THE WINDS OF CHANGE:
INVESTING IN FLOATING OFFSHORE WIND DEVELOPMENT

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Introduction

The offshore wind power industry in the United States is at an inflection point. Only two projects have been constructed up to this point: the Block Island wind farm off Rhode Island, and the Coastal Virginia Offshore Wind pilot project off Virginia.[1] Together, these projects consist of seven turbines with a combined maximum capacity of only forty-two megawatts ("MW") of electricity.[2] But all signs point to an explosion in the construction of offshore wind projects in the next few decades, with multiple states setting targets of gigawatts ("GW") of offshore wind power, and projections showing that more than eighteen GW of offshore wind capacity could be built just in the next decade.[3]

The potential for offshore wind power in the United States is enormous. In 2016, the Department of Energy and Department of the Interior published a report entitled "National Offshore Wind Strategy."[4] Updating a 2011 report on the same topic, the 2016 report was intended to highlight the potential of offshore wind development, and the largest hurdles that must be overcome to achieve that potential.[5] The report concluded that using only technology available at the time of publication, the total potential offshore wind power capacity in U.S. waters was roughly double the total electricity consumption of the country in 2015.[6] And, under a realistic development scenario, 86 GW of offshore wind turbines could be installed by 2050, producing 14% of projected electricity demand in the United States.[7] The value of offshore wind, and floating turbines

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[1] *See Our Offshore Wind Projects in the U.S.*, ØRSTED, https://perma.cc/D6BQ-KHS9.

[2] *Id.* For comparison, the average natural gas–powered electric generating unit installed in 2017 had a capacity of 820 MW. *Power Blocks in Natural Gas–Fired Combined-Cycle Plants Are Getting Bigger*, ENERGY INFO. ADMIN. (Feb. 12, 2019), https://perma.cc/4XP6-UHLL.

[3] John Fialka, *U.S. Has 7 Ocean Turbines. Companies See Hundreds Soon*, CLIMATEWIRE (July 30, 2020), https://perma.cc/BJS2-AUQV. One gigawatt equals one thousand megawatts.

[4] PATRICK GILMAN ET AL., U.S. DEP'T OF ENERGY, & FRED BECK, U.S. DEP'T OF THE INTERIOR, NATIONAL OFFSHORE WIND STRATEGY (2016) [hereinafter NATIONAL OFFSHORE WIND STRATEGY].

[5] *Id.* at vii.

[6] *Id.* at viii.

[7] *Id.*

in particular, is that the technology provides the carbon-free electricity that fossil fuel–fired electricity sources cannot, while providing more consistent electricity than other renewable sources such as utility-scale solar and land-based wind power.[8]

Significant offshore wind development, however, is not inevitable. Further technology and infrastructure development is essential, as the ability to efficiently produce and transport electricity from turbines to consumers will determine how far developers will stray beyond the optimal sites to install turbines. Competing interests—including fishermen who work in or transit the areas where wind farms are planned, environmental groups focused on protecting vulnerable species, and landowners seeking to avoid visual impacts—can use various methods to delay or block wind projects. Regulatory requirements at the federal, state, and local levels can increase costs, limit alternatives, and hamper any wind power development. This Article focuses on one area of offshore wind development that is still in the early stages of development globally but carries significant environmental and economic upsides: floating offshore wind. I begin by looking at the advantages of floating turbines over their fixed-bottom counterparts and the status of floating turbine installations today. I then discuss two areas in which federal policymakers should focus their attention to encourage the development and deployment of floating turbines. First, I recommend a significant increase in research, development, demonstration, and commercialization ("RDD&C") funding, particularly for full-scale demonstration projects, an area where the United States lags far behind European nations. Second, I recommend the development of a federally managed floating turbine testbed that would facilitate the testing of floating turbines by private turbine developers. The combined goal of these proposals is to make the United States a global hub of floating turbine development, thereby lowering barriers to entry for competitors and sparking the development of supply chains that are prerequisites for commercial-scale deployment of floating turbines both in the United States and abroad.

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[8] *Compare Capacity Factors for Utility Scale Generators Primarily Using Non-Fossil Fuels*, ENERGY INFO. ADMIN., https://perma.cc/JY3B-RCPF (listing the average capacity factors for utility-scale solar and land-based wind in 2020 as 24.9% and 35.4%, respectively), *with UK Offshore Wind Capacity Factors*, ENERGY NOS., https://perma.cc/69FB-H8E6 (listing the lifetime capacity factor for the floating turbine Hywind Scotland project as 53.6%). Capacity factor is the percentage of total energy actually produced by a source as compared to the total energy that could be produced if the source operated continuously at full capacity.

