REDACTED

State of Maine Public Utilities Commission

Long-term Contracting for Offshore Wind, Pursuant to Maine LD 336, P.L. 2021, Ch 327

Painting by Jill Pelto, Climate Scientist, *Gulf of Maine Temperature Variability (*Watercolor and Colored Pencil, 2016) used by permission of the artist, and featured on the cover of the Maine Climate Council, "Scientific Assessment of Climate Change and its Effects on Maine"

Petition for Approval of Power Purchase Agreement for Maine's Offshore Wind Research Array

May 27, 2022

Submitted by PINE TREE OFFSHORE WIND

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PREFACE

Achieving Maine's Vision: The Prudent Next Step

Maine's essential next step in the protection and prudent use of the Gulf of Maine is the Maine research array (Research Array or Project), a constellation of ten floating offshore wind turbines intended to scientifically determine proper integration of offshore wind with the ecosystem and traditional uses of the Gulf of Maine. This petition for approval of a power purchase agreement (PPA) and supporting exhibits (the Petition) tells many facets of the conception, design, and future of the Research Array, including its role in Maine's economy and energy future. The first is that two forces combined to create the impetus for the Research Array: Maine's responsibility to protect the Gulf of Maine, and the vision born at the University of Maine (UMaine) to create and commercialize the VolturnUS floating wind platform, to be built in Maine, by Maine people. Here we summarize the origin and fulfillment of that vision, including the critical roles of the Research Array and the PPA.

For centuries, the Gulf of Maine's vast fisheries, efficient shipping routes, and steady winds have powered a vibrant coastal life for all of Maine. The physical geography of Maine's marriage to the Gulf—scores of peninsulas reaching into Gulf waters, creating a varied coastline of nearly 3,478 miles in an expanse of only 220 air miles—has enabled human development to foster strong societies that adapt and thrive in Maine.[1] Faced with the existential threat of climate change, with rising and warming oceans and increasingly destructive weather, Maine again turns to the Gulf of Maine, both to protect the Gulf and to carefully create renewable energy essential to eliminate fossil fuels over time.

As stated by the Maine Climate Council, "Maine won't wait."

The Research Array and PPA are only parts of a larger story of societal adaptation, yet they are essential parts. The terms of any resulting PPA are the vital work of the Maine Public Utilities Commission (MPUC or Commission). The genesis of UMaine's patented VolturnUS floating platform technology, the bipartisan consensus that has sustained the development of VolturnUS over more than a decade, the world-wide need for floating technology, and the confluence of federal and Maine climate and renewable policy provide context for the Commission's work. VolturnUS has emerged as a viable technology that will contribute to human mitigation of and adaptation to climate change while creatively employing Maine's people and natural resources. These events are more than history; they live today as a vision by Maine to protect the Gulf and bring this unique technology to commercial viability.

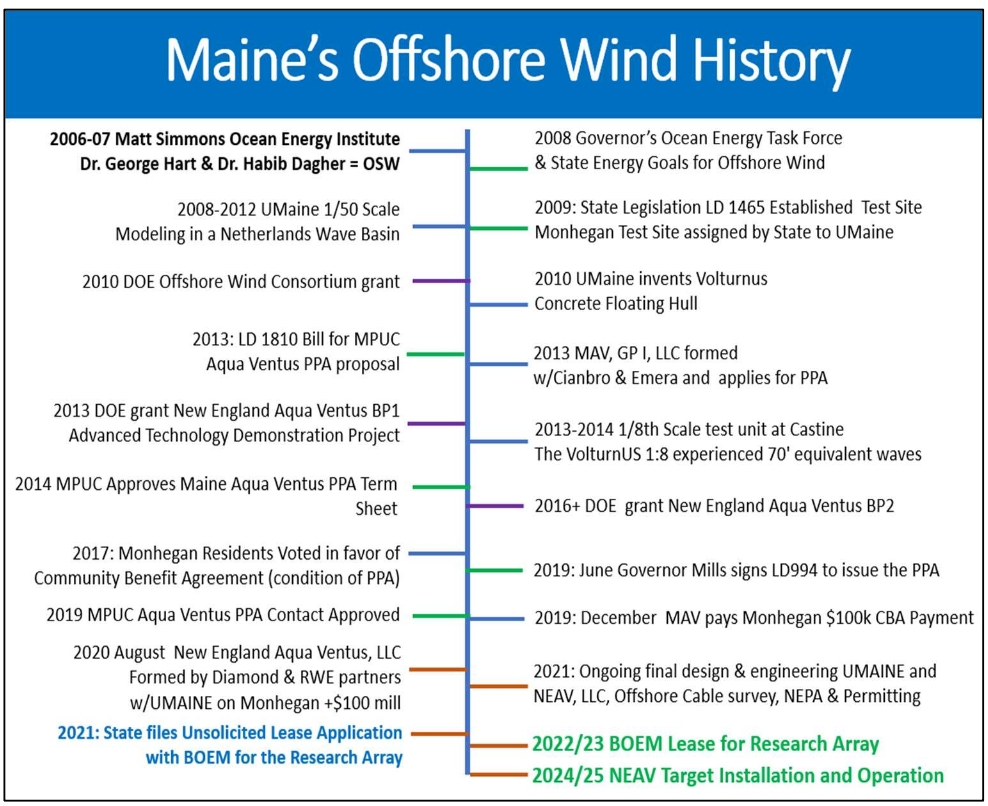
[1] Diamond, J. Guns, Germs and Steel: The Fates of Human Societies. New York: Norton Books, 1997.

Genesis of the Vision

Within the research labs of UMaine formed a vision ahead of its time: the State of Maine as a global hub for a progressive energy technology— floating offshore wind generation, built from local materials by Maine workers and located first and foremost in the Gulf of Maine. UMaine scientists, led by Professor Habib Dagher, created, shaped, and shared this vision.

Today, when the usefulness of VolturnUS is apparent, Dr. Dagher's creative ingenuity seems obvious. In the early 2000s, however, VolturnUS may have been the longest shot among academic ideas. Dr. Dagher persisted, finding support from Maine environmental groups, U.S. Senator Susan Collins, U.S. Senator Angus King, and Governor John Baldacci. Aware that Maine launched more ships from 1840 to 1900 than any other state and has continued to build the "best ships[2]"; these leaders recognized the legacy of Maine marine craftsmanship, Maine's natural resources and deep-water, and the many protected ports that could be repurposed for offshore wind.

Bipartisan Political and Public Support for Maine's Vision



Bipartisan support for offshore wind in Maine has spanned more than a decade. Senator Collins sought early design funding from the United States Department of Energy (DOE) and was instrumental in creating DOE's offshore wind research program. Governor Baldacci created the Task Force on Wind Power Development,

[2] "Bath Built Is Best Built." (https://gdbiw.com/)

encouraging wind onshore and offshore, and promoted legislation creating initial (300 MW) and then more prominent (5,000 MW) offshore wind goals. In 2009 Governor Baldacci's new Ocean Energy Task Force urged funding for offshore wind and tidal technology research and commercialization, leading to overwhelming Maine voter approval of an $11 million ocean energy research bond issuance. The Task Force recommended and the legislature mandated MPUC approval of long-term ocean energy power purchase agreements, even at above market rates. The Ocean Energy Act also provided unique environmental permitting by rule for demonstration projects. With the Ocean Energy Act, UMaine's vision of offshore wind commercialization of VolturnUS technology became the vision of the State of Maine.

Although renewable energy resistance subsequently emerged in Maine, stalling offshore wind, support from the DOE continued, allowing progress on design and the siting of a 1/8 scale VolturnUS project installation during a 2013 Maine winter off the coastal village of Castine. Inevitably, the promise of UMaine's technology encountered other tests. In a DOE funding competition, the MPUC-approved term sheet for a power purchase agreement kept UMaine's Monhegan 12-MW demonstration project alive. The MPUC, then led by offshore wind skeptics, reopened the term sheet, rendering the Monhegan project stalled. Objection by Maine political, civic, and business leaders combined with citizen support for offshore wind persevered to keep the vision alive.

In 2015, Senators Susan Collins and Angus King announced a joint funding award to the Maine Governor's Energy Office by the U.S. Department of Energy (DOE) to support the Maine Energy Planning Roadmap project to establish a stakeholder-driven strategy to meet energy objectives set within the 2015 GEO Comprehensive Energy Plan. Achievement of Maine's offshore wind vision was further invigorated by the 2018 election of then-Attorney General Janet Mills, a supporter of offshore wind, as Governor of Maine. Following the election, the legislature enacted a Resolve directing MPUC finalization of the Monhegan project Power Purchase Agreement.

Maine's Vision Finds the World

By 2019, the focus of European nations and Atlantic states on offshore wind had proven the skeptics wrong. Experts on both sides of the Atlantic, and more recently in Asia, concluded climate mitigation could not succeed without huge commitments to offshore wind. First movers employed fixed foundations on sites on shallow continental shelves. Costs fell dramatically at scale. Local economic benefits were unprecedented. As these commitments compounded, so did the capacities of the technologies, and soon exhaustion of fixed-bottom development in sites on shallow continental shelves became apparent. An imperative arose for floating technologies such as UMaine's to access deep water locations.

As other Atlantic states and the Biden Administration advanced offshore wind, the offshore wind industry found the Gulf of Maine. The Gulf of Maine's world class winds, especially powerful during winter, and proximity to New England load centers, attracted developers and the Bureau of Ocean Energy Management (BOEM) leasing interest. Governor Mills and others realized that traditional Maine fisheries and other Gulf of Maine users might suffer impacts from floating offshore wind development without protective influence by Maine government, and without the economic benefit of UMaine's technology built and maintained in Maine ports. To avoid both possibilities Governor Mills and the Maine Legislature acted.

In 2020, Governor Mills announced the Maine Offshore Wind Initiative by Executive Order. Governor Mills' Governor's Energy Office (GEO) then launched the Offshore Wind Roadmap, a public two-year process to involve marine users and the public in guiding offshore wind development. Public participation in the federally funded road map dwarfs that of any other state government initiative and is a prominent example of an effective participatory endeavor.

Next, the GEO filed an unsolicited research lease application with BOEM (Lease Application) for the State of Maine to develop an array of ten floating turbines for scientific study regarding impact minimization on the ecosystem and traditional uses of the Gulf of Maine.

Senator Mark Lawrence, a lobsterman in his earlier years, sponsored legislation (L.D. 336) requiring the MPUC to cause the negotiation and execution of a PPA for Research Array power "at lowest reasonable cost" to ratepayers. This legislation was passed with bipartisan support to encourage the research necessary to advance the Maine offshore wind industry. Furthermore, it directed,"…within 9 months of receiving a petition from New England Aqua Ventus, LLC or its designated affiliate [Pine Tree Offshore Wind, LLC (Pine Tree)] for a long-term contract for capacity, energy or renewable energy credits to be generated from a floating offshore wind research array project…the Public Utilities Commission shall order the negotiation of, and direct an investor-owned transmission and distribution utility to enter into, a long term contract for at least 20 years with New England Aqua Ventus, LLC or its designated affiliate if the commission determines the contract furthers the objectives of this Act and is in the public interest."

The collaborative approach of the Mills Administration furthered this cause. Although certain political and fisheries interests continued to oppose offshore wind, legislators began to find common ground. A compromise was soon reached: offshore wind would be banned in State of Maine waters (within the three nautical mile limit) and the Research Array would be bolstered by an Advisory Committee including fishing industry representatives. This would give Maine fisheries interests a "seat at the table" in Washington. The Mills Administration proposed to locate the Research Array far into the Gulf (farther offshore than most wind farms worldwide, big or small), setting an example for future BOEM leasing. Legislation wholly banning offshore wind cables and construction in Maine was defeated and offshore windmills, turbines, or towers were banned within three nautical miles of land. The Research Array, a pioneering effort to scientifically determine deployment and operational impacts of floating offshore wind, would proceed. Maine's Vision—to protect the Gulf and the opportunity to strengthen the Maine economy—persevered.

The Future of the Vision

None of us can predict the future. Right principles help, however, and the principles on which UMaine, Senators Collins and King, Governors Baldacci, King, LePage, and Mills, hundreds of Maine Legislators, hundreds of thousands of Maine bond issue voters, and the MPUC have applied in creating and protecting the Vision were the right principles: The Gulf of Maine remains critical to Maine life; its winds are a valuable untapped resource. Lower cost, Maine-constructed technology makes economic sense; Maine citizens and businesses play an important role in seizing the opportunity to simultaneously protect the Gulf and commercialize UMaine's technology. Floating offshore wind in the Gulf of Maine can generate reasonably priced renewable energy at scale, well suited to replace heating oil in Maine homes. At the start, the Vision was just another idea; today evidence from around the world affirms the need for commercialization of the Vision.

Obvious challenges remain. BOEM must grant a lease. Maine must seize the opportunity to be the first to build a port capable of launching the VolturnUS platforms and other floating technologies. There are no such ports in existence in the United States for floating offshore wind, and no others planned, as the focus elsewhere has been on fixed-bottom foundations in shallow water. At the direction of Governor Mills, Maine's Department of Transportation (MDOT) is examining potential offshore wind ports in Maine, focusing particularly on identifying a feasible deep-water port location to support this budding new industry.

The Need to Execute the PPA Now

A PPA is crucial for the Research Array to progress. Maine has chosen to harness the financial capabilities of its designated operator, Pine Tree, to fund development of the Research Array and basic environmental research to answer many of the outstanding questions about how offshore wind and other ocean stakeholders can co-exist. Full funding by Pine Tree commences once there is a financially viable PPA. Ultimately, approval of the PPA in early 2023, in accordance with L.D. 336, will allow the multi-million-dollar development investments to proceed. Finalization of the foundation design, performance of the geophysical and geotechnical survey, avian, fisheries and marine mammal surveys, along with offshore data gathering buoys are just a few of the actions to be performed immediately after PPA execution. Any delay in this sequence runs the risk of Maine ceding its leadership in the Gulf of Maine.

For reasons we explain in detail in our Petition, the window of opportunity to both use the best floating offshore wind science to protect the Gulf and to seize the economic benefits of constructing and operating a port and building floating offshore wind remains "open" but is at risk from rapidly intensifying competition from neighboring states. For the Gulf of Maine and Maine's VolturnUS, time is of the essence.

We attach the GEO's BOEM Application as **Exhibit 2.** With appropriate transparency, public involvement and attention to detail, the GEO set an example for the nation of site selection for floating offshore wind. Numerous webinars, large amounts of public information and the benefits of public engagement meetings are well reflected in the application. GEO and Maine's Department of Marine Resources (DMR) evaluated tens of thousands of acres of ocean, surface to bottom, for a site with the least negative impact to species and the environment, users, and one that is of optimal value for research. We invite review of the application: it is exemplary, and it is literally a testament to the advancement of Maine's Vision.

1.0 EXECUTIVE SUMMARY: THE RESEARCH ARRAY — MAINE'S NEXT PRUDENT STEP

This Petition builds upon Maine's decade-long pursuit of offshore wind. This pursuit has become more important because large-scale offshore wind is clearly coming to the Gulf of Maine—for the benefit of Maine and New England, at large. According to World Energy Reports, there are already more than $100 billion of offshore wind projects planned off the East Coast of the United States. BOEM has also announced plans to start large-scale leasing in the Gulf of Maine in 2024.

The proposed 10-turbine, 144 MW floating offshore wind Research Array is far more than a new renewable energy project—it is the next step in charting Maine's long-term energy future. This is a future where Maine needs "all of the above," onshore wind, solar, offshore wind, and batteries to eventually electrify everything and wean itself off fossil fuels.

Climate change is here, already impacting Maine. The State has decided that it won't wait and needs to act now to achieve its 2045/2050 climate goals (targeting carbon neutrality by 2045 and 100 percent renewable power by 2050). Offshore wind has a big role to play. The Research Array will provide an essential, high capacity factor, winter peaking power source that will ultimately allow Maine to achieve its climate goals at the lowest cost—working in tandem with onshore wind and solar. Details on the role offshore wind plays in Maine's energy future appear in Sections 2, 3, and 4.

DEVELOPER: The State, with the help of the University of Maine, has attracted a pair of world class developers to help achieve its goals: RWE Renewables and Diamond Offshore Wind, a subsidiary of Mitsubishi Corporation. Together, these companies are planning to invest nearly $1.[redacted] billion in Maine, first to build the single-turbine New England Aqua Ventus project (NEAV) and eventually to build the proposed Research Array through their Pine Tree partnership.

Diamond Offshore Wind (DOW), its parents and affiliates, bring decades of experience successfully developing, constructing, and operating major energy assets, both domestically within the U.S. and internationally including experience owning and operating seven commercial scale offshore wind projects as well as 12 independent offshore wind transmission lines totaling more than 1,300 kilometers in length. Most recently, Mitsubishi Corporation was awarded three commercial scale projects in Japan totaling more than 1,600 MW.

RWE Renewables is one of four subsidiaries under RWE Aktiengesellschaft (RWE AG), with an overall capacity of around 11 GW of renewable energy and 20,000 employees. RWE's experience in deploying offshore wind, combined with its in-house engineering expertise and global approach means it is particularly well placed to become a leader in floating wind. By developing a multi-gigawatt global pipeline, RWE aims to have 1 GW of floating capacity underway by 2030.

More details on Pine Tree appear in **Exhibit 1**.

MAINE'S GOALS FOR THE RESEARCH ARRAY: The State's goals[3] in pursuing the Research Array are two-fold:

1. "The State is taking this action now because there is significant interest in commercial development of offshore renewable energy in the Gulf of Maine, and because it believes the proposed Research Array is the right, prudent step to take before commercial scale floating offshore wind development occurs in the Gulf of Maine." The full spectrum of stakeholders can learn from the Research Array and create a set of best practices that can be incorporated into future commercial scale projects in the Gulf of Maine that will better allow offshore wind and fisheries to co-exist.

2. "Research will allow the State, the fishing industry, and many others to learn about potential impacts of floating offshore wind together, in order to ensure Maine develops this industry in a manner that capitalizes on our innovative technology and abundant resources, while protecting our interests, industries, environment and values." This will establish Maine as a hub for floating offshore wind construction, operations, and maintenance—creating jobs for generations and lowering the cost of energy over the long term, while mitigating impacts on fisheries.

Establishing Maine as the hub for floating offshore wind construction extends from the state's maritime heritage, whereas Maine taking a leadership position in setting the standards for future projects, protects the most important of Maine's heritage industries—fishing—from imprudent development in the Gulf of Maine. Details on Maine's plans for offshore wind appear in Section 4.

