Environmental and Energy Study Institute

Fact Sheet

Offshore Wind: Can the United States Catch up with Europe?

January 2016

Wind energy power generation is on the rise around the world, due to its low fixed prices and lack of greenhouse gas emissions. A cumulative total of 369,553 megawatts (MW) of wind energy capacity was installed globally by the end of 2014.[1] Of that total, only two percent came from offshore wind farms, which are able to capture stronger and more reliable ocean winds to generate electricity.[2]

Most offshore wind capacity is in Europe, where there are 3,072 grid-connected offshore wind turbines at 82 farms spanning 11 countries, for a total of 10,393.6 MW of wind energy capacity as of June 30, 2015.[3] China, the leader in offshore wind in Asia, had 718.9 MW of installed capacity; Japan, 52 MW; and South Korea, 5 MW as of October 2015.[4, 5, 6]

In comparison, the United States is just beginning to invest in offshore wind energy, and is rapidly approaching the operational launch of its first commercial offshore wind farm. There is incredible potential for offshore wind development in the United States – the National Renewable Energy Laboratory (NREL) has estimated the United States has over 4,000 gigawatts (GW) of offshore wind potential, enough to power the country four times over.[7]

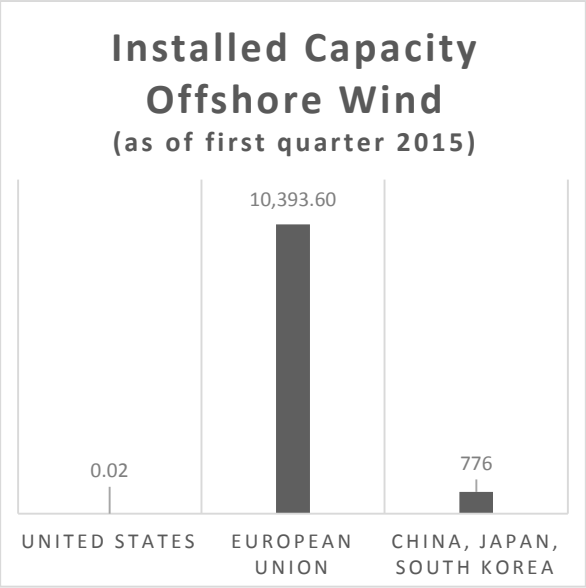

Figure 1: Megawatts of offshore wind in the world[8]

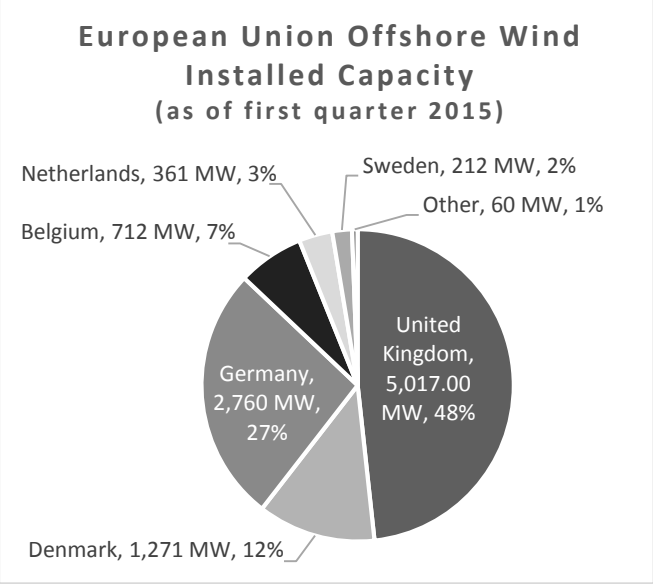

Figure 2: E.U. offshore wind installed capacity[9]

Efforts are underway to bring more offshore wind capacity to the United States. The first U.S. offshore wind farm is scheduled to come online in the fourth quarter of 2016 at Block Island, a small island 12 miles off the coast of Rhode Island. The Block Island project, run by Deepwater Wind, will be much smaller than European installations, with just five wind turbines generating 30 MW, enough to power 17,000 homes. The six-megawatt turbines will be some of the tallest in the world, rising 589 feet above sea level. They are being supplied by Alstom, a French company that

was recently acquired by General Electric.[10] The Block Island project will serve as a pilot for Deepwater Wind, which is planning a larger, 1,000+ MW capacity project in the area called Deepwater ONE.

