resources Specialists	1.18	19,879	
Environmental Engineers	2.21	2,954	
Mechanical Drafters	1.26	1,784	
Lawyers	1.24	25,501	
Paralegals and Legal Assistants	0.87	7,300	
Construction Managers	1.01	11,046	
First-Line Supervisors of Construction Trades and Extraction Workers	0.91	16,465	
Materials Engineers	1.01	667	
Aerospace Engineers	0.34	568	
Civil Engineers	0.99	8,010	
Insurance Underwriters	0.84	2,231	
Environmental Science and Protection Technicians, Including Health	0.71	595	
Power Plant Operators	1.05	926	
Environmental Scientists and Specialists, Including Health	1.03	2,198	
Zoologists and Wildlife Biologists	0.9	467	
Atmospheric and Space Scientists	0.58	182	
Electrical Engineers	1.52	7,092	
Sales Engineers	2.25	3,791	

Natural Sciences Managers	2.3	3,989	
Geoscientists, Except Hydrologists and Geographers	0.9	700	
Occupational Health and Safety Specialists	0.74	1,695	
Anthropologists and Archeologists	0.45	91	
Surveying and Mapping Technicians	0.45	637	
Mining and Geological Engineers, Including Mining Safety Engineers	0.41	67	
Mechanical Engineering Technologists and Technicians	0.9	967	
Budget Analysts	1.21	1,629	
Cost Estimators	1.16	6,164	
Buyers and Purchasing Agents	0.89	9,672	
Sales Managers	1.75	17,906	
Training and Development Managers	1.74	2,106	
Postsecondary Teachers	1.47	49,934	
Training and Development Specialists	1.12	8,882	
Operations Research Analysts	1.03	2,581	
Personal Service Managers, All Other; Entertainment and Recreation Managers, Except Gambling; and Managers, All Other	0.82	8,255	
Bus and Truck Mechanics and Diesel Engine Specialists	0.72	5,101	
Industrial Truck and Tractor Operators	0.39	6,149	

Appendix D. Common Certifications

The 2020 MassCEC Workforce Assessment (p.11) identified the following certifications as common to the OSW industry.

The **Global Wind Organization** (GWO) has developed a certification for the onshore and offshore wind industries. GWO Technical and Safety training are important to the industry, as they set a standard for technical performance and competency. The training providers are certified by third-party certification bodies, with 12 training providers currently certified in North America. RelyOn Nutec (working with Mass Maritime Academy) and Maersk Training (working with Bristol Community College) are the two largest GWO-certified training providers worldwide. Certificates include Basic Safety Training, Basic Technical Training, and Blade Repair, among others.

The **Occupational Safety and Health Administration** (OSHA) has established industry-recognized curricula for general and specific safety training of manufacturing, installation, and O&M workers. Common certifications needed in the OSW industry include 10-Hour Training for General Industry, Confined Space Entry Training, and Fall Protection. To note, the Bureau of Safety and Environmental Enforcement has established itself as the primary workforce safety regulator for construction and operations tasks conducted offshore but is still in the process of developing standards or training curricula.

Lean Six Sigma Green and Black Belt certificates, which focus on team collaboration and efficiency, are awarded by the American Quality Society. Six Sigma training is offered through universities, community colleges, for-profit, and not-for-profit businesses, and organizations and is generally readily available.

Certified Composites Technician certification – both Open Molding and Wind Blade Repair – is offered through the American Composites Manufacturers Association. It is widely recognized in the composites industry for the production and/or management personnel working with or producing composite components, such as blades, or nacelle and rotor housings.

The **International Organization for Standardization** (ISO) has developed global industrial and commercial standards. Third-party training providers host courses on relevant standards like quality management systems (9001) and the newly developed offshore wind energy (29400) standards.

QC Inspector certification is needed for welding inspection throughout the turbine construction and installation processes. The American Welding Society offers QC Inspector certification, and MassDOT offers Field Weld Inspection Certification.

The **United States Coast Guard** is the primary worker safety regulator for OSW vessels. They offer certificates and training curricula in accordance with the international Standards of Training, Certification and Watchkeeping (STCW), as well as Captain's licensure.