I. Why Floating Turbines

Most offshore wind farms use fixed-bottom turbines, where the turbine is built on a foundation attached to the seabed.[9] Fixed-bottom turbines are challenging to build in water deeper than fifty meters, and the advanced designs and materials needed at these depths make most turbines prohibitively expensive outside of shallower waters.[10] Floating turbines, where the turbine sits atop a floating base anchored to the seabed by long cables, could make turbines economical in water deep as one thousand meters or more.[11] Accessing these deepwater areas is crucial because they contain approximately 58% of the offshore wind energy in U.S. waters that could be captured by turbines, and closer to 95% along the Pacific Coast.[12] Floating turbines, therefore, are a necessity for fully exploiting offshore wind power's potential in areas like the Northeast and for having any commercial-scale offshore wind off California and Hawaii.

On top of increasing the total energy potential of offshore wind, floating turbines offer multiple potential benefits over fixed-bottom turbines. Because the winds further from land are often stronger and more consistent, floating turbines can provide more reliable energy production.[13] Floating turbines can also have lower construction costs, as some floating turbines can be fully built in port and towed to their final location, rather built on-site with specialized ships.[14] Floating turbines could have smaller environmental impacts at the installation site, since the cables used to hold the turbine in place spare nearby fish and marine mammals any harm from the pile driving that fixed-bottom turbines require.[15] Finally, there may be fewer conflicts with fishermen, who are less likely to fish in these deeper waters, as well as property owners on the coast, who are less likely to see the turbines from shore.[16] All of these potential benefits are contingent on policymakers and developers recognizing that floating turbines are a viable technology that deserves investment and regulatory focus.

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[9] WALT MUSIAL ET AL., NAT'L OFFSHORE WIND RSCH. & DEV. CONSORTIUM, RESEARCH AND DEVELOPMENT ROADMAP VERSION 2.0, at 8 (2019), https://perma.cc/VM8B-C64B.

[10] Garrett E. Barter et al., *A Systems Engineering Vision for Floating Offshore Wind Cost Optimization*, RENEWABLE ENERGY FOCUS, Sept. 2020, at 1.

[11] MUSIAL ET AL., *supra* note 9, at 8.

[12] Barter et al., *supra* note 10, at 1.

[13] *See supra* note 8 and accompanying text.

[14] *See* Barter et al., *supra* note 10, at 2.

[15] *See* ARTHUR N. POPPER ET AL., BUREAU OF OCEAN ENERGY MGMT., EFFECTS OF PILE DRIVING SOUNDS ON NONAUDITORY TISSUES OF FISH, at x–xi (2013), https://perma.cc/XKJ6-X3P2.

[16] Barter et al., *supra* note 10, at 7.

The main goal of policymakers concerning floating turbines should be to quickly drive down their cost. A rapid decrease in the cost of fixed-bottom turbines has helped offshore wind development explode in Europe in the past few years. Estimates from the U.K. government of the expected levelized cost of electricity ("LCOE")[17] for offshore wind in the country in 2025 have dropped from £140/MWh in 2013, to £107/MWh in 2016, to £57/MWh in 2020.[18] This major cost reduction allowed the U.K. to set the ambitious goal of 40 GW of offshore wind by 2030, a 300% increase over current levels and enough to power every home in the U.K.[19] Because it remains a nascent technology, however, the cost reductions seen for fixed-bottom turbines have not yet materialized for floating turbines. Of the 29.1 GW of offshore wind that have been installed globally through 2019, floating turbines contributed only 65.7 MW, or 0.2% of all offshore wind capacity.[20]

This lack of floating turbine development is beginning to change as private developers—with significant support from national governments and the EU—are continuing to scale up their floating turbine demonstration projects throughout Europe. One developer, Equinor, went from a single floating turbine deployed for testing in 2009, to a five-turbine pilot project in 2017, to beginning construction on an eleven-turbine project in the fall of 2020.[21] Another example is

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[17] Levelized cost of energy estimates the total cost of all aspects of an energy source spread over the lifespan of that source. A developer would need to charge the LCOE for all energy produced over the lifespan of the project to break even on that project. *See* Laura Malaguzzi Valeri, *Not All Electricity Is Equal—Uses and Misuses of Levelized Cost of Electricity (LCOE)*, WORLD RES. INST. (Aug. 1, 2020), https://perma.cc/U2ZD-PQ4B.

[18] Simon Evans, *Wind and Solar Are 30–50% Cheaper than Thought, Admits U.K. Government*, CARBONBRIEF (Aug. 27, 2020), https://perma.cc/4YMB-QXR5. The report found that increased size of wind farms resulted in economies of scale savings, while higher than expected capacity factors resulted in higher energy production. DEP'T OF BUS., ENERGY & INDUS. STRATEGY, ELECTRICITY GENERATION COSTS 2020, at 23 (2020), https://perma.cc/GL29-B42G. The report does not distinguish between fixed-bottom and floating turbines, but the one example project given is for a fixed-bottom turbine project. *See id.* At the time of publication, these costs are equivalent to approximately $192/MWh, $147/MWh, and $78/MWh, respectively.