These projects are just the beginning for the U.S. offshore wind industry, with the federal government predicting the United States will have 22,000 megawatts of offshore wind capacity by 2030.[11] However, it remains to be seen if the United States can duplicate the European Union's broad success with offshore wind production.

Why Offshore Wind?

Offshore wind has several benefits compared to onshore wind. Suitable locations for onshore wind installations are limited by available land, wind speed, transmission access and distance, and wind turbulence. Offshore wind is often a better energy source in relation to these factors. In addition, offshore wind can sidestep complaints some communities have about nearby wind turbines – namely, that they are noisy and unsightly. In 2014, the average distance of offshore wind farms was 32.9 km (about 20.5 miles) from the coast, which minimizes their visibility from land and eliminates noise pollution.[12]

The best onshore wind resources in the United States are located in the Great Plains region, where relatively few people live. In contrast, some of the best offshore wind resources are along the East Coast, where many Americans live. Globally, almost half the world's population lives on coasts, and 40 percent of the U.S. population resides in a coastal county.[13, 14] Offshore wind facilities can, therefore, be installed close to large coastal population centers, reducing the need to install long transmission lines and avoiding increased congestion on existing lines. Installing offshore wind prevents electricity from having to be transmitted great distances to reach local demand.[15]

Offshore wind is also stronger, more consistent, and more abundant than onshore wind.[16] This has an outsized effect on electricity production, since the potential energy produced from a wind turbine is equal to the cube of wind speed. Winds just a few miles per hour faster produce significantly more electricity; for example, a turbine operating in winds at 16 mph will produce 50 percent more electricity than the same turbine operating in 14 mph winds.[17]

Siemens Analytical Tool Demonstrates Offshore Wind's Competitiveness

Accurately comparing the cost of different types of power generation is more complex than just comparing electricity sale prices. Conventionally, such a comparison is carried out with a ratio called the Levelized Cost of Electricity (LCoE). LCoE divides the total cost of a power station over its expected lifetime (in terms of operating costs and investment) by the electricity it produces over the same period, and comes up with a standard measure to compare different energy sources (coal power versus solar, for example). As an alternative to LCoE, Siemens developed the Social Cost of Electricity (SCoE). Siemens's SCoE takes into consideration a wider array of factors, including employment effects, transmission costs, environmental impacts, and more. Using this tool, Siemens has shown the cost of offshore wind energy is only about half its estimated LCoE cost.[18]

In addition to being stronger and more abundant than onshore wind, offshore wind also better corresponds to peak electricity demand (especially along the East Coast of the United States). Offshore winds along the East Coast are fastest in the afternoon and evening, when electricity demand is high, unlike onshore winds which blow the hardest at night. In addition, at times when hot weather pushes electricity demand higher than usual, the differential between land and sea temperatures causes sea winds to pick up, in what is known as the "sea breeze effect." This can put more offshore wind power on the grid when it is needed.[19]

Offshore wind turbines are also generally much larger than onshore turbines. This is due in part to constraints on shipping large turbine parts over relatively small roads and bridges on land. Offshore wind turbine parts are not limited this way, since they are generally shipped on barges. The European Wind Energy Association (EWEA) reports that the average onshore wind turbine is between 2.5-3 MW, with the ability to power 1,500 average E.U. households, whereas offshore, the average wind turbine is 3.6 MW, enough to power more than 3,300 E.U. households.[20] In May 2015, an 8.0 MW offshore wind turbine prototype manufactured by Vestas broke world records by generating 192,000 kWh in 24 hours. When this turbine is installed at sea, it will produce enough electricity to power about 7,500 European households.[21]

