U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

2018 **Offshore Wind Technologies Market Report**

NOTICE

Available electronically at SciTech Connect http:/www.osti.gov/scitech

Available for a processing fee to U.S. Department of Energy and its
contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
OSTI http://www.osti.gov Phone:
865.576.8401
Fax: 865.576.5728
Email: reports@osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce National
Technical Information Service 5301
Shawnee Road
Alexandria, VA 22312 NTIS
http://www.ntis.gov
Phone: 800.553.6847 or 703.605.6000
Fax: 703.605.6900
Email: orders@ntis.gov

2018 Offshore Wind Technologies Market Report

Primary Authors

Walter Musial, National Renewable Energy Laboratory

Philipp Beiter, National Renewable Energy Laboratory

Paul Spitsen, U.S. Department of Energy

Jake Nunemaker, National Renewable Energy Laboratory

Vahan Gevorgian, National Renewable Energy Laboratory

List of Figures

List of Tables

Acknowledgments

This work was supported by the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308 with the National Renewable Energy Laboratory (NREL). Funding for the work was provided by the DOE Office of Energy Efficiency and Renewable Energy Wind Energy Technologies Office. The report was reviewed by a diverse group of offshore wind industry stakeholders including four developers, three wind turbine manufacturers, two state government representatives, one nongovernmental organization, seven internal Office of Energy Efficiency and Renewable Energy staff, three NREL management staff, four consultants, and three regulators. The authors would like to extend thanks to Patrick Gilman and Gary Norton (contractor) from the DOE Wind Energy Technologies Office for supporting this research. Thanks also to Valerie Reed, Liz Hartman, Rich Tusing, Dan Beals, and Alana Duerr of the DOE Wind Energy Technologies Office for their support and strategic guidance.

The authors would like to thank the following reviewers and contributors from NREL including Brian Smith, Paul Veers, and Eric Lantz (NREL).

This report covers a wide range of industry projects, policies, and past reports that the authors have documented with extensive support from a diverse group of peer reviewers. These experts and stakeholders include Tom Harries (Bloomberg New Energy Finance), Darryl Francois and Stephen Boutwell (Bureau of Ocean Energy Management), James Glennie (Danish Trade Council/Embassy), Stephanie McClellan (Delaware Special Initiative on Offshore Wind and Renewable Consulting Group and Renewables Consulting Group), Knut Aanstad (Equinor), Albert Fisas (GE), Nils Bolgen (Massachusetts Clean Energy Center), Jason Folsom (MHI/Vestas), Nathanael Greene (National Resources Defense Council), Anne Marie McShea (New Jersey Board of Public Utilities), Gavin Smart (ORE Catapult), Kris Ohleth (Ørsted), Aaron Smith and Loris Canizares (Principle Power Inc.), and Fergus Costello and Soeren Daugaard (Siemens Gamesa).

Editing was provided by Sheri Anstedt (NREL) and graphics and cover design were created by John Frenzl (NREL). Additional communications and coordination were provided by Alex Lemke (NREL), Kiki Carpenter (NREL), Tiffany Byrne (NREL), and Carol Laurie (NREL).

Nomenclature or List of Acronyms

AC	alternating current
BESS	battery energy storage system
BNEF	Bloomberg New Energy Finance
BOEM	Bureau of Ocean Energy Management
BPU	Board of Public Utilities
CapEx	capital expenditures
CIP	Copenhagen Infrastructure Partners
COD	commercial operation date
DOE	U.S. Department of Energy
EDF	Électricité de France Renouvelables
EDPR	Energias de Portugal Renováeis
EnBW	Energie Baden-Württemberg AG
GW	gigawatt
HVDC	high-voltage direct current
IEC	International Electrotechnical Commission
IRENA	International Renewable Energy Agency
ITC	investment tax credit
kV	kilovolt
km	kilometer
LEEDCo	Lake Erie Energy Development Corporation
Berkeley Lab	Lawrence Berkeley National Laboratory
LCOE	levelized cost of energy
m	meter
MW	megawatt
MWh	megawatt-hour
nm	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
O&M	operation and maintenance
OEM	original equipment manufacturer
OpEx	operational expenditures
OREC	offshore renewable energy certificate
OWDB	offshore wind database
PPI	Principle Power Inc.
PPA	power purchase agreement
REC	renewable energy certificate
RPS	renewables portfolio standard
s	second
SIOW	Special Initiative on Offshore Wind
TBD	to be determined
WEA	wind energy area

Executive Summary

Offshore wind energy is a rapidly growing global industry that creates electricity from wind turbines installed in coastal waters on either rigid or floating substructures anchored to the seabed or lake bottom. The *2018 Offshore Wind Technologies Market Report* was developed by the National Renewable Energy Laboratory (NREL) with support from the U.S. Department of Energy (DOE) and is intended to provide offshore wind policymakers, regulators, developers, researchers, engineers, financiers, supply chain participants, and other stakeholders with up-to-date quantitative information about the offshore wind market, technology, and cost trends in the United States and worldwide. This report provides detailed information on the domestic offshore wind industry to contextualize the U.S. market and help policymakers, researchers, and the general public understand technical and market barriers and opportunities. Globally, the scope of the report covers the status of the 176 operating offshore wind projects through December 31, 2018, and provides the status of, and analysis on, a broader global pipeline of 838 projects in various stages of development.[1] To provide the most up-to-date discussion of this dynamically evolving industry, this report also tracks the most significant domestic developments and events from January 1, 2018, through March 31, 2019. The following is a summary of the key offshore wind market findings.

U.S. Offshore Wind Energy Market–Key Findings

The U.S. offshore wind energy project development and operational pipeline[2] grew to a potential generating capacity of 25,824 megawatts (MW), with 21,225 MW under exclusive site control.[3] The overall size of the U.S. offshore wind pipeline grew from 25,464 MW to 25,824 MW in 2018—about 1.4% growth. The 25,824 MW that make up the U.S. offshore wind project development and operating pipeline comprise one operating project (Block Island Wind Farm), eight projects that have reached the permitting phase with either a construction and operations plan or a viable offtake mechanism for sale of electricity, 15 commercial lease areas in federal waters with exclusive site control, two unleased wind energy areas, and five projects (all Pacific-based) that have submitted unsolicited applications to the Bureau of Ocean Energy Management (BOEM),[4] the government agency that regulates energy development in federal waters. The pipeline has three projects located in state waters, including the operating Block Island Wind Farm, the Aqua Ventus I floating-wind project in Maine, and the Lake Erie Energy Development Corporation Icebreaker Wind project on Lake Erie. In addition, there is one BOEM research lease in Virginia federal waters.

Offshore wind project development and regulatory activities span multiple U.S. regions. Historic development and regulatory activities were concentrated in the North Atlantic region from Virginia northward. New offshore wind activities have been initiated in the Pacific, Great Lakes, and South Atlantic regions as well. In the past, there have been project proposals and leasing activity in the Gulf of Mexico that have been limited to Texas state waters, but in 2018 offshore wind development and regulatory activity in this region was inactive. Figure ES-1 shows a map of offshore wind pipeline activity as of March 31, 2019, as well as BOEM Call Areas, for the entire United States.

---

[1] Note that the *2016 Offshore Wind Technologies Market Report* covered operating projects through June 30, 2017, with a focus on developments in 2016 and the first half of 2017 (Musial et al. 2017).

[2] The project development and operational pipeline, commonly referred to as "the pipeline," is represented by the database that the National Renewable Energy Laboratory uses to monitor the progress of the commercial offshore wind industry. It includes sites under development as well as operating projects. In the United States, the pipeline does not include Call Areas because their boundaries are not fixed. Unleased wind energy areas in the United States are included because they have a defined area.

[3] Federal law requires the Bureau of Ocean Energy Management to conduct a fair public auction for offshore wind sites in which there is interest from more than one developer (i.e., "competitive interest"). A developer cannot proceed until they have been awarded exclusive rights to the site through the competitive auction process.

[4] A lease area is a parcel of ocean area that is auctioned to prospective developers. Wind energy areas can comprise one or more lease areas. A Call Area is a precursor to a wind energy area.

State-level policy commitments accelerated, driving increased market interest. At the end of 2017, U.S. offshore state wind procurement policies totaled over 5,300 MW targeted for deployment by 2030. By early 2019, the sum of official state offshore wind capacity commitments increased to 19,968 MW by 2035. In 2018, new commitments were added in Massachusetts (additional 1,600 MW authorized by 2035), New York (6,600 MW added by 2035), and New Jersey (2,400 MW added by 2030), while Connecticut and Rhode Island both agreed to purchase power from Ørsted's 600-MW Revolution project. In 2019, new policy commitments were enacted in Connecticut (2,000 MW) and Maryland (1,200 MW). In some states without offshore-wind-specific targets, like California and Hawaii, 100% renewables portfolio standards and carbon reduction policies are driving these markets, which are progressing toward the creation of new offshore wind lease areas.

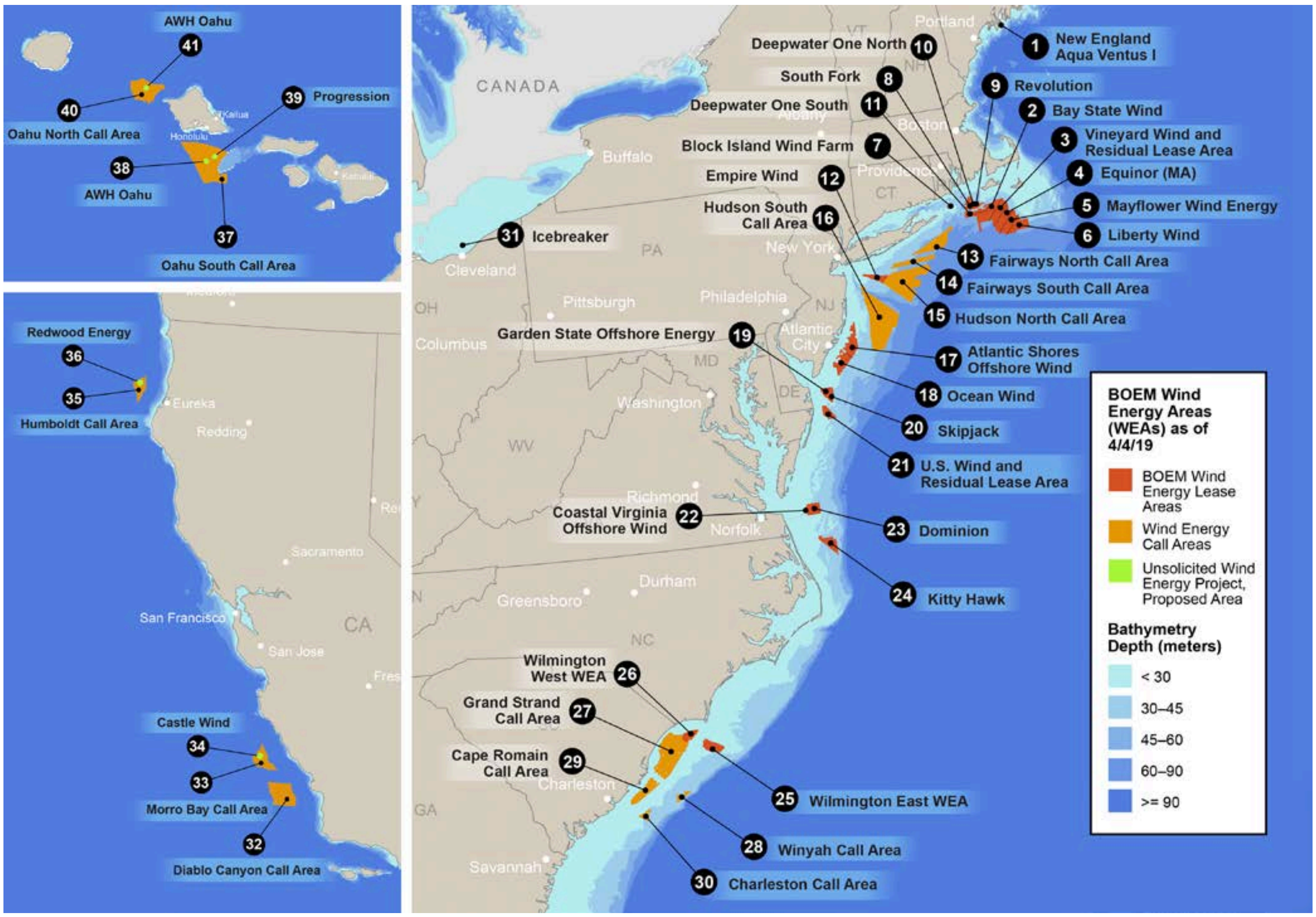


Figure ES-1. Locations of U.S. offshore wind pipeline activity and Call Areas as of March 2019. *Map provided by NREL*

Increased U.S. market interest spurred strong competition at offshore wind lease auctions. BOEM auctioned a total of 1,573 square kilometers (km^2), an area about half the size of Rhode Island, in three adjacent offshore wind lease areas off Massachusetts in December 2018. Each winner (Equinor, Mayflower Wind, and Vineyard Wind) submitted a bid of $135 million, more than tripling the previous lease area sale price record for a single lease area of $42 million in 2016 for the New York lease area submitted by Equinor. Higher offshore wind lease sale prices indicate 1) increased confidence in future market growth driven by state policies, 2) confidence in the regulatory and financial institutions to support offshore wind project development in the nascent U.S. market, 3) continued cost reductions, and 4) heightened demand for offshore wind in the northeastern United States.