THE RACE FOR JOBS: This Petition facilitates participation in the race on the East Coast—states from Massachusetts to Virginia are feverishly planning and building ports to compete for jobs associated with projects that utilize fixed-bottom foundations (monopiles and jackets). According to 2021 project information shared by the Business Network for Offshore Wind (a trade group), these states are working to develop offshore wind hubs in port cities, with large corporate job commitments already made in New Jersey, New York, Massachusetts, Connecticut and Virginia[4]. While Maine is not in *that* particular race, Maine can learn how to win the next: the Research Array is the catalyst to design and build a port custom tailored to build *floating* offshore projects. Ports being built in other Atlantic states will not be able to accommodate floating foundations (see Section 4). Building the nation's first purpose-built floating offshore wind port would give Maine an insurmountable lead and the ability not only to build projects for its own needs but also to build projects that will deliver power to the rest of New England. *The combination of the Research Array and port construction is how Maine wins the floating offshore wind race*.

[3] https://www.maine.gov/energy/initiatives/offshorewind/researcharray
[4] https://insideclimatenews.org/news/28102021/inside-clean-energy-wind-energy-jobs-virginia/

CENTERPIECE, THE UNIVERSITY OF MAINE FOUNDATION: The Research Array is planned around utilizing UMaine's award winning floating offshore wind foundation. Unlike most foundations in the offshore wind industry which use steel, the novelty of the foundation is that it is made of concrete and can therefore be built locally. This component alone is expected to bring more than $375 million of direct construction spending to the state from the Research Array.

FLOATING OFFSHORE WIND AND THE TECHNOLOGY RACE: It is predicted that the worldwide floating offshore wind market will be 264 GW by 2050 and the United States will lead development starting in the early 2030s. It turns out that there is a lot more technical potential for floating offshore wind than there is for fixed-bottom foundations. Because the emerging market is understood to be so large, there is a technology race taking place worldwide. There are myriad hull designs across three major classes all vying for commercialization. The first technologies that are proven at commercial scale will be the ones that developers will look to again and again as this greater than $1 trillion buildout happens over the next three decades. The Research Array will put UMaine's VolturnUS technology squarely in the race, and potentially, firmly in the lead.

RESEARCH ARRAY OVERVIEW: The Research Array is sited 45 miles east-southeast of Portland at a site that the State selected after extensive analysis and stakeholder engagement, with two primary features: (i) low level of lobster fishing; and (ii) farther from shore than virtually any small-scale project worldwide. The Project will produce power with almost a 50 percent capacity factor and approach 60 percent during the winter months when the needs for heating are the highest and solar output is the lowest. A more detailed explanation of the benefits of the Project appears in Section 6.

General Arrangement:	10 turbines / 144 MW / 45 miles east southeast of Portland
Energy Delivered:	635,000 MWh
Capital Cost:	$1.2 Billion
Spending in Maine:	>$500 Million
Port Capital Cost:	$250 Million
Direct Job Creation:	3,250
Taxes Paid During Construction:	$43 million
Planned Commercial Operation:	2028

[redacted]

[redacted]

[redacted]

[redacted]

[5] It is expected that it will take approximately three years to complete stakeholder engagement and fully define the optimal system configuration details to become the basis for research as well as complete design and detailed capital costing. [redacted]

2.0 MEETING THE CLIMATE CHALLENGE

2.a The Climate Challenge and Its Importance to Maine

Climate change may impact Maine more than any other state because of its vast shoreline and dependence on fishing. Fisheries constitute a large percentage of Maine's economy, more than in any other state. Tourism relies on the state remaining pristine.

> *"The strength of Maine's economy, the preservation of our natural resources, the long-term health and well-being of our communities and of future generations depend in great part on our transitioning to clean energy and tackling the threat of climate change."*
>
> - Governor Janet Mills

The cost of failing to rise to this challenge is inestimable. Maine lobsters are already following cooler waters toward Canada, a pattern that caused lobsters to vacate the Long Island Sound. Clearly, Maine can't wait.

The unique actions planned by Maine and other New England states will have a big impact on Maine. We already see this in the form of extensive wind and solar projects, transmission projects, and of course, opposition both to the physical footprint of the projects and their associated costs. Several 2020-2021 reports of the Maine Climate Council (MCC) astutely assess in detail the many risks climate change poses to Maine[7]. The MCC's findings are foundational to the Research Array initiative.

2.b Climate Objectives and the Drive Toward Electrification

All New England states have implemented Renewable Portfolio Standards (RPS) (EIA 2021). In addition, five of the six New England states (Maine, Connecticut, Massachusetts, Rhode Island, and Vermont) have mandated economy-wide greenhouse gas (GHG) reductions with a goal to achieve greater than 80 percent reductions from 1990 levels (ISO-NE 2021).

More important than simply replacing traditional fossil fuel generation with renewable sources is the drive to zero carbon, which requires electrification of practically everything that now relies upon fossil fuels, referred to as beneficial electrification.[8] This is the more elusive, longer-range goal that will take a generation to achieve[9] and eliminate the bulk of remaining emissions.

The drive to electrification requires not just replacing power plants, but also almost tripling the amount of power generated to satisfy electrification needs *and* paying careful attention to producing power when it is needed in the wake of decommissioning traditional power plants that can deliver power on demand. Wind power is a critical component of this new fleet and will be relied upon to deliver power in the winter months when other sources are less available.

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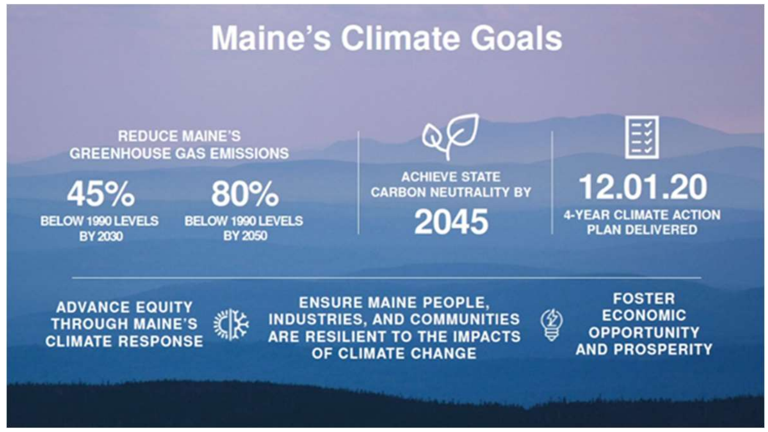
7 https://www.maine.gov/future/initiatives/climate/climate-council/reports

8 The New England States Committee on Electricity (NESCOE) New England States' Vision for a Clean, Affordable, and Reliable 21st Century Regional Electric Grid (2020) report describes significant changes necessary for the New England electric grid to achieve New England's renewable energy vision. [https://yq5v214uei4489eww27gbgsu-wpengine.netdna-ssl.com/wp-content/uploads/2020/10/NESCOE_Vision_Statement_Oct2020.pdf]

9 The Energy Pathways to Deep Decarbonization report was commissioned by Massachusetts in April 2020, establishing a goal of net zero carbon emissions by 2050. https://www.mass.gov/doc/ma-2050-decarbonization-roadmap/download



Maine has set some of the most aggressive renewable energy requirements in the country – 80 percent renewable energy by 2030, and a goal of 100 percent for 2050. Maine also enacted aggressive targets to cut greenhouse gas emissions—45 percent by 2030, and 80 percent by 2050—and pledged to achieve carbon neutrality by 2045.[10] One of the most comprehensive studies that illustrates how Maine can achieve its goals and more is Dr. Richard Silkman's 2019 study, "A New Energy Policy Direction for Maine—A Pathway to a Zero-Carbon Economy by 2050." The increase in electric energy consumption necessary for Maine to achieve a zero-carbon economy by 2050 appears in Figure 2-1, roughly tripling current annual consumption.[11]

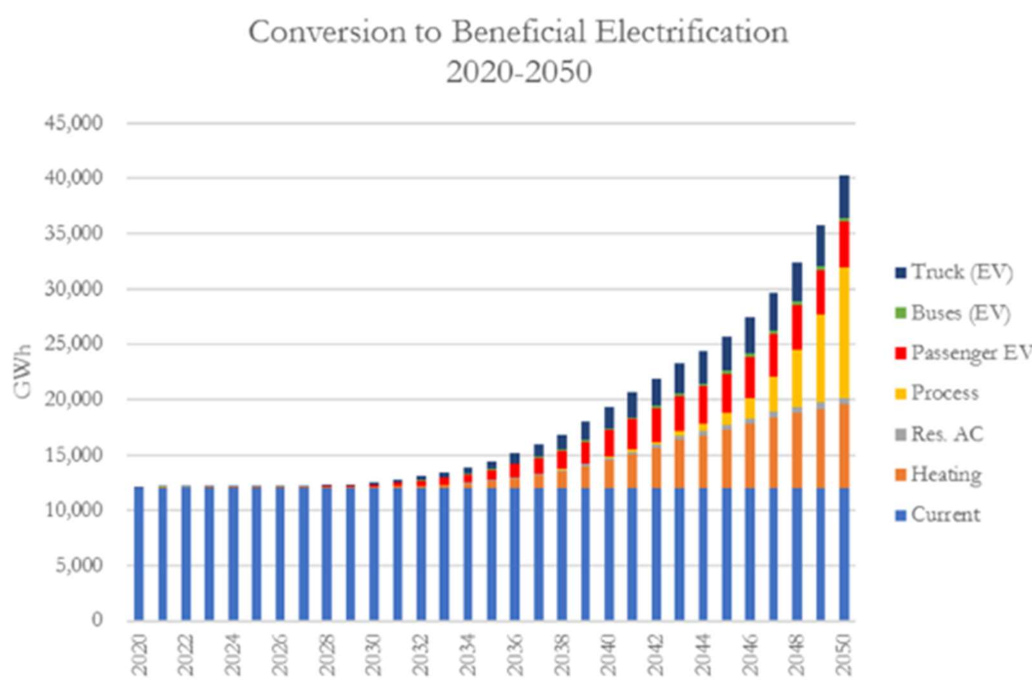
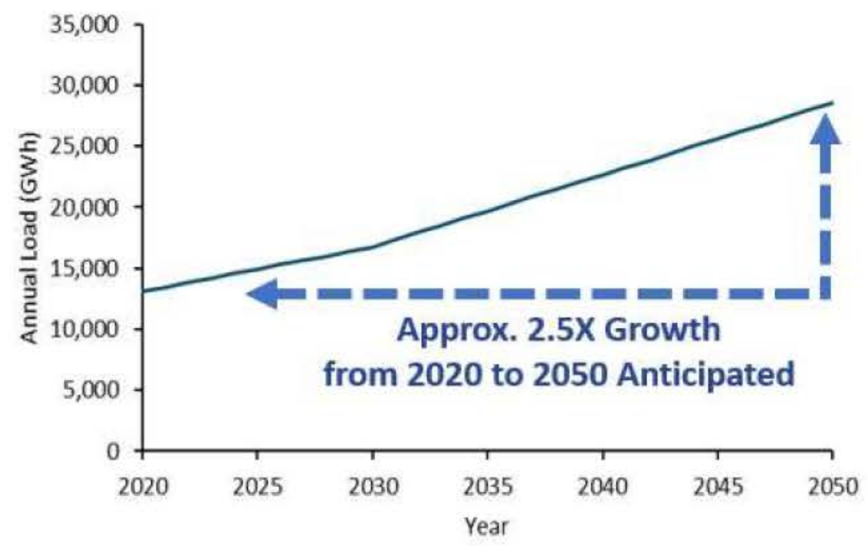


Figure 2-1. Predictive rates of Electrical Conversion for Heating, Processes and Transportation in Maine (Source: Silkman 2019)

10 https://www.maine.gov/governor/mills/news/governor-mills-welcomes-plan-combat-climate-change-announces-actions-protect-maine-people-2020

11 It is not just Maine anticipating this tripling; New York is planning on transitioning to roughly 90 GW of electric generating capacity from its current 30 GW. Given the footprint of renewable energy relative to traditional power plants, it can be reasonably expected that renewable energy projects will become substantially more noticeable.

Figure 2-2. Load forecast (Source: GEO - "State of Maine Renewable Energy Goals Market Assessment – March 2021")



A similar analysis was published by the GEO in its report, "State of Maine Renewable Energy Goals Market Assessment—March 2021." The report shows load and generation projections through 2050 needed to meet Maine's 2030 greenhouse gas reduction targets, which incorporate aggressive levels of transportation and heating electrification. While not as aggressive as Dr. Silkman's load projection, because it does not assume a zero-carbon economy, the GEO's load projection (see Figure 2-2) still shows an increase from 2020 to 2050 of close to 2.5X.

2.c Where Will All This New Power Come From?

New England and Maine will in fact need all of the above: solar, onshore and offshore wind, and eventually storage in many forms. Offshore wind is an essential component, and an increasingly important part of the long-term energy mix. To a great extent, offshore wind helps fill the role of baseload generation, and with its exceptionally high-capacity factor[12] during winter, helps satisfy winter peak needs as more heating comes from electric sources rather than fossil fuels. Some examples of the role of offshore wind:

> ***Key Point:*** Offshore wind becomes an increasingly important source of power for all New England

- Massachusetts plans on 11 to 15 gigawatts of offshore wind[13] and has already contracted for 3,200 MW.
- ISO-NE is both inundated by offshore wind interconnection applications and is planning on accommodating up to 22 gigawatts by 2050.[14]
- Here in Maine, we are looking to gigawatt scale production[15] in the longer term.

[12] An example of the potential of floating offshore wind comes from one of Europe's floating offshore wind demonstration projects: "Hywind Scotland remains the UK's best performing offshore wind farm" During its first two years of operation, the wind farm achieved an average capacity factor of 54%. That compares to an offshore wind average in the U.K. of around 40%. https://www.equinor.com/en/news/20210323-hywind-scotland-uk-best-performing-offshore-wind-farm.html
[13] The Massachusetts Energy Pathways to Deep Decarbonization report concludes that offshore wind is critically important to net-zero carbon energy systems for Massachusetts, with a minimum of 15 GW of offshore wind installed in Massachusetts in seven out of eight pathways, and at least 10.9 GW in the offshore wind-constrained pathway.
[14] As of January 2021, 63% of the total 24,100 MW proposed generation in the ISO-NE queue was for wind energy generation (ISO-NE 2021).
[15] Maine Climate Council Study update November 2020; Hall et al., "Volume 3: Maine Emissions Analysis Consolidated Energy Sectors Modeling Results."

In fact, in MCC's report (Hall et al. 2020), on which the GEO's report is based, it is stated that almost *four gigawatts of new wind generation will be needed by 2050 for decarbonization*. It is virtually impossible, and quite likely economically infeasible, for the majority of this to come from onshore sources. One of the main problems, highlighted in the GEO's report, is that the best wind resources are in the northern and western regions of Maine, far away from load centers and blocked by multiple transmission constraints. The report estimates that the transmission cost alone to connect 1.9 GW of wind generation would be over $3.1 billion. Cost is only part of the equation; permitting and public opinion cannot be underestimated, as New England Clean Energy Connect has seen. To deliver 3.6 GW of power from Aroostook county, Maine would need to approve construction of three new transmission corridors, each akin to that depicted at the right, with such an approval alone likely to prove challenging. Offshore wind can serve to help fulfill this essential part of the power production mix, working alongside solar and the feasible fleet of onshore wind projects.

A snapshot of the importance of offshore wind in the electric transition in New England is further depicted in Figure 2-3 from the ISO-NE 2050 Transmission Study. The market for floating offshore wind will be critical to New England, with a projected growth to 22,456 MW by 2050.

State	Resource Type	2031 NA Case (MW)	2050 Transmission Study		
			2035 (MW)	2040 (MW)	2050 (MW)
Connecticut	Floating	0	0	0	0
Maine	Floating	0	902	3,015	6,933
Massachusetts	Floating	0	302	2,667	9,791
New Hampshire	Floating	0	41	714	1,177
Rhode Island	Floating	0	1,153	2,205	4,555
Vermont	Floating	0	0	0	0
New England Total	Floating	0	2,398	8,601	22,456

Figure 2-3. Offshore Wind MWs by Resource Type: Floating Data (Source: ISO-NE 2050 Transmission Study—Preliminary Assumptions and Methodology for the 2050 Transmission Study Scope of Work—Revision 2, 2021)

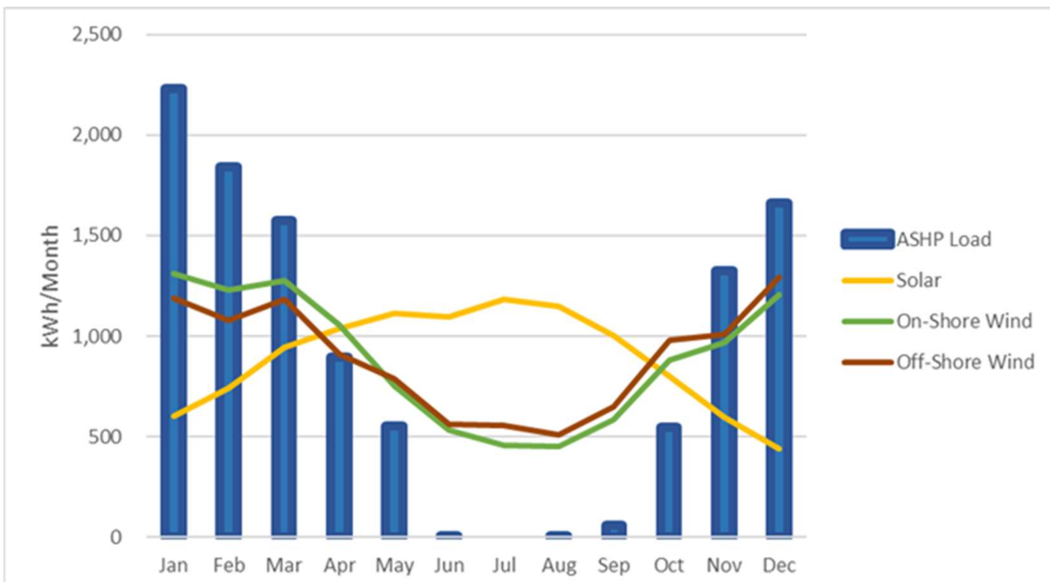
2.d Offshore Wind in the Future Energy Mix

To see how offshore wind fits better into the future energy mix in Maine, it is necessary to consult Dr. Richard Silkman's report in **Exhibit 3** and his 2019 report, "A New Energy Policy Direction for Maine—A Pathway to a Zero-Carbon Economy by 2050".

Maine faces a historical fight against global warming and climate change. To have any chance of correcting decades of damage, its long-term energy future must be built upon the twin pillars of beneficial electrification and decarbonization. Both pillars will not be possible without converting space heating from fossil fuels to renewable, zero-emission electricity. This all-important conversion is simply not economically feasible without offshore wind.