United States Offshore Wind Development

The United States has offshore wind energy potential on all of its coasts: in the Great Lakes, off its East, West and Gulf coasts, and off Hawaii and Alaska. Hawaii has the highest single potential for offshore wind, accounting for about 17 percent of the U.S. total. While wind speeds are slowest along the Gulf Coast and the mid-Atlantic Coast, those areas have relatively shallow waters that make them attractive for offshore wind using currently proven wind turbine technology, which cannot be deployed at great depths. However, even in the shallower Atlantic Outer Continental Shelf, 90 percent of the region's estimated 1,000 GW of potential offshore wind energy is in waters too deep to be exploited using current technologies.[22]

In early 2015, the U.S. Department of Energy (DOE) released a report, *Wind Vision: A New Era for Wind Power in the United States*. DOE predicted in *Wind Vision* that the United States would have three gigawatts of offshore wind by 2020, 22 GW by 2030, and 86 GW by 2050, meeting two percent of U.S. electricity demand in 2030 and seven percent in 2050. At these levels, the United States would be using 5.5 percent of its available offshore wind resources. *Wind Vision* also predicted offshore wind development would take place along both the East and West Coasts, in the Great Lakes, and in the Gulf of Mexico by 2050.[23]

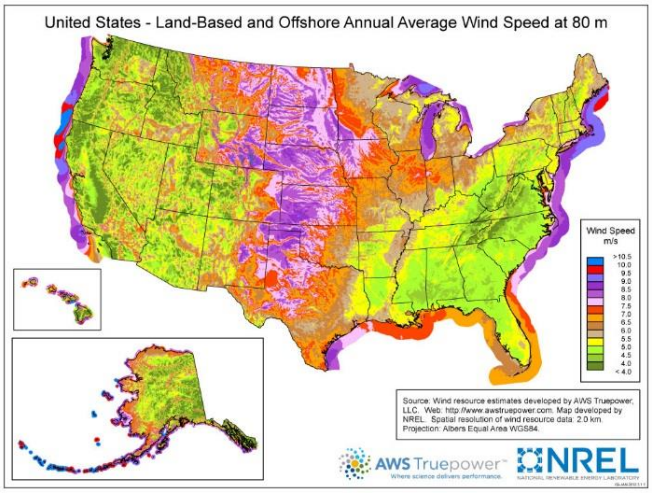

Figure 3: land and offshore average wind speeds

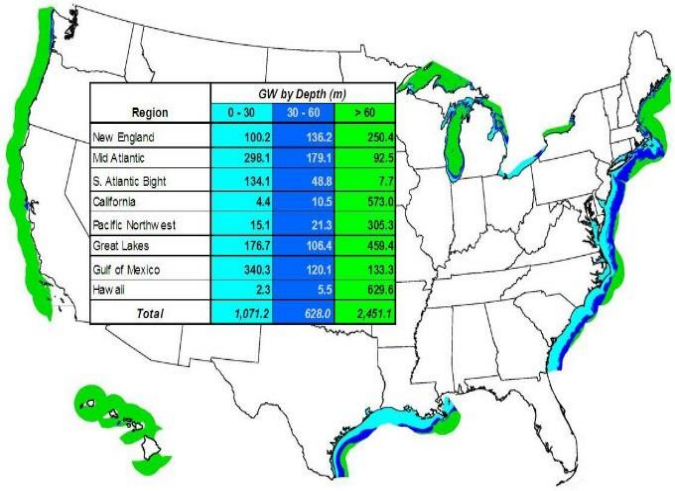

Figure 4: average depth offshore.[24]

For a complete list of the current offshore wind projects in advanced stages of development in the United States, see Appendix 1.