Several U.S. projects advanced in the development process. U.S. offshore wind market progress was more evident from the advancement of major projects in the pipeline in 2018 than the capacity growth of the pipeline. Most notably, the commercial-scale Vineyard Wind project and Ørsted's Revolution project negotiated electricity sale offtake agreements with major electric distribution companies and utilities and took major steps in permitting at both the state and federal level. Overall, in the United States, four projects have submitted construction and operations plans, nine projects have had site assessment plans approved, and six have signed power offtake agreements. Vineyard Wind and South Fork are the most advanced commercial-scale U.S. projects, having both obtained a power purchase agreement (PPA) and completed state permits and site surveys, with a construction and operations plan under review by BOEM. Vineyard Wind reports a commercial operation date of 2022 for their Phase 1 facility, consisting of the first 400 MW.

Industry forecasts suggest U.S. offshore wind capacity could grow from 11 to 16 gigawatts (GW) by 2030. Figure ES-2 shows three industry forecasts for offshore wind deployment in the United States for the period extending to the year 2030. These estimates were developed by Bloomberg New Energy Finance (BNEF 2018a), 4C Offshore (2018), and University of Delaware's Special Initiative on Offshore Wind (SIOW 2019),[5] respectively. Together, they illustrate the degree of possible market growth as well as the potential variability associated with future deployment.

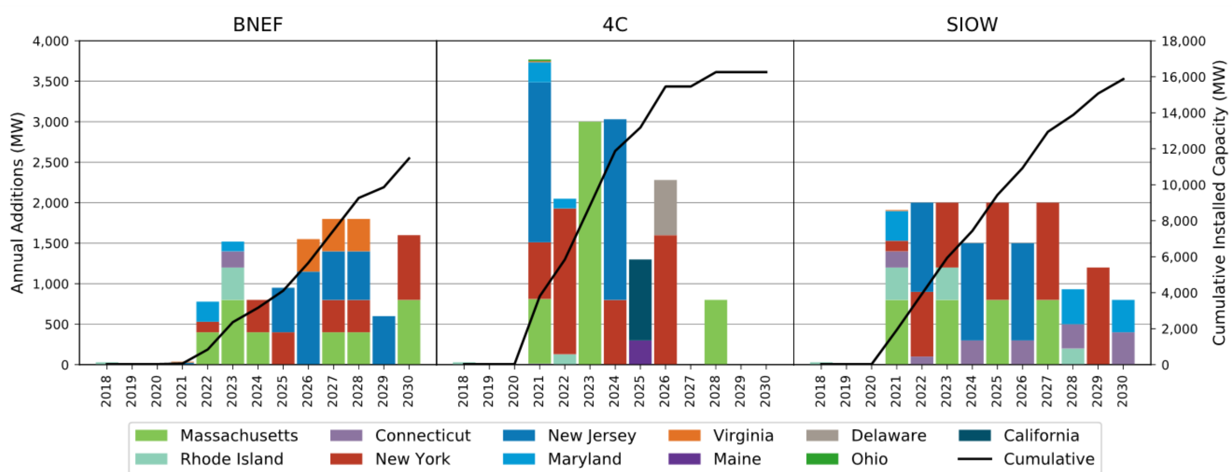


Figure ES-2. U.S offshore wind market forecasts for annual additions (left axis) and cumulative capacity (right axis) through 2030

Offtake prices for the first commercial-scale offshore wind project in Massachusetts were lower than expected. On July 31, 2018, Massachusetts electric distribution companies and Vineyard Wind LLC negotiated a PPA for delivery of offshore-wind-generated electricity at a first-year price of $74/megawatt-hour (MWh) (2022$) for Phase 1 (400 MW) and $65/MWh (2023$) for Phase 2 (400 MW). An NREL study showed that these PPA prices may not accurately reflect the true cost of the project at face value because other revenue sources, such as the investment tax credit, are not accounted for (Beiter et al. [2019]; see Section 5). Nevertheless, this price was lower than expected given the presumed risks associated with building the first U.S. commercial project with an immature U.S. supply chain. Vineyard Wind's apparent ability to access relatively low-cost financing and take advantage of the waning federal investment tax credit helped them set a competitive benchmark for the U.S. offshore wind industry. The Vineyard Wind PPA price provides a reference point for commercial-scale offshore wind generation in the United States that falls within the price

[5] Please note University of Delaware's SIOW forecast is based on the expected date a state selects to procure offshore wind capacity. A 3-year time lag is assumed from the time the procurement occurs until the project becomes fully operational.

range of European offshore wind projects scheduled to begin commercial operations in the early- to mid-2020s. Additional commercial price points are anticipated in New York and New Jersey in 2019.

Attention to offshore wind in California increased in 2018. California passed Senate Bill 100, The 100 Percent Clean Energy Act of 2018, making it the largest state to establish a 100% electric renewable energy goal, and setting a carbon-free target year of 2045. Amid continued negotiations with the U.S. Department of Defense, on October 18, 2018, BOEM published a Call for Information and Nominations and received 14 nominations from companies interested in commercial wind energy leases within three proposed Call Areas off central and northern California. All together, these three Call Areas total approximately 2,784 km^2 (687,823 acres), which could support an offshore-wind-generating capacity for nascent floating wind technology of up to 8.4 GW.

New national technical research consortium was launched to spur innovation. DOE has committed $20.5 million to the New York State Energy Research and Development Authority to form a National Offshore Wind R&D Consortium. The New York State Energy Research and Development Authority agreed to match the DOE contribution and launched a funding organization to make research and development awards on prioritized topics that will support developers in achieving their near-term deployment and cost targets. The first solicitation was released on March 29, 2019, and the first awards are expected in 2019.

Global Offshore Wind Energy Market–Key Findings

Globally, industry installed a record 5,652 MW of offshore wind capacity in 2018. Annual capacity additions increased by more than 50% relative to 2017. The increase in global generating capacity can be attributed to increased deployment in China, with 2,652 MW of new capacity, followed by 2,120 MW commissioned in the United Kingdom, 835 MW in Germany, 28 MW in Denmark, and about 17 MW divided among the rest of the world. By the end of 2018, cumulative global offshore wind installed capacity grew to 22,592 MW from 176 operating projects. Projections indicate 2019 global capacity additions will be even higher based on projects currently under construction. As of December 31, 2018, the global pipeline for offshore wind development capacity was about 272,000 MW.

The pace of European auctions slowed in the second half of 2018, but forecasts show sustained industry growth. European auction strike prices[6] in 2018 validated earlier cost reduction trends (see Section 5) but the number of auctions decreased, with only three occurring in the first two quarters of 2018. Adjusted strike prices[7] for these auctions ranged from $74/MWh to $79/MWh for commercial-scale projects. The slowdown can be partially attributed to the depletion of viable grid connections in the German markets (Foxwell 2018a). However, long-term forecasts indicate that this trend may be temporary as global offshore wind capacity is projected to reach between 154 and 193 GW by 2030, with more than 50% coming from Europe (and another major fraction coming from China).

Offshore Wind Energy Technology Trends–Key Findings

Industry is seeking accelerated cost reductions through larger turbines with rated capacities of 10 MW and beyond. Through technology innovation, turbine original equipment manufacturers have been able to limit the rise in turbine cost ($/kilowatt) and manage the increase in mass (kilogram/kilowatt) to allow turbine growth to continue upward to at least 12 MW, if not 15 MW, in the next decade. There are no indications that

[6] The strike price for an offshore wind project from an auction is usually the lowest bid price at which the offering can be sold. It usually covers a specific contract term for which that strike price will be paid for the energy produced. The offeror of that strike price is awarded the rights to develop a particular parcel under predetermined conditions set in the tender offer that may vary by country or market. It should not be confused with levelized cost of energy, which may be calculated using different financing and cost assumptions.
[7] The strike prices were adjusted to enable comparisons among projects in different countries to consider a range of possible subsidies and benefits that are available to some projects, such as the cost of the electrical grid connections.

turbine growth is slowing or has reached a limit for offshore wind. Although the market has experienced a steady upgrade of turbine drivetrain nameplate generating capacity, turbine rotor diameters have grown more slowly. The Vestas V174-9.5 is currently the largest machine in the commercial market (Richard 2019). However, the next generation of turbines promises larger rotors and lower specific power ratings[8] suited for U.S. offshore markets in the next few years. Specific examples of next-generation turbines include Siemens Gamesa SG 10.0–193DD turbine announced in January 2019, which is planned by Siemens Gamesa to be market ready by 2022, and the GE Haliade-X 12-MW turbine, which should arrive on the market by 2021 (Siemens 2019; GE 2018b).

Adoption of 66-kV(kilovolt) array cables is increasing to lower electrical infrastructure costs. As the rated power capacity of offshore wind turbines continues to grow, project developers and operators are increasing their use of 66-kV array cable technology instead of the conventional 33-kV systems to connect individual turbines within an array. In 2018, three projects incorporated 66-kV array cables versus only one in 2017. Operation at a higher voltage offers important life cycle cost-efficiency benefits, such as the possibility of reducing the number of offshore substations, decreasing the overall length of installed cables, and minimizing electric losses. During 2018, the 66-kV technology was demonstrated by Nexans in three pilot wind power plant projects: the Blyth Offshore Demonstrator (United Kingdom), Nissum Bredning Vind (Denmark), and Aberdeen Bay (United Kingdom).

The floating wind energy project pipeline is growing, with multiple floating pilot projects advancing. The global pipeline for floating offshore wind energy reached 4,888 MW in 2018. The pipeline comprises 38 announced projects, including 46 MW of operating projects. The floating offshore wind energy industry is well into a second-generation, multiturbine, precommercial pilot phase. There are 14 projects representing approximately 200 MW that are currently under construction, having achieved either financial close or regulatory approval. These projects are distributed over nine countries. Figure ES-3 shows a turbine in Equinor's 30-MW floating array off the coast of Peterhead, Scotland—the world's first commercial floating wind energy project—which is now operating into its second year.

[8] Specific power is the ratio of the nameplate rating of the turbine divided by the rotor's swept area and is given in Watts per meter squared.

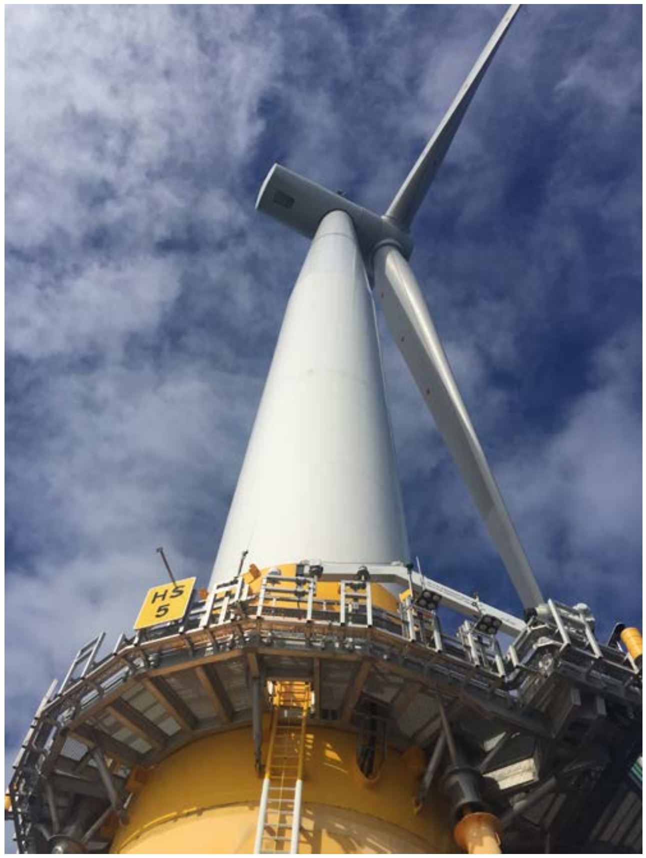


Figure ES-3. A 6-MW floating wind turbine in Equinor's 30-MW array near Peterhead, Scotland.
Photo from Walt Musial, NREL

Semisubmersible substructures dominate the market for floating support structures, but new hybrid platform technologies are being introduced that could compete in future projects. Semisubmersibles, which use buoyancy and the water plane area to achieve stability, make up 94% of floating projects on a capacity-weighted average because they are inherently a stable buoyant floating substructure with low draft that allows for in-port or nearshore assembly. Several new hybrid technologies (platforms that combine the characteristics of spars, tension-leg platforms and semisubmersibles) are being introduced this year that may rival these substructures. Stiesdal Offshore Technologies's TetraSpar and the SBM tension leg platform are highlighted in Section 4 and may be deployed as early as 2019.

Offshore Wind Energy Cost and Price Trends–Key Findings

Offshore wind auction strike prices in 2018 validate current cost reduction trends. Prices from European offshore wind auctions and PPAs in 2018 help validate the previously documented trends indicating prices dropping from approximately $200/MWh for projects beginning operation between 2017 and 2019 to approximately $75/MWh for projects beginning operation between 2024 and 2025. In the United States, Vineyard Wind LLC signed two PPAs with Massachusetts electric distribution companies in July 2018 for a combined 800 MW of offshore wind capacity expected to become operational in 2022 and 2023, respectively. After adjusting for contract type, transmission, policy, and access to external revenue, the Vineyard Wind project has an all-in price of $98/MWh. The Vineyard Wind price point indicates that U.S. projects may not be subject to a large price premium because of nascent U.S. market structures or a limited domestic supply chain. Figure ES-4 indicates the adjusted Vineyard Wind PPA prices are competitive with European offshore wind prices.