Air Source Heat Pumps (ASHPs) can absorb heat from outside a structure and release it inside, using a process similar to the one used by air conditioners. ASHPs can meet virtually all the space heating requirements of the majority of Maine's residential units and use roughly 35 percent of the energy as heating oil or natural gas (Exhibit 3). However, space heat is required seasonally, not year-round, and even during the heating season, intermittently. As such, it is more difficult to match seasonal heating demands with electricity generation from renewable resources than with either oil or natural gas, because seasonal storage of electricity is very expensive. Solar power cannot bridge this gap because its output is concentrated in the summer months (helping with summer peak loads) but is generally not available to address winter loads. In contrast, both onshore and offshore wind generation occur in a pattern more closely resembling seasonal ASHP load requirements (see Figure 2-4).

Figure 2-4. Monthly ASHP Loads and Renewable Generation (Source: Exhibit 3)



None of the three renewable generation technologies on its own matches the load requirements of ASHPs perfectly, so some form of storage will be needed. The two main possibilities are batteries and green hydrogen. Production of green hydrogen is presently too immature and expensive a technology on which to plan.

Key Point: Offshore wind is the most cost-effective path to support the necessary conversion to electric heating, mitigating extensive seasonal energy storage otherwise required

Similarly, using batteries coupled with renewable generation sized for electric heating loads is also prohibitively expensive because the installed cost of batteries for long-term storage is so high. The least expensive storage option needed for a zero-carbon Maine in 2050 involves using batteries coupled with overbuilt renewable generation to minimize the amount of battery storage capacity necessary. With this option, relying solely on solar generation, which requires roughly five times the amount of installed capacity as offshore wind, to meet ASHP load is highly problematic, if not impossible, due to the amount of land needed per kW of solar installed. Maine will need a proper mix of solar and onshore and offshore wind (see Figure 2-5) to achieve a zero-carbon economy that will require 5 GW or more of offshore wind capacity in the Gulf of Maine. No other generating technology, even when combined with massive amounts of battery storage or the production of hydrogen, can meet these requirements as cost-effectively as floating offshore wind.

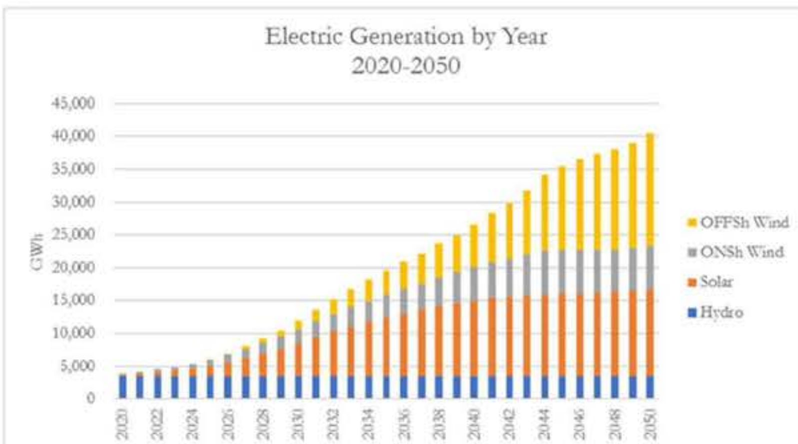


Figure 2-5. Renewable Energy Generation Development - Output (Source: Silkman 2019)

Dr. Silkman's thesis (detailed further in Section 6.e), consistent with studies completed by DNV and others addressing similar production/consumption challenges, would fully justify the development of commercial offshore wind in the Gulf of Maine, such as pursuant to the 2024 BOEM target date for Gulf of Maine federal leasing, and Maine's purchase of energy from projects when they come online in 2032 or thereafter.

Maine could "wait", miss the opportunity to lead and influence development of offshore wind in the Gulf of Maine, and decline to foster development of floating offshore wind built in Maine by Mainers with local materials. In this case, the enormous economic benefit, now within Maine's reach, may fall to other eagerly awaiting states and nations. Due to increased demand for electricity, floating offshore wind development, construction, and maintenance will come to the Gulf of Maine; the question is, when it comes, who will most benefit from it.

3.0 FLOATING OFFSHORE WIND (THE ONLY OFFSHORE WIND TECHNOLOGY FOR THE GULF OF MAINE)

The magnitude of offshore wind required by Maine and the rest of New England can only be accommodated by deploying floating offshore wind technology.

3.a The Gulf of Maine is Deep: It Requires Floating Offshore Wind

The Gulf of Maine is deep. Offshore wind, properly sited reasonably far from shore, will be in waters more than 300 feet (90 meters) deep, as depicted in Figure 3-1. Fixed-bottom foundations are not suitable at these depths, leaving floating wind turbines as the only viable option.

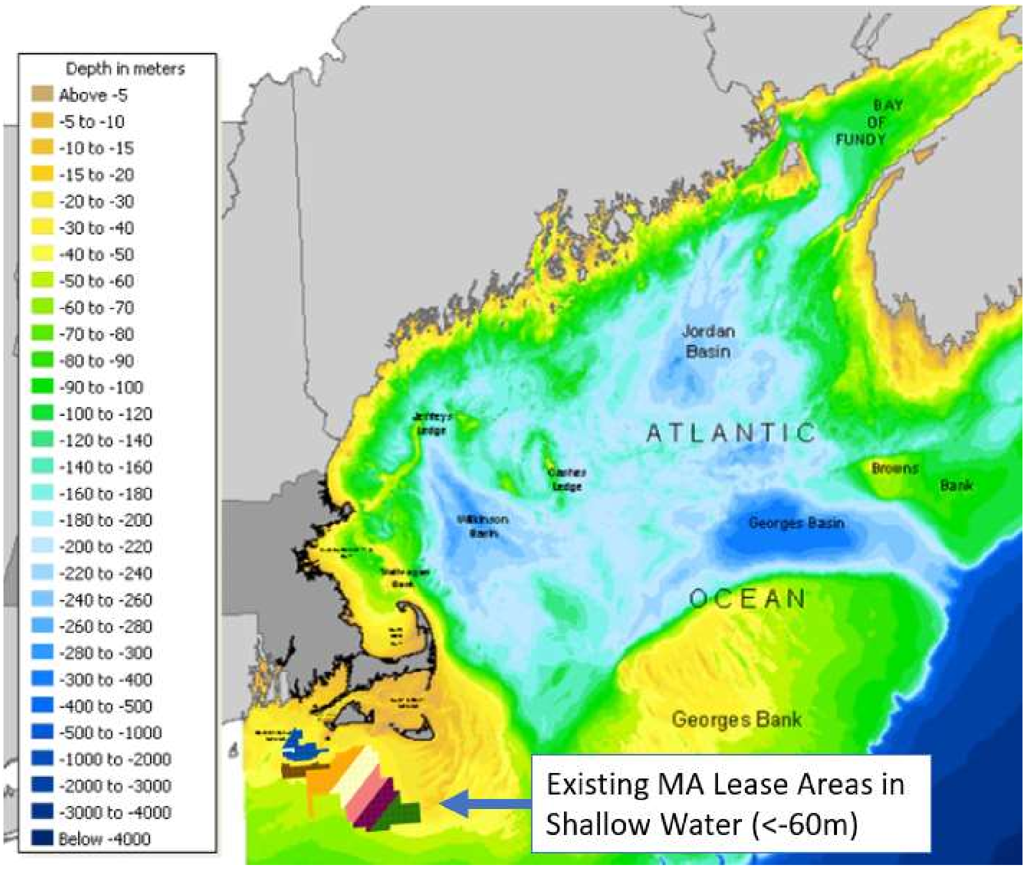


Figure 3-1. Bathymetry (Depth) within the Gulf of Maine (Source: MassGIS with polygon overlay by Pine Tree)

As overlayed within the image above, existing lease areas offshore New England (two polygons with multi-colored bands south of Cape Cod) have been concentrated in areas where the outer continental shelf is relatively shallow and fixed-bottom solutions are viable. In fact, the contours of the leases south of Cape Cod were defined based on the depth limitations of fixed-bottom foundations (the edge of the green depth coloration immediately adjacent to the yellow areas shown in Figure 3-1).

For context, the existing leases south of Cape Cod can support approximately 8,000 MW of offshore wind development. Accommodating the future needs of Maine and New England will potentially require 9,000 MW or more, occupying an area larger than the Massachusetts lease areas within the

Gulf of Maine, and representing, in Pine Tree's estimation, roughly $50 billion in construction over the coming decades.

3.b The World Market for Floating Offshore Wind is Taking Off

What we see locally is reflected around the world. Offshore wind has become the go-to technology for large scale, near-baseload, winter-producing power production that works in synergy with solar and onshore wind. It turns out that there is a lot more technical potential for floating offshore wind than there is for fixed-bottom foundations.[16] As shown in Figure 3-2, the regions suitable for floating wind are significantly greater worldwide than those of fixed-bottom (green = floating, blue = fixed-bottom).

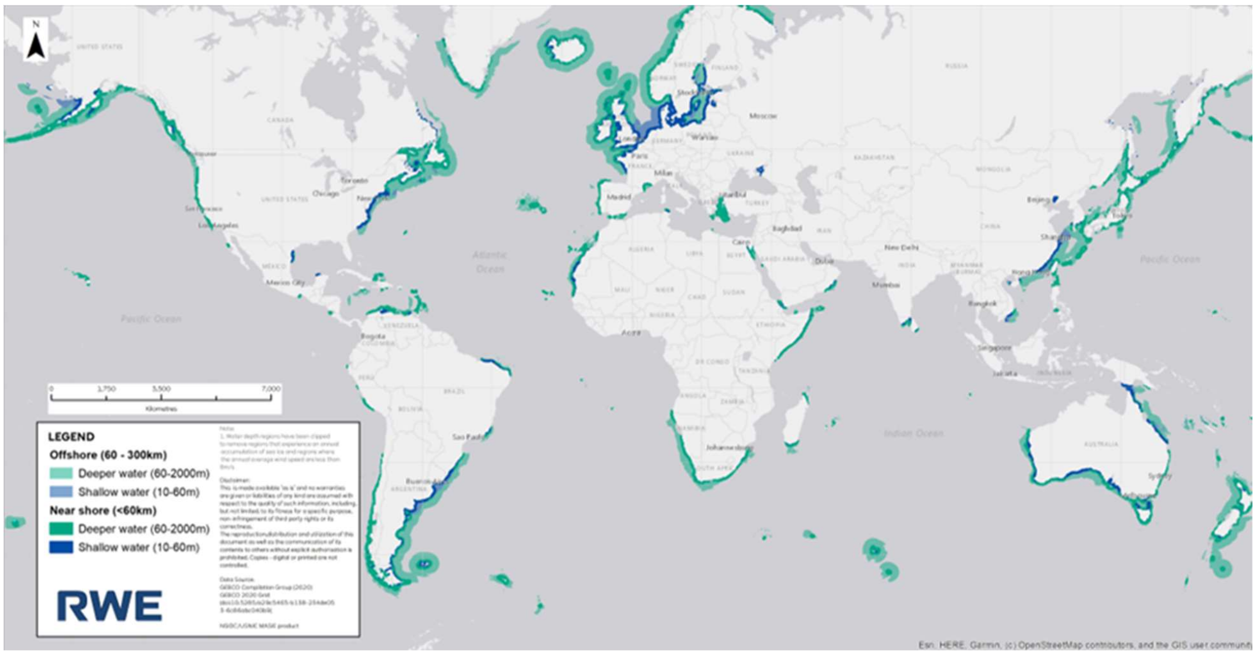


Figure 3-2. Global regions suitable for fixed-bottom (blue) and floating (green) offshore wind (Source: RWE, 2021)

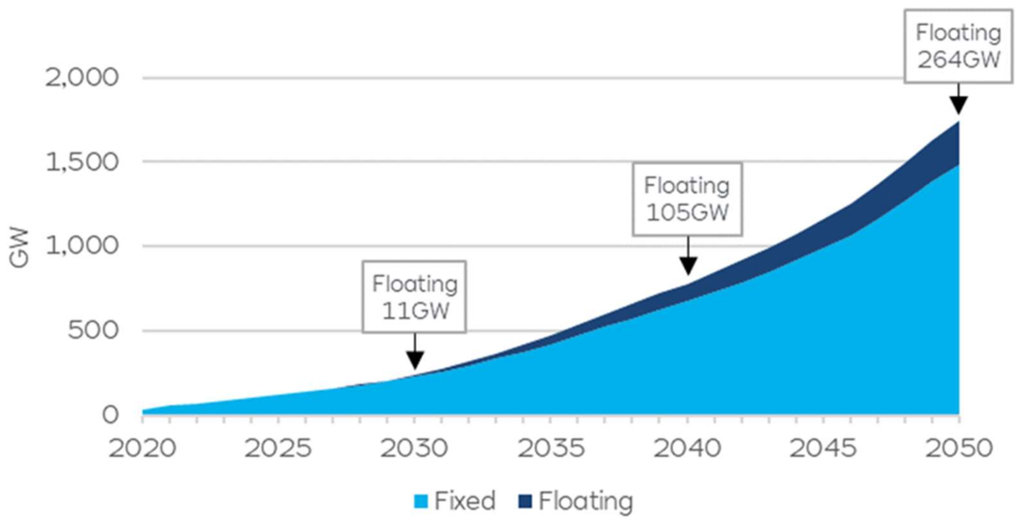
Driven by the dramatic price reductions observed in fixed-bottom offshore wind, it is now apparent that floating offshore wind will similarly become cost competitive as the industry gets established and matures. Consequently, demand and competition for seabed leases and innovative technology are becoming fierce in the floating industry.

It is predicted that the worldwide floating offshore wind market will be 264 GW by 2050, as depicted in Figure 3-3. In Pine Tree's estimation, this translates to an astounding $1 trillion in capital expenditures.

---

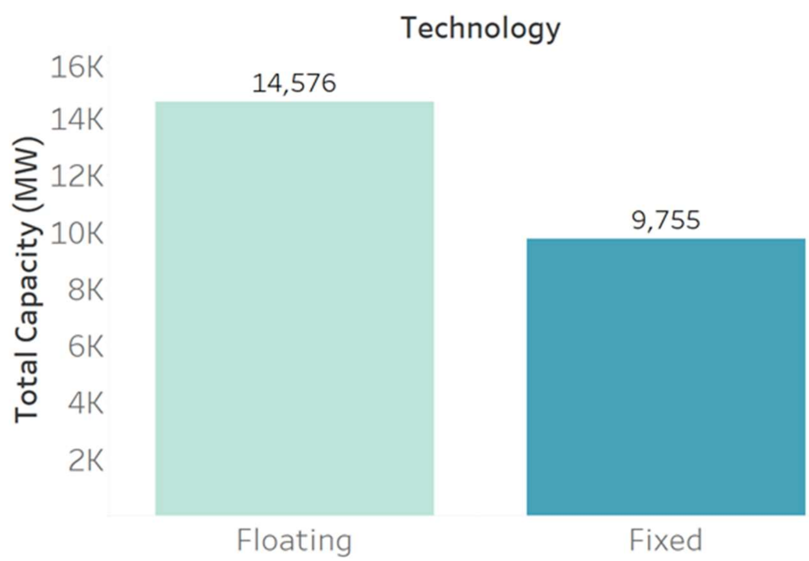
16 Much of the world's potential offshore wind resources are physically located within water depths greater than 60 meters (~200 ft). Within the United States, 58% of the offshore wind resource is located within water depths that are greater than 60 meters, and in Europe, the percentage grows to 80% (Musial et al. 2016, WindEurope 2018).

Figure 3-3. Forecast of global fixed and floating offshore wind to 2050, (post-FID) (Source: DNV, 2021)



Case in point: In January 2022, Crown Estate Scotland, in its ScotWind seabed leasing round, awarded leases for projects totaling over 24 GW. Sixty percent of that capacity is for floating projects, demonstrating the growing importance of floating technology in offshore wind (see Figure 3-4).

Figure 3-4. ScotWind Leasing total capacity by fixed or floating technologies (as of Jan. 2022)



3.c The Gulf of Maine's Optimal Floating Offshore Wind Conditions

It is expected that the United States will lead the early development of the floating offshore wind industry, as depicted in Figure 3-5, starting in the early 2030s, and, as outlined below, the Gulf of Maine will play a large, if not dominant, role.

[redacted]

The U.S. market will center on the Gulf of Maine and the Pacific Coast where the strongest winds are located, an important element in offsetting the relatively high capital cost of floating relative to fixed-bottom projects. The wind resources off Maine are among the strongest in the country (Figure 3-6).[17]

[17] According the NREL 2018 report, entitled, "Offshore Wind Resource, Cost, and Economic Potential in the State of Maine," 90 percent of Maine's wind resource exceeds 9 meters per second. In principle, Maine could use its offshore wind resource to supply offshore wind power to serve its in-state electric load as well as electricity markets in adjacent states such as New Hampshire and Massachusetts. The Gulf of Maine contains the strongest wind resource along the entire East Coast with an average wind speed of approximately 10 meters/second.

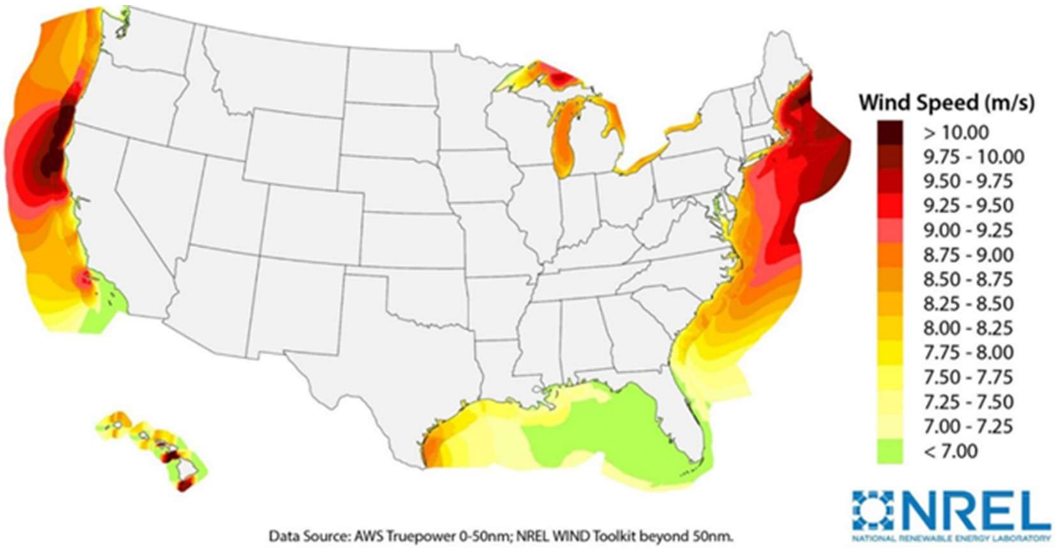


Figure 3-6. Wind Resource Offshore the United States (Source: NREL)

Currently, the global offshore wind market consists almost entirely of fixed-bottom foundation types (Figure 3-7). As a result, virtually all the port infrastructure now being planned and built in the U.S. is dedicated to fixed-bottom foundation projects. Further, most of the planned port infrastructure is dedicated just to staging areas and not the actual manufacturing or fabrication. A proper port will give Maine a historic competitive advantage.