White House Offshore Wind Initiatives

On September 28, 2015, the White House held a summit on offshore wind, which convened industry, federal and state leaders to discuss the budding U.S. offshore wind sector. At the summit, the White House announced the establishment of an Interagency Working Group on Offshore Wind, which will enhance cooperation among all the federal agencies working on offshore wind. The Department of Energy (DOE) also announced a new multi-state project to create a roadmap for offshore wind in the Northeast, particularly in New York, Maine, Massachusetts and Rhode Island. The roadmap is intended to help create a regional supply chain for offshore wind projects, and coordinate state development plans.

In addition, the Department of Interior's (DOI) Bureau of Ocean Energy Management (BOEM) has been coordinating with offshore wind regulators in Germany, Denmark and the United Kingdom to create an International Offshore Wind Regulators Forum. The Forum will be a venue to share knowledge, regulatory approaches and environmental information as the offshore wind industry expands globally.

DOE and DOI have also given notice that they are working to update the jointly produced National Offshore Wind Strategy, last published in 2011. The new report, expected in 2016, will discuss the state of the industry, including technology, electricity demand and resource potential, and will include a five-year development plan.[25]

Offshore Wind Leasing

The Bureau of Ocean Energy Management's (BOEM) Office of Renewable Energy Programs (OREP) is responsible for managing offshore renewable energy, including offshore wind. BOEM handles the leasing of offshore sites for wind farms, as well as easements and right-of-ways for electricity transmission lines. A lease from BOEM does not entitle a project to begin construction; instead, it gives a lease-holder the right to seek BOEM's approval to develop an area.

As of November 2015, BOEM had issued 11 commercial offshore wind energy leases, off Massachusetts, Rhode Island, New York, New Jersey, Delaware, Maryland, Virginia and North Carolina. BOEM is also in the early planning stages of leasing areas off Hawaii, Oregon, New York, North Carolina and South Carolina.[26, 27] In January 2015, an Oceana report found that BOEM's leasing for offshore wind projects has surpassed its leasing for offshore drilling.[28]

Department of Energy (DOE) Support

The U.S. Department of Energy (DOE) has been actively supporting offshore wind research and development. From 2006 to 2015, DOE supplied more than $301 million in funding for 72 offshore wind projects.[29] The majority of DOE's funding (54 percent) has supported advanced technology demonstrations, with another 39 percent going toward technology development activities and seven percent for market acceleration and deployment.[30]

In 2012, DOE offered grants of $4 million to seven offshore wind advanced technology demonstration projects, to assist them in completing the first phase of their projects. In 2014, DOE selected three of the seven grantees for a potential $46.7 million each in additional funds over a four-year period, subject to their project's success. DOE hopes these three offshore wind projects, located off the coasts of Virginia, Oregon and New Jersey, will help lower the cost of offshore wind and demonstrate the technology is ready for wider commercial application.[31] These projects – the Virginia Offshore Wind Technology Advancement Project (VOWTAP), Fishermen's Energy Atlantic City Windfarm, and Principle Power Windfloat in Oregon – were still in very early stages as of October 2015.[32] If these projects fall through, DOE will consider funding the runner-up projects, including Lake Erie Energy Development Corporation's (LEEDCo) Icebreaker project in Ohio and the University of Maine's DeepCwind Consortium's New England Aqua Ventus I in Maine.[33]

Europe's Offshore Wind Industry

Europe is by far the world leader in offshore wind development, with over 90 percent of the world's total installed offshore wind capacity. The European Union has 3,072 grid-connected offshore wind turbines at 82 farms spanning 11 countries, for a total of 10,393.6 MW of offshore wind energy capacity, as of June 30, 2015.[34]

Market Leaders

The United Kingdom, Denmark, and Germany are the clear leaders in offshore wind energy development in Europe. The United Kingdom has installed the most of the three, with 48 percent of Europe's offshore wind capacity in its waters, followed by Germany (27 percent), and Denmark (12 percent). In the beginning of 2015, Germany moved to catch up with Britain, installing 1,706 MW of offshore wind. Over the same time period, the United Kingdom installed 523 MW and the Netherlands installed 114 MW – bringing the total of new capacity installed in early 2015 to 2,343 MW. With those additions, the United Kingdom currently has 5,017 MW of operating offshore wind, followed by Germany with 2,760 MW, and Denmark with 1,271 MW. Belgium has the next highest capacity, with 712 MW.[35, 36]