[19] John Parnell, *Already the World's Leading Market, U.K. Doubles Support for Offshore Wind*, GREEN TECH MEDIA (Oct. 6, 2020), https://perma.cc/QK8X-4U4J.

[20] JOYCE LEE ET AL., GLOB. WIND ENERGY COUNCIL, GLOBAL OFFSHORE WIND REPORT 2020, at 11–12 (2020), https://perma.cc/E5QV-Z6G3.

[21] *The Future of Offshore Wind Is Afloat*, EQUINOR, https://perma.cc/23YA-QGGW (follow three tabs under the heading, "Our Floating Offshore Wind Projects"). The turbine size also grew between each project, with the first turbine being 2.3MW, the

the WindFloat Atlantic project off the coast of Portugal, which began operating in 2020 and is made up of three floating turbines with a combined capacity of 25 MW.[22] These projects alone outmatch the entire U.S. offshore wind industry, fixed-bottom and floating, which today counts only seven turbines.[23] Nonetheless, the projects remain expensive, with WindFloat Atlantic having an estimated LCOE of €200/MWh.[24] The National Renewable Energy Lab ("NREL") estimated in 2020 that the LCOE of the average commercial-scale floating offshore wind project was between $110 and $175/MWh, well above other energy sources such as onshore wind, utility-scale solar, and natural gas.[25]

Cost reductions could come quickly, however, if the right steps are taken. NREL estimates that the LCOE of commercial-scale floating offshore wind projects could fall to around $60/MWh by 2032,[26] and floating turbine projects could become cheaper than fixed-bottom projects before 2030.[27] The following two sections outline steps the U.S. government should take to make these cost reductions a reality.

II. Investing in Floating Turbine Development

Because floating turbine technology is still young, federal investment in RDD&C can yield high returns on investment. Congress, through the Department of Energy ("DOE"), should fund

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pilot project using 6MW turbines, and the most recent project using 8MW turbines. *Id.*

[22] *See* Craig Richards, *WindFloat Atlantic Fully Operational*, WINDPOWER MONTHLY (July 27, 2020), https://perma.cc/W85D-KUGQ (discussing the completion of the WindFloat Atlantic project).

[23] *See Our Offshore Wind Projects in the U.S.*, *supra* note 1 (discussing the Block Island Wind Farm and Coastal Virginia Offshore Wind project); Fialka, *supra* note 3 (discussing the total number of offshore wind turbines operating in the United States).

[24] Stanley Reed, *A New Weapon Against Climate Change May Float*, N.Y. TIMES (June 10, 2020), https://perma.cc/2VWC-MVT6. At the time of publication, this is equivalent to approximately $237/MWh.

[25] WALTER MUSIAL ET AL., NAT'L RENEWABLE ENERGY LAB'Y, 2019 OFFSHORE WIND TECHNOLOGY DATA UPDATE 68 (2020), https://perma.cc/2X4F-DUK4 (estimating the LCOE for offshore wind to be between $100 and $175/MWh); INT'L ENERGY AGENCY, PROJECTED COSTS OF GENERATING ELECTRICITY 2020 (2020), https://perma.cc/7EJH-E9CL (estimating the average LCOE for onshore wind to be $50/MWh, for utility-scale solar to be $56/MWh, and for natural gas to be $71/MWh).

[26] Musial et al., *supra* note 25, at 68.

[27] PHILIPP BEITER ET AL., NAT'L RENEWABLE ENERGY LAB'Y, A SPATIAL-ECONOMIC COST-REDUCTION PATHWAY ANALYSIS FOR U.S. OFFSHORE WIND ENERGY DEVELOPMENT FROM 2015–2030, at xiii (2016), https://perma.cc/9VTV-U8QZ.

programs that invest in offshore wind technology development more, particularly demonstration and commercialization projects, to reflect offshore wind's significant potential and to match European investments.

A. Jumpstarting Research and Development

Research and development funding for offshore wind technology in the United States typically comes from the DOE and the Advanced Research Projects Agency-Energy ("ARPA-E"). ARPA-E is a subagency of the DOE that funds research and development of energy projects deemed too experimental for private-sector investment.[28] ARPA-E funds in two ways: open funding, where researchers can submit proposals based on any energy technology; and specific programs, where the agency focuses funding around a specific energy source.[29] In 2019, ARPA-E funded twelve projects specifically focused on floating wind turbines with a total of around $28 million through its ATLANTIS program.[30] This grant funding, however, was a one-time award, and ARPA-E generally does not provide regular, annual funding for specific projects or research areas.[31] The agency's open funding opportunities typically happen every three years, with the last one occurring in 2018.[32] Of the seventy-nine projects funded by the OPEN 2018 funding, only five were related to wind turbines and none focused on offshore wind.[33]

The solution is not for Congress to shift all of ARPA-E's funding to offshore wind research, but to increase appropriations for this underfunded agency. The original proposal to create ARPA-E in

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[28] *See About*, ADVANCED RSCH. PROJECTS AGENCY-ENERGY, https://perma.cc/C37A-5MBA.

