U.S. OFFSHORE WIND CURRENT PROGRESS AND COST DRIVERS

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To: Clients and Colleagues

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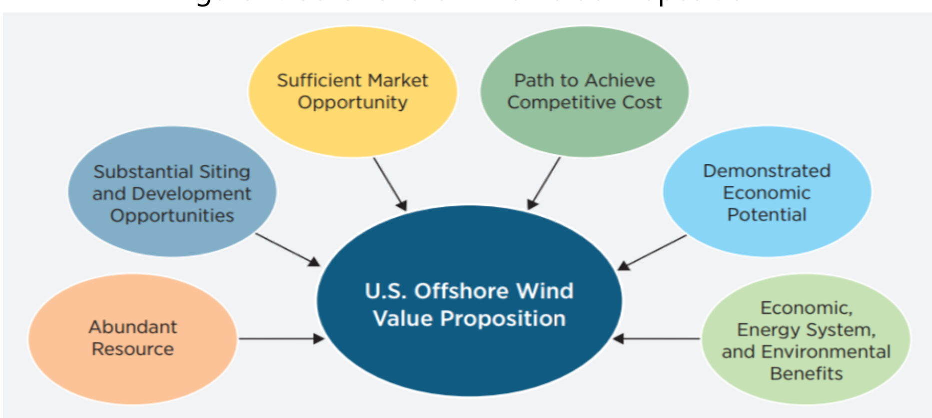
Though the offshore wind (OSW) industry in the United States has lagged behind Europe, given the commitment by policymakers to support the development of the industry and allow the realization of economies achieved in Europe, future prospects for the industry appear bright. The purpose of this report is to summarize the short history of offshore wind in the United States, outline the current state of the industry, and then consider the cost drivers that will shape the industry in the future.

Figure 1: US Offshore Wind Value Proposition[1]



INDUSTRY HISTORY

One of the groundbreaking, albeit controversial landmarks in the U.S. offshore wind industry was the Cape Wind Project. Cape Wind submitted an application in 2001 to the US Army Corps of Engineers (USACE) to construct a met tower. Though the USACE gave Cape Wind permission to build a met tower, the *Energy Policy Act of 2005* shifted Federal authority to the Department of the Interior, which slowed the project's progress. For the next decade, Cape Wind faced numerous obstacles, including determinations that the planned site in the Nantucket Sound qualified as traditional cultural, historic and archaeological property. Cape Wind's power purchase agreements provided a price of $187/MWh, escalating at 3.5% per annum for 15 years. In January 2015, National Grid and Northeast Utilities notified Cape Wind that they were terminating their power purchase agreements (PPAs) given the project hadn't

[1] US Department of Energy and Department of the Interior, National Offshore Wind Strategy, 2016