Offshore wind's greater success in some countries over others can be attributed to many factors, including differences in offshore wind potential, regulatory structures, and policy support. The United Kingdom has been able to make strong headway in setting up offshore wind farms, which it has identified as its most scalable source of bulk renewable energy, due to its large available offshore resources and excellent policy support. The country is predicted to have 10 GW of offshore wind by 2020.[37] In contrast France has 80,000 MW of offshore wind potential, the second largest potential capacity in Europe behind only the United Kingdom, but has none currently installed, although 3,000 MW are in the pipeline.[38, 39]

Denmark: A Proven Environmental Success Story

Denmark, the nation with the third-most offshore wind in the world, conducted a comprehensive environmental monitoring program from 1999 to 2006 to assess the environmental impact of two of the largest offshore wind farms in the world: the Horns Rev and Nysted Offshore Wind Farms. Together, these two wind farms have 152 turbines and 325 MW of capacity. The study compared the ocean's state before the wind farms were installed and after, and found that the number of species and biomass increased at the wind farms, where artificial reef communities were developing. The study could not prove any linkage between fish behavior and electromagnetic pollution. Impacts on seal populations were negligible, although one site saw a small decrease in porpoise abundance; both seals and porpoises left wind farm sites during construction. Finally, the study found that bird collision risk was low, and any bird population displacement was not biologically significant.

Additionally, the Danish Government polled locals near the wind farms about their opinion on offshore wind. More than 80 percent reported they were "positive" or "very positive" towards offshore wind, and most believed that impacts on bird and marine life were neutral.[40]

Europe's Future

The market for offshore wind in Europe is not anticipated to slow at any point in the near future. Driven in part by the European Union's (EU) goal of deriving 20 percent of its electricity from renewable sources by 2020, the European Wind Energy Association (EWEA) projects substantial industry growth through 2030.[41] EWEA has set a target of 40 GW of offshore wind by 2020, and 150 GW by 2030. Also by 2030, EWEA predicts annual installations of offshore wind will equal 13,700 MW, offshore wind electricity generation will meet 13.9 percent of total EU demand, and annual investments in turbines will increase to 17 billion euros ($19.4 billion).[42]

Financial firm Ernst and Young has a more restrained view of Europe's offshore wind future. Ernst and Young predicts the European Union will increase its offshore wind capacity to a total of 23.5 GW by 2020, and 43.8 – 64.8 GW by 2030. At the 64.8 GW level, offshore wind would supply 8.4 percent of total EU electricity demand and avert 18 billion euros in fossil fuel imports.[43]

An important consideration for Europe's offshore wind industry is the rise of Asian and U.S. offshore wind markets. Ernst and Young notes that China, Japan, South Korea, India, and Taiwan all have ambitious offshore wind targets, adding up to 15 GW of new offshore wind capacity by 2020 – a large opportunity for EU technology and knowhow.[44, 45] The world's largest offshore wind developer, Denmark-based DONG Energy, has already made a move to invest in the U.S. market, proposing a 1,000 MW project off the coast of Martha's Vineyard in Massachusetts called Bay State Wind.[46] Overall, Ernst and Young projects the global offshore wind market could see investments of 690 billion euros ($786.6 billion) by 2040, a huge market which Europe is poised to dominate, until the United States begins to develop its own supply chain as it builds several offshore wind projects.[47]

Companies

Ever since German engineering company Siemens provided the turbines for the first offshore wind farm in 1991, it has consistently been the largest supplier of offshore wind turbines.[48] Siemens's turbines represent 65.2 percent of all installed capacity in Europe, and 86.2 percent of the capacity installed in 2014 (by turbine MW). Other companies that have become large suppliers of offshore wind turbines include Denmark-based MHI Vestas, representing 20.5 percent of installed capacity, Germany-based Senvion, with 6.6 percent of installed capacity, and Germany-based BARD, with five percent of installed capacity.[49]