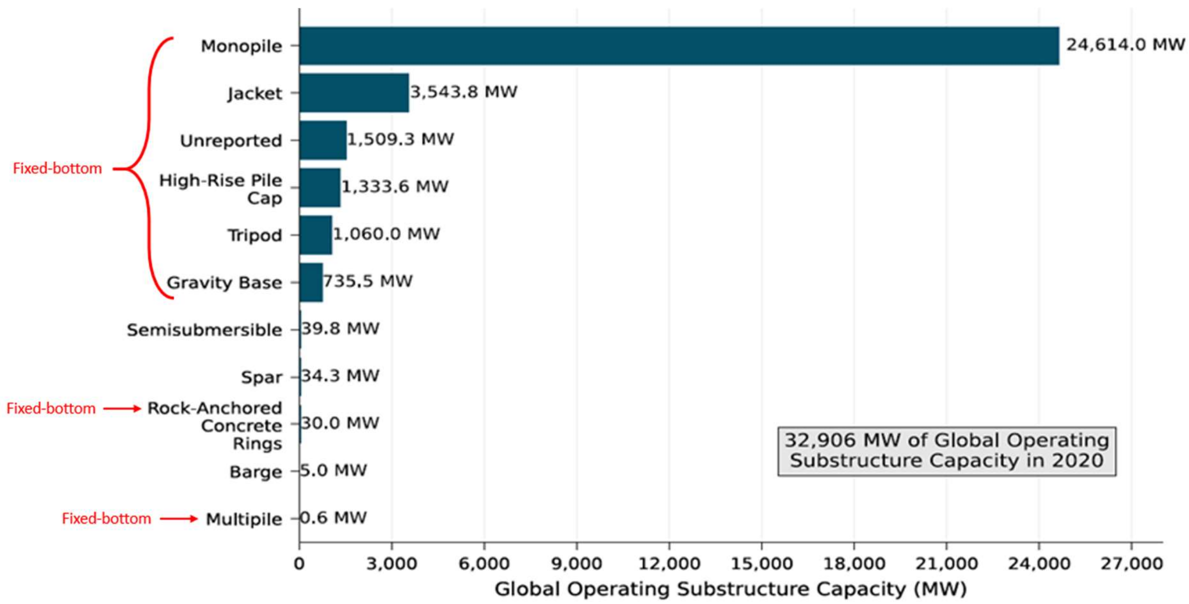


Figure 3-7. Substructure Types for Installed Offshore Wind Turbines (Source: NREL 2021)

3.d The Floating Offshore Wind Technology Race

Because the emerging market is understood to be significant, there is a race taking place worldwide driven by the need for floating wind technologies. A high-level overview of the general structures driven by water depth is shown in Figure 3-8.

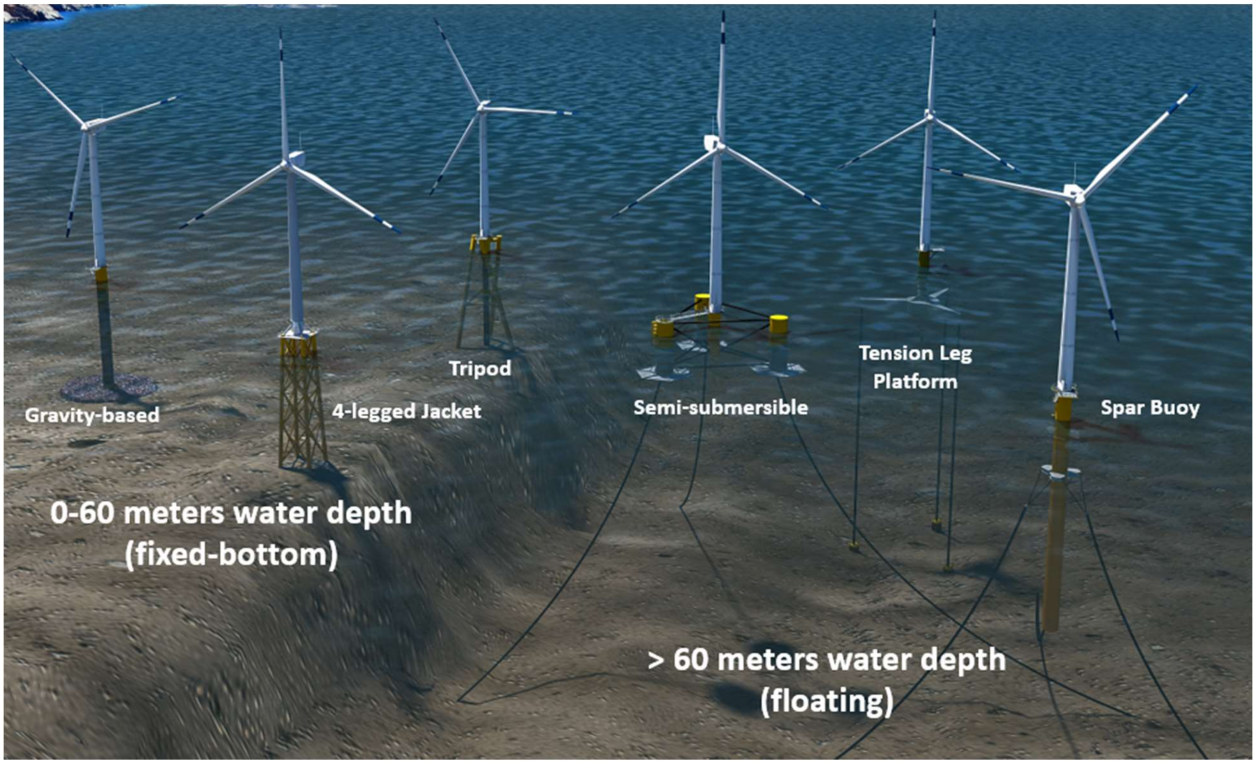


Figure 3-8. The technology deployed is driven by water depth (Source: NREL)

Examples of the myriad floating designs being pursued appear in Figure 3-9. Among the leading candidates for commercialization are the "semi-submersible" designs (third from the right in Figure 3-8 above)–the same as the University of Maine's VolturnUS foundation.

Figure 3-9. Selected examples of floating foundation designs (Source: Pine Tree / Various)

To date, there are only a handful of demonstration-scale floating offshore wind projects, mostly one or two small-scale turbines, all of which are in Europe. Roughly 135 MW (11 projects, 19 units) of floating wind capacity has been installed through the end of 2021, with more than 200 MW expected to be deployed by the end of 2022. These planned deployments include the first so-called "precommercial" scale project, Equinor's 88 MW HyWind Tampen, which is under construction and will be deployed in Norway. Although the global floating offshore wind market is largely within its pilot and/or demonstration phase(s), it is predicted that commercial-scale projects may be installed as early as 2025 (DOE 2021).

There is a lot of speculation about how much floating wind could be deployed over the next three decades. Ultimately, the success of the industry will depend on how much it can reduce the cost of energy, and how quickly.

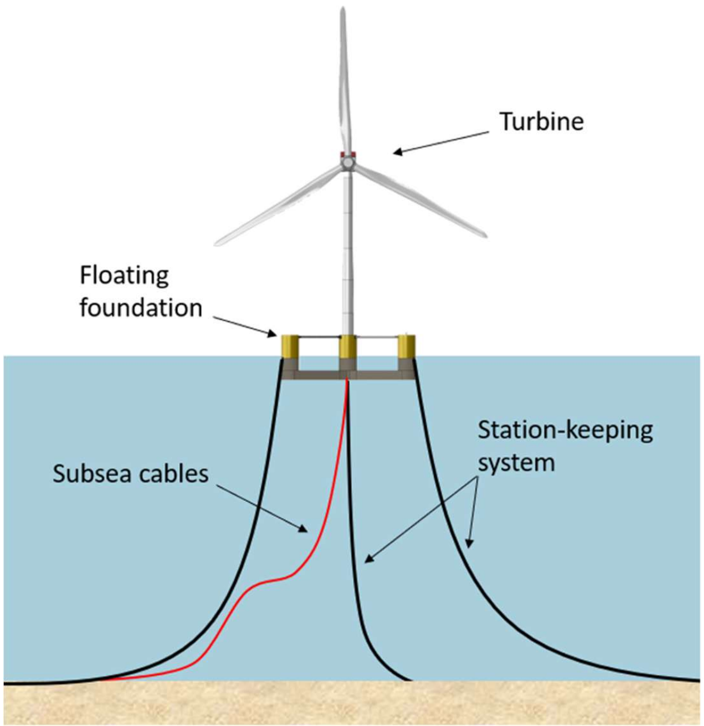
As previously shown above (Figure 3-3), up to 11 GW of floating project capacity is expected to be operational or to have reached FID by 2030, as the industry ramps up deployment with more pilot and early commercial projects.

Growth is expected to accelerate quickly. DNV estimates that almost 18 percent of all offshore wind capacity in 2050 will be from floating wind, with approximately 264 GW of floating wind capacity deployed (DNV, 2021).

In such a scenario, the average global installation rate would need to be more than 12 GW every year between 2030 and 2050. This is the essence of the "race"; technologies that have been proven at commercial scale will be the technologies developers rely on for this mass buildout. This is what Maine is poised to establish in the Research Array: a proven technology, manufactured by an experienced labor force, and deployed from an upgraded and operational port—a system ready to "go big."

3.d.i Key Elements of Floating Wind Technology

Some main components of a floating wind system appear in Figure 3-10. Floating offshore wind shares turbines and cables with fixed-bottom foundations. In the near term, these will continue to be manufactured outside of the United States. It is the foundation and station keeping system that includes mooring lines, chains, and anchors that will first be manufactured in the U.S.



Turbine:

- 12-15 MW range; only built in Europe at present

Subsea cables:

- 66kV & up; sourced worldwide

Station-keeping system:

- Mooring lines, chains, and anchors all custom designed and largely domestic; potentially sourced in Maine

Foundation:

- Will have to be fabricated domestically; can be 100% fabricated in Maine (if the UMaine VolturnUS design)

Figure 3-10. Conceptual representation of a floating offshore wind system and components

Most foundation types primarily consist of steel, both for fixed-bottom and floating. At present the rolling mills required to build the steel foundations are larger than any mills in the US. An example of a monopile appears below in Figure 3-11.

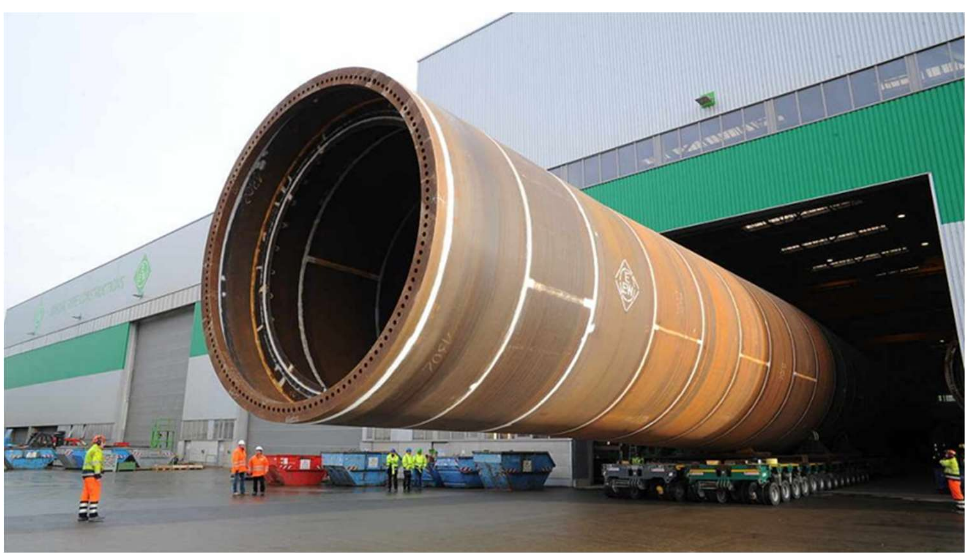


Figure 3-11. Significant steel components typically required for fixed-bottom foundation designs (i.e., monopiles) (Source: EEW SPC)

The first U.S. monopile fabrication facility (Figure 3-12), currently under construction on a 70-acre site is expected to cost $250 million to build.[18]

Figure 3-12. Planned monopile fabrication facility in Paulsboro, New Jersey (Source: NJEDA)

These figures depict the scale of the components of offshore wind farms, the scale of the facilities required, and the maturation of fixed-bottom foundation infrastructure. Virtually all port efforts on the East Coast are focused on building fixed-bottom foundation projects. Translated to floating offshore wind, the "race" is both a technology race (the foundation) and a port infrastructure race. The "first" will enjoy dominant market share for years to come. The Paulsboro monopile facility is a case in point. Paulsboro will establish a hub for sub-suppliers and skilled labor, making it more likely that development of a subsequent facility (if necessary) will be located nearby. The race to secure future development efforts and beneficial job creation within each state is underway.

3.e This is a Technology Race Maine Can Win

The proposed Research Array is the catalyst that will put Maine into a leadership position. Given that the floating offshore wind buildout in the Gulf of Maine appears to be measured in the tens of billions of dollars of investment, if Maine captures even a fraction of this business it will become a multi-billion-dollar annual business that employs thousands for a generation.

We summarize here how UMaine's VolturnUS hull has emerged as a leading technology that, coupled with Maine's decade-long efforts, the DOE, and more recently with Pine Tree, is positioned to become the Maine-based solution for floating offshore wind in the Gulf of Maine.

The VolturnUS is the first floating offshore wind turbine foundation in the Americas, developed and designed by UMaine, and has been issued 43 patents to-date. Since 2008, UMaine has researched floating offshore wind technology as a solution to Maine's overdependence on imported fossil fuels.

[18] https://www.windpowerengineering.com/offshore-monopile-manufacturing-facility-breaks-ground-in-new-jersey/

The ingenuity of Dr. Habib Dagher in UMaine's Advanced Structures and Composites Center (ASCC) created a design that could be made of concrete, as opposed to steel, so that it could be fabricated locally. **The concept is simple: put Mainers to work solving Maine's climate challenge**.

After winning funding from the DOE, UMaine worked with Maine-based construction firm Cianbro to build and deploy the first grid-connected offshore wind turbine in the U.S. in 2013, a one-eighth scale prototype of its VolturnUS floating hull, shown at right.

The VolturnUS 1:8 successfully completed its 18-month deployment as planned, working as a floating laboratory with over 50 sensors onboard measuring wind, waves, current, temperature, accelerations, strains, turbine performance, and mooring line loads. The turbine experienced numerous storm events representative of design environmental conditions prescribed by the American Bureau of Shipping (ABS) Guide for Building and Classing Floating Offshore Wind Turbines (2013) and was retrieved for post-deployment analysis by UMaine in November 2014.

The success of the project led to additional funding from the DOE to advance the VolturnUS technology. The University and Cianbro sought to partner with a world-class offshore wind developer to demonstrate the technology on a commercial scale. UMaine selected RWE and DOW to develop the 11 MW NEAV demonstration project, and now the larger-scale 144 MW Research Array, both of which will use the VolturnUS hull. UMaine has licensed its hull design to Pine Tree and its affiliate for both.

The 15+ year path to full commercialization is depicted in Figure 3-13.