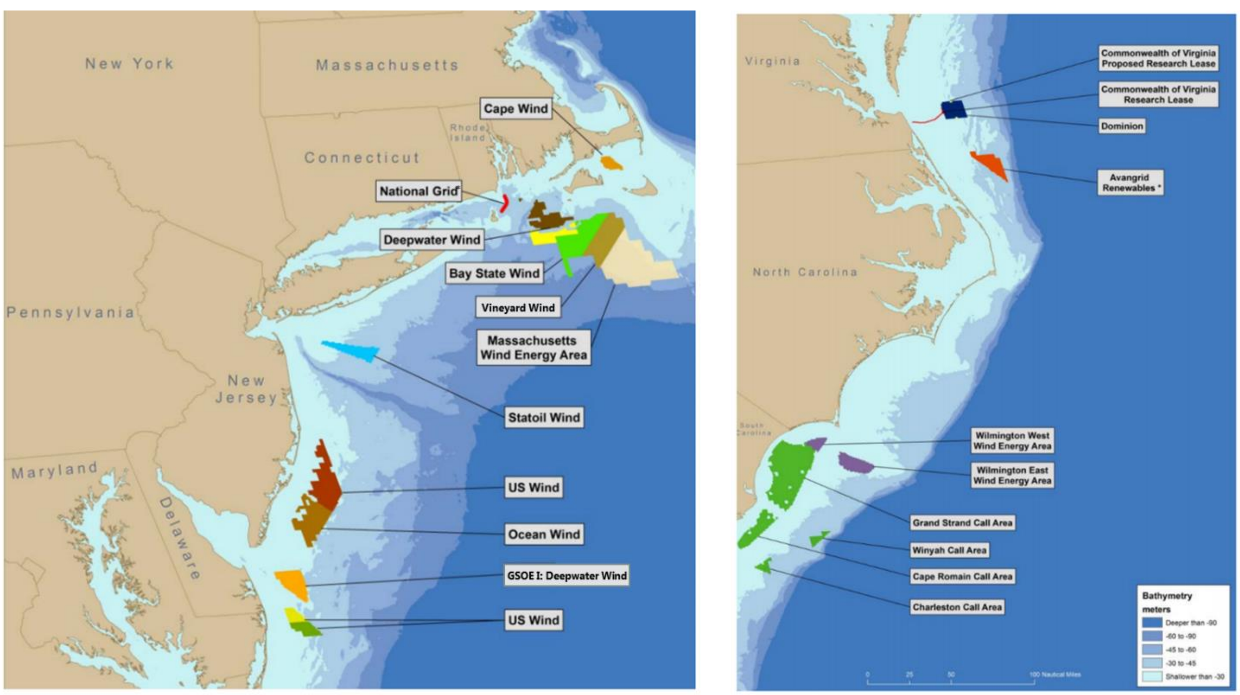
achieved its financing and construction initiation milestones in the PPAs. Cape Wind was planned to total 468 MW, with these two PPAs covering about 75% of its capacity.

Avoiding many of the regulatory hurdles of its predecessor, but requiring legislative changes to the regulatory standard for approval of its PPA, Block Island Wind Farm (BIWF) began construction in 2015, and became the US's first operational offshore wind farm in December 2016. It is located 3 miles off of Block Island, in Rhode Island state waters. The project includes 5 turbines, capable of producing 30 MW. BIWF signed a 20-year PPA with National Grid for its full output, set at $244/MWh for the first year of commercial operation with an annual escalation of 3.5 %. One factor contributing to the project's support is that it connects Block Island to the New England grid, allowing it to avoid high cost diesel generation that the island otherwise relied upon.

CURRENT DEVELOPMENTS

Leases for OSW have been issued in Massachusetts, Delaware, Maryland, Virginia, New Jersey, North Carolina, and New York by the Bureau of Ocean Energy Management (BOEM).[2]These states are leaders in promoting the development of an OSW industry, with the greatest activity in Massachusetts, New York, and Maryland. Activities in each are reviewed below.

Figure 2: US Atlantic Offshore Wind Projects and Lease Areas[3]



*National Grid area represents electric cable from Block Island Wind Farm

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2 Norton Rose Fulbright, US Offshore Wind, 2017

3 BOEM 2016

The Massachusetts investor-owned electric distribution companies issued a Request for Proposals (RFP), seeking long-term contracts for 400 MW and up to 800 MW of OSW generation. Proposals are due December 20, 2017. This RFP is open to the three-existing wind energy area leaseholders: Deepwater Wind; Bay State Wind LLC (Dong Energy and Eversource); and, Vineyard Wind (Copenhagen Infrastructure Partners and Avangrid Renewables). This will be the first procurement in response to the state's legislated goal to reach 1,600 MW of OSW development by 2027.

Because more than one party expressed interest in securing leases for the two remaining Massachusetts lease areas within the Massachusetts Wind Energy Area (WEAs), BOEM will hold a lease sale auction in late 2017 or early 2018. BOEM has yet to announce the specific auction date. These lease areas are adjacent to those that are expected to bid in the first Massachusetts RFP, though they are further from shore and have the greatest average water depths. The two lease areas to be auctioned are 248,015 acres and 140,554 acres, which can support a maximum of approximately 4,717 MW of OSW generation. Winners of these leases will be eligible to bid into the second auction for long term contracts in Massachusetts.