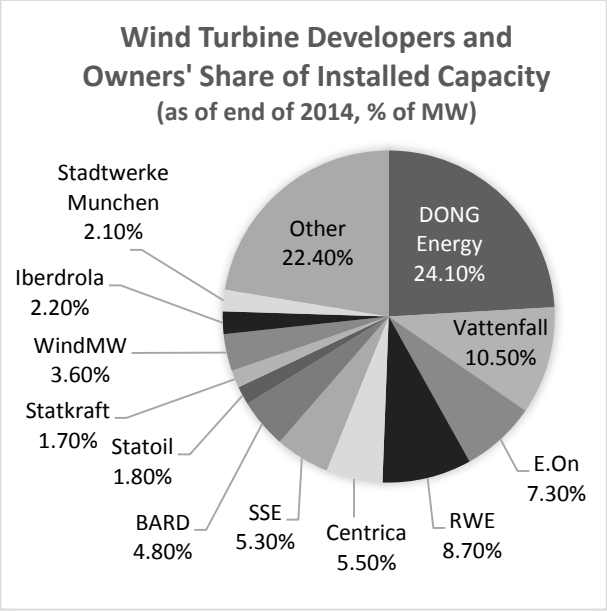

Figure 5: Wind turbine developers and owners

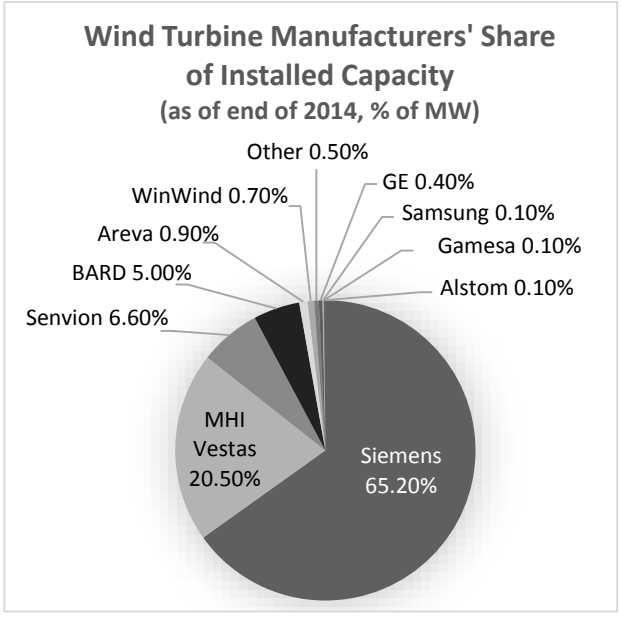

Figure 6: Wind turbine manufacturers[50]

While the turbine industry has been dominated by Siemens, the offshore windfarm development industry has evolved more evenly. Denmark-based DONG Energy, which worked with Siemens to create the world's first offshore wind farm, owns the largest share of offshore wind, with 24.1 percent of all installed capacity. Sweden-based Vattenfall owns 10.5 percent of installed capacity, Germany-based RWE Innogy has 8.7 percent, and Germany-based E.ON has 7.3 percent.[51]

Beyond turbines and wind farm development, the offshore wind industry supports a supply chain of cable suppliers and installers, port operators, large construction firms, marine contractors, electrical equipment suppliers and installers, structural manufacturers (to build substructures, foundations, and offshore substations), and others. The supply chain is relatively fluid, with new companies challenging incumbents for market share. EWEA explains that this is due to the relative youth of the offshore wind industry, as compared to other mature industries, such as the automotive sector.[52]