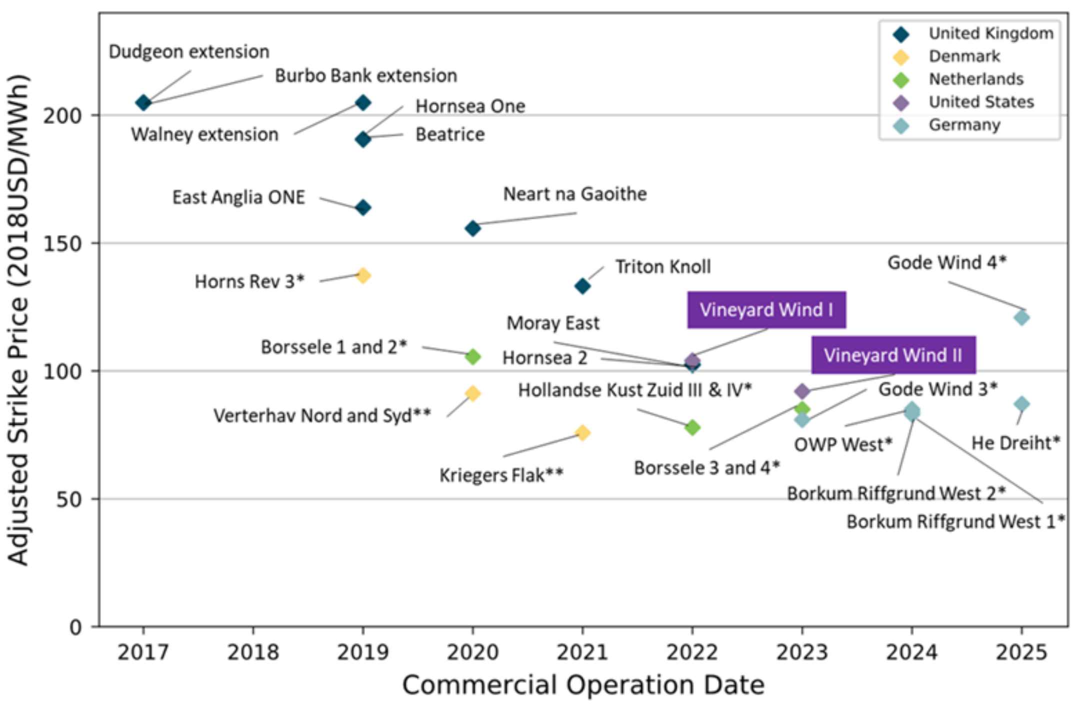


Figure ES-4. Adjusted strike prices from European offshore wind auctions

Sources: 4C Offshore (2018, 2019) and Beiter et al. 2019

Notes: *Grid and development costs added; **Grid costs added and contract length adjusted

Future Outlook

Offshore wind market projections show accelerated growth in the next decade, with cumulative capacity ranging from 154 to 193 GW by 2030, and long-range predictions of over 500 GW by 2050 (BNEF 2018a; 4C Offshore 2018; International Renewable Energy Agency 2018). In this context, offshore wind is still at an early stage with respect to the maturity of the technology, supply chain, and infrastructure. The pace of progress and development of the global supply chain is likely to be strongly influenced in the near term by the growth in turbine generating capacity, rising toward 15 MW. Although larger turbines improve project costs in the long run, they may also delay industry maturity. It may take several years for the corresponding industrial facilities and infrastructure needed for fabrication, installation, and maintenance to stabilize at ever-increasing turbine scales. This upscaling issue is likely to persist not only in the United States but globally as well.

In the United States, individual states may continue to push for greater commitments for offshore wind, but further declines in offshore wind offtake prices are far from certain in the near term. Offshore wind projects, such as Vineyard Wind, will be able to take advantage of the expiring investment tax credit (see Section 5.1.1.), which will enable low prices (on par with Europe) for the first commercial solicitation in Massachusetts. However, as the investment tax credit expires in 2020, projects will have to make up the difference by raising prices or lowering costs. This may increase the urgency to implement near-term solutions to manage costs, such as developing U.S.-flagged Jones-Act-compliant vessels or accelerating the growth and maturity of the domestic manufacturing supply chain (see Section 4).

If demand for offshore wind energy continues to increase in states along the U.S. Atlantic and Pacific coasts, as it did in 2018, state policy commitments that are now almost 20 GW could exceed the capacity of the available sites. Presently, there is just over 21 GW of capacity in BOEM lease areas where developers have been granted exclusive site control. Additional state policy commitments may create possible site shortages in some regions, which could trigger the development of more lease areas.

1 Introduction

Offshore wind energy is a rapidly growing global industry that creates electricity from large wind turbines installed in coastal waters on either rigid or floating substructures anchored to the seabed or lake bottom. The *2018 Offshore Wind Technologies Market Report* was developed by the National Renewable Energy Laboratory (NREL) for the U.S. Department of Energy (DOE) to provide offshore wind policymakers, regulators, developers, researchers, engineers, financiers, and supply chain participants with up-to-date quantitative information about the offshore wind market, technology, and cost trends in the United States and worldwide. This report includes detailed information on the domestic offshore wind industry to provide context to help navigate technical and market barriers and opportunities. It also covers the status of the 176 operating offshore wind projects in the global fleet through December 31, 2018, and provides the status and analysis on a broader global pipeline of 838 projects at varying stages of development. In addition, this report provides a deeper assessment of domestic developments and events through March 31, 2019, for this dynamically evolving industry.

This report includes data, obtained from a wide variety of sources about offshore wind projects that are both operating and under development, to offer current and forward-looking perspectives. It is a companion to the *2018 Wind Technologies Market Report* and *2018 Distributed Wind Market Report* funded by DOE and written by the Lawrence Berkeley National Laboratory (Berkeley Lab) (Wiser et al. 2019) and Pacific Northwest National Laboratory (Orrell et al. 2019), respectively. The reports cover the status of utility-scale and distributed, land-based wind energy located primarily in the United States, and provide quantitative, independent data for use by the wind industry and its various stakeholders.

Global offshore wind deployment in 2018 set a new record for a single year (5,652 megawatts [MW]), and optimism for the future is high, with long-term industry projections of over 150 gigawatts (GW) by 2030 and over 500 GW by 2050 (Bloomberg New Energy Finance [BNEF] 2018b; 4C Offshore 2018; International Renewable Energy Agency [IRENA] 2018). However, 2018 was somewhat unusual by historical standards as the Chinese market saw its largest deployment ever, with over 2,600 MW of new installations. Offshore wind in Europe installed 2,994 MW, representing about 50% of the new installed capacity.

The offshore wind market in the United States evolved rapidly in 2018 because of a series of positive global and domestic market growth indicators. After bids for a few offshore wind projects in Europe reinforced developers' confidence of zero-subsidy projects in some markets, the United States also saw low-price signals from its first commercial project. In 2018, the U.S. market logged the first competitive bid for an 800-MW commercial wind power plant—Vineyard Wind—in Massachusetts, which seemed to indicate that European market prices can be achieved in the northeastern United States for projects commissioned as early as 2022. The possibility of achieving European offshore wind price levels in U.S. waters coincided with a new wave of state policy support for offshore wind, which originally began in 2016, but increased in late 2018 through the present day. Several new states made offshore wind commitments in 2018, whereas several of the already-committed states aggressively increased their commitments (McClellan 2019). In addition, market optimism likely helped drive lease area auction prices to record highs, as observed in the Massachusetts wind energy area (WEA) lease sales in December 2018 ($135 million per lease area), which were each three times higher than the previous winning lease area bid in New York just 2 years earlier. These record-high prices may indicate a heightened demand for new WEAs as well as an increase in the financial caliber of the bidders, as new members of well-capitalized oil companies and utilities try to establish themselves as offshore wind developers in the emerging U.S. market. All told, the U.S. market developments in 2018 appear to be laying the groundwork for the formation of a new multibillion-dollar offshore wind industry that is likely to bear fruit in the next 5 to 10 years (BNEF 2018a; 4C Offshore 2018; McClellan 2019).

The data and information in this report provide insight into the domestic and global market status, technology trends, and costs, and are key inputs to the annual *Cost of Wind Energy Review* report, which provides an updated summary of the cost of land-based and offshore wind energy in the United States to support DOE's programmatic reporting on the cost of wind energy (Stehly et al. 2017, 2018).

1.1 Approach and Method

1.1.1 NREL Offshore Wind Database

The *2018 Offshore Wind Technologies Market Report* uses NREL's internal offshore wind database (OWDB), which contains information on more than 1,700 offshore wind projects located in 49 countries and totaling approximately 623,329 MW of announced project capacity (both active and dormant). The database includes both fully operational projects dating back to 1990 and anticipated future projects that may or may not have announced their commercial operation date (COD). The OWDB contains information on project characteristics (e.g., water depth, wind speed, distance to shore), economic attributes (e.g., project- and component-level costs and performance), and technical specifications (e.g., component sizes and masses). The database also contains information on installation and transport vessels, as well as ports used to support the construction and maintenance of offshore wind projects.

The OWDB is built from internal research using a wide variety of data sources including peer-reviewed literature, press releases, industry news reports, manufacturer specification sheets, subscription-based industry databases, and global offshore wind project announcements. Unless stated otherwise, the data analysis in this report—both globally and domestically—is derived by NREL from the OWDB and reflects the best judgment of the authors and industry subject matter experts that were consulted. To ensure accuracy, NREL verified the OWDB against the following sources:

- The 4C Offshore Wind Database
- The Bureau of Ocean Energy Management (BOEM)
- The WindEurope Annual Market Update
- BNEF's Renewable Energy Project Database
- The University of Delaware's Special Initiative on Offshore Wind (SIOW).

Although the data were validated and harmonized with these other sources, minor differences in their definitions and methodology may cause the data in this report to vary from data reported in other published reports. For example, the method for counting annual capacity additions often varies among different sources, because of terms such as "installed" or "operational," and "first power" or "commercial operation date" are defined differently. NREL considers a project to be commercially operational when all turbines are fully operational and transmitting power to a land-based electricity grid (see Table 1). Data may also vary in quality and are subject to high levels of uncertainty, especially data for future projects that are subject to change based on developer and regulatory requirements. Despite annual variability and potential future project-level uncertainty, longer-term trends reported elsewhere are consistent with long-term market trends in NREL's OWDB.

Cost and pricing data in the OWDB span a lengthy time period and are reported in different currencies. To analyze these data, all information in this report were normalized into 2018 U.S. dollars (USD) by:

- Converting costs and prices to USD, using the exchange rate for the year in which the latest data were reported (United States Treasury Bureau of Fiscal Service 2019)
- Inflating the values, which are in nominal USD after the exchange rate conversion, to 2018 USD using the U.S. Consumer Price Index (United States Department of Labor Bureau of Statistics 2019).

1.1.2 Classification of Project Status

The "pipeline" is an offshore wind project development and operating project tracking process, which provides the ability to follow the status of a project from early-stage planning through decommissioning. The primary tracking method is aligned with the regulatory process. All offshore wind projects must navigate through the regulatory process that formally begins when a regulator initiates a leasing process to offer developers the opportunity to bid for site control through a competitive lease auction[9] or when an unsolicited project application is formally submitted. In parallel with the regulatory process is the developer's efforts to characterize the economic viability of the project and its capability for long-term energy production to obtain financing. The parallel regulatory and financing pathways have several dependencies, but information about the regulatory path is more easily accessed in the public domain and is therefore the primary method used to track projects in this report. Therefore, the "pipeline" is defined as the set of all offshore wind projects, beginning with those that have formally entered the regulatory leasing process to bid for site control and development rights through projects that have been decommissioned. If known, information on a project's offtake mechanisms and financial close is specifically reported as well.[10]

Offshore wind projects remain in the pipeline from early-stage planning through the operating and decommissioning phases. In the early stages of a project, the exact project footprints and capacities are not always known, but NREL assumes that all lease areas will eventually be fully developed with an array density of 3 MW/square kilometer (km^2). This is a common metric for computing the available wind resource over an area but is not meant to be restrictive (Musial et al. 2013, 2016). Some developers may want higher array densities for their lease areas, or conversely, could decide or be required to leave areas undeveloped for various reasons. The pipeline is adjusted when these decisions are publicly announced.

Table 1 describes the system used in this report for classifying and tracking the development of offshore wind projects and that has been used in past DOE-sponsored offshore wind market reports (Smith, Stehly, and Musial 2015; Musial et al. 2017; Beiter et al. 2018). Note that the criteria used in Table 1 also apply to the global project classification, but some differences may not allow for direct comparisons, especially during the earlier stages of planning. This disconnect is mainly because some countries have different methods of establishing "site control."

[9] Applies to U.S. projects on the Outer Continental Shelf but varies internationally and in state waters.

[10] The "pipeline" is often measured by the quantity of policy commitments made by states. These figures are tracked separately in Section 2.4.2 and offer a good metric for comparison.