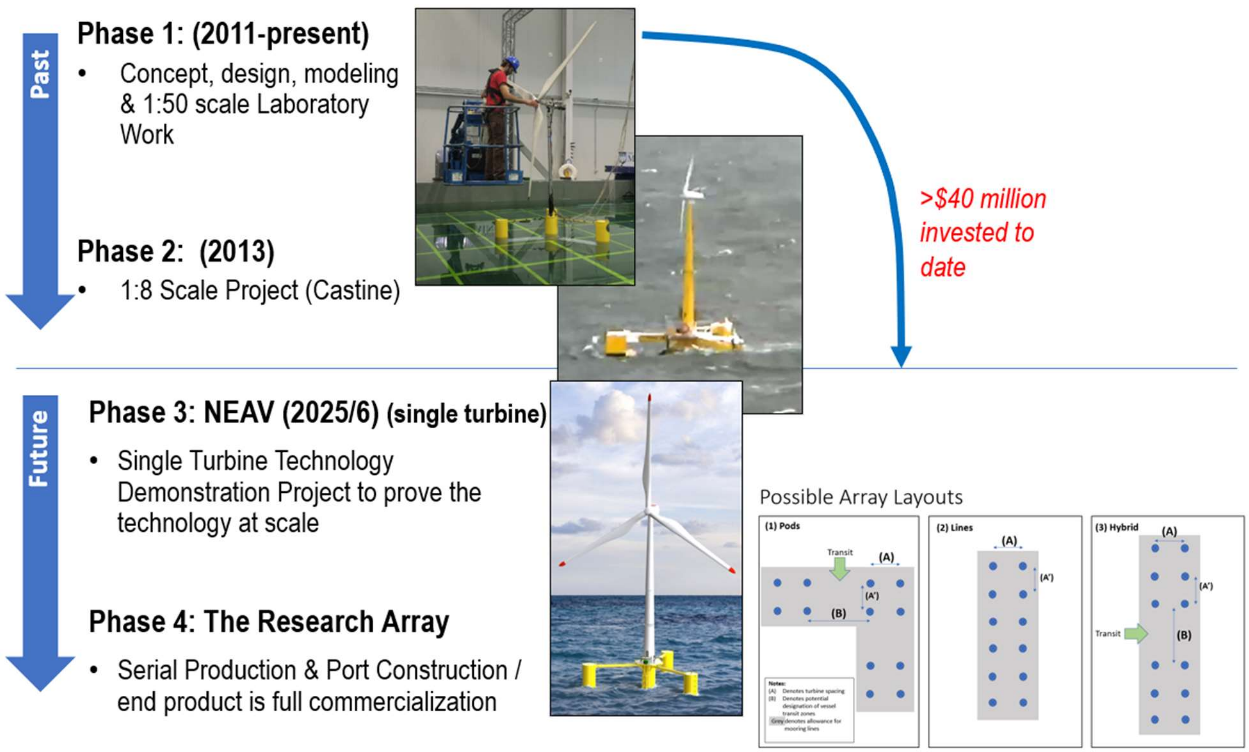


Figure 3-13. Pathway to full commercialization of the UMaine Foundation (Source: Pine Tree and UMaine)

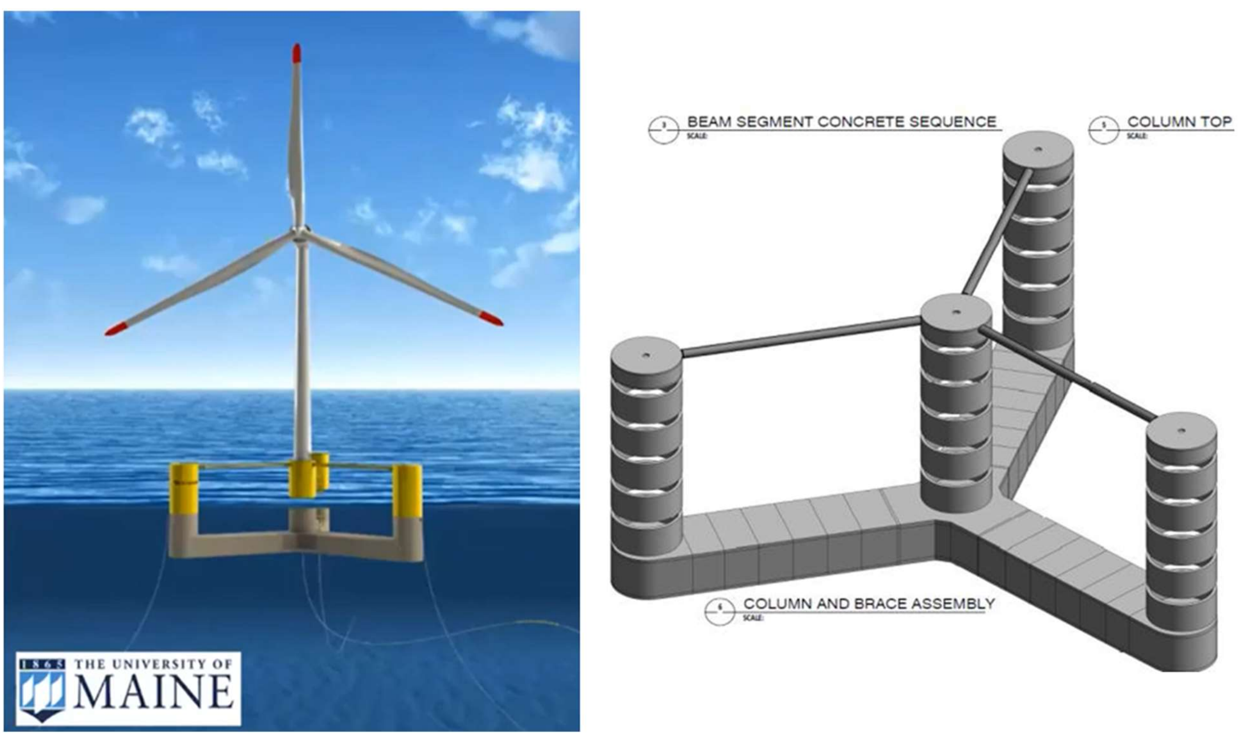


Figure 3-14. The UMaine floating offshore wind technology (Source: UMaine)

UMaine's technology is specifically designed to utilize existing manufacturing and construction industries within Maine.

By using concrete rather than steel wherever possible (Figure 3-14), the hull can be manufactured locally, and the Project will not rely solely upon technologies developed and serviced by the oil and gas industry fabricated in distant ports. In this regard, the Research Array will be instrumental in creating economic opportunities for local Mainers (for this generation and beyond), and Maine will be well positioned to serve diverse global markets (Maine.gov 2020). Furthermore, the UMaine foundation components can be assembled with turbines on and near shore, prior to being towed to the site using barges and vessels sourced in Maine.

This thoughtful design comes through years of development effort by UMaine, and tens of millions in investments to the ASCC. In 2011, ASCC officially opened its Offshore Wind Laboratory, adding structural testing of blades, towers, and foundation components up to 230 feet in length to its list of capabilities. In 2015, it received its largest philanthropic gift to-date from the Harold Alfond Foundation to name the $13.8 million Alfond Wind and Wave (W2) Ocean Engineering and Advanced Manufacturing Labs. The Foundation provided $3.9 million to match the $9.98 million raised by the NSF, EDA, a State of Maine bond, and other sources. The expansion of the Alfond labs brought the total size of the ASCC to 100,000 square feet (Figure 3-15).

> *"As Maine's research university, UMaine is continually advancing its broad land grant, sea and space grant mission. The path from fundamental research to economic realization is complex, and success takes incredible innovation, persistence, and strategic partnerships. Many faculty, staff, and students have participated in the development of this technology and will continue to support the energy and marine economy as this project transitions to the private sector. This collaboration exemplifies our role and commitment to creating and supporting the future of Maine."*
>
> - UMaine President Joan Ferrini-Mundy

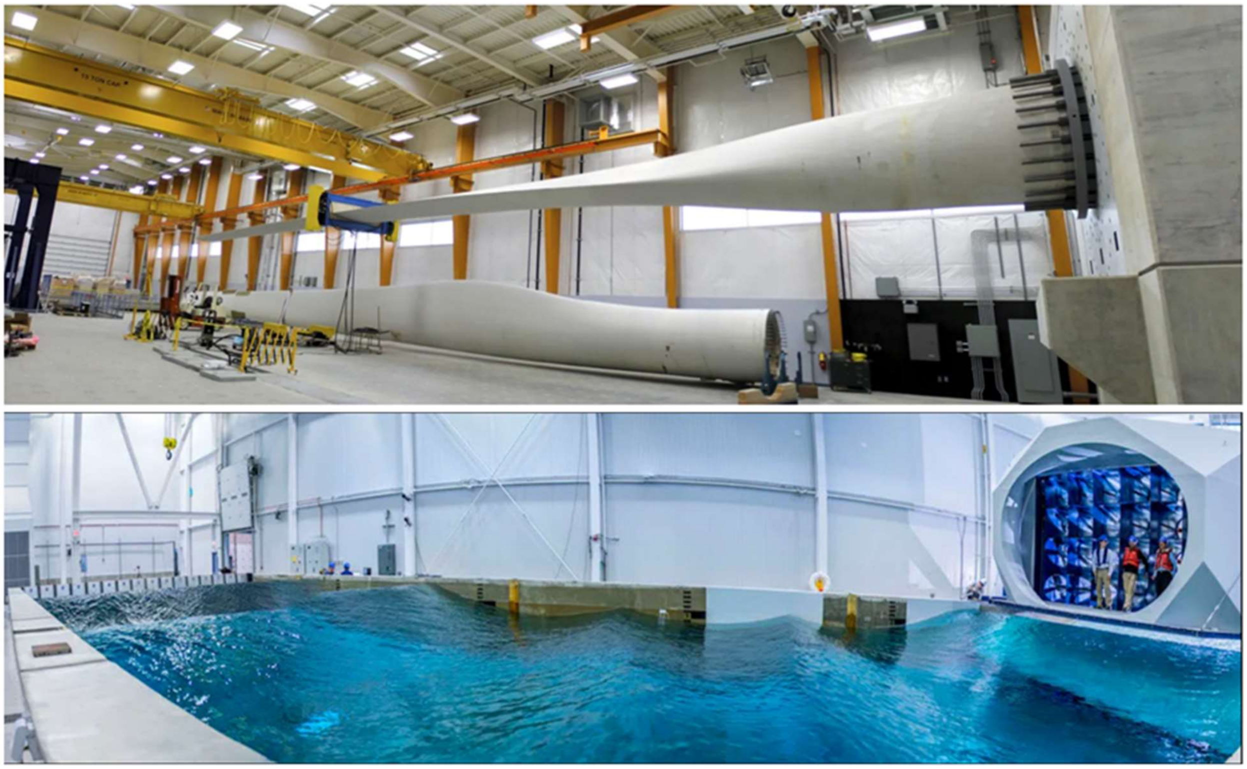


Figure 3-15. The UMaine ASCC Offshore Wind Lab and Alfond W2 Ocean Engineering Lab (Source: UMaine)

In summary, UMaine's foundation will be proven technically viable with the NEAV single-turbine deployment and then actually commercialized by deploying ten foundations in the Research Array. Simultaneously, Maine's commitment to the Research Array, specifically the economic development and research, justifies federal funding for a dedicated floating offshore wind port that will create the hub for foundation fabrication, sub-suppliers, contractors, and a labor force for the generation-long buildout of floating offshore wind in the Gulf of Maine.

4.0 THE PLAN TO MAKE OFFSHORE WIND WORK FOR MAINE

Maine has a historic opportunity to lead what is expected to be a massive buildout of floating offshore wind in the Northeast, but to paraphrase Governor Mills, "Maine can't wait." Much like how Iowa became the hub for onshore wind, so too can Maine for floating offshore wind, and reap the economic benefits and job creation for generations to come. At the same time, Maine can protect the Gulf of Maine, its fishing industry, and the environment, and accomplish this all through the thoughtful development and research planned for the Research Array. But, make no mistake, Maine is competing with other states to be the home for floating offshore wind and to obtain the federal funding needed to develop an offshore wind port. President Biden's Bipartisan Infrastructure Law will invest $17 billion in port improvements and new construction, much of which will be highly sought by states looking to develop an offshore wind port.

4.a Protecting the Gulf of Maine

With only a few floating offshore wind turbines operating in the world, and none currently in the U.S., research and scientific study is needed to understand floating offshore wind technology, its generation of electricity, and its effect on fishing and the marine environment. The Research Array will provide the information to make data-driven decisions and create a pathway for future offshore wind projects to maximize compatibility with other ocean users and the marine environment. With Maine's commercial fishing industry a cornerstone of its economy, providing approximately $1.5 billion in annual economic benefit to Maine, protecting the Gulf from uninformed leasing and subsequent development is imperative.

BOEM has initiated a process to define and auction lease areas, including the Gulf of Maine, which has been projected through 2025 (see Figure 4-1 below).

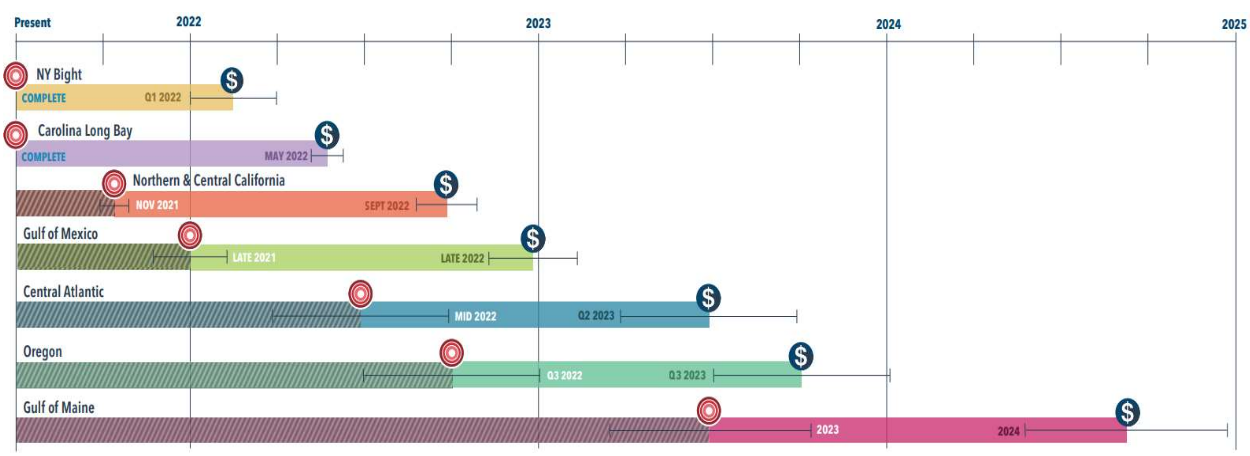


Figure 4-1. BOEM Leasing Timeline (Source: BOEM 2022)

> *"Maine's fishing industry is a vital part of our state's economy, heritage, and identity. Its voice must be heard when considering this new offshore wind technology…the Department welcomes the chance to work proactively with the fishing industry to hear and understand its concerns about offshore wind, and to ensure its perspectives inform the development and operation of the research array in the Gulf of Maine"*
>
> *- Patrick Keliher, Commissioner of the Department of Marine Resources, 2020*

The Research Array seeks to get ahead of this large-scale leasing and establish a science-based set of best practices for offshore wind projects that will inform future commercial leasing. Without it, for instance, there is a strong likelihood that Gulf of Maine commercial leases could have unnecessary restrictions around accessing, transiting, and fishing in a lease area. Taken to an extreme, this can lead to phased-in large scale fishing restrictions having a material negative impact on Maine's fishing industries. The Research Array would enable the State of Maine to work side-by-side with fishermen and other maritime stakeholders so that harm can be minimized, and benefits from offshore wind maximized (**Exhibit 2**).

4.b Maine Needs to Act Now to Harness the Economic Benefits from the Multi-Billion-Dollar Buildout of Floating Offshore Wind

To capitalize on its decade worth of work on offshore wind, Maine now needs to act to consolidate its leadership position, build a port, and become the hub for construction, operations, and maintenance for floating offshore wind.

As shown throughout this Petition, the offshore wind industry is expected to grow significantly through 2050. With the forecasted rise in offshore wind, QBIS, a consulting group, studied the socio-economic impact of the offshore wind industry in Denmark, known to have the largest and most comprehensive offshore wind supply chain in the world (QBIS, 2020). The results show how Denmark's economy benefited from the country being an early mover and leader in offshore wind and the potential for extensive job creation with the global expansion of the industry. If Maine seizes the opportunity of investing early in the emerging floating offshore wind market, Maine will likely see disproportionate benefits akin to what Denmark enjoys today.

Similar to Maine's maritime legacy, Denmark is the largest fishing nation in the European Union, and its ports are critical transit points for around 80 percent of its imports and exports. Denmark invested in the offshore wind industry through its ports and manufacturing businesses. Over 30 years ago, it became the first country to install a commercial offshore wind farm, the 5 MW Vindeby project, followed by the first two large scale arrays in 2004/05 consisting of 72 and 80 turbines at Nysted and Horns Rev. Denmark now has a 40 percent market share of the European offshore wind market and has positioned itself as a one-stop-shop for global offshore wind. To achieve this status, Denmark built a highly skilled workforce throughout the entire life stage of a wind farm, including labor for the construction of turbines and major components, specialized maritime and logistics services, leading facilities for testing prototypes, research institutions, ports specialized in offshore wind, and a comprehensive network of local suppliers. Its wind energy industry is estimated to directly employ close to 33,000 people, or 2 percent of private sector employment.

One of Denmark's largest ports, the Port of Esbjerg (Figure 4-2), has been involved in more than 50 European wind farm projects. In 2001, the port supported the first Danish offshore wind farm and through years of port expansion, Esbjerg has captured 55 percent of accumulated European offshore wind capacity. Esbjerg is now home to 250 different offshore wind suppliers.

Figure 4-2. Port of Esbjerg

If the Commission takes this crucial step of approving the Research Array PPA, it will position Maine to be the Denmark of U.S. floating offshore wind.

4.b.i Port Development in Other States

The U.S. offshore wind market continues to be driven by increasing state-level offshore wind procurement activities and policies. In aggregate, these activities now call for deploying at least 39,298 MW of offshore wind capacity by 2040 (NREL 2021) which translates into more than $100 billion in investment. To meet this capacity, coastal states are funding their own port development projects with the hopes of creating jobs and providing local supply chain content.

According to the National Renewable Energy Laboratory (NREL) Offshore Wind Market Report: 2021 Edition, the development and timing of port infrastructure could become a significant bottleneck for the industry. There are several ports in the United States that will be able to support offshore wind deployment in various capacities, either as full-service wind hubs or smaller staging or service ports. These ports have begun construction in anticipation of the first round of fixed-bottom projects. A sampling of recent state investments has been summarized in Figure 4-3.

> *"Offshore wind is an enormous opportunity for Maine's energy and marine businesses to further strengthen the state's economy…Maine's companies are well positioned to seize this opportunity and build expertise for the 21st century, and I applaud the Mills Administration for making this a priority."*
>
> - Dana Connors, President of the Maine State Chamber of Commerce, 2020

Figure 4-3. Examples of recent offshore wind port investments on the U.S. East Coast

These port infrastructure projects are focused on supporting fixed-bottom projects. Currently, no U.S. port exists that can support a commercial-scale floating wind project, creating the opportunity for Maine's port development, as further detailed in Section 5.g below.

4.c Maine's Offshore Wind Roadmap

The State of Maine has put in place initiatives for the expansion of offshore wind off the coast of Maine since 2008, when then Governor Baldacci set a goal to position Maine's companies to become leaders in offshore wind. In 2020, Governor Mills announced the Maine Offshore Wind Initiative by Executive Order. The GEO then launched the Maine Offshore Wind Roadmap (Roadmap), a public two-year process to create an economic development plan for the offshore wind industry in Maine. The Roadmap is being developed by an expert advisory committee and several working groups with broad public input, focusing on energy markets, ports and infrastructure, socioeconomic impacts, equity, manufacturing and supply chains, workforce development, and ocean and environmental compatibility (MaineOffshoreWind.org).

The goal of the Roadmap is to identify how to foster an offshore wind industry that works for Maine's people, Maine's economy, and Maine's heritage. The Roadmap is scheduled for completion by the end of 2022 but preliminary recommendations, which align well with the Research Array, were recently released. Highlights are as follows:

- ***Supply Chain*** – "Formally establish and initiate a clear and consistent State policy for OSW (offshore wind), along with a sustained, sequenced effort to support it."—The Research Array is clear evidence to the supply chain that Maine is serious about OSW by continuing what it set in motion with the single-turbine NEAV project.
- ***Ports*** – "Move forward with port development plans with urgency."— Without the Research Array, development, and construction of an OSW port in Maine would not be feasible at this time. Federal funding is of paramount importance, but those funds will go to states that have fostered OSW by entering into offtake agreements.
- ***Fisheries*** – "Work with BOEM and other New England states to pursue establishment of a series of monitoring requirements for offshore wind leaseholders"—Monitoring within the lease area of the Research Array will be extensive, well thought out, and dictated by the State, giving Maine fisheries the opportunity to give input that is heard and acted upon.
- ***Energy Markets and Strategies*** – "Establish and initiate a floating offshore wind requirement and procurement process."—The Research Array is the beginning of both and will greatly inform the expected results of the procurement process and cost associated with a floating OSW MW requirement.
- ***Workforce Development*** – "Enhance & Expand OSW Training & Registered Apprenticeship Opportunities"—There is no better way to promote training in OSW than by building a project, and since the Research Array will be built in partnership with the State, requirements for Pine Tree to provide training can be mandated in one or more agreements.