[29] *See OPEN Programs*, ADVANCED RSCH. PROJECTS AGENCY-ENERGY, https://perma.cc/Q8WM-QGL3.

[30] *See Atlantis*, ADVANCED RSCH. PROJECTS AGENCY-ENERGY, https://perma.cc/N8DQ-PCMZ. ATLANTIS stands for Aerodynamic Turbines Lighter and Afloat with Nautical Technologies and Integrated Servo-control. *Id.* Unless the DOE allocates additional money to the program, $28 million appears to be its full appropriation. *See Department of Energy Announces $28 million for Offshore Wind Energy*, U.S. DEP'T OF ENERGY (Feb. 1, 2019), https://perma.cc/4MK9-K8GU.

[31] *See* U.S. DEP'T OF ENERGY, ADVANCED RESEARCH PROJECTS AGENCY-ENERGY ANNUAL REPORT FOR FY2018, at 6 n.4 (2019), https://perma.cc/9UNL-K94V.

[32] *See OPEN 2021*, ADVANCED RSCH. PROJECTS AGENCY-ENERGY, https://perma.cc/G9AS-UHUA.

[33] *See OPEN 2018 Projects*, ADVANCED RSCH. PROJECTS AGENCY-ENERGY, https://perma.cc/XCJ3-LAE2.

2005 suggested the agency should have a $1 billion annual budget,[34] but in reality the agency has never had more than $427 million in a single year.[35] The DOE spends nearly twice as much on research and development for fossil energy and thirty times as much on maintaining the U.S. nuclear weapons stockpile.[36] The Energy Act of 2020 authorized ARPA-E's funding to increase from $435 million in fiscal year 2021 to $761 million by fiscal year 2025.[37] Congress did appropriate $427 million for fiscal year 2021,[38] nearly the full authorized amount, but it remains to be seen whether Congress will continue to increase appropriations in line with the larger budget authorizations in upcoming years. Matching appropriations to what Congress authorized for ARPA-E would nearly double the funding the agency could distribute to renewable technology research such as floating wind turbines and is a realistic short-term goal. Long-term, Congress should go further and increase ARPA-E's funding to at least $3 billion annually to approach that of the Defense Advanced Research Projects Agency ("DARPA"), the Defense Department's equivalent of ARPA-E, as was recommended by the House Select Committee on the Climate Crisis.[39]

B. Using the DOE to Bridge the "Valley of Death"

While ARPA-E focuses on cutting-edge technologies, the DOE provides grants and loans to renewable energy projects from preliminary research all the way to the commercialization stage. This funding could be particularly useful in moving projects from laboratory-scale demonstrations to commercial viability, a gap that is often referred to as the "valley of death."[40] The first full-scale projects for a technology like offshore wind turbines can be prohibitively expensive for all but the largest companies due to the high capital

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[34] NORMAN R. AUGUSTINE ET AL., NAT'L ACADS. OF SCIS., ENG'G, & MED., RISING ABOVE THE GATHERING STORM 154 (2007), https://perma.cc/FK53-N2XU.

[35] *Budget Requests*, ADVANCED RSCH. PROJECTS AGENCY-ENERGY, https://perma.cc/97FM-AZQK.

[36] ADVANCED RSCH. PROJECTS AGENCY-ENERGY, FY2020 BUDGET REQUEST 1 (2019), https://perma.cc/G7US-GUN7; *see also* U.S. DEP'T OF ENERGY, FY 2021 CONGRESSIONAL BUDGET REQUEST 1 (2020), https://perma.cc/R3DL-8WX2.

[37] Consolidated Appropriations Act of 2021, Pub. L. No. 116-260, tit. X, § 10001(g) (2020), https://perma.cc/2DE6-TCPE.

[38] *Id.* tit. III, https://perma.cc/2DE6-TCPE.

[39] *See* HOUSE SELECT COMMITTEE ON THE CLIMATE CRISIS, SOLVING THE CLIMATE CRISIS 220 (2020), https://perma.cc/V4N3-MJ42.