Table 1. Offshore Wind Project Pipeline Classification Criteria

Step	Phase Name	Start Criteria	End Criteria
1	Planning	Starts when a developer or regulatory agency initiates the formal site control process	Ends when a developer obtains control of a site (e.g., through competitive auction or a determination of no competitive interest in an unsolicited lease area [United States only])
2	Site Control	Begins when a developer obtains site control (e.g., a lease or other contract)	Ends when the developer files major permit applications (e.g., a construction and operations plan for projects in the United States) or obtains an offtake agreement
3	Permitting = Site Control + Offtake Pathway	Starts when the developer files major permit applications (e.g., construction and operations plan or obtains an offtake agreement for electricity production)	Ends when regulatory entities authorize the project to proceed with construction and certify its offtake agreement
4	Approved	Starts when a project receives regulatory approval for construction activities and its offtake agreement	Ends when sponsor announces a "financial investment decision" and has signed contracts for construction work packages
5	Financial Close	Begins when sponsor announces a financial investment decision and has signed contracts for major construction work packages	Ends when project begins major construction work
6	Under Construction	Starts when offshore construction is initiated[11]	Ends when all turbines have been installed and the project is connected to and generating power for a land-based electrical grid
7	Operating	Commences when all turbines are installed and transmitting power to the grid; COD marks the official transition from construction to operation	Ends when the project has begun a formal process to decommission and stops feeding power to the grid
8	Decommissioned	Starts when the project has begun the formal process to decommission and stops transmitting power to the grid	Ends when the site has been fully restored and lease payments are no longer being made
9	On Hold/Cancelled	Starts if a sponsor stops development activities, discontinues lease payments, or abandons a prospective site	Ends when a sponsor restarts project development activity

1.2 Report Structure

The remainder of the report is divided into four sections:

- Section 2 summarizes the status of the offshore wind industry in the United States, providing in-depth coverage on the project development pipeline, regulatory activity, offtake mechanisms, infrastructure trends, and regional developments.
- Section 3 provides an overview of the global offshore wind market. Operational and proposed future projects are tracked by country, status, commercial operation date, and capacity. Developments on international floating offshore wind projects are also covered in detail.
- Section 4 describes offshore wind siting and technology trends focusing on turbine technologies, turbine manufacturers, project performance, fixed-bottom substructures, electrical power, export systems, and floating technologies.
- Section 5 provides insight into global and domestic offshore wind prices, capital and operational costs, and financing trends for both fixed-bottom and floating technologies. This section also compares historical and forecasted future prices between the European and U.S. offshore wind markets.

[11] Note that some developers may elect to start construction at an onshore landing area to secure certain subsidies or tax incentives.

2 U.S. Offshore Wind Market Assessment

2.1 U.S. Offshore Wind Industry Overview

In 2018, the U.S. offshore wind market continued to attract significant attention from the global community, primarily brought on by a large increase in state policy commitments. From the end of 2017 until June 10, 2019, the total offshore wind capacity that was committed by the states nearly quadrupled. At the end of 2017, U.S. state offshore wind procurement policies required over 5,300 MW of offshore wind by 2030. By June 2019, the sum of official state offshore wind targets increased to 11,468 MW by 2030 and 19,968 MW by 2035. Even in states without offshore wind procurement targets like California and Hawaii, 100% renewables portfolio standards (RPS), clean energy, or carbon reduction goals are driving new market activity and the potential development of new offshore wind lease areas.

The U.S. offshore wind project pipeline was 25,824 MW at the end of 2018, remaining relatively constant, with only a 1.4% increase in total pipeline capacity relative to 2017. Multiple projects made significant progress with electricity offtake agreements and environmental permitting at both the state and federal level. Currently, nine projects have an offtake agreement or are negotiating offtake terms. State-level procurement goals have increased the attractiveness of the U.S. offshore wind market and encouraged competition between developers at recent BOEM auctions. BOEM's auction of three offshore wind lease areas off Massachusetts in December 2018 established a new lease sale price record of $135 million each, more than tripling the previous record of $42 million, signaling increased market confidence, higher demand, and the existence of a committed pool of well-capitalized bidders (BOEM 2019a, 2019b). Interest in the Pacific offshore wind markets also continued to grow in 2018 (BOEM 2019c). BOEM issued Calls for Information and Nominations for offshore wind development in California prompted by multiple prospective floating wind developers. In addition, a 20-year power purchase agreement (PPA) signed with Vineyard Wind in 2018 revealed a first-year price of $74/megawatt-hour (MWh) (2022$) and $65/MWh (2023$), respectively (Beiter et al. 2019).

Despite an increasing number of offshore wind projects submitting their construction and operations plans and engaging local suppliers, supply chain investment in the United States was not commensurate with regulatory advancement. There has yet to be a U.S.-flagged installation vessel or any domestic manufacturing centers built. Also, states have not yet engaged significantly in land-based grid planning or transmission infrastructure upgrades necessary to integrate the expected levels of offshore wind power (Lefevre-Marton et al. 2019). Nevertheless, two U.S.-flagged crew transfer vessels are being built, multiple ports received significant investments to upgrade infrastructure, and states have developed portals to connect developers with local suppliers. Moreover, the near-term lag in the development of a robust domestic supply chain may not be a barrier to the first few commercial-scale projects because the European supply chains can serve the U.S. market in the near term. At the same time, delays in the development of the domestic supply chain could force U.S. project costs above European market costs for large-scale commercial deployment in the mid-2020s and beyond. New technical programs sponsored by DOE and others aim to spur innovation and increase industry supply chain activity (New York State Energy Research and Development Authority [NYSERDA] 2019).

2.2 U.S. Offshore Wind Market Potential and Project Pipeline Assessment

2.2.1 U.S. Offshore Wind Pipeline

As of December 31, 2018, NREL estimates the U.S. offshore wind pipeline to be 25,824 MW of capacity, which is based on the sum of current installed projects, existing lease areas, unleased WEAs, and unsolicited project applications. Table 2 shows the U.S. market broken into five segments by capacity. The U.S. pipeline capacity has one operational project (30 MW), 15 lease areas where developers have site control (estimated 19,151 MW), two unleased WEAs (estimated 2,250 MW), and five unsolicited project applications (2,350 MW). Only installed projects (30 MW) and projects with site control that have advanced through the initial permitting process and are negotiating offtake agreements (2,043 MW) use actual developer-specified capacity values. This is roughly 8% of the total capacity, or 2,073 MW. These projects have a clear project plan and a site boundary that has been specified including much of the design details.

The rest of the pipeline capacity in the other three categories—lease areas with site control, unleased WEAs, and unsolicited project applications—are all estimations based on the potential of the lease area using a capacity density function of 3 MW/km^2 (Musial et al. 2016). Therefore, these estimated values are likely to change over time as project parameters are defined more precisely and lease areas are converted from an unspecified or residual area to actual project capacity. Figure 1 shows each of those categories as a percent of the total U.S. pipeline.

Table 2. U.S. Offshore Wind Pipeline Capacity for Five Categories

	Status	Description	Capacity
1	**Installed**	The project is fully operational with all turbines generating power to the grid.	30 MW
2	**Projects Permitting with Site Control and Offtake Pathway**	The developer has site control and has initiated permitting processes to construct the project and sell its power.	2,043 MW
3	**Lease Areas with Site Control**	Developer has acquired the rights to a lease area. Capacity is estimated using a turbine density of 3 MW/km^2. Depending on market demand, developers may or may not incrementally build out projects to use a given lease area's entire size/potential.	19,151 MW (Estimated)
4	**Unleased Wind Energy Areas**	The rights to lease areas have yet to be auctioned to developers. Capacity is estimated using a 3 MW/km^2 turbine density function.	2,250 MW (Estimated)
5	**Unsolicited Project Applications**	Developer lacks site control but has submitted a project proposal to BOEM. Project application capacities estimated using a 3-MW/km^2 density and project footprint size identified in the proposal.	2,350 MW (Estimated)
		Total	**25,824 MW**

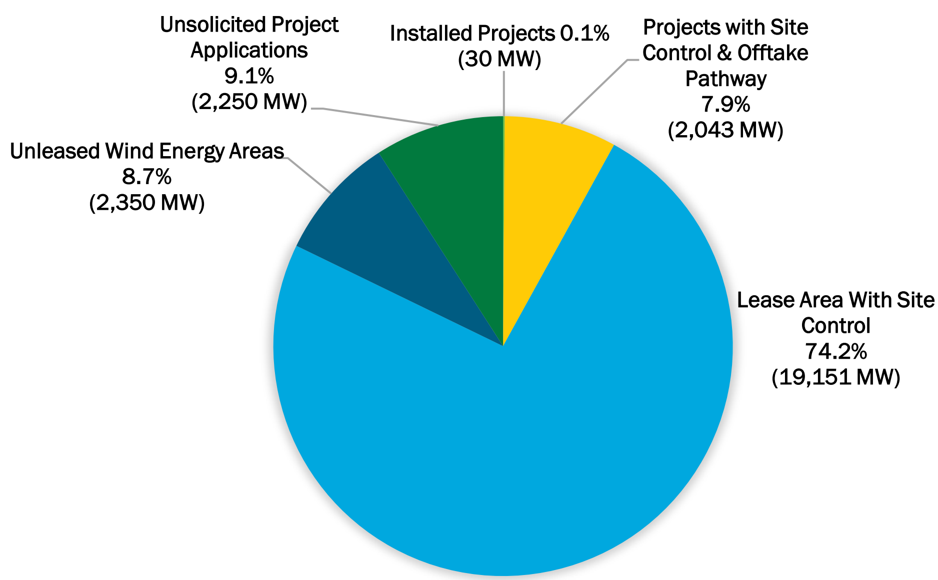


Figure 1. Percentages of U.S offshore wind pipeline (25,824 MW) by classification category

Figure 2 shows the U.S. pipeline activity as of June 10, 2019, for all categories shown in Table 1 by state.[12] Breaking down the 2018 U.S. pipeline by project status: one project (30 MW) has been installed; nine projects (2,043 MW) have site control, made major permitting progress, or secured a power offtake contract or have a viable pathway to obtaining one; developers have the rights to possibly develop projects in 15 lease areas with a technical potential of 19,151 MW; two unleased WEAs have the potential to support 2,250 MW; and six unsolicited project applications (2,350 MW) may be developed but must comply with BOEM's competitive leasing processes. Projects progressing through offtake and permitting approval processes continued to be primarily located in the northeast United States, where state-level procurement drives the market and project development. However, there is also an increased interest in developing floating projects along the Pacific Coast, as described in Section 2.3.2.

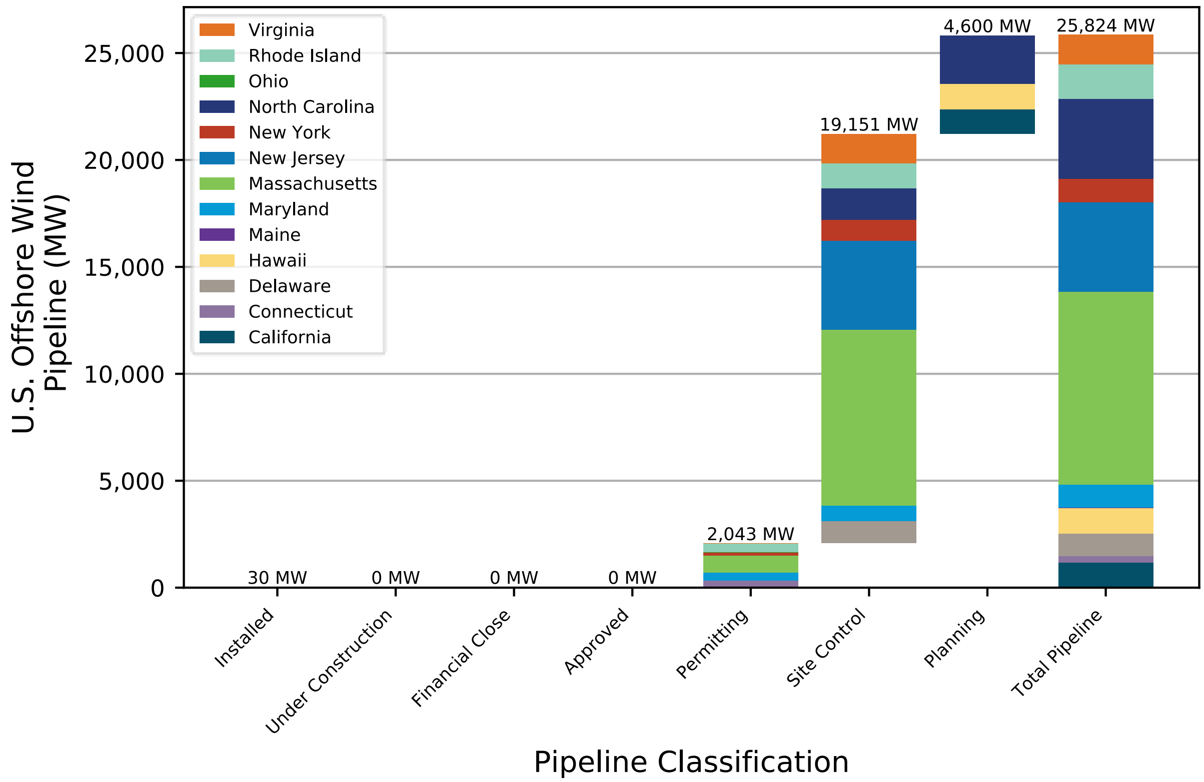


Figure 2. U.S. project pipeline classification by state[13]

There were only minor changes in NREL's estimation of the U.S. offshore wind pipeline from 2017 to 2018 (reporting 25,464 MW in 2017 [Beiter et al. 2018]). The cancellation of the Nautilus Offshore Wind Project in New Jersey accounted for a 24-MW reduction; the expansion of South Fork from 90 MW to 130 MW shifted 40 MW from the Deepwater One North lease area; the Redwood Coast Offshore Wind Project in California added 150 MW; and the proposed Castle Wind Project in California increased its capacity from 765 MW to 1,000 MW. All told, the pipeline only increased by a slight 1.4%.

---

[12] State in Figure 2 refers to the state the project intends to sell its power to. If a project has not signed an offtake agreement, the state refers to its physical location.

[13] The location of the project is defined by where the project's power is intended to be sold. If the project does not have an offtake agreement, the location is its physical location. This clarification is needed where projects are located in a certain location but sell their power to a neighboring state market.