European Offshore Wind Jobs

From 2007 to 2014, offshore wind sector employment in the European Union increased twelvefold, from 6,370 jobs to 75,000, according to the International Renewable Energy Agency (IRENA). This estimate includes direct and indirect employment.[53] Germany employed about 19,000 of these workers, while the United Kingdom employed about 13,000.[54, 55]

According to the International Economic Development Council (IEDC), offshore wind creates more jobs per megawatt than fossil fuels or onshore wind, because of the sizeable labor required for installing, operating and servicing wind turbines offshore. The European Wind Energy Agency (EWEA) refers to this as the "additional employment effect," and estimates offshore wind supplies an extra 2,800 jobs per MW compared to onshore wind.[56] These jobs are more likely to positively affect economically depressed shipyards and ports, which are used to assemble and stage offshore wind components. A good example of this is the revitalization offshore wind has provided to the German port city of Bremerhaven, after its economic downturn in the 1980s and 90s.

This additional employment effect means offshore wind energy employment should surpass onshore wind energy employment in Europe by 2025, even though the offshore wind energy industry is considered to be 10 to 15 years behind the onshore wind industry.[57] EWEA projects that in 2030, over 375,000 people will be employed in the EU wind energy sector; 215,000 of those jobs will be in offshore wind, and 160,000 will be in onshore wind.[58]

Key Findings

- Europe has more than 90 percent of the world's total installed offshore wind capacity, and will continue to dominate the offshore wind market for years to come.
- Differing estimates say Europe will have 23.5 – 40 GW of offshore wind by 2020, and 43.8 – 150 GW by 2030.
- The United States is expected to ramp up its deployment of offshore wind—with three gigawatts of offshore wind by 2020, 22 GW by 2030, and 86 GW by 2050—which will spur the development of a U.S. supply chain.
- China, Japan, South Korea, India, and Taiwan all have ambitious offshore wind targets, adding up to 35 GW of new offshore wind capacity by 2020.
- European companies have decades of experience installing offshore wind farms, and stand to gain the most from offshore wind's global expansion.

This fact sheet is available electronically (with hyperlinks and endnotes) at www.eesi.org/papers.

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Appendix 1: U.S. Offshore Wind in the Pipeline

The Department of Energy released a report in September 2015 which found 21 offshore wind projects in development in the United States, for a total of 15,650 MW of potential capacity. Thirteen of these projects are at a more advanced stage. The following chart explores the 13 advanced stage projects, including their size, status, target completion date and location.[59]

U.S. OFFSHORE WIND PROJECTS in advanced stages						
Project Name (State)	**Proposed Capacity (MW)**	**Turbines (#)**	**Distance to Shore (miles)**	**Average Water Depth (meters)**	**Status**	**Target Completion Date**
Block Island (RI)	30	5	3	26	Construction	Fall 2016
Cape Wind (MA)	468	130	8	10	Arranging PPAs/ Financing	Extended
U.S. Wind (MD)	500	85-125	55	26	Conducting Surveys	2020
Fishermen's Energy: Phase I (NJ)	24	6	3	11.5	Fully Permitted (Legal battle)	Extended
DONG Energy (MA)	1,000	30-35	15	40-50	Acquired Lease	N/A
Deepwater One (RI/ MA)	1,000	167-200	20	40	Arranging PPAs/Financing	2020
Dominion Virginia Power (VA)	2,000	~333	27	30	Acquired Lease	2022-2024
NRG BlueWater's Mid-Atlantic Wind Park (DE)	450	150	12.7	20	On Hold	2021
Virginia Offshore Wind Technology Advancement Project (VA)	12	2	27	26	Conducting Surveys	2018
Principal Power – WindFloat Pacific (OR)	25	6-8	15	350	Conducting Surveys	2017
Lake Erie LEEDCo Icebreaker (OH)	18	6	7	18	Arranging PPAs/Financing	2019
University of Maine (ME)	12	2	13	95	Arranging PPAs/Financing	2019
OffshoreMW (MA)	400	N/A	14	N/A	Acquired Lease	2018

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FOOTNOTES

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