[40] *See generally* L.M. MURPHY, NAT'L RENEWABLE ENERGY LAB'Y, & P.L. EDWARDS, ALTRIA GROUP LLC, BRIDGING THE VALLEY OF DEATH: TRANSITIONING FROM PUBLIC TO PRIVATE SECTOR FINANCING (2003), https://perma.cc/3BFK-2NRZ.

costs of turbines and the low expected returns from small-scale initial projects. Government funding can help demonstrate commercial viability, build and develop markets, and prove to investors that a technology is worth their capital.[41] The WindFloat project in Portugal demonstrates the necessity of government funding for the first full-scale projects using a particular technology. The project cost around €120 million, €90 million of which came in the form of grants and loans from the European Investment Bank, an agency of the European Union.[42] This funding is essential for building a bridge over the "valley of death" by supporting wind developers in solving the problems that inevitably come when building the first full-scale versions of a technology. The WindFloat turbines, for example, were delayed by challenges in fine-tuning the computer system that balances the turbine's floating platform.[43] With that done, the next turbines will not face the same delays, and floating turbines can be installed faster and less expensively.

For comparison, the DOE's funding for wind projects is far smaller than investment by the European Union and European countries. The DOE has allocated $200 million since 2011 for offshore wind project grants for a variety of projects, from research to demonstration projects.[44] Meanwhile, just since 2014 the EU has approved €314 million in grant funding for offshore wind demonstration and commercialization projects, including over €120 million for floating wind projects, through its NER300 program.[45] Two projects funded by the DOE's Offshore Wind Advanced Technology Demonstration program, the Icebreaker Project in Lake Erie, and the Aqua Ventus project off Maine, have both received approximately $14 million in funding and are eligible for up to $37 million more if they achieve specific milestones as outlined by the DOE.[46] Compare this

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[41] *See id.* at 32.

[42] €30 million came from a renewable energy development grant, and €60 million came from a loan for renewable technologies. *EU Loan Helps Kick-Start Construction of Floating Wind Farm Off the Coast of Portugal*, EUR. COMM'N (Oct. 19, 2018), https://perma.cc/2KF6-4JF6.

[43] *See* Reed, *supra* note 24.

[44] *Offshore Wind Research and Development*, U.S. DEP'T OF ENERGY, https://perma.cc/Z8RJ-PA27.

[45] *NER300 – Documentation*, EUR. COMM'N, https://perma.cc/KR28-BD3W. The NER300 program's funding comes from the money raised by the EU's Emissions Trading System, *NER 300 Programme*, EUR. COMM'N, https://perma.cc/BQC6-GTQK, and the DOE has no comparable funding source.

[46] *See Offshore Wind Advanced Technology Demonstration Projects*, U.S. DEP'T OF ENERGY, https://perma.cc/TT9T-QNQL. The Aqua Ventus project is the only floating turbine project of these two; the Icebreaker Project is focused on fixed-bottom turbine technology for the Great Lakes. *Id.*

with the Veja Mate offshore wind project in Germany, which was awarded €112.6 million by the European Commission in 2015,[47] and the Hywind Tampen pilot project, the eleven-turbine floating wind farm discussed above,[48] which was awarded 2.3 billion Norwegian kroner (about $273 million) by the Norwegian government in 2019.[49] Overall, Europe is far outspending the United States for offshore wind projects.

C. The Opportunity of Renewable Energy Loans

The disparity between U.S. and EU green energy funding is even starker in renewable energy loans. The European Investment Bank ("EIB") provided €53 billion in energy efficiency, renewable energy, and grid infrastructure loans between 2015 and 2019, including €4 billion in loans for innovative renewable energy projects in 2019 alone.[50] Under the EU's InnovFin Energy loan program that WindFloat benefited from, up to 50% of a project's costs can come from these loans, which can support experimental projects that would otherwise struggle to get funding.[51] And, these loans are not just for new renewable technologies; they also help expand renewable energy to new locations. The Lake Turkana wind farm in Kenya, for example, received €200 million in loans—30% of the total project cost—from the EIB.[52]

The DOE, meanwhile, has provided a total of $13.6 billion in loans and loan guarantees for low-carbon energy projects since 2010 through its Loan Programs Office.[53] The loan program was critical in launching utility-scale solar energy projects, with the DOE loan guarantees backing the first five such projects in the United States. But only one project, the Vogtle nuclear plant, has received a loan since 2011.[54] Only four wind projects, all funded in 2010 or 2011, have received any loans or loan guarantees from the agency, and these were

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[47] *Veja Mate*, EUR. COMM'N, https://perma.cc/PRT9-BQN8.

[48] *See supra* note 21 and accompanying text.

[49] *Hywind Tampen Floating Offshore Wind Farm Secures £210m Funding from Enova*, NS ENERGY (Aug. 23, 2019), https://perma.cc/4SAM-G2JC.

[50] EUR. INV. BANK, ENERGY OVERVIEW 2020, at 2–3 (2020), https://perma.cc/H8EK-7HTA.

[51] EUR. INV. BANK, INNOVFIN ENERGY DEMO PROJECTS 1 (2017), https://perma.cc/Y379-7RTQ.