Figure 3 provides a different breakdown of the U.S. pipeline by state. From the chart, Massachusetts, New Jersey, and North Carolina possess the most offshore wind potential[14] as of March 31, 2019. Note that the hashed bars on the chart indicate the pipeline capacity that was estimated on a 3 MW/km^2 area basis and the solid (green) colored bars are specific projects.

It is important to be cautious about interpreting these geographic lease areas that have been assigned to specific states, because their physical location does not indicate where the offshore wind power will ultimately be delivered. For example, power from Massachusetts can feasibly be delivered to New York and vice versa. In this sense, projects being developed in nearby WEAs may sell power and other grid services to adjacent states because of market demand, state-level offtake policies, or other factors. Current projects in the pipeline that plan to sell power to neighboring markets include:

- Revolution Wind in the Rhode Island/Massachusetts WEA is planning to deliver power to both Connecticut and Rhode Island
- South Fork in the Rhode Island/Massachusetts WEA is planning to deliver power to Long Island New York
- Skipjack in the Delaware WEA is planning to deliver power to the Delmarva grid in Maryland.

Accordingly, state policy may be a more important driver in determining what projects move forward and which markets they serve than the physical location of the leases.

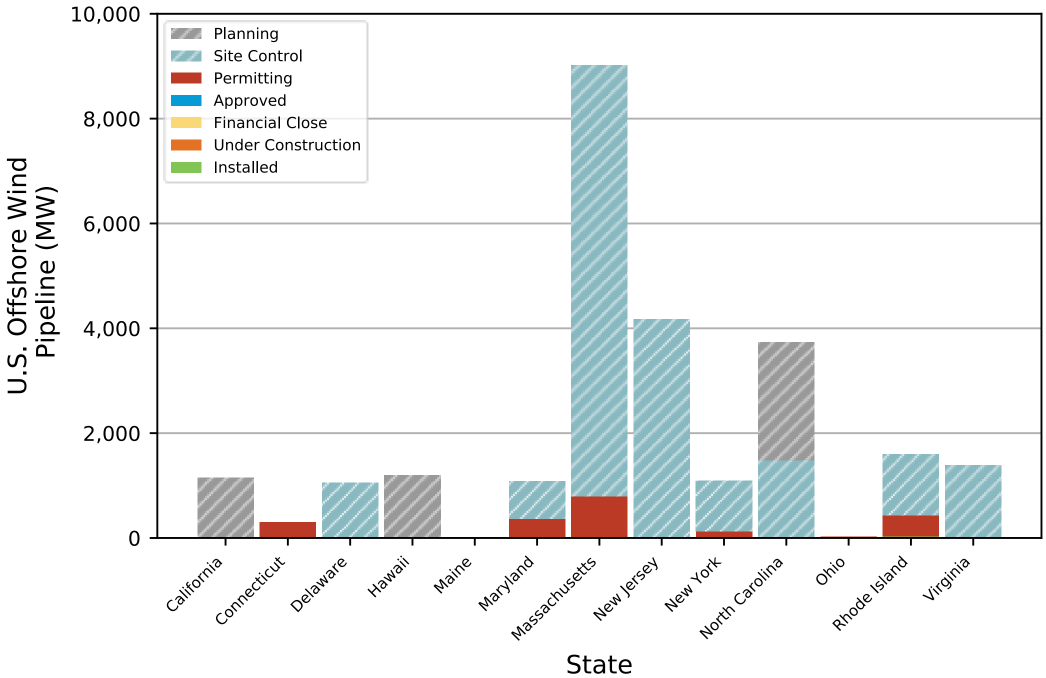


Figure 3. U.S. project pipeline by state[15]

[14] Offshore wind potential estimates are made with a significant amount of uncertainty. Uncertainty comes from future market demand, assumed density function, and regulatory proceedings.
[15] The location of the project is defined by where the project's power is sold to. If the project does not have an offtake agreement, the location is the project's physical location. This clarification is needed for projects located in a state's WEA that sells their power to a neighboring state market.

All of the 25,824 MW that make up the U.S. offshore wind pipeline in the United States are itemized as an individual project or project opportunity in Table 3, and in the maps shown in Figures 4, 5, and 6, corresponding to the eastern Atlantic Coast (and Great Lakes[16]), California Coast, and Hawaii, respectively.

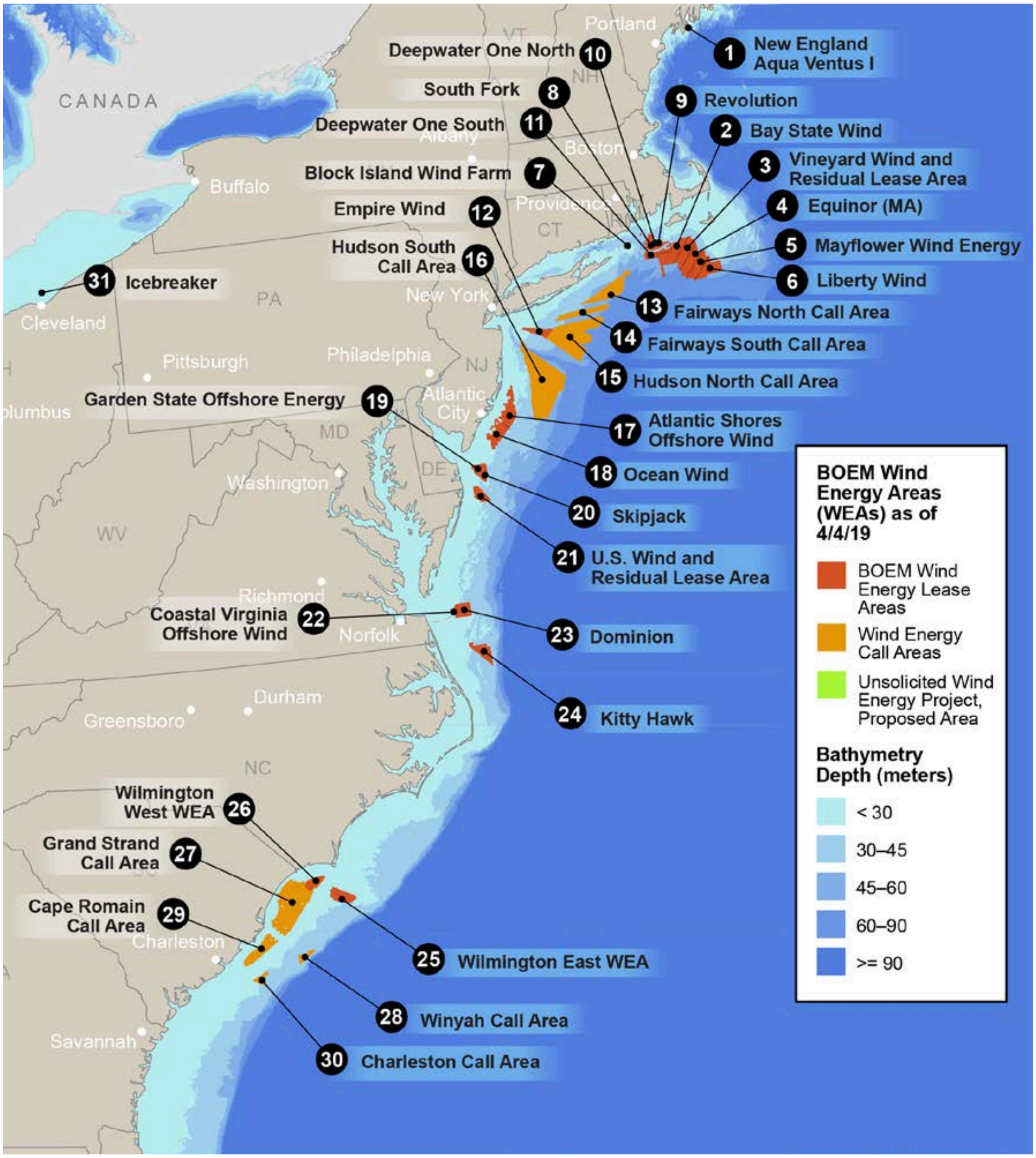


Figure 4. Locations of U.S. Atlantic Coast offshore wind pipeline activity and Call Areas as of March 2019.
Map provided by NREL

[16] Please note the Great Lakes are outside BOEM's jurisdiction.

Most activity is concentrated in the North Atlantic region (Figure 4), but the pipeline activities extend to the Pacific, Great Lakes, and South Atlantic regions. Although there is interest in offshore wind development in the Gulf of Mexico, proposed projects and leasing activities have remained inactive since 2014.

In addition, Table 3 includes 13 Call Areas[17] that are located in three regions, but the capacity of the Call Areas is not calculated or counted in the total pipeline capacity because Call Areas are too preliminary and likely to change in size and location. In total, there are 41 sites in the United States (as shown on the maps) where there is significant offshore wind development activity. The 25,824 MW of pipeline activity comprises

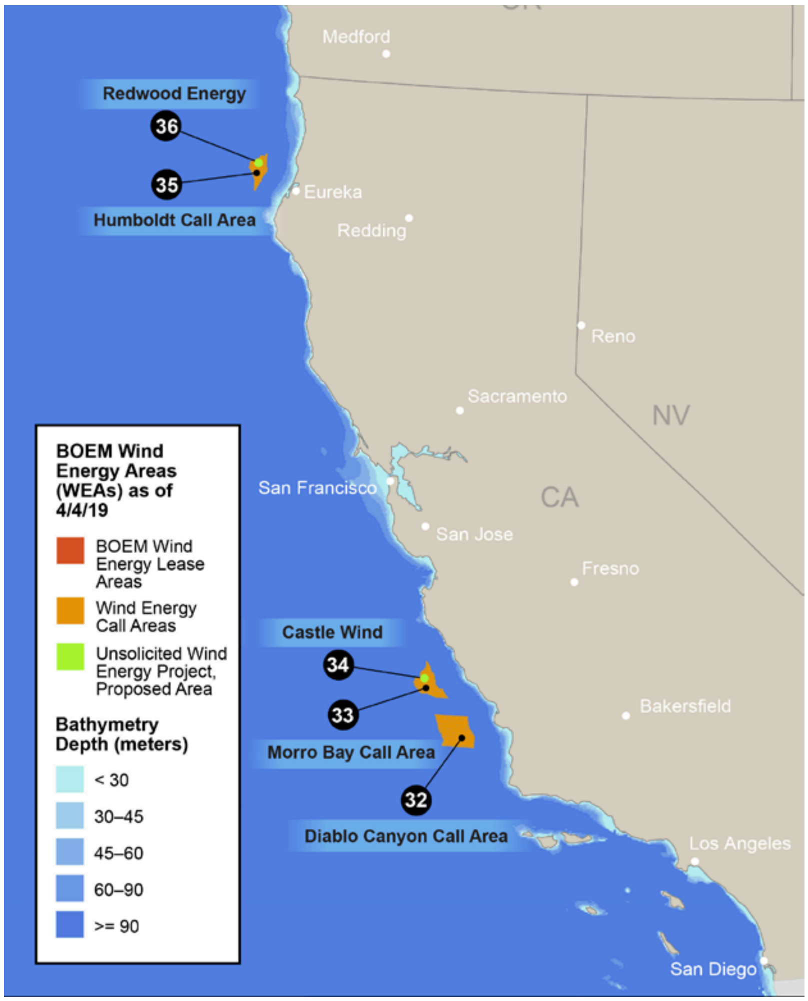


Figure 5. Locations of U.S. West Coast offshore wind pipeline activity and Call Areas as of March 2019.
Map provided by NREL

one operating project (Block Island Wind Farm), nine projects at the permitting phase with an offtake strategy, 15 lease areas with exclusive site control, two unleased WEAs, and five projects (all Pacific-based) that have submitted unsolicited applications to BOEM (BOEM 2019c, 2019d). The pipeline has three projects located in state waters, including the operating Block Island Wind Farm in Rhode Island, New England Aqua Ventus I in Maine, and the Lake Erie Energy Development Corporation (LEEDCo) Icebreaker project located in Lake

[17] BOEM periodically issues calls for information and nominations (Call Areas) to obtain public and developer feedback on what ocean areas may be suitable for future commercial offshore wind development.

Erie, just north of Cleveland. Both Aqua Ventus and Icebreaker were originally funded under the DOE Advanced Technology Demonstration Project program, which began in 2012 (DOE 2019). As a result, they have advanced further in the permitting process than many other projects, having acquired most site approvals from their respective states and establishing reasonable pathways to finalize their PPAs.