In New York, Deepwater was recently awarded a contract from the Long Island Power Authority (LIPA) to construct South Fork Wind Farm, providing Long Island with 90 MW of OSW at an undisclosed price. Construction off Rhode Island is scheduled to start in 2019 and the project to be operational in 2022. This is the first step towards fulfilling LIPA's goal of procuring 280 MW of renewable energy, in response to New York's Reforming the Energy Vision initiative

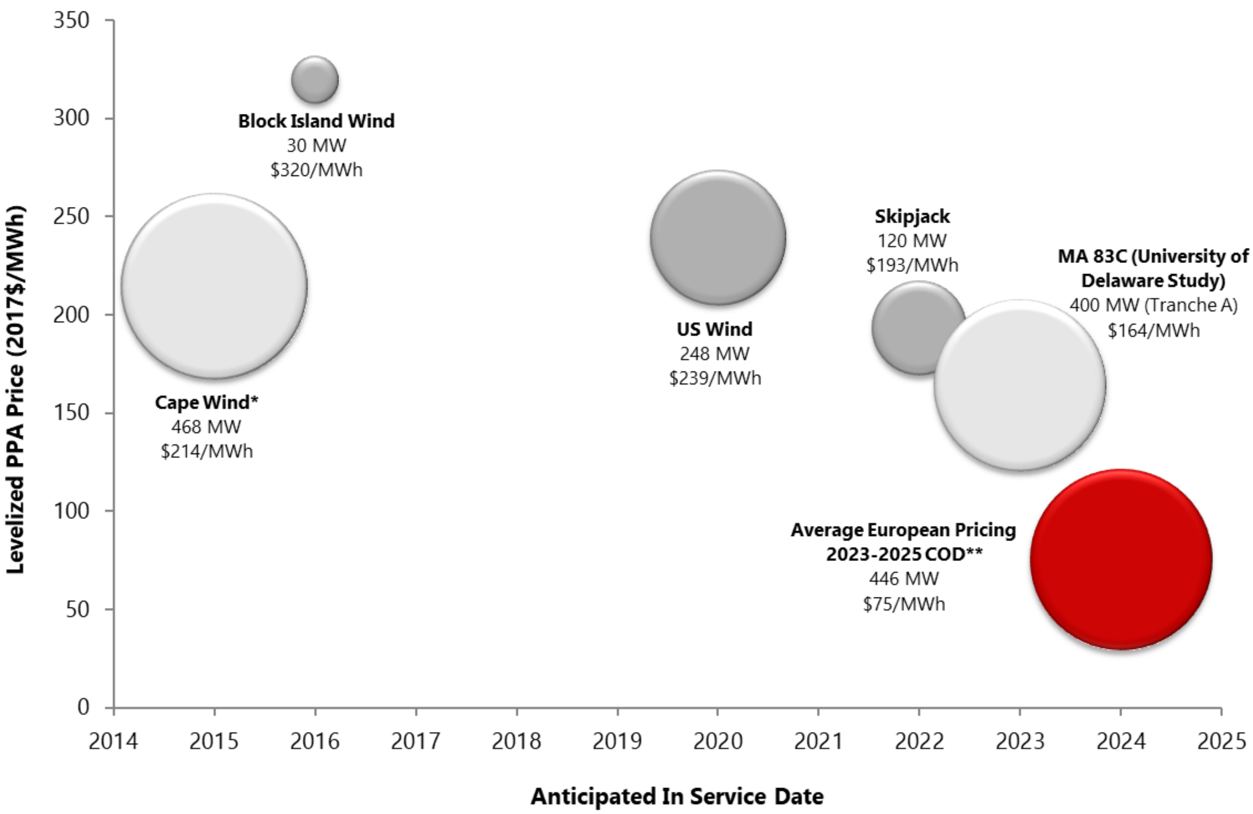
In December 2016, BOEM awarded Statoil an OSW lease for $42,469,725 for 79,350 acres south of Long Island, NY. NYSERDA proposes to purchase the OSW energy on behalf of the three major New York utilities. Later in December 2016, PNE Wind USA submitted an unsolicited request for another lease south of Long Island for 41,000 acres. There will certainly be additional interest in this site which would necessitate another competitive auction by BOEM. In addition, a BOEM - New York Task Force is exploring additional potential OSW lease areas for BOEM to auction to help meet the New York Governor's target of 2000 MW of offshore wind by 2030. Additional companies will have an opportunity to demonstrate to BOEM that they are legally, technically and financially qualified to bid for all these leases.