5.0 THE MAINE RESEARCH ARRAY

5.a Research Array Description, Objective, and Goals

Maine's Research Array (also referred to as MeRA), as described within the BOEM application (**Exhibit 2**), although small by offshore wind standards, is large enough to simulate how a full-scale project will function in the ocean environment. The Project will be in federal waters greater than 20 miles from shore at a location that is reasonably indicative of future commercial-scale project locations. The site is 15.2 square miles or 0.04 percent of the 36,000 square miles in the Gulf of Maine (see the small black polygon in Figure 5-1). The Research Array is planned to utilize [redacted] [redacted] wind turbines mounted atop floating concrete foundations built in Maine, utilizing UMaine's patented VolturnUS foundation design. The Project will likely connect to the grid at, or near, Wyman Station or Maine Yankee.

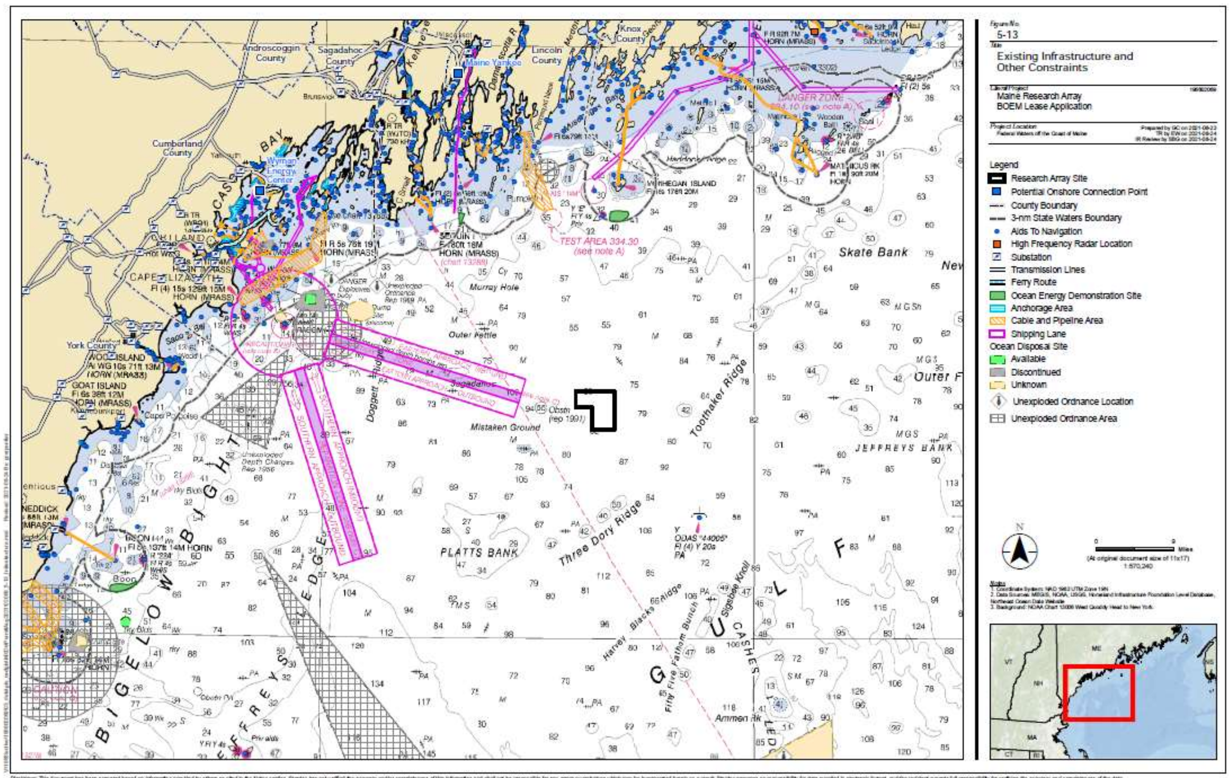


Figure 5-1. Research Array Project Area (Source: Exhibit 2)

The Research Array will be developed and constructed in four distinct phases as depicted in Figure 5-2 below. It is anticipated that it will take at least four years to compete the site assessment and permitting phases, with an additional two to three years needed for construction. Of course, the timing and schedule for construction are largely dependent on the availability of the purpose-built port which the Maine Department of Transportation is pursuing.

[19] Turbine ratings are rapidly changing and can be site specific.

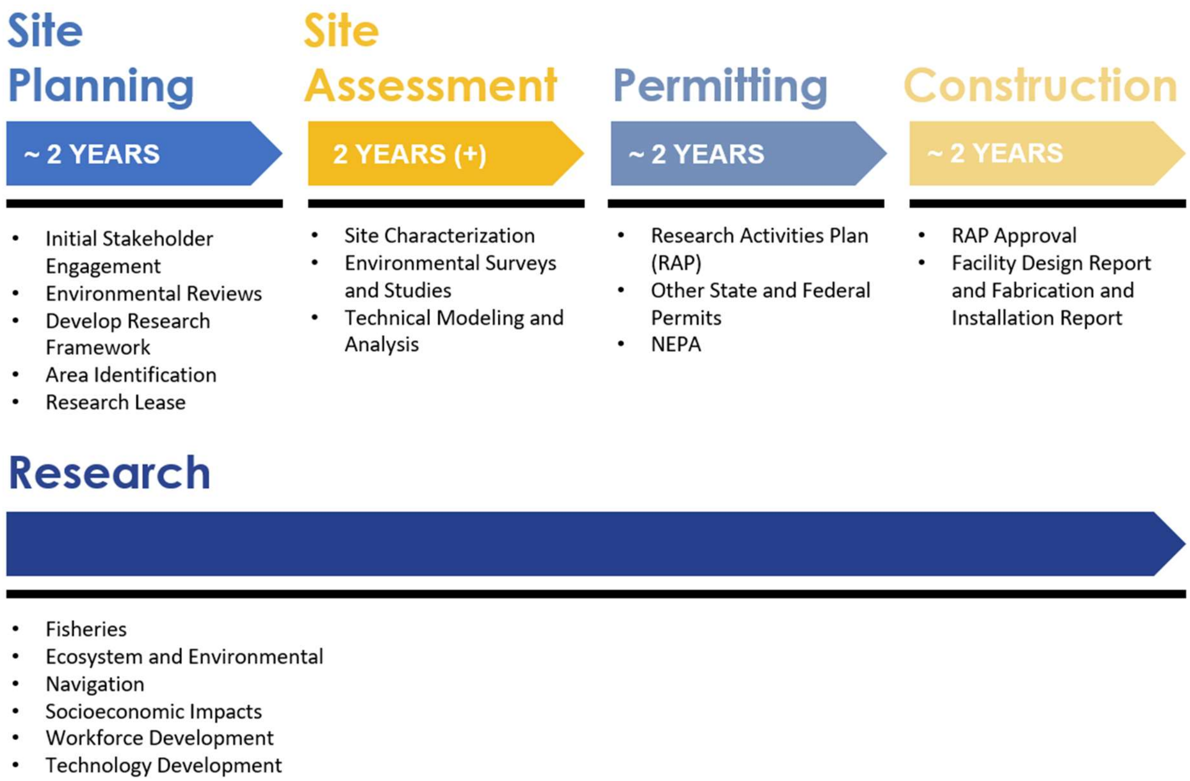


Figure 5-2. Indicative Project Schedule for the Research Array (Source: Exhibit 2)

The goal of the Research Array is to inform future commercial-scale projects by arriving at a set of best practices and standards to utilize in planning, permitting, and construction; all in a fashion that optimizes co-existence with traditional marine users and the ecosystem. The Research Array aims to provide real-world experience with a multi-turbine array to maximize co-existence with the fishing industry and advance floating offshore wind (both technically and commercially) so that full-scale deployment will be responsibly implemented.

The State of Maine clearly articulated the objectives of the Research Array in the BOEM application:

- Investigate science-based avenues to maximize co-existence with the fishing industry.
- Advance technical and commercial considerations related to floating offshore wind development that will result in more efficient, cost effective, energy production that can be integrated into full-scale deployment.
- Evaluate interactions and minimize potential impacts of the array on marine environment and protected wildlife species.
- Create a set of real-world tested best practices and standards that can foster more prudent development of commercial-scale projects in the future.

5.b Siting

Site selection for the Research Array was an extensive, multi-party, coordinated effort, that was accomplished in three phases: 1) Identifying the Area of Interest (AOI); 2) Refining the AOI Through

Stakeholder Engagement; and 3) Final Site Identification. To identify the AOI, the State developed the following siting criteria and constraints:

- Proximate to onshore high-voltage electric grid connections.
- At least 150 ft bottom depth and mud or gravel bottom for anchoring.
- At least 20 miles and no more than 40 miles offshore.
- Minimal conflict with known fishing grounds, exclusion areas, and highly trafficked areas.

Following these considerations, the State introduced a broad AOI of approximately 770 square miles from which to identify the 15.2 square mile lease area. To refine the AOI the State conducted extensive stakeholder outreach which generated input from hundreds of individuals, groups, and organizations via public meetings, informational webinars, one-on-one meetings and more (GEO 2020). The GEO coordinated with the DMR who engaged directly with fishing industry members to understand their activity and solicit input to inform the siting process. Information on intensity of use, value to the community, seasonality, and diversity of fisheries was received and considered. Inland Fisheries and Wildlife (IFW) was also consulted and performed a desktop analysis to identify the areas within the AOI of greatest relative potential risk to marine birds. Further consultations were also conducted with other state and federal agencies, NGOs, and research institutions ultimately leading to a narrowed AOI of 54 square miles (**Exhibit 2**).

The GEO's final site selection, which reduced the AOI to 15.2 square miles, received minimal negative feedback from interested parties. The site reduces potential impacts to wildlife and fisheries while minimizing impacts to navigation and defense and balances the needs and safety of all waterway users. The siting process overview is outlined in Figure 5-3, below.

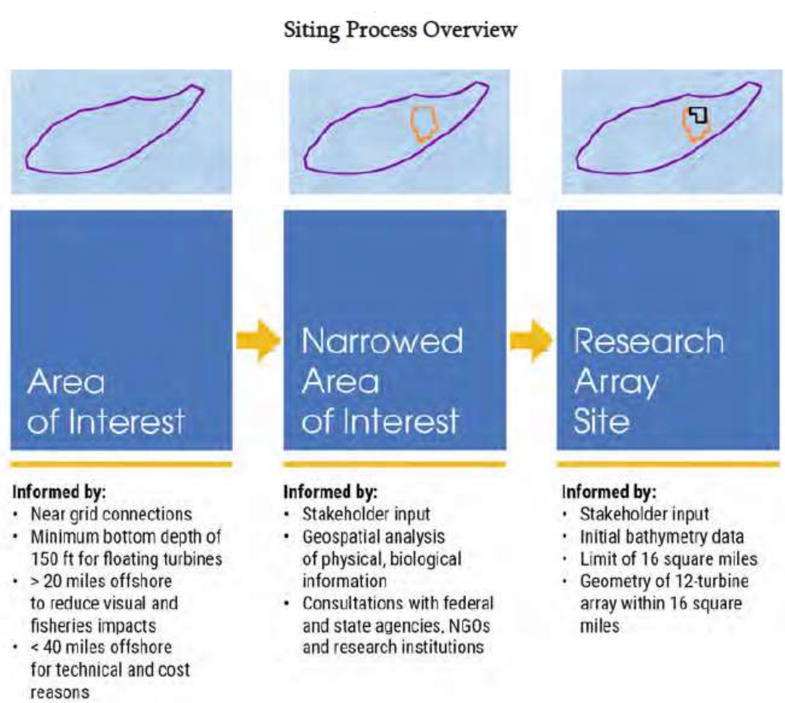


Figure 5-3. Siting Process Overview (Source: The Maine Floating Offshore Wind Research Array Pre-Application Siting and Stakeholder Summary, Dec. 2020 to July 2021, GEO's Website)

The State's siting process for determining the location of the Research Array occurred in advance of, and separate and apart from, a federal review process that will be undertaken by BOEM to determine whether the proposed research lease area will be awarded.

5.c Research

The research the GEO is contemplating is detailed in the Lease Application. Much of it centers around the many questions the fishing industry and others have about the basic architecture and behavior of offshore wind projects. Issues such as the ability to optimize (reduce) the footprint to allow proximate fishing, the burial of cables, how projects behave in storms, whether developers, insurers, or the United States Coast Guard (USCG) will create exclusion zones, and whether vibration or electromagnetic fields impact the behavior of important marine species such as lobster or right whales are of interest. The research can be used to prove that site-level exclusion zones for lobstering and vessel navigation are not necessary, which can substantially reduce impacts to fisheries and other marine users (see Figure 5-4).

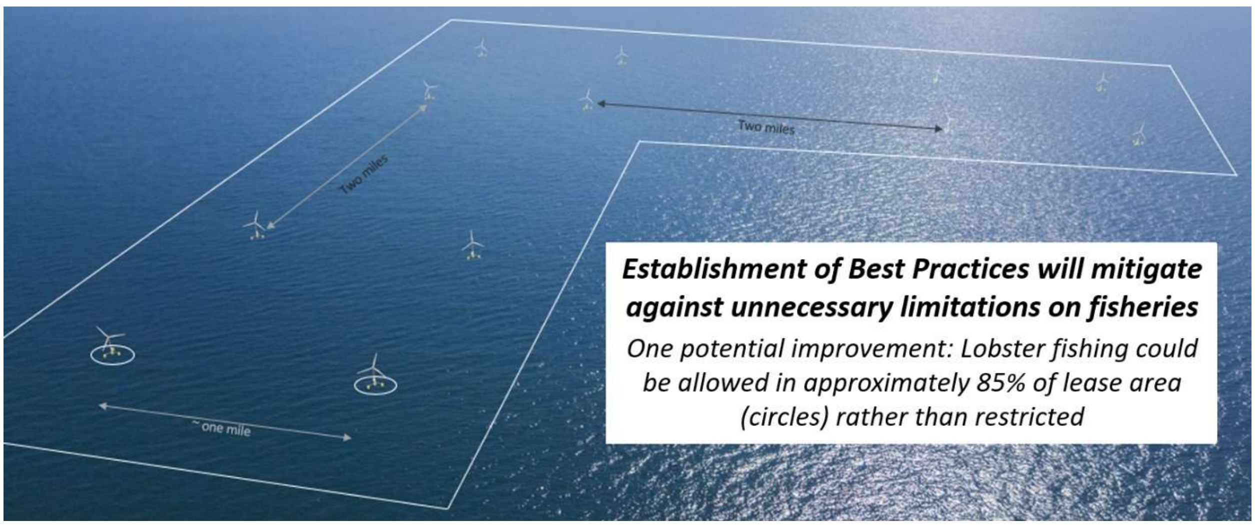


Figure 5-4. Indicative Turbine Arrangement and Spacing Allowing Fishing Access

In addition, the impacts of mooring line configuration and materials on fish behavior and fishing activity can be evaluated (Figure 5-5) and informed by surveys.

5.d The BOEM Application and Research Lease

There can be no Research Array without a research lease of federal waters. As such, the State, acting through GEO, filed an Application for an Outer Continental Shelf Renewable Energy Research Lease with BOEM in October 2021 (**Exhibit 2**). BOEM is currently processing the Lease Application. Once BOEM's process is complete, it will issue a lease to the State as lessee.

5.e The State of Maine Research Array Agreement

In anticipation of the lease being issued to the GEO, Pine Tree and the GEO are preparing a Research Array Agreement (RAA) which details the contractual relationship between the two entities. Research leases may only be held by a state or federal agency for renewable energy research activities that support the future production, transportation, or transmission of renewable energy (30 CFR § 585). Accordingly, Pine Tree cannot be the lessee under a research lease, but at the same time the GEO is not a developer, owner, operator of offshore wind projects. For Pine Tree to develop, permit, construct, and operate the Research Array, and otherwise fulfill the State's obligations under the lease, it needs a contractual relationship with the GEO as lessee. This relationship will be detailed in the RAA.

5.f The Research Collaboration Agreement

Unlike offshore wind turbines with fixed-bottom foundations, there is no world-wide body of scientific knowledge to draw upon to evaluate impacts of floating offshore wind turbines on the ocean environment. The GEO contemplates being the driver of research within the lease area of the Research Array, intended to provide real-world experience to industry, researchers, states, and the fishing industry regarding how best to co-exist and retain functionality of floating offshore wind projects. GEO and Pine Tree will enter into a Research Collaboration Agreement which will define their respective rights and responsibilities regarding any research activities undertaken by the GEO or its designated researchers in the lease area.

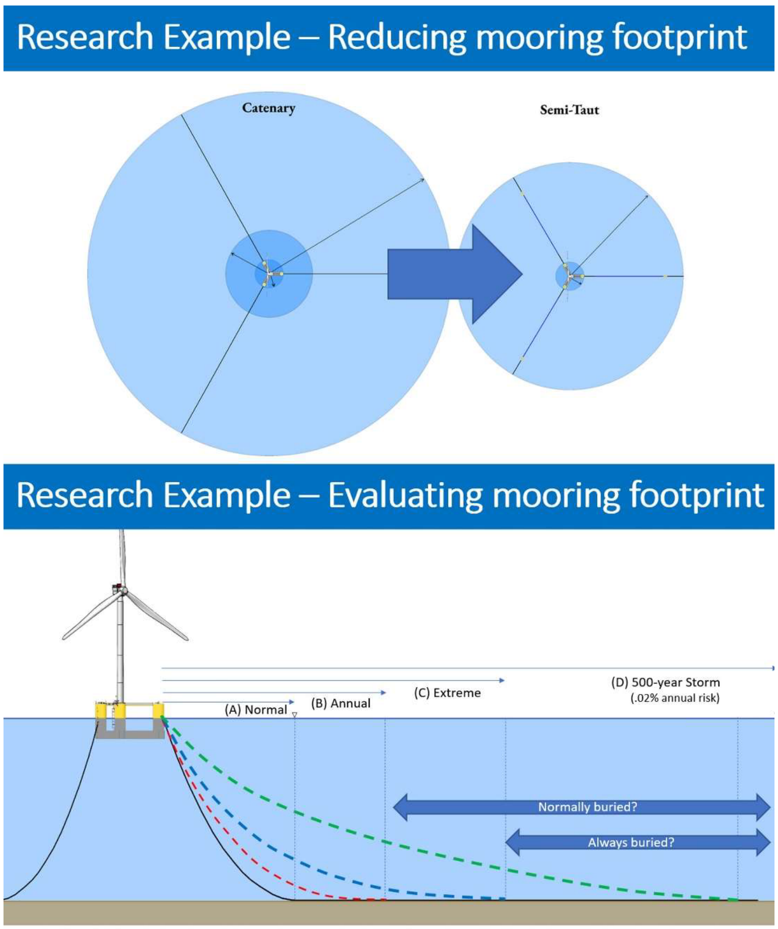


Figure 5-5. Research examples: Impacts of mooring line configuration and materials (Source: Exhibit 2)

5.g A Port for Building and Launching Floating Offshore Wind

Investment in port infrastructure is an essential component in building the floating offshore wind industry and affiliated operations within the State of Maine.