[52] *EIB and Lake Turkana Wind Power*, EUR. INV. BANK (Apr. 3, 2019), https://perma.cc/8AB8-YRC7.

[53] *Portfolio Projects*, U.S. DEP'T OF ENERGY, https://perma.cc/6DPA-HNH5.

[54] Jacqueline Toth, *DOE Program's $3.7 Billion Loan Highlights Lack of Action on Other $40 Billion It Holds*, MORNING CONSULT (Apr. 8, 2019), https://perma.cc/N2G6-6PPV.

all onshore wind farms.[55] The limited use of the DOE's loan program can be attributed to the restrictive nature of its authorizing statute. The program was split between two main sections, section 1703[56] and section 1705.[57] Section 1703 is still operating,[58] and has $3 billion left for loan guarantees for clean energy projects,[59] but projects funded with this money must use "new or significantly improved technologies."[60] Section 1705 was a temporary program created as part of the 2009 stimulus bill that allowed for loan guarantees for renewable energy projects and did not require the technology to be innovative.[61] Unlike most onshore and fixed-bottom offshore wind projects, the first handful of full-scale floating turbine projects may still be able to take advantage of the section 1703 loan guarantees due to their use of new-to-the–United States technology, but it is unlikely any floating turbine developers are close enough to full-scale turbine deployment in the United States to pursue this option.

In the long term, Congress should reauthorize the section 1705 program to support a broader array of offshore wind projects without the need to employ innovative technology and raise the current $3 billion limit on how much the DOE can provide in loan guarantees for renewable energy projects. As with ARPA-E, Congress should also increase the DOE's funding for grants for wind energy research and demonstration projects, with a particular focus on technologies seeking to bridge the valley of death, such as floating turbines. Floating turbine technology continues to rapidly advance, but increased funding to jumpstart the industry is needed to help the United States catch up with Europe's larger offshore wind sector and to achieve the cost reduction expectations discussed above.[62]

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[55] *Wind Energy Projects*, U.S. DEP'T OF ENERGY, https://perma.cc/P6CQ-KLCW.

[56] Energy Policy Act of 2005, Pub. L. 109–58, tit. XVII, § 1703, 119 Stat. 1120, 1453–55 (2005) (codified at 42 U.S.C. § 16513).

[57] American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, tit. XVII, § 1705, 123 Stat. 115, 145–48 (2009) (codified at 42 U.S.C. § 16516); *see also* PHILLIP BROWN ET AL., CONG. RSCH. SERV., IN11432, DEPARTMENT OF ENERGY LOAN PROGRAMS: TITLE XVII INNOVATIVE TECHNOLOGY LOAN GUARANTEES 1 (2020).

[58] BROWN ET AL., *supra* note 57, at 1.

[59] LOAN PROGRAM OFF., ANNUAL PORTFOLIO STATUS REPORT FISCAL YEAR 2019 3 (2019), https://perma.cc/4K3H-55UH.

[60] 42 U.S.C. § 16513(a)(2).

[61] BROWN ET AL., *supra* note 57, at 2.

[62] The DOE would also benefit from a dedicated funding source for renewable energy grants, like the EU's Emissions Trading System funding the NER 300 program, although the potential and characteristics of a carbon tax or cap-and-trade system in the United States are far outside the focus of this Article.

III. Floating Turbine Testbed

In addition to increased funding for experimental offshore wind projects, the DOE and Bureau of Ocean Energy Management ("BOEM") could take more proactive steps with congressional support to advance technological developments in floating turbines. One such option would be to create a federally managed floating turbine testing site where universities, agencies like NREL, and private developers can all test new floating turbine technology without having to go through the hurdles of leasing and multi-year environmental review for each project.[63] This would create a form of a regulatory sandbox,[64] where developers can save money by being able to sell their electricity onshore without having to install the transmission infrastructure, all while testing innovative floating turbine designs for later use in commercial-scale wind farms.

Granting research leases is already within BOEM's regulatory power. The agency can grant research leases and rights-of-way to federal agencies and states for projects that "support the future production, transportation, or transmission of renewable energy."[65] In granting a research lease, BOEM must still consult states, tribes, and other agencies and find there is no competitive interest in the lease,[66] but the necessary environmental review under the National Environmental Policy Act ("NEPA") can be much simpler and quicker than a commercial-scale offshore wind project. As a comparison, BOEM announced its intent to draft an environmental impact statement for the Vineyard Wind project—a 800MW offshore wind farm off Massachusetts—in March of 2018, and the process has yet to conclude three years later.[67] Meanwhile, the Coastal Virginia Offshore Wind ("CVOW") project—a small two-turbine pilot project operating under BOEM's research grant authority—only required an

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[63] The challenges and delays for commercial offshore wind leasing in the United States are outside the scope of this Article, but the disparity in offshore wind development between Europe and the United States suggests this is more than just a problem of technology development.