BOEM has also issued two leases off New Jersey, whose legislature has authorized the sale of 1100 MW of OSW to be purchased by the state's electric distribution companies through Offshore Renewable Energy Credits (ORECs). The NJ Board of Public Utilities has been developing the rules for these Ocean Renewable Energy Credits for several years.

Off the coast of Maryland and Delaware, two projects have recently been awarded ORECs in response to the state's 2013 RFP for offshore wind. US Wind LLC has outlined a proposed 62 turbine, 248 MW wind farm, to be connected to the Indian River Substation in Delaware and operational in 2020. Skipjack Offshore Wind, a subsidiary of Deepwater Wind, has proposed a 15 turbine, 120 MW wind farm to be connected to the Ocean City, Maryland substation and operational in 2022. Maryland has issued unbundled ORECs to US Wind LLC and Deepwater Wind Skipjack. US Wind bid a first year OREC price of $201.57/MWh or a levelized price of $177.64/MWh (2012$) and Skipjack an OREC price of $166.0/MWh or a levelized price of $134.36/MWh (2012$). A 1% price escalator will be applied to these first-year prices for the next 20 years of each project's operation.[4] In addition to the revenues from these ORECs, the projects will realize production tax credits and energy and capacity market revenues. These energy and capacity market revenues are likely to represent a value of about $50/MWh.

Figure 3 summarizes US OSW PPA pricing to date by project vintage. Recent European PPA prices are also reported for reference.

Figure 3: US Offshore Wind PPA Pricing[5]



* Cape Wind PPAs terminated do to a failure to achieve financing and construction milestones.

** Average adjusted strike price and average capacity for 2023-2025 projects in the Netherlands, Denmark and Germany from NREL 2017.

Already, there is some evidence of PPA price reductions in the US market. However, trends are masked by varying competitiveness of RFP processes; in particular, the Maryland process where it

[4] US Department of Energy: Offshore Wind Technologies Market Report, 2016

[5] Power Advisory analysis of various public orders and studies. Size of marker represents the relative nameplate capacity

appears that US Wind was able to capitalize on its position as the sole leaseholder in Maryland. Future reductions will be driven by the factors discussed in the next section.

COST-DRIVER ANALYSIS: 4 MAIN DRIVERS

1. Site Evaluation and Characterization

While potential sites for offshore wind in the US share some characteristics with those of the more mature European market, there are major differences. Sites in the US lack critical data about geological, oceanographic, and meteorological conditions, which increases the initial development risks of OSW projects, and therefore the costs to finance them. With the development of additional projects and collection and verification of data the uncertainty associated with these variables and the impacts on project costs and performance would fall.

2. Technological Advancement

Continuing research and development to produce larger, more cost-effective equipment (including wind turbine generators, which benefit from European experience, and foundations) will be necessary to further decrease costs. This applies to adapting and advancing existing technologies from Europe, developing new technologies, and creating new installation techniques.

Currently, 75% of the world's deployed offshore wind resources use monopile fixed-bottom structures, which may not be feasible for water depths of greater than 60 meters. As more than 58% of the US's technical resource capacity is located at water depths greater than 60 meters, many new projects will use lattice steel foundations installed at the Block Island Wind Farm and pioneered by the oil and gas industries and floating foundation technology anchored to the seabed with tension anchor chains. Floating foundation technology is just being constructed in Europe. Norwegian energy giant Statoil is scheduled to connect the first floating wind farm in late 2017 with their 30 MW Hywind farm[6], with 237 MW expected to be fully installed globally by 2020[7]. Currently, floating offshore wind accounts for 7% of the known global pipeline[8], making future developments in this area likely.