Both fixed-bottom and floating offshore wind require the use of very large ports. Other states on the East Coast have emphasized marshalling or staging ports that can receive major turbine components from overseas and prepare them for deployment. A typical planned port outfitted for this purpose appears below in Figure 5-6, planned at a cost of $250 million to support New Jersey's multi-GW goals.

Figure 5-6. Example: New Jersey Wind Port on an artificial island (Source: New Jersey Economic Development Authority)

Other states' efforts do not leave extra capacity for floating offshore wind. In many cases, port facilities are obstructed by low bridges (impeding ability to launch fully erected turbines on floating foundations) and do not have required floating offshore wind specific launch mechanisms. UMaine's VolturnUS hull, sized for the Research Array, will weigh more than 14,000 metric tons and have a diameter of greater than 340 feet. To accommodate hull manufacture and launch, tower and wind turbine part storage and marshalling, along with turbine erection and launch for the Project, an approximately 60-acre purpose-built port equipped with a 1,300-foot high-capacity quay, and 40-foot draft will be needed.

Floating offshore wind needs substantially distinctive ports, especially if foundation fabrication will take place locally. In addition to marshalling area for the large wind turbine components, area is needed (at least as large) to fabricate the foundations themselves, and notably, a launch mechanism to launch foundations. The launching of floating offshore wind harkens back to the era, forgotten by too many, when Maine launched large-scale clipper ships (as depicted in Figure 5-7), such as when Percy & Small launched the largest wooden ship ever built (450' long) in Bath and hundreds of other commercial sailing vessels, more recently, with the launching of the Arleigh Burke-class Aegis destroyer (500' long).

Figure 5-7. 1909, Maine's own Percy & Small launched the largest wooden ship ever built at 450' long (Source: Maine Maritime Museum)

A launch system is also required to accommodate floating offshore wind. This is the component that will make Maine's planned port a true purpose-built floating offshore wind port. A candidate for the planned launch system appears below in Figure 5-8.

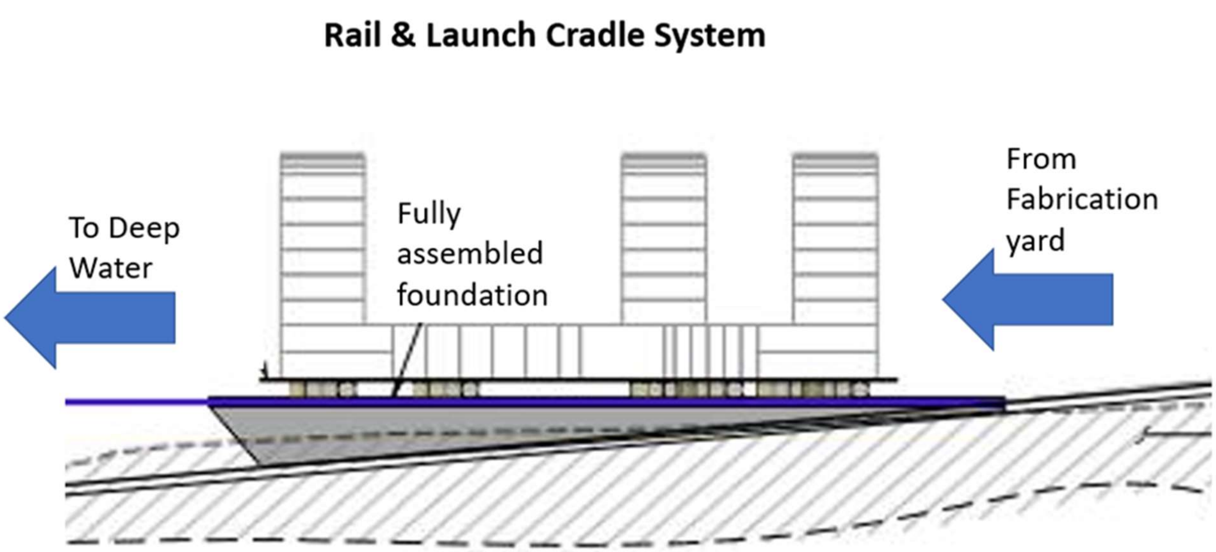


Figure 5-8. Indicative Foundation Launch Mechanism (Source: Mott MacDonald for Pine Tree)

The importance of the launch mechanism is that it will be the first on the East Coast. It will be designed to accommodate even the largest foundations, not just for launching but also for servicing. A port configured with this type of infrastructure will be truly unique. Being proximate to the Gulf of Maine will ensure that this port will become home for the vast majority of offshore wind projects built in the Gulf of Maine.

Figure 5-9. Pine Tree Offshore Wind rendering of potential Searsport development (Source: Pine Tree)

MDOT has embarked upon a design, fund, and build process that will enable a port in Maine to be built in time for the Research Array. For the purposes of this Petition, Pine Tree has assumed the State of Maine would supply a designated fit-for-use port facility (see Figure 5-9) that would be ready for occupation at the same time as the planned start of construction for the Project. MDOT is promoting the creation of a "Wind Port Hub" which is a long-term, multi-terminal concept that will support both research and commercial-scale projects; MDOT is currently evaluating potential sites to meet these requirements. Without this port facility, jobs associated with floating offshore wind foundation fabrication will be forced out of state and Maine would risk paying for the cost of offshore wind power without benefiting from construction, operations, and maintenance jobs and otherwise positive economic impacts.

Pine Tree is working extensively and collaboratively with MDOT to ensure that the future port facility is best designed to support the Project while simultaneously differentiating itself to serve as the first, and therefore most dominant, floating offshore wind port on the East Coast of the United States.

6.0 ECONOMIC BENEFITS TO MAINE

With this Petition, the State of Maine is at a decision point in choosing its long-term energy future. Benefits, and costs, should be evaluated in this context.

This section draws upon significant contributions from Competitive Energy Services and London Economics International (LEI) to illustrate both the classic project specific benefits and costs, as well as some of the longer-term farther-reaching benefits, along with an exploration of costs associated with pursuing the State's decarbonization goals without offshore wind.

6.a Direct Benefits are More than Just Construction of the Project

Construction of the Research Array itself accounts for just a portion of the benefits that will accrue to the State of Maine from the path charted by the Project. Of course, the Project has all the construction, operations, and maintenance benefits one would expect of a large power project, including direct input into Maine's economy along with induced and indirect impacts, and jobs—more than a thousand of them.

The primary unique aspect of this Project is that it comes coupled with construction of a sizeable port. It is not expected that the port construction will be funded by Maine ratepayers. The Project will put the State in a good position to obtain federal funding for port construction. The same way that the MAV project attracted DOE funding to prove the technology, the Biden administration seeks infrastructure projects that align with the federal government's climate goals.

The second unique aspect of this Project is that it is the catalyst for Maine to become a hub for floating offshore wind. If the Project and the port are built, subsequent floating projects will build using this port infrastructure, intellectual property, and know-how for generations to come.

In addition, there is one other category of benefits that is quite important to ocean stakeholders – keeping the Gulf of Maine accessible to fishing. The Research Array is Maine's best chance to set a path (Roadmap, Section 4.c) to co-existence so that wind power can be harvested alongside, rather than instead of, traditional marine harvests.

[redacted]

6.b Timeline

It is also important to understand the timeline associated with the Research Array. Planning and construction of the port and Research Array will span six years, with power flowing toward the end of the decade. Larger commercial-scale wind farms, built in areas planned to be leased by BOEM in 2024, will only be fully permitted and commence construction after 2030, leaving time for scientific lessons learned to be incorporated into these future commercial-scale projects.

[redacted]

[redacted]

6.c Project Costs

Capital spending for the Research Array

Direct spending associated with the Research Array and the port is detailed in Figure 6-2.

Construction implemented in Maine will be twofold and consist primarily of the following:

- An estimated [redacted] would be spent to build the nation's first port designed for building floating offshore wind projects.
- More than $300 million would be spent in Searsport building ten of the UMaine-designed floating foundations.

While these are the two largest areas of Maine spending regarding construction, there are several others, including onshore substation construction, staging of equipment, like wind turbine components, and construction of an operations and maintenance center.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] The project-specific portion of this spending curve is reasonably indicative of larger-scale projects that will also spread their construction across three or more years.

[redacted]

[redacted]

The anticipated job creation from offshore wind projects will accumulate over time with jobs from construction of projects eventually accompanied by jobs associated with operations and maintenance. This evolution of job creation is best represented within the following chart prepared by the New York State Energy Research and Development Authority (NYSERDA) (Figure 6-4), which shows the accumulation of overlapping job creation from construction and operations, building over time. NYSERDA estimates that 10,000 jobs will be created from 9,000 MW of offshore wind projects. This represents a magnitude similar to that expected in the Gulf of Maine.

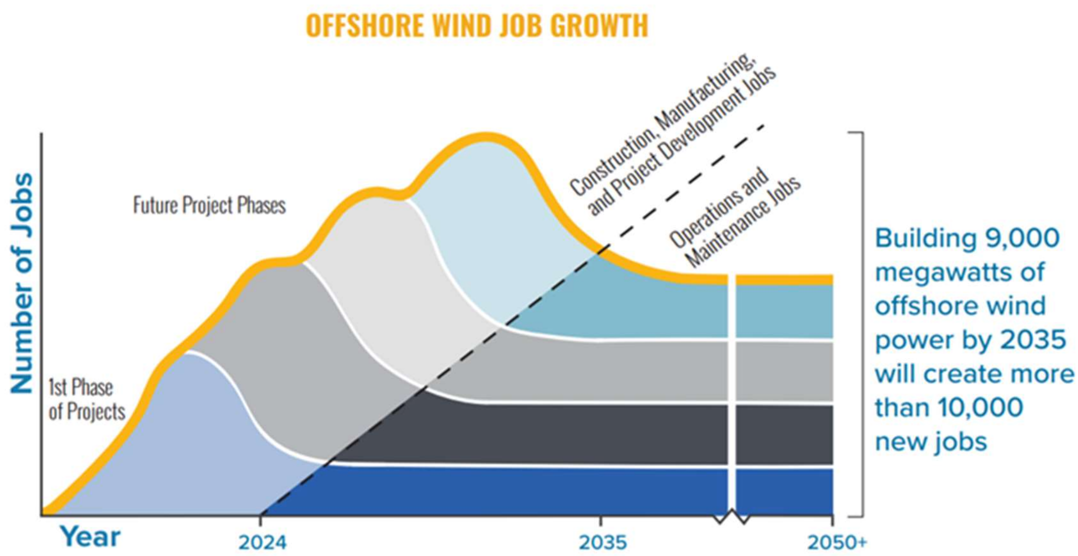


Figure 6-4. Forecasted Job Creation for an Example 9,000 MW of Development (Source: NYSERDA)

6.d London Economics Analysis

LEI was engaged by Pine Tree to evaluate the potential economic benefits of the Project for the State of Maine. LEI was also engaged to illustrate the economic impacts that could accrue to the state's benefit if 5,000 MW of the build-out of floating offshore wind in the Gulf of Maine were staged out of Maine, as a result of Maine taking leadership with the Research Array. Both scenarios were evaluated using the IMPLAN model (short for "impact analysis for planning"). The LEI report is included in its entirety as **Exhibit 4**.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Modeling on the 5,000 MW buildout involved cascading seven 500 to 750 MW projects (5,000 MW in total) commencing construction in 2033, five years after the Research Array commences operations (as depicted in Figure 6-5). The Research Array will have jumpstarted establishment of the supply chain and production facilities necessary to facilitate long-term realization of lower costs as the industry begins to mature.

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7
	Commercial operation year						
	2036	2037	2038	2039	2040	2041	2042
Annual capacity additions (MW)	750	750	750	750	750	750	500
Cumulative capacity (MW)	750	1,500	2,250	3,000	3,750	4,500	5,000

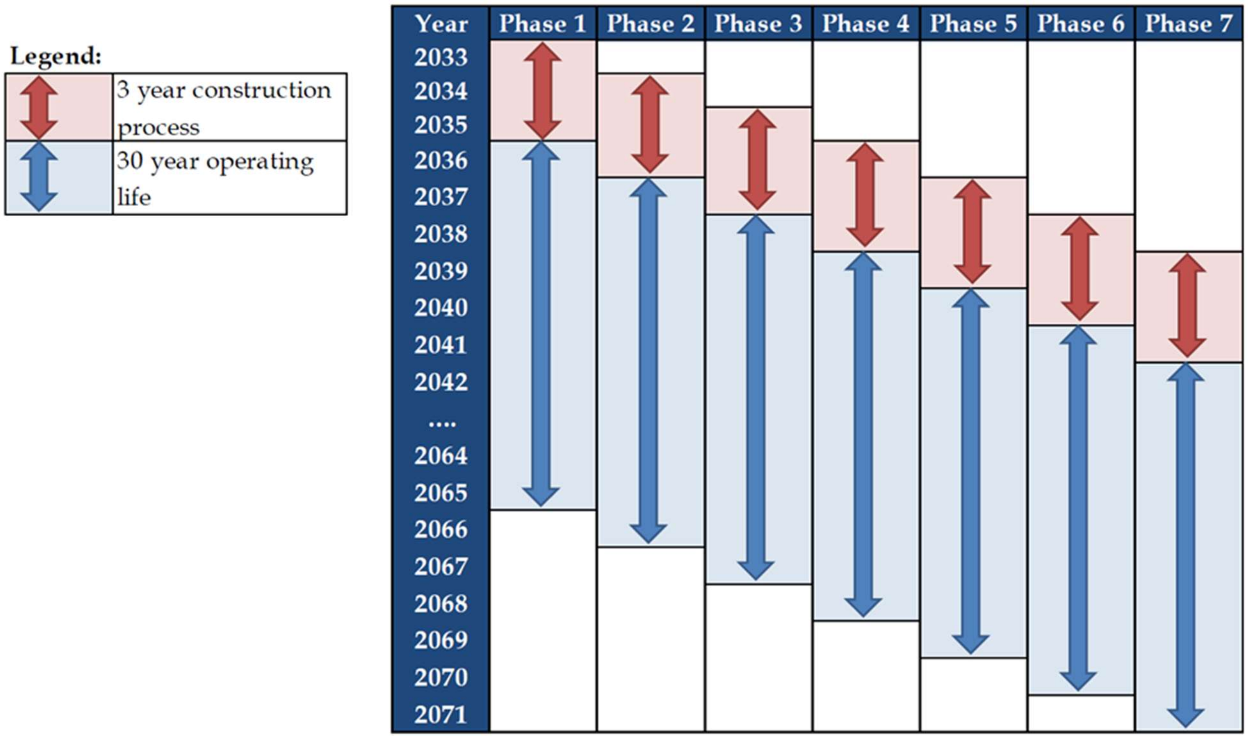


Figure 6-5. Construction and operations timeline for offshore wind build-out of Scenario 2 (Source: Exhibit 4)

6.e Dr. Richard Silkman Thesis & Ratepayer Impact

The attached report by Competitive Energy Services (**Exhibit 3**) details Dr. Silkman's thesis, specifically that, "Maine can't get to a decarbonized economy from where we are today – we can't, that is, unless we develop the wind resources of the Gulf of Maine." This report shows that while Maine must also continue to expand solar generation and unlock land-based wind by approving new transmission lines, these resources will be inadequate to achieve Maine's long-term goals.

6.e.i Maine Cannot Achieve Its Goals Without Offshore Wind

Dr. Silkman shows in Exhibit 3 that:

> "Of the new generation capacity that is currently "on the drawing board", so to speak, an additional 2 GW of solar capacity will generate roughly 3.5 million MWh; 1.2 GW of Aroostook wind an additional 3.5 million MWh. If we combine these with the roughly 3.5 million MWh generated each year by hydroelectric plants in Maine, the total falls short of Maine's **CURRENT** electric use, **BEFORE** we add 1 kWh of incremental use resulting from beneficial electrification."

And as noted in Section 2.b, *Maine needs to more than double, and possibly triple, its existing electric production capacity*. While pursuing the addition of solar and land-based wind production is essential, as shown in Dr. Silkman's report, and summarized in Section 2.d, offshore wind will prove more cost effective in achieving Maine's goal because its power production profile (particularly effective in winter months) better suits Maine's emerging power needs in a zero-carbon economy by avoiding extensive hydrogen or battery storage that at present cannot provide the necessary seasonal storage. Pursuing only solar and land-based wind over the next decade, without offshore wind, will squander an opportunity to prudently develop "...Maine's largest and most important energy resource – the Gulf of Maine."

Dr. Silkman summarizes:

> "The NEAV proposal starts Maine down this path so that by 2035 we will have proven the technology, understood its impact on the resource, improved and expanded assembly, installation, and operations of floating offshore wind turbines in Maine, contributed to driving down the LCOE (long-run cost of energy) for future floating offshore wind, and positioned Maine to maximize the economic benefits attendant to this new industry. It would be shortsighted and most unfortunate to miss this opportunity."