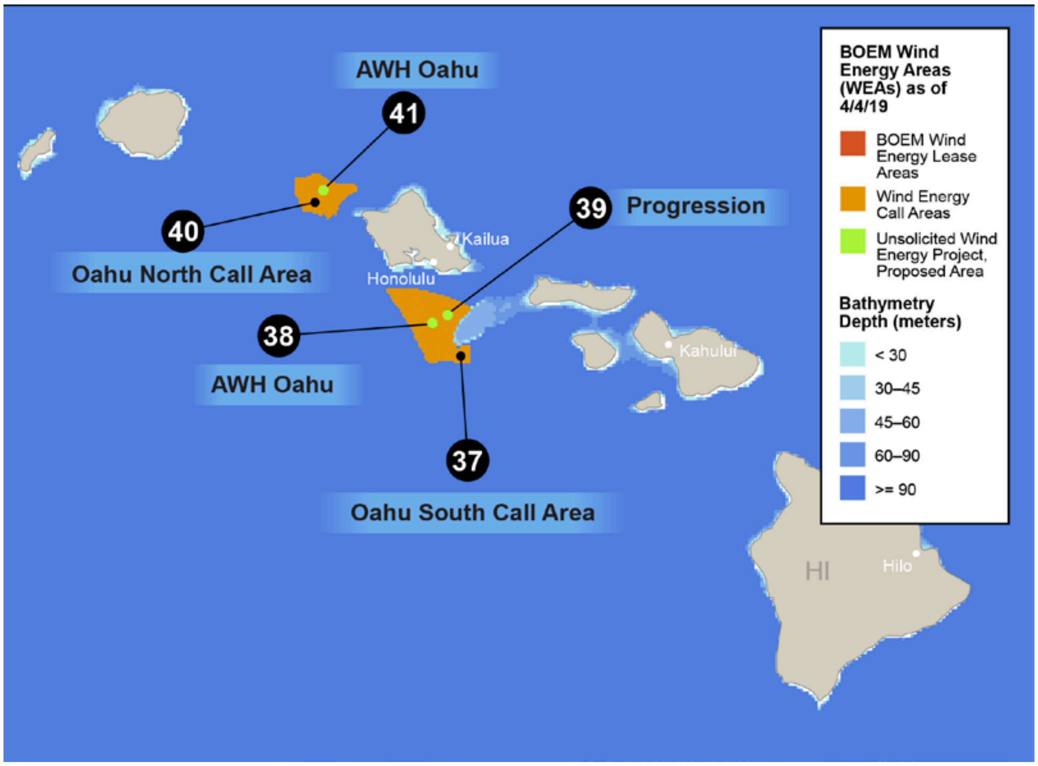


Figure 6. Locations of Hawaiian offshore wind pipeline activity and Call Areas as of March 2019.
Map provided by NREL

Table 3. 2018 U.S. Offshore Wind Pipeline

#	Location[1]	Project Name[2]	Status	COD[3]	Announced Capacity (MW)[4]	Lease Area Potential (MW)[5]	Pipeline Capacity (MW)[6]	Lease Area	Size (km^2)[7]	Offtake (MW)	Developer(s)
1	ME	New England Aqua Ventus I	Permitting	2022	12	0	12	State Lease	9	ME-12	Aqua Ventus
2	MA	Bay State Wind	Site Control	-	0	2,277	2,277	OCS-A 0500	759	TBD	Ørsted/Eversource
3	MA	Vineyard Wind + Residual[8]	Permitting	2023	800	1,225	2,025	OCS-A 0501	675	MA-800	Avangrid/CIP
4	MA	Equinor (MA)	Site Control	-	0	1,564	1,564	OCS-A 0520	521	TBD	Equinor
5	MA	Mayflower Wind Energy	Site Control	-	0	1,547	1,547	OCS-A 0521	516	TBD	EDPR/Shell
6	MA	Liberty Wind	Site Control	-	0	1,607	1,607	OCS-A 0522	536	TBD	Avangrid/CIP
7	RI	Block Island Wind Farm	Installed	2016	30	0	30	State Lease	10	RI-30	Ørsted/Eversource
8	RI	South Fork	Permitting	2022	130	0	130	OCS-A 0486		NY-130	Ørsted/Eversource
9	RI	Revolution	Permitting	2023	700	0	700	OCS-A 0486	395	CT-300 RI-400	Ørsted/Eversource
10	RI	Deepwater ONE North	Site Control	-	0	355	355	OCS-A 0486		TBD	Ørsted/Eversource
11	RI	Deepwater ONE South	Site Control	-	0	816	816	OCS-A 0487	272	TBD	Ørsted/Eversource
12	NY	Empire Wind	Site Control	-	0	963	963	OCS-A 0512	321	TBD	Equinor
13	NY	Fairways North	BOEM Call Area	-	-	-	-	N/A	-	-	-
14	NY	Fairways South	BOEM Call Area	-	-	-	-	N/A	-	-	-
15	NY	Hudson North	BOEM Call Area	-	-	-	-	N/A	-	-	-
16	NY	Hudson South	BOEM Call Area	-	-	-	-	N/A	-	-	-
17	NJ	Atlantic Shores Offshore Wind	Site Control	-	0	2,226	2,226	OCS-A 0499	742	TBD	EDF/Shell
18	NJ	Ocean Wind	Site Control	-	0	1,947	1,947	OCS-A 0498	649	TBD	Ørsted
19	DE	Garden State Offshore Energy	Site Control	-	0	1,050	1,050	OCS-A 0482	284	TBD	Ørsted
20	DE	Skipjack	Permitting	2023	120	0	120	OCS-A 0519	107	MD-120	Ørsted
21	MD	US Wind + Residual[8]	Permitting	2023	248	718	966	OCS-A 0490	322	MD-248	US Wind
22	VA	Coastal Virginia Offshore Wind	Permitting	2022	12	0	12	OCS-A 0497	9	VA-12	Ørsted/Dominion Energy
23	VA	Dominion	Site Control	-	0	1,371	1,371	OCS-A 0483	457	TBD	Dominion Energy
24	NC	Kitty Hawk	Site Control	-	0	1,485	1,485	OCS-A 0508	495	TBD	Avangrid
25	NC	Wilmington East WEA	Unleased[9]	-	0	1,623	1,623	N/A	209	-	-
26	NC	Wilmington West WEA	Unleased[9]	-	0	627	627	N/A	541	-	-
27	SC	Grand Strand	BOEM Call Area	-	-	-	-	N/A	-	--	-
28	SC	Winyah	BOEM Call Area	-	-	-	-	N/A	-	-	-
29	SC	Cape Romain	BOEM Call Area	-	-	-	-	N/A	-	-	-
30	SC	Charleston	BOEM Call Area	-	-	-	-	N/A	-	-	-
31	OH	Icebreaker	Permitting	2022	21	0	21	State Lease	10	OH-21	LEEDCo/Fred Olsen
32	CA	Diablo Canyon	BOEM Call Area	-	-	-	-	-	-	-	-
33	CA	Morro Bay	BOEM Call Area	-	-	-	-	-	-	-	-
34	CA	Castle Wind	Unsolicited Project Application	-	0	1,000	1,000	N/A	334	TBD	Trident Winds/EnBW
35	CA	Humboldt	BOEM Call Area	-	-	-	-	-	-	-	-
36	CA	Redwood Energy	Unsolicited Project Application	-	0	150	150	N/A	50	TBD	EDPR/PPI
37	HI	Oahu South	BOEM Call Area		-	-	-	-	-	-	-
38	HI	AWH Oahu South	Unsolicited Project Application	-	0	400	400	N/A	133	TBD	AW Wind
39	HI	Progression	Unsolicited Project Application	-	0	400	400	N/A	133	TBD	Progression Wind
40	HI	Oahu North	BOEM Call Area	-	-	-	-	-	-	-	-
41	HI	AWH Oahu North	Unsolicited Project Application	-	0	400	400	N/A	133	TBD	AW Wind
		Total			**2,073 MW**	**23,751 MW**	**25,824 MW**				

1. Location refers to physical location of the project. The offtake column identifies where the project sells its power and other attributes.
2. Some project names may change based on successful bids to state procurement solicitations
3. Future commence operation dates are subject successfully negotiating offtake agreement and may change
4. Announced capacity describes the size of a project as stipulated by a developer to regulators
5. Lease Area Potential describes the potential capacity that could be installed in a lease area using a 3MW/km^2 density
6. Pipeline capacity represents the lease area potential minus any developer announced capacity
7. Sizes for Unsolicited Project Applications are likely to change during stakeholder and regulatory review processes and may be eliminated in the future
8. Lease areas can often accommodate multiple projects or project phases built incrementally. The "+ Residual" refers to remaining space in the lease area that may be utilized in the future
9. The two Wind Energy Areas in North Carolina have currently not been leased by BOEM

2.2.2 U.S. Offshore Wind Market Forecasts to 2030

Figure 7 is a compilation of three independent industry forecasts for offshore wind deployment in the United States for the period extending to the year 2030. These estimates were developed by BNEF (2018b), 4C Offshore (2018), and University of Delaware's SIOW (2019),[18] respectively. Combined, they illustrate the degree of expected market growth and the possible variability associated with the year, size, and location of future projects.

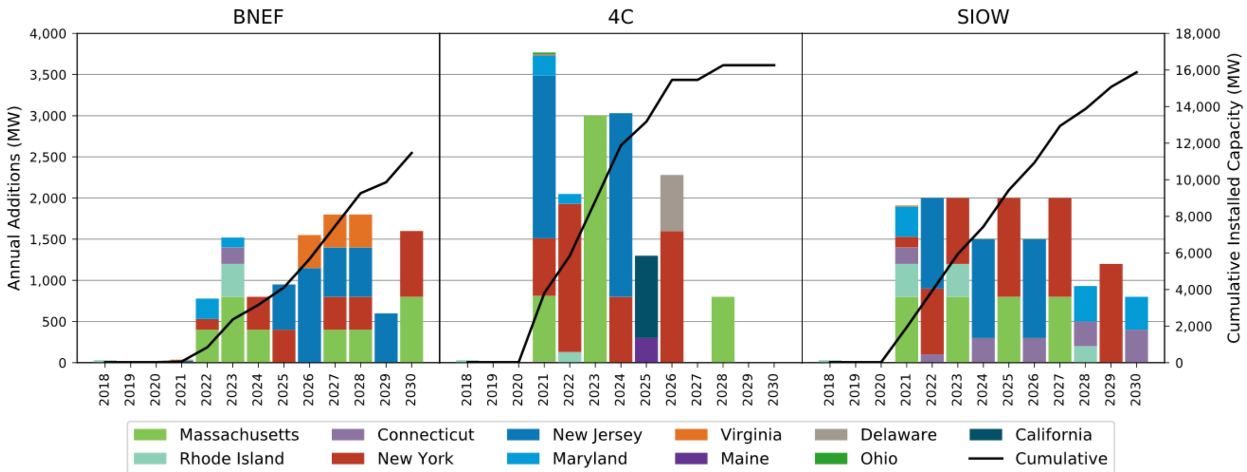


Figure 7. U.S offshore wind market forecasts (annual additions–left axis) (cumulative capacity through 2030–right axis)

The forecasts estimate that the U.S. offshore wind market will cumulatively deploy between 4 and 13 GW by 2025, and 11 and 16 GW by 2030. All three forecasts agree that the U.S. market has the potential to be greater than 10 GW by 2030, but the size and speed of build-out are likely to be impacted by regulatory uncertainty, availability of installation vessels and port infrastructure, land-based grid planning and upgrades, and evolving market demand. All forecasts predict the majority of future offshore wind deployment out to 2030 will occur on the East Coast in states with currently existing or planned offshore wind procurement goals. Only 4C Offshore's forecast includes commercial-scale floating projects by 2030: one on the West Coast off California, and one off the state of Maine.

The main factor causing variability in the forecasts is uncertainty regarding state policy as well as the size and regularity of future procurements beyond state-level solicitations that have already been announced. Other significant factors include potential problems acquiring project financing, vessel availability, cost reduction challenges, problems with environmental and geotechnical surveys, and unexpected issues with competing ocean uses. The forecasts likely assume the creation of new offshore wind lease areas to fully support state procurement targets, but this is not stated explicitly. For example, New York's 9-GW-by-2035 target may necessitate obtaining capacity from neighboring WEAs in states like Rhode Island, Massachusetts, and New Jersey, and establishing new lease areas. As such, there has been much speculation over the four Call Areas in the New York Bight but at this time it is not known if or when BOEM will propose new WEAs (BOEM 2019b).

[18] Please note University of Delaware's Special Initiative for Offshore Wind forecast is based on the expected date a state selects to procure offshore wind capacity. A 3-year time lag is assumed from the time the procurement occurs until the project becomes fully operational.

2.3 Regulatory Activity

2.3.1 Lease Activity

Acquiring exclusive rights to develop a lease area in federal waters (where most lease areas are located) is the first fundamental step toward building an offshore wind project in the United States. Market consolidation was a major trend in 2018, driven by international developers purchasing the assets of smaller U.S. companies. Although construction for commercial projects has not yet begun in earnest, approximately $1.39 billion was exchanged in the United States this year in gross revenue involving lease areas and corporate acquisitions:

- In April 2018, Ørsted asked BOEM to reassign 107 km^2 in the southern portion of lease area OCS-A 0482 (Garden State Ocean Energy) in Delaware to the Skipjack project. Skipjack now has its own lease area: OCS-A 0519.

- In December 2018, Atlantic Shores Offshore Wind, a partnership between Électricité de France Renouvelables (EDF) and Shell New Energies, bought lease area OCS-A 0499 from US Wind for $215 million pending regulatory approval (offshoreWIND.biz 2018a).

- In November 2018, Ørsted completed the acquisition of Deepwater Wind's offshore assets including their lease areas for a reported $510 million (Ørsted 2018).

- In February 2019, Ørsted sold a partial ownership stake for $225 million in some of their newly acquired Deepwater projects to Eversource Energy, a utility serving Connecticut, Rhode Island, and Massachusetts (Eversource Energy 2019).

Another major market trend in 2018 was an increase in offshore lease area prices, as demonstrated in BOEM's sale of three offshore wind lease areas in the Massachusetts WEA. Each lease area sold for at least $135 million. The lease areas had previously been up for auction in January 2015 but did not receive any bids. The results of this auction are shown in Table 4.