[64] A regulatory sandbox is a controlled environment where new ideas and technologies can be tested without having to go through what can often be long permitting processes. *See* Brien J. Sheahan & Jimmie Zhang, *Experiment Without Penalty: Can Regulatory 'Sandboxes' Foster Utility Innovation?*, UTILITYDIVE (Mar. 21, 2019), https://perma.cc/TB84-3363.

[65] 30 C.F.R. § 585.238(a) (2019).

[66] *Id.* § 585.238(b), (c).

[67] *See Vineyard Wind*, BUREAU OF OCEAN ENERGY MGMT., https://perma.cc/5WDQ-R69U.

environmental assessment that took only fifteen months from announcement to completion and permit approval.[68]

In addition to the CVOW project, three projects that could inform the development of such a floating turbine testbed are NREL's controllable grid interface ("CGI"), the PacWave project, and the University of Maine's Deepwater Offshore Wind Test Site. The CGI is a microgrid at the National Wind Technology Center in Colorado that NREL uses to mimic real electric grid conditions and test commercial-scale renewable energy technology.[69] In addition to photovoltaic solar and battery storage systems, the CGI has five wind turbines from four different manufacturers connected to the system.[70] The CGI is unique in that it is directly managed by a federal agency, and it is valuable both for testing wind turbines and other renewable energy technologies independently and studying how these technologies would interact with each other and the larger grid.[71]

The PacWave project, developed by Oregon State University and permitted by BOEM and the Federal Energy Regulatory Commission ("FERC"), proposes to test wave energy technology in federal waters off the Oregon coast.[72] Operating under the same research lease authority as the CVOW project, the PacWave project will consist of four "berths" where different developers can install experimental wave energy generators.[73] Oregon State will install and manage a dedicated electrical transmission cable for each berth to allow developers to sell the power they generate and monitor their installations from shore.[74] The permitting process differs between wave energy projects like this and offshore wind.[75] But BOEM should replicate this general structure of a testing site with permitting and infrastructure handled by one party (like the DOE or a university like

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[68] *See Coastal Virginia Offshore Wind Project (CVOW)*, BUREAU OF OCEAN ENERGY MGMT., https://perma.cc/THW3-G9YW. The lease is actually held by the Commonwealth of Virginia's Department of Mines, Minerals and Energy, which then gave Dominion Energy, the state's regulated utility, the authority to construct the project. *Id.*

[69] *Grid Integration Facilities at the National Wind Technology Center*, NAT'L RENEWABLE ENERGY LAB'Y, https://perma.cc/5DC6-VJWA.

[70] *Id.*

[71] *Controllable Grid Interface*, NAT'L RENEWABLE ENERGY LAB'Y, https://perma.cc/S2AL-9NQR.

[72] *PacWave South Project*, BUREAU OF OCEAN ENERGY MGMT., https://perma.cc/95ZL-2JES.

[73] *South Test Site*, PACWAVE, https://perma.cc/43NK-6ERL.

[74] *Id.*

[75] *PacWave South Project*, *supra* note 72 (discussing FERC's authority to permit construction of wave energy projects).

Oregon State) that facilitates testing by other groups for floating turbines.

The Deepwater Offshore Wind Test Site, created through state legislation in 2009,[76] is in state waters near Monhegan Island, more than twelve miles off the coast of Maine.[77] The site is meant to be used for offshore wind demonstration projects pursued by private developers in association with the University of Maine,[78] and the state legislature appears to have designed it specifically for the Aqua Ventus project.[79] A joint venture with the University of Maine and multiple private offshore wind developers, the Aqua Ventus project began by deploying a sixty-five-foot tall floating turbine in 2013 nearer to the Maine coast for preliminary tests.[80] After receiving approval in 2019, the group is moving forward with plans to install one 10MW floating turbine at the Deepwater Offshore Wind Test Site by 2022.[81] The test site was selected based on its deep waters, strong winds, minimal conflicts with fishermen, and proximity to both the mainland and an island with high energy costs.[82] The developers have also signed a twenty-year power purchase agreement with the Maine Public Utilities Commission.[83] Aqua Ventus will be able to test its innovative floating turbine while also providing clean energy to Maine, helping offset the project's cost.

Congress could learn from these four projects to create a unique, multi-turbine, floating offshore wind testbed. This would start with Congress directing the DOE and BOEM to identify an appropriate area in federal waters with strong, consistent winds, appropriate depths, and sufficient distance from shore to avoid complaints from coastal landowners.[84] Congress should also direct and fund the DOE to install electrical infrastructure to both monitor and test the turbines, as with the CGI facility, and to transmit generated

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[76] ME. REV. STAT. ANN. tit. 38, § 480-HH (2021).