Higher capacity turbines offer significant reductions in OSW LCOEs. The Block Island Wind Farm utilized 6 MW WTGs, compared to current turbines produced in Europe that can produce upwards of 9 MW and 10 and 12 MW turbines in design. Capacity factors will also rise with larger rotor diameters and improved accessibility to turbines for maintenance, as this will decrease their downtime. Improved accessibility is an especially important consideration on the Pacific Coast, where ocean conditions are generally rougher than those on the Atlantic Coast.[9]

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[6] Statoil: Hywind Scotland

[7] Bloomberg: Race to Build Offshore Wind Farms That Float on Sea Gathers Pace, 2017

[8] NREL: Offshore Wind Energy Resource Assessment for the United States, 2016

[9] US Department of Energy and Department of the Interior, National Offshore Wind Strategy, 2016

Technological developments will enable the integration of turbine and substructures to create a single system that will enable design optimization that will drive further cost reductions. Installation cost would also fall as more specialized vessels suited for installation are deployed in the US. Such vessels currently exist in Europe, but are not available in the US due to limited market that hasn't justified the construction of such vessels. As turbines and rotors become larger, these vessels become more important.

As for operating expenses, cost reductions will occur with improvements in turbine reliability and monitoring technology that will allow operators to identify problems in real-time, keeping resources operating longer and at higher availabilities.

3. Supply Chain Development

Not surprisingly, there are significant gaps in the current US OSW supply chain that prevent the realization of cost savings being achieved in Europe. Currently, the US supply chain is not well inventoried, and lacks necessary workforce, port facilities, and vessels needed to support a robust and efficient industry.

Geographic concentration of the supply chain would further reduce OSW costs, as proximity decreases transportation costs and fosters better communication between supply chain members. This "clustering" strategy also allows for more robust project management and top-to-bottom collaboration on wind energy projects[10].

Almost all of the OSW components, including rotors and turbines, are currently manufactured in Europe. Specialized equipment for installing offshore wind turbines, like installation vessels, are also often only available from European firms, resulting in high costs. Desired investments in the supply chain that will realize these cost savings will occur, if there is a visible, stable development pipeline.

4. Market Visibility

Market visibility is a commitment to the steady procurement of a pipeline of OSW projects over a defined period of time. Greater market visibility would reduce costs for OSW for two main reasons. First, more entrants will be attracted to the market, increasing competition and lowering their bargaining power. Second, as projects get relatively less risky, investors with a lower hurdle rate may be drawn to invest when they had not previously. A visible pipeline of projects can reduce capital, maintenance, and insurance costs and is critical to ensuring that these costs are minimized. Construction of turbine manufacturing facilities on European coastlines have reduced the levelized cost of OSW below $100/MWh. The lack of certainty around the US PTC and how this frustrated the development of US onshore wind energy supply chain is a relevant warning. Per the 2015 extension of the PTC it is to be phased on it steps by 2020, so that the value in 2017 is 80% of the initial $0.023/kWh value, 60% in 2018

[10] Clean Energy Pipeline, Offshore Wind Project Cost Outlook, 2014

and 40% in 2019. Also, by generating repeated investments from equity investors with knowledge of the renewable energy sector, WACC could be lowered, reducing the cost of equity and debt.

CONCLUSION

Though the U.S. OSW market has taken longer to develop than its European counterpart, its future prospects are promising. The comparatively high OSW costs in the U.S. reflect the immaturity of the industry; however, by adopting best practices from Europe and committing long-term to OSW development, the U.S. can drive costs down significantly. Coupled with future technological innovation, the U.S. OSW industry is well-positioned to represent a cost-effective source of clean energy.

Power Advisory would welcome the opportunity to assist clients in assessing opportunities in the US offshore wind market, especially the upcoming BOEM Massachusetts and NY lease sale auctions, submission of comments on the 83C RFP, and participation in subsequent solicitations.