Table 4. BOEM's Massachusetts Offshore Wind Auction Results from December 2018

State	Lease Area	Auction Date	Provisional Winner	Winning Bid	Size (km^2)	Lease Area Potential
MA	OCS-A 0520	12/14/18	Equinor	$135,000,000	521	1,564 MW
MA	OCS-A 0521	12/14/18	Mayflower Wind Energy	$135,000,000	516	1,547 MW
MA	OCS-A 0522	12/14/18	Vineyard Wind	$135,100,000	536	1,607 MW

In aggregate, the three lease areas in Massachusetts have the potential to support at least 4.7 GW of new capacity. Figure 8 shows the overall trend of increasing lease sale prices in the United States since 2013, on the basis of $/$km^2$.

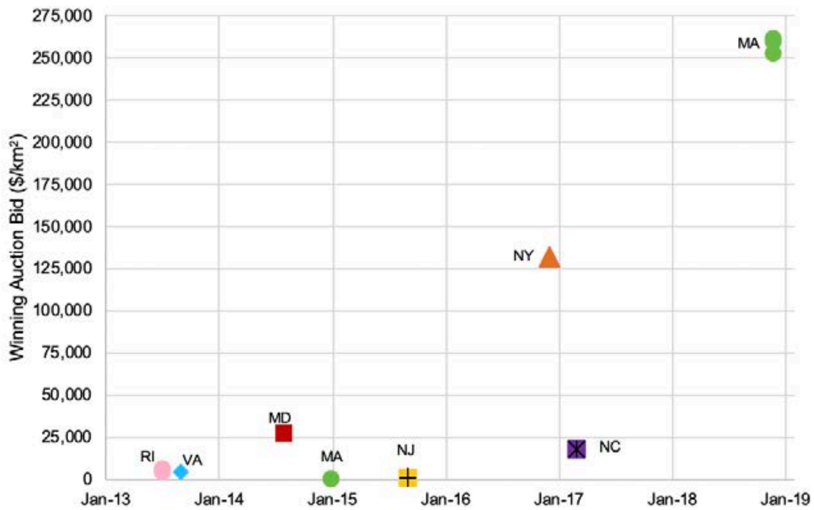


Figure 8. U.S. offshore wind lease sale prices to date by year

Notably, the winning auction bid price of $135 million surpassed the previous record-winning sale price of $42.4 million in Equinor's 2016 acquisition of the New York lease area. Not surprisingly, the highest-priced leases were in states with both proposed and implemented offshore wind offtake policies (e.g., Massachusetts, New York, Maryland, and Massachusetts) in 2018.

Although increased lease sale prices may be a signal that the offshore wind market is maturing and the bankability of future projects is increasing, it may also offset some expected (or required[19]) project price reductions and could increase the delivery price of a project's electricity. As an example, NREL calculated that recent Massachusetts lease sale prices could increase the levelized cost of energy (LCOE) for a hypothetical 800-MW project by about 5% relative to U.S. projects that acquired lease areas prior to 2016.

2.3.2 New Area Identification

BOEM periodically publishes Calls for Information and Nominations to assess commercial competitive interest for offshore wind development on specific parcels of ocean acreage in federal waters. The information gathered during these calls is used by BOEM in conjunction with other stakeholder input to identify future WEAs and subsequent lease area auctions. A Call Area is a precursor to a defined wind energy area, but not all Call Areas become wind energy areas, and they are typically modified (reduced in size) to address stakeholder input. In 2015, BOEM issued calls for four areas in federal waters off South Carolina and in 2016 issued calls for two areas off the Hawaiian island of Oahu (BOEM 2019d). There are currently 13 Call Areas for offshore wind today in the United States. Table 5 lists the seven newest Call Areas created by BOEM in 2018, including four in New York and three in California. These can also be found on the maps in Figures 4 and 5, and in Table 3 (BOEM 2019b, 2019c).

Table 5. 2018 BOEM Offshore Wind Call Areas

State	Name	Call Period
NY	Fairways North Call Area	4/11/2018–7/30/2018
NY	Fairways South Call Area	4/11/2018–7/30/2018
NY/NJ	Hudson North Call Area	4/11/2018–7/30/2018

[19] Some states, such as Massachusetts, have procurement policies that mandate that project prices in future solicitations must be lower than previous project prices to require a downward cost trend.

NY/NJ	Hudson South Call Area	4/11/2018–7/30/2018
CA	Humboldt Call Area	10/19/2018–1/28/2019
CA	Morro Bay Call Area	10/19/2018–1/28/2019
CA	Diablo Canyon Call Area	10/19/2018–1/28/2019

2.3.3 Stakeholder Engagement

The offshore wind industry in the United States continues to look for strategies to responsibly develop projects that minimize interference with the environment as well as the following preexisting ocean uses:

- **Fishing**. In cooperation with the Rhode Island Coastal Resources Management Council and local fishermen, Avangrid-Copenhagen Infrastructure Partners (CIP) established a $12.5-million trust fund to compensate fishermen who may be negatively impacted[20] by Vineyard Wind's construction (Rhode Island Coastal Resources Management Council 2019). The Responsible Offshore Science Alliance has partnered with fishermen, the National Oceanic and Atmospheric Administration (NOAA), Equinor, EDF, Shell, and Ørsted to disseminate salient and credible fisheries data (Froese 2019a). Ørsted partnered with the Responsible Offshore Development Alliance to improve communication between fishermen and their project planners (Saltzberg and Dowd 2019). Equinor and EDF also joined the alliance's Joint-Industry Task Force to ensure fishing and offshore wind development can coexist (Froese 2019b). The Responsible Offshore Development Alliance has also partnered with BOEM, NOAA, the U.S. Coast Guard, and other fishing industry liaisons to ensure that stakeholder concerns and best mitigation practices are incorporated into regulatory review processes. The group conducted multiple workshops in 2019 to minimize potential impacts of offshore wind development on fishermen.

- **Environmental**. Offshore wind construction and operations could potentially impact marine mammals,[21] fisheries, or avian species. Of specific interest in the northeast is the North Atlantic right whale, one of the world's most endangered marine mammals with historical migration routes that transit multiple offshore WEAs. In April 2018, Bay State Wind announced it would provide $2 million in research grants to help protect New England marine mammals (Bay State Wind 2018). In 2019, Equinor partnered with the Conservation Society and Woods Hole Oceanographic Institute to deploy acoustic buoys to better understand whale activities near proposed construction areas (Lillian 2019). Vineyard Wind signed an agreement with the National Wildlife Federation, Natural Resources Defense Council, and Conservation Law Fund to develop a construction strategy that minimizes pile driving and geophysical surveys during North Atlantic right whale migration periods, sets vessel speed limits to minimize marine mammal collision, and adopts new technologies like bubble screens to minimize installation noise (Skopljak 2019a). Vineyard Wind is also accepting proposals from universities and private companies for new passive acoustic monitoring systems to detect when whales are in the vicinity and appropriately pause construction activities to mitigate negative impacts (Skopljak 2019b). LEEDCo continues to work through federal and state regulations to minimize the impact of offshore wind energy on bird and bat species. As a resource for the public, DOE's Tethys database[22] provides users with access to scientific studies that can help developers, regulatory staff, stakeholders, and researchers effectively site renewable projects and employ installation and operations techniques that minimize impact to the environment (DOE 2018). Additional public resources relevant to offshore wind include BOEM's Environmental Science Database (BOEM 2019e), the Northeast Regional Ocean Council Data Portal (NOAA 2019a), and the Mid-Atlantic Ocean Data Portal (NOAA 2019b).

[20] Offshore wind construction may impact the availability of certain fish species or interfere with the ability of fishermen to fish in certain locations.
[21] Underwater noise associated with offshore wind construction (especially pile driving) may impact marine mammal communication and migration.
[22] Please visit DOE's Tethys database at https://tethys.pnnl.gov/.

- **Navigation**. To avoid collisions and entanglement of fishing gear, Vineyard Wind proposed maritime transit corridors through their lease area with the support of BOEM, local stakeholders, and the U.S. Coast Guard (Vineyard Wind 2018d).

- **Military**. As reported in the *2017 Offshore Wind Technologies Market Update*, offshore wind developers, state agencies, the U.S. Department of Defense, and BOEM have been working together to resolve potential offshore wind conflicts with military operations, training, and radar. Areas with military activities and potential offshore wind development include California, Hawaii, New York, Delaware, Maryland, North Carolina, and South Carolina. These discussions are continued in 2018 and are likely to remain active in the foreseeable future.

2.4 U.S. Offshore Wind Project Offtake and Policy Assessment

2.4.1 Project Offtake Agreements

In addition to obtaining site control and regulatory approval, negotiating an offtake agreement to sell the electricity and other possible clean power attributes (e.g., offshore renewable energy credits [ORECs]) is one of the three crucial steps to developing a bankable project. In the United States, each state has unique procurement targets and uses different mechanisms to negotiate the duration and terms of buying an individual project's electrical generation from a developer.[23] Eight offtake agreements have been signed for seven U.S. projects and two projects are in the process of negotiating terms with electric distribution companies, as shown in Table 6. (Note that Revolution is one project but is selling power to two different states.)

Table 6. U.S. Offshore Wind Offtake Agreements as of June 10, 2019

Project	Offtake State	Offtake Mechanism	Public Utility Commission Approved	Offtake Mechanism Price	Description
Block Island Wind Farm	RI	PPA	Yes	$244/MWh	In 2014, Deepwater Wind signed a 20-year PPA with National Grid for $244/MWh, with a 2.5% annual escalator.
South Fork	NY	PPA	Yes	Undisclosed	In 2017, Deepwater Wind signed a 20-year PPA with Long Island Power Authority for 90 MW at an undisclosed price. In 2019, Long Island Power Authority executed an amendment in the PPA to increase the offtake agreement to 130 MW.
US Wind	MD	MD ORECs	Yes	$131.92/MWh	In 2017, Maryland awarded US Wind ORECs[24] for 248 MW of capacity for 20 years. Each year, 913,945 ORECs will be sold. The levelized OREC price is $131.94/MWh.
Skipjack[25]	MD	MD ORECs	Yes	$131.92/MWh	In 2017, Maryland awarded Skipjack ORECs for 120 MW of capacity for 20 years. Each year, 455,482 ORECs will be sold. The levelized OREC price is $131.94/MWh.
Vineyard Wind	MA	PPA	Yes	$74/MWh $65/MWh	In 2018, Vineyard Wind signed two 400-MW PPAs with Massachusetts utilities for 20 years. The levelized first-year prices of the PPAs were $74/MWh (2022$) and $65/MWh (2023$), respectively.
Coastal Virginia Offshore Wind	VA	Utility Owned	Yes	$780/MWh[26]	In 2018, Virginia regulators approved Dominion/Ørsted to construct a 12-MW demo project. The estimated levelized cost of energy is $780/MWh.

[23] As shown in Table 6, some of the most common offtake agreement types are PPAs; legal contracts where a developer sells a project's power and other attributes to a buyer for a specified price and term; offshore renewable energy credits, in which each credit represents 1 MWh of energy and other attributes generated from an offshore wind energy project; and utility owned, wherein an offshore wind project is fully owned by a utility and sells power directly to utility customers.

[24] Each OREC represents 1 MWh of offshore wind generation and is a remuneration mechanism for the environmental attributes of offshore wind generation.

[25] Note that Skipjack is both a lease area and a project.

[26] Please note the levelized price for Coastal Virginia Offshore Wind is significantly higher than other projects because it is a demonstration project and is unable to leverage economies of scale.

Project	Offtake State	Offtake Mechanism	Public Utility Commission Approved	Offtake Mechanism Price	Description
Revolution Wind	CT	PPA	Yes	$94/MWh	In 2018, Ørsted signed a 20-year PPA with Eversource and United Illuminating for 200 MW, with a levelized PPA price of approximately $94/MWh. Ørsted has been approved to start negotiations on an additional 100 MW.
Revolution Wind	RI	PPA	Yes	$98.43/MWh	In 2019, Ørsted signed a 20-year PPA with National Grid for 400 MW. The proposal was approved by the Public Utility Commission, and the all-in price is $98.43/MWh.
Icebreaker	OH	PPA	Pending	TBD	LEEDCo is working to secure offtake with multiple partners for the project's electricity.
Aqua Ventus I	ME	PPA	Pending	TBD	Aqua Ventus I is negotiating a PPA with Central Maine Power.

2.4.2 State Policies

The U.S. offshore wind market continues to be driven by an increasing amount of state-level offshore wind procurement activities and statutory policies. In aggregate, these activities now call for the deployment of 19,968 MW of offshore wind capacity by 2035, almost four times the aggregate state-level targets identified at the end of 2017. These commitments are shown in Table 7.

Note that the states that have adopted offshore wind energy policies listed in Table 7 may not have their own offshore wind resources. For several projects (e.g., Revolution, Skipjack, South Fork), deployment is being planned in a WEA adjacent to the state[27] that will receive the power, generally at a location where the most favorable PPAs can be negotiated. The primary requirement is that the project is close enough to the onshore injection point to avoid prohibitive costs for the export cables.