[77] *UMaine Deepwater Offshore Wind Test Site at Monhegan Island*, UNIV. OF ME., https://perma.cc/T7N4-2856.

[78] *Using the Test Site*, UNIV. OF ME. (Oct. 29, 2020), https://perma.cc/8HFM-CGGP.

[79] The Aqua Ventus project has been one of the largest recipients of DOE funding for offshore wind. *See supra* note 44.

[80] Kristoffer Tigue, *Can America's First Floating Wind Farm Help Open Deeper Water to Clean Energy?*, INSIDE CLIMATE NEWS (Nov. 20, 2019), https://perma.cc/84TR-PEWB.

[81] *Id.*

[82] *The Project*, AQUA VENTUS, https://perma.cc/964H-RYA9.

[83] *Id.*; *see also Site Selection*, UNIV. OF ME., https://perma.cc/KCE9-5JHV.

[84] Federal waters refers to the area of the ocean beyond state-controlled waters, typically three nautical miles from shore, out to twelve nautical miles. *Outer Continental Shelf*, BUREAU OF OCEAN ENERGY MGMT., https://perma.cc/B76J-KYJE.

electricity to shore for sale.[85] The majority of the NEPA review process could be completed upfront to include both the infrastructure built and managed by the DOE and expected turbines.[86] Once this preliminary review and infrastructure development is completed, individual turbines could likely be installed after just a categorical exclusion[87] is issued, or at most an environmental assessment is completed.

An accessible test site like this would be in high demand if set up right. Floating turbine technology, unlike fixed-bottom turbines, has yet to become commercially economical, but the existence of numerous pilot projects such as Aqua Ventus, WindFloat Atlantic, and Hywind Tampen demonstrates that developers are eager to test full-scale floating turbine designs. Developers would be attracted to using the testbed due to the low barriers to entry (i.e., not needing to obtain their own lease or install most of the transmission infrastructure and a simplified permitting process), and the ability to sell their electricity. Development of the testbed could also encourage existing turbine designers like Siemens Gamesa,[88] MHI Vestas,[89] and GE Renewable Energy,[90] who are all developing their own floating turbines, to increase their presence in the United States. It could also help new groups, such as the consortium developing the Aqua Ventus project, to become market competitors, accelerating turbine development and driving down costs. Technological developments supported by the testbed would help wind farm developers expand and improve their installations not just in the United States, but worldwide. Overall, it would be a cost-effective way to spur innovation in floating turbine

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[85] The Aqua Ventus project is currently demonstrating the challenges of this siting and permitting process, as it is considering multiple landfall sites for its cable after consulting with fishermen, and the group does not appear to have requested the federal right-of-way that will be needed from BOEM, as the cable crosses federal waters. *Proposed Cable Landings in St. George and East Boothbay*, AQUA VENTUS, https://perma.cc/UL98-RDR4.

[86] Whether this would require an environmental assessment, like the CVOW project, or a full environmental impact statement, like Vineyard Wind, would likely depend on the number of turbines the site is planned for.

[87] A categorical exclusion is a predetermined type of action found by an agency to not have significant effects on the environment, which therefore does not require an environmental assessment or environmental impact statement under the National Environmental Policy Act. *Categorical Exclusions*, COUNCIL ON ENV'T QUALITY, https://perma.cc/WAY9-KJDT.

[88] Press Release, Siemens Gamesa, Giant Leap Forward in Floating Wind: Siemens Gamesa Lands the World's Largest Project, the First to Power Oil and Gas Offshore (Oct. 31, 2019), https://perma.cc/YGP6-JMGS.

[89] *First Ever V164-9.5 MW Turbine Installed on a Floating Wind Project*, MHI VESTAS OFFSHORE WIND (Nov. 11, 2020), https://perma.cc/4T3A-PNWU.

[90] *Ship Shape: This Floating Offshore Wind Farm Could Be the Future of Renewable Energy*, GEN. ELECTRIC (Aug. 30, 2016), https://perma.cc/YJQ8-TYN3.

technology, encourage offshore wind development in the United States, and drive down costs globally.

Conclusion

Floating wind turbines represent one part of the larger offshore wind industry. While fixed-bottom turbine technology—supported by European investment and installations—is already economically viable and supported by private development, floating turbines need investment, research, and testing. Although largely absent from participation in the development of the first generation of offshore wind turbines, the United States can still be a champion in the development and deployment of floating turbines. This would require increased investments in everything from preliminary research supported by ARPA-E, to loan guarantees from the DOE's Loan Program Office. The federal government should also go beyond simply funding research by others to actively supporting testing through the creation of a floating turbine testbed in federal waters. Such a project could make the United States a hub for floating turbine development, allowing for wind farms in previously inaccessible waters and providing significant amounts of renewable energy in the United States and other nations.