[redacted]

7.0 OFFSHORE WIND COSTS AND PROPOSED PRICING FOR THE PROJECT

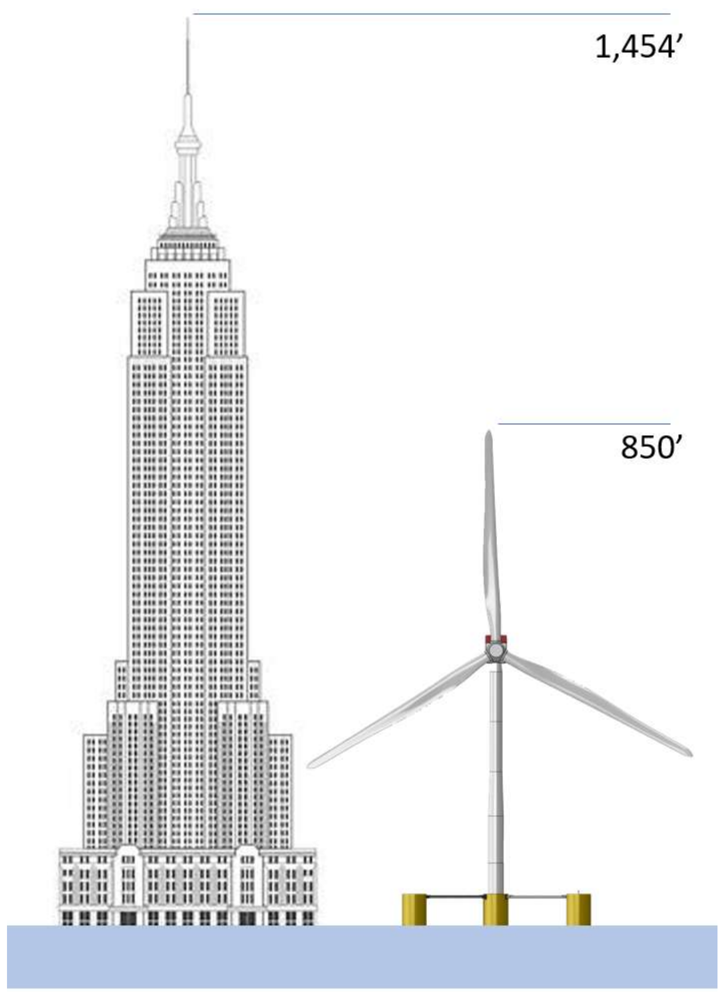
Building the United States' first floating offshore wind farm is a complex proposition. The Project will be forging a new path in that there are no established methods, procedures, and precedent—no previously built ports for construction, much less experienced contractors and marine service providers to draw upon. However, as discussed in prior sections, it is precisely this set of circumstances that creates the opportunity for Maine to prove it here first and establish the capability of ports, contractors, and workforce so that successive projects can follow the path laid down by this Project here in Maine. The challenge accepted by Pine Tree is pricing energy output sufficient to finance construction of the nation's first floating wind farm, to ensure that the purpose of the Project is fulfilled, establishing Maine as the economic hub, creating jobs, and setting best practices regarding co-existence with fisheries and other viable stakeholders. Pine Tree has had a global team working on foundation design, construction methods, port design, interconnection, contracting, and costing for over a year.

7.a Magnitude of Project and its Construction

The magnitude of the Project is formidable: the construction costs will be more than $1 billion; the Project will include more than 75 miles of subsea electric cable, and it will create thousands of jobs. It will take three or more years to plan, engineer, and permit and another three years to build, eventually coming online near the end of the decade.

To provide some perspective on what is being built, Figure 7-1 depicts one of the 10 planned floating wind turbine assemblies relative to the Empire State Building.

Figure 7-1. Relative height comparison of the UMaine VolturnUS floating turbine to the Empire State Building



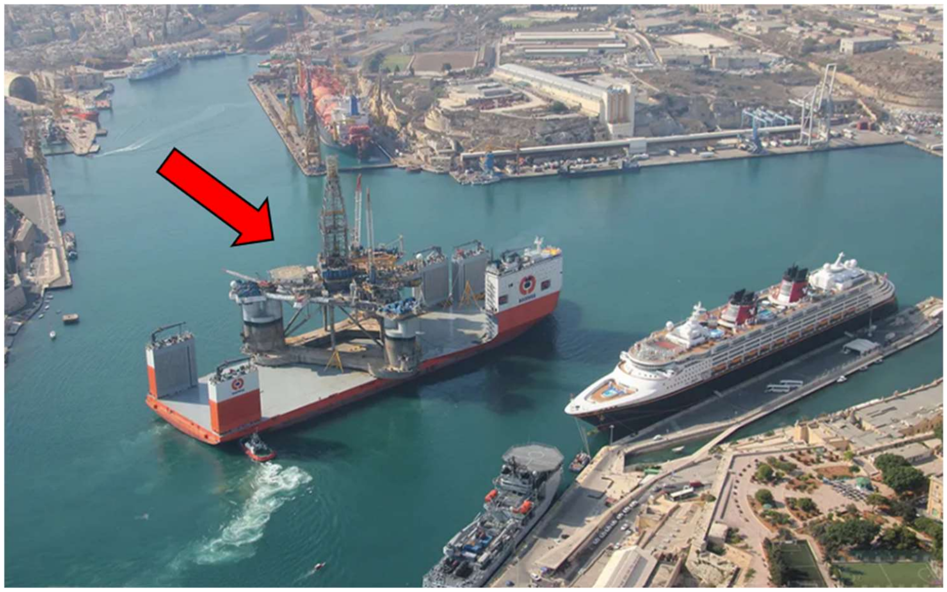


Figure 7-2. Floating Oil and Gas rig foundation approx. 20% smaller than the UMaine VolturnUS foundation design

Similarly, Figure 7-2 depicts a single floating rig built for the Oil & Gas Industry with a floating foundation that is about 20 percent *smaller* than the planned UMaine foundation. While there are many fabricators that are competent at building one such floating rig at a time, the undertaking here is to build the foundations in serial production using a custom-designed process that initiates a path to cost effectiveness. Near the end of the production of these initial units, the planned Maine-based fabricator will only begin to experience economies of scale. It is this learning curve that paves the way for future larger projects to achieve true economies of scale and lower energy prices.

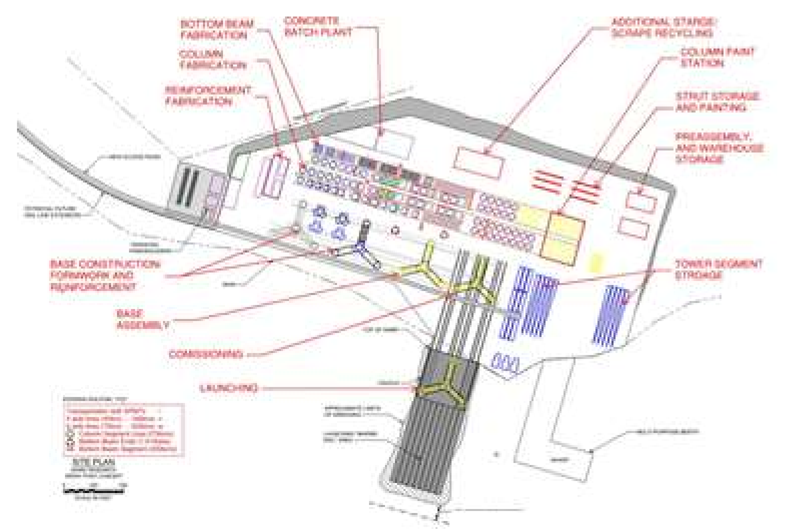
[redacted]

In early 2021, in preparation for this submission and assisting the State in its BOEM lease application, Pine Tree sought to define a project that would achieve the State's goals, understanding that an array of nine, and possibly as large as 16, turbines would be required to truly mimic the effects of a commercial-scale array. Gradually, through many permutations based on feedback from a full spectrum of stakeholders, location, size, point of interconnection, and number of turbines were determined.

Pine Tree then commenced a process to estimate the cost of construction based on location, two potential points of interconnection, and turbine selected. The decision was made to proceed with an [redacted]. To date, Pine Tree has consulted with dozens of external subject matter experts (SMEs) on essentially all aspects of the Project, including foundation design and fabrication, port design, launch mechanism and sequence, moorings, anchors, insurance, and finance.

The costing process first required refining the design of the foundation and mooring system with UMaine and a cadre of related SMEs to scale up from the 11 MW turbine being used in the NEAV project to the [redacted] turbine planned for the Research Array. Then the Pine Tree team, assisted by a separate team of SMEs, commenced design of a fabrication assembly line and conceptual design of a port layout using multiple locations. Examples of the port layout and assembly process appear in Figure 7-4. Given the scope of this Petition, this is but an example of the depth of the analysis and design options that were reviewed. Should the Commission desire a full briefing on the planned port and assembly process, Pine Tree would be pleased to conduct it.

Figure 7-4. Example of Fabrication & Launch Schematic



Three other major work packages were addressed to arrive at a capital cost: (1) erecting turbines on the foundations (near shore), (2) cable supply and installation (including specialty "dynamic" cable),[20] and (3) marine works, which include towing foundations (without turbines) away from the fabrication area for wet storage, towing the foundation back to a location that would allow for turbine erection, and finally towing the foundation and turbine assembly out to sea and setting the anchors and mooring lines. Lastly, Pine Tree contacted local and international contractors and service providers to provide costs for these scopes of work. This last point is important in the pricing of power given that capital cost is the predominant driver of the PPA price. It is extremely difficult to estimate the cost of construction with precision for a Project that will not be built for five or six years, especially in an emerging market with few domestic installation service providers. This is further compounded by volatility in commodities markets (the Project requires thousands of tons of concrete, steel and copper), and international service providers scrambling to set up shop in the United States to address the many fixed-bottom foundation projects already awarded. It is expected that costs to build the

20 Dynamic cable is the cable hanging in the water column nearest the turbine, subject to continuous movement of waves and currents. It is differentiated from "normal" subsea cable which is quite static.

Project will eventually benefit from this migration of experienced contractors and vessel infrastructure to the U.S.

Figure 7-5. Scale of wind turbine components (11 MW nacelle shown here, 14 MW nacelles planned) (Source: Siemens Gamesa)

One further example of the magnitude of the construction (illustrative of the costing effort), is the crane needed to erect the turbines – capable of lifting the 800+ ton nacelles (Figure 7-5) approximately 500 feet in the air. The crane itself comes in 250 individual containers and must be erected on site over a period of months. An example of the type of crane required for turbine delivery and erection appears in Figure 7-6. It is an order of magnitude larger than the cranes necessary to handle the turbines for onshore projects that are typically delivered to Searsport.

Figure 7-6. Example of the type of crane required at Searsport to accommodate turbine erection atop the floating foundations

Offshore wind projects have more in common with big infrastructure projects than they do with onshore wind and solar. Elements of the Project have durations far beyond the PPA life. Most of the electrical infrastructure can last 40-50 years. The foundations will likely last more than 25 years, especially because the embedded safety factors in this first-of-a-kind project are generally overbuilt. Offshore wind turbines are now routinely found to outlast their planned 25-30-year life spans. The Vindeby Offshore Wind Farm in Denmark (the first offshore wind farm in the world) was erected in 1991 and decommissioned in 2017, yielding a 25-year turbine operational life[21]. Altogether, this is important because it means that the Project will likely produce power far beyond the term of the PPA. And, when repowered, the capital cost will be far less (per MW) than the initial construction, allowing power to be sold at a much lower cost.

[21] https://orsted.com/en/media/newsroom/news/2017/09/the-worlds-first-offshore-wind-farm-is-retiring

Offshore wind projects also take a long time to realize. A smaller project (Southfork wind @ 135 MW) that just started construction was awarded a lease in 2013 and will complete construction in 2023, taking 10 years from lease award to generation. Maine needs to initiate offshore wind now to be able to deliver power prudently at scale in the mid-2030s, and the Research Array is an essential building block.

The next section explains the resultant budgeted capital cost. It is anticipated that it will take three to four years and more than [redacted] in development costs to finalize the capital cost. This finalization in fact, relies on such things as a final port design, designation of point of interconnection, ISO-NE studies and allocations, extensive physical investigations of the site and cable route, environmental studies, and finalization of every package described above.

7.b Capital Cost and Comparables in the Global Market

[redacted]

- [redacted]

[redacted]

[redacted]

[redacted]

At the urging of public officials, the Research Array was intentionally sited far from shore where it would least interfere with lobster fishing (approximately 52 miles from downtown Portland and more than 45 miles from any potential point of grid interconnection). While this location accommodates the fishing industry and serves as an example for future leases, it does impact the Project by introducing electric losses and increasing

[redacted]

costs. Figures 7-8 and 7-9 below, depict the Research Array as an outlier relative to the capacity and export cable length of other offshore wind projects worldwide.

As seen in Figure 7-8, the Research Array is:

- Farther from shore than 90 percent of European offshore wind projects.
- Farther from shore than any European project under 300 MW.

[redacted]

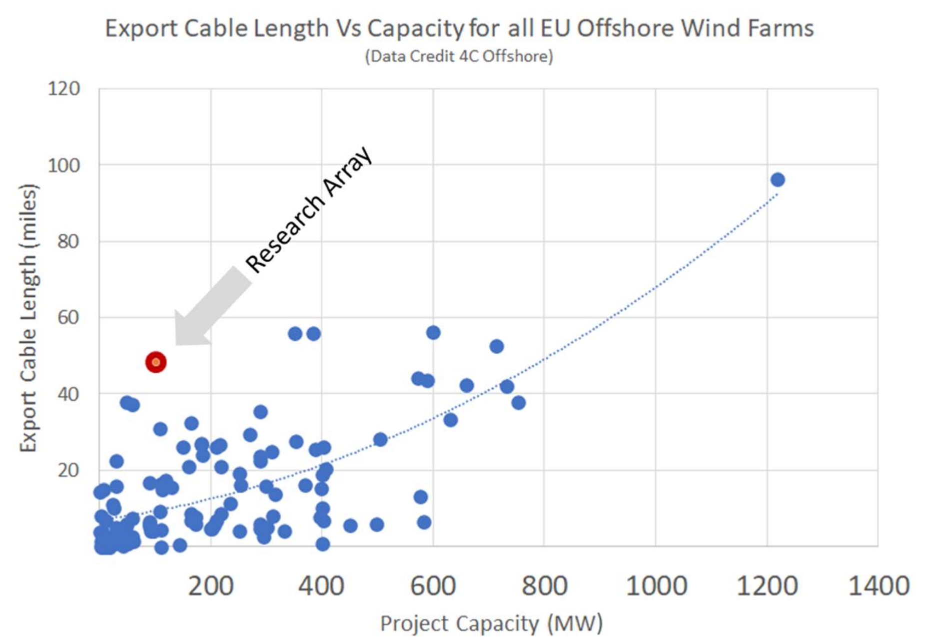


Figure 7-8. Export Cable Length relative to Capacity (Source: Pine Tree)

[redacted]

[redacted]

7.c Capital Cost Variability

Costs associated with permitting, building, and operating the Project are based on the Project consisting of 10 wind turbines being built at the planned site, utilizing a port in Maine and within the boundaries of a Research Lease obtained by the State of Maine. In addition to the first-of-its-kind budgetary estimation challenges and cost variability that a developer is normally expected to absorb, there are a variety of unique factors associated with this Project that introduce costing variability, some of which are beyond Pine Tree's control, such as:

- **State & Stakeholder Collaboration**. This Project is to some extent a public/private partnership in that certain elements are subjected to public discussion. These include the eventual point of interconnection and (generally speaking) certain aspects of the Project design such as the turbine layout, mooring, and anchoring design (to accommodate co-existence with fisheries and help set the standard for future projects). By participating in this process, the developer may consent to what would otherwise be considered non-optimal arrangements. For example, it is possible that six anchor lines (rather than three) with a less expansive spread are optimal from a fishing impact perspective. It may be that the point of interconnection preferred by communities or environmental groups is Wiscasset vs. Wyman (or vice versa). Cable burial, to satisfy fishermen, and set a precedent, may be targeted deeper than industry standards. There are many other variables like this that cannot be finalized until extensive stakeholder engagement occurs over a period of two to three years.
- **Grid Upgrade Costs**. [redacted]
- **Port Construction and Outfitting**. MDOT has embarked on a port development plan with a goal of building the first port specifically designed to accommodate *floating* offshore wind. Pine Tree and MDOT engineers collaborated on port design for most of the last year. Port development is one of the lynchpins of the Project and an important step in bringing jobs to Maine. The goal is to have most of the port construction funded by the federal government and the Research Array is essential to MDOT's quest for federal dollars. Pine Tree will be the anchor tenant, essentially justifying the port development. Approval of the Research Array demonstrates the need for a floating offshore wind port and makes the case for federal funding as important infrastructure necessary to achieve Maine's and the nation's climate goals. As part of the Project, Pine Tree has committed [redacted] in co-funding of the port, in addition to another [redacted] in engineering and design assistance. The pricing presented below assumes that the port will be built by MDOT as fit-for-use to construct the Project. The Research Array heavily relies on the port readiness date—any

delay in port construction could delay Project construction, exposing Pine Tree to cost increases.

- **Commodity Price Volatility**. It is equally important to understand that pricing for the Project has been arrived at during a period of commodity price turmoil, supply chain interruptions, and explosive growth of offshore wind in the United States. It is possible that by the time the Project is built, the domestic offshore wind industry matures (the floating industry shares turbines, cable, and many service providers with fixed-bottom projects), commodity prices revert to average, and growth of the offshore wind business is accommodated by supply chains that have moved to the United States. Many of these are factors which could drive costs down.
- **Department of Energy Funding**. Many federal agencies also consider it vitally important to harvest the wind power available in the Gulf of Maine. Both BOEM and the DOE consider it important to achieve our energy needs. Agencies like NOAA consider it important to conduct research to ensure offshore wind can be developed prudently[23]. It is therefore expected that there will be some form of federal funding available that will reduce costs.

7.d Pricing Philosophy

Pine Tree is committed to deliver energy from the Project at the lowest reasonable cost, and therefore, proposes a pricing mechanism that reconciles the level of uncertainty arising from the nascent nature of the industry with the State's desire to keep energy costs down.

[redacted]

[redacted]

[redacted]

[redacted]

[23] https://www.boem.gov/renewable-energy/state-activities/gulf-maine

[redacted]

7.e Contract Price Mechanics

[redacted]

7.f Price Comparable

[redacted]

[redacted]

8.0 THE POWER PURCHASE AGREEMENT (PPA)

A draft Research Array PPA, based on the NEAV PPA approved by the Commission, is attached as **Exhibit 5**.

The key commercial terms of the PPA are as follows:

[redacted]

EXHIBIT 1

PINE TREE OFFSHORE WIND DEVELOPMENT TEAM

EXHIBIT 2

BOEM APPLICATION

EXHIBIT 3

COMPETITIVE ENERGY SERVICES (SILKMAN) REPORT - "AN ASSESSMENT OF THE NEW ENGLAND AQUA VENTUS RESEARCH ARRAY PROPOSAL AND COMMERCIAL-SCALE FLOATING OFFSHORE WIND TURBINE ASSEMBLY AND INSTALLATION PORT FACILITIES AT SEARSPORT AND SEARS ISLAND"

EXHIBIT 4

LONDON ECONOMICS INTERNATIONAL REPORT - "ECONOMIC BENEFITS TO MAINE OF PINE TREE OFFSHORE WIND RESEARCH ARRAY AND COMMERCIAL OFFSHORE WIND BUILD-OUT"

EXHIBIT 5

DRAFT PPA