Table 7. Current U.S. Offshore Wind State Policies and Activity as of June 10, 2019

State	2018 Capacity Commitment[28] (MW)	Offshore Wind Solicited (MW)	Contract Type	Target Year	Statutory Authority	Year Enacted	RPS Goal[29]	State RPS Year
MA	**1,600**	1600	PPA	2027	An Act to Promote Energy Diversity (H.4568)	2016	35%	2030
	1,600[30]	-	PPA	2035	An Act to Advance Clean Energy (H.4857)	2018		
RI[31]	**400**	400	PPA	-	-	-	31%	2030
NJ	**3,500**	1,100	OREC	2030	Executive Order 8 AB No. 3723	2018	50%	2030
MD	**368[32]**	368	OREC	2030	Maryland Offshore Wind Energy Act	2013	24%	2020
	400	-	OREC	2026		2019		

[27] For example, the Phase 1 New York offshore wind solicitation allows generators to interconnect with other markets (PJM Interconnection or ISO New England), as long as the power can be sold into the New York control area.
[28] State commitments in this table are listed incrementally and are additive (e.g., New York has a 9,000 MW goal by 2035).
[29] RPS goals are often staged over time; for this table, only the nearest-term RPS goal is included for simplification purposes.
[30] H.4857 authorized Massachusetts Department of Energy Resources to consider an additional 1,600 MW procurement by 2035. On May 31, 2019, the Department of Energy Resources said it would use the authorization and hold ~800-MW solicitations in 2022 and 2024, and in 2026, if needed.
[31] Rhode Island has a strategic goal to increase the state's clean energy to 1,000 MW by 2030. However, the state has no offshore-wind-specific statutory requirement or goal.
[32] The Maryland Offshore Wind Energy Act of 2013 limits an offshore wind RPS carve-out to 2.5% of total retail electric sales in state. This proportional goal corresponds to the OREC award on May 11, 2017, for 368 MW awarded to Skipjack Offshore Energy (120 MW) and US Wind (248 MW). (Total retail electric sales in Maryland were 59,303,885 MWh in 2017 [Energy Information Administration 2019]).

	400	-		2028	Senate Bill 516[33]			
	400	-		2030				
NY	**2,400**	930[34]	OREC	2030	Case 18-E-0071 Order Establishing Offshore Wind Standard and Framework for Phase 1 Procurement	2018	50%	2030
	6,600	-	TBD	2035	Climate Leadership and Community Protection Act	2019		
CT	**300**[35]	300	PPA	2020	House Bill 7036 (Public Act 17-144)	2017	44%	2030
	2,000	-	TBD	2030	House Bill 7156[36]	2019		
VA	-	12	Utility Owned	2028	Virginia Energy Plan	TBD	-	-
TOTAL	**19,968 MW**	**4,710 MW**						

In April 2018, New Jersey increased its RPS goal to 50% by 2030 and its offshore wind goal from 1,100 MW to 3,500 MW by 2030 (New Jersey State Legislature 2018). In August 2018, Massachusetts passed new legislation to increase its offshore wind procurement goal from 1,600 MW by 2027 to 3,200 MW[37] by 2035 (Commonwealth of Massachusetts 2018). In October 2018, Virginia published a state energy plan that proposed an offshore wind target of 2,000 MW by 2028 (BVG Associates 2018a).[38] In January 2019, New York's Governor Cuomo increased the state's offshore wind goal to 9,000 MW by 2035 (New York State 2019a), which was codified into law in the *Climate Leadership and Community Protection Act* in June 2019 (New York State 2019b). Maryland also passed legislation in April 2019 to mandate the deployment of an additional 1,200 MW of offshore wind by 2030 (Maryland General Assembly 2019). In June 2019, Connecticut passed new legislation to procure 2,000 MW of offshore wind capacity by 2030 (Connecticut General Assembly 2019).

To meet their committed procurement targets, multiple states issued solicitations for commercial projects in 2018, and executed significant planning around future solicitations including the following:

- In New York, NYSERDA issued a solicitation for approximately 800 MW of capacity worth of ORECs. Bids were due February 19, 2019, and NYSERDA announced that Atlantic Shores Offshore Wind (EDF/Shell), Empire Wind (Equinor), Liberty Wind (Avangrid/CIP), and Sunrise Wind (Ørsted and Eversource) all responded to the solicitation. Winners are expected to be announced in spring 2019.

- New Jersey issued a solicitation for 1,100 MW of ORECs that was open from September 20 to December 28, 2018. Three developers responded to the solicitation: Board Walk Wind (Equinor), Atlantic Shores Offshore Wind (EDF/Shell), and Ocean Wind (Ørsted). The Board of Public Utilities (BPU) is expected to announce a winner by summer 2019.

- NYSERDA plans to have another 800-MW solicitation in 2019 (NYSERDA 2019).

- The New Jersey BPU also announced plans for two additional solicitations for 1,200 MW in 2020 and 2022 (New Jersey BPU 2019).

---

[33] Maryland legislature passed SB516 May 25, 2019. It mandates the procurement of 400 MW by 2026, 800 MW by 2028, and 1,200 MW by 2030.
[34] Long Island Power Authority solicited 90 MW for the South Fork project in 2017. The project size was later increased to 130 MW. NYSERDA solicited 800 MW in 2018.
[35] Public Act 17-144 limits authority to procure offshore wind to 3% of Connecticut electric distribution companies' total electric, which corresponds to approximately 200 MW. The other 100 MW come from technology-neutral auctions.
[36] CT House Bill 7156 was signed into law June 10, 2019. It requires Connecticut to procure 2,000 MW by 2030 and DOE and Environmental Protection to issue a solicitation by June 24, 2019.
[37] Note the additional 1,600 MW is at the discretion of the Massachusetts Department of Energy Resources, so the ultimate procurement target could change.
[38] The state energy plan recommends 2,000 MW and is awaiting action from the governor.

- Maryland's new offshore wind procurement legislation requires the state to procure 400 MW by 2026, 800 MW by 2028, and 1,200 MW by 2030 (Maryland General Assembly 2019).

- Massachusetts Department of Public Utilities issued its second offshore wind solicitation on May 27, 2019, to meet the state's 1,600-MW-by-2027 goal. The request for proposals asks developers to submit plans for designs between 400 and 800 MW (Massachusetts Department of Energy Resources 2019a). Bids are due by August 9, 2019.

- The Massachusetts Department of Energy Resources conducted an offshore wind study to investigate the necessity, benefits, and costs of requiring Massachusetts's electric distribution companies[39] to conduct additional offshore wind generation solicitations of up to 1,600 MW. The agency found that the additional capacity was in the best interest of the state and announced it will hold additional solicitations for up to 800 MW of offshore wind in 2022 and 2024, and if necessary to meet the 1,600 MW target, in 2026 (Massachusetts Department of Energy Resources 2019b).

2.5 U.S. Infrastructure Trends

2.5.1 Vessels and Logistics

A lack of specialized, U.S.-flagged offshore wind installation vessels and limitations imposed by the Jones Act[40] continues to be a potential bottleneck for the nascent U.S. offshore wind industry. As reported in past market reports, multiple marine engineering companies (e.g., Gusto MSC, Zentech, AK Suda) have drafted designs and conducted cost studies for U.S.-flagged installation vessels, but no offshore installers publicly announced construction of a new vessel in 2018. The only known vessel development in 2018–2019 was Ørsted entering into partnership with WindServe Marine to construct two crew transfer vessels—one in North Carolina and the other in Rhode Island—for use at the Coastal Virginia Offshore Wind and Revolution Wind projects (Foxwell 2019). The lack of specialized U.S.-flagged installation and support vessels will likely prompt initial commercial-scale projects to use foreign-flagged installations vessels and U.S.-flagged feeder barges.

2.5.2 Ports and Harbors

Although no investments have been made for U.S.-flagged offshore wind installation vessels, developers and state bodies have started to make investments in port infrastructure to make sure there are sufficient cranes and laydown space required for large-scale commercial projects. There are a number of ports in the United States that are potentially suitable for offshore wind construction, staging, and assembly. The few ports that have made recent infrastructure investments to upgrade and prepare for the first wave of projects are listed in Table 8. Going forward, this list is expected to grow.

Table 8. Ports with Recent Investments for the U.S. Offshore Wind Industry

State	Location	Description	Offshore Wind Projects
MA	Port of New Bedford	Vineyard Wind is leasing the New Bedford Commerce Terminal for 18 months as the primary staging and deployment base for its 800-MW project (Mass Live 2018).	Vineyard Wind
MA	Brayton Point	Anabaric and Commercial Development Company signed an agreement to invest $650 million into Brayton Point's Commerce Center to create an offshore wind hub that has a 1.2-GW high-voltage direct-current converter, 400-MW battery storage, and additional wind turbine component laydown space.	Multiple in MA and RI

[39] Electric distribution companies are regulated entities that purchase wholesale energy and sell it to retail customers.

[40] The Jones Act prohibits the maritime shipment of merchandise and passengers between two points in the United States by any vessel that is not U.S.-flagged (domestically manufactured, owned, and operated). For offshore wind development, this means foreign-flagged turbine installation vessels are unable to carry turbine components from a U.S. port to a construction site in U.S. waters.

CT	New London	Ørsted, the Connecticut Port Authority, and Gateway will invest $93 million in the State Pier at New London to expand the laydown space, increase its heavy-lift capacity, and add other features necessary for large-scale offshore wind development activities. Ørsted will lease rights to use the pier for 10 years.	Revolution Wind
MD	Tradepoint Atlantic (Formerly Sparrow Point)	In 2017, US Wind and Deepwater Wind agreed to invest $115 million in new manufacturing and port infrastructure.	US Wind and Skipjack

The development and timing of port infrastructure could become a significant bottleneck for the industry. This may be especially true as wind turbines and project sizes continue to grow and put a strain on the capacity of existing infrastructure in terms of heavy lifting, ship access, clearances, channel draft, and physical laydown space. According to a recent McKinsey report, approximately five staging ports will be required to meet the needs for the first 10 GW of offshore wind deployment on the Atlantic Coast alone (Lefevre-Marton et al. 2019).

2.6 Other Regional Developments

Most activity is centered on the WEAs and states that have specific offshore wind procurement activities. The activities highlighted here by region are notable yet were not documented earlier in this report.

2.6.1 North Atlantic

Other offshore wind activities for the North Atlantic region included the following:

- In February 2019, Maine's Governor Janet Mills signed an Executive Order to end a 2018 moratorium on the issuance of offshore wind permits in the state (Mills 2019). The University of Maine is now in the process of renegotiating the Aqua Ventus I PPA for its 12-MW floating demonstration project. If built, this project would likely be the first wind project using floating turbines in the United States.

- In January 2019, New Hampshire's Governor Christopher Sununu requested that BOEM establish an intergovernmental offshore renewable energy task force to coordinate renewable energy activities on the New Hampshire Outer Continental Shelf, including potential commercial leases for offshore wind (Sununu 2019).

- The New Jersey BPU denied EDF's application for 20 years of ORECs for its 24-MW Nautilus demonstration project (formerly known as Fishermen's Energy) (New Jersey BPU 2018). This ends a long process, which began in 2008, to build this offshore wind demonstration project approximately 2.8 miles off the coast of Atlantic City, New Jersey. Ultimately, the project failed because it was unable to demonstrate net-economic benefits, as required under law by the Offshore Wind Economic Development Act.

2.6.2 South Atlantic

Offshore wind activities for the South Atlantic region included the following:

- In September 2018, BVG Associates and the Sierra Club published their *Offshore Wind in Virginia: A Vision* report. This study recommended that the state set a target to support 2 GW of offshore wind development by 2028 and claimed this policy could create thousands of local jobs and make the state an offshore wind hub (BVG Associates 2018a). In 2018, *The Virginia Advantage: The Roadmap for the Offshore Wind Supply Chain in Virginia* assessed the state's port infrastructure and found that five ports could support offshore wind construction and manufacturing activities without significant upgrades (BVG Associates 2018b).

- In March 2019, North Carolina Governor Roy Cooper approved an offshore wind study to assess the state's ability to develop successful ports and manufacturing facilities (Durakovic 2019).

2.6.3 Pacific

Offshore wind activities for the Pacific region included the following:

- In 2018, California passed SB 100 (*100 Percent Clean Energy Act*), committing the state to realizing 100% of its total retail electricity sales from eligible renewable energy and zero-carbon resources by 2045. To comply with this mandate, California will consider the large-scale development of offshore wind. The state's offshore wind technical resource has been determined by NREL to be over 100 GW, and offshore wind deployment scenarios studied suggest that a potential build-out of several gigawatts may be feasible using floating technology. Floating technology is expected to be commercially available by the mid-2020s (Musial et al. 2016, 2017).

- On October 18, 2018, BOEM published a Call for Information and Nominations to gauge interest from prospective floating wind developers in commercial wind energy leases within three proposed areas off central and northern California (BOEM 2019c). The Call Areas are shown in Figure 5 on the central and northern California coasts. All together, these three Call Areas total approximately 2,784 km^2 (687,823 acres), which could potentially deliver a generating capacity of up to 8.4 GW. In response to the call, BOEM received 14 nominations from developers identifying their interest in developing certain portions of the Call Areas. Interested developers include Algonquin Power Fund, Wpd Offshore Alpha, Avangrid Renewables, Castle Wind/Energie Baden-Württemberg AG (EnBW), Cierco Corporation, EDF Renewables, EDP Renewables North America, E.ON Development, Equinor Wind US, Mission Floating Wind, Northcoast Floating Wind, Northland Power America, Redwood Coast Energy Authority, and US Mainstream Renewable Power.

3 Overview of Global Offshore Wind Development

3.1 Global Offshore Wind Market

Following the 2017 deployment of more than 3,500 MW, a record capacity of 5,652 MW new offshore wind was commissioned globally in 2018, as shown in Figure 9. The increase in global capacity can be attributed to a strong increase in deployment from the Chinese market, with 2,652 MW of new Chinese offshore wind capacity coming on line, followed by 2,120 MW commissioned in the United Kingdom, 835 MW in Germany, 28 MW in Denmark, and about 17 MW divided between the rest of Europe and Vietnam. By the end of 2018, the global offshore wind installed capacity grew to 22,592 MW from 176 operating projects. Projections for 2019 indicate greater amounts of new global capacity based on projects currently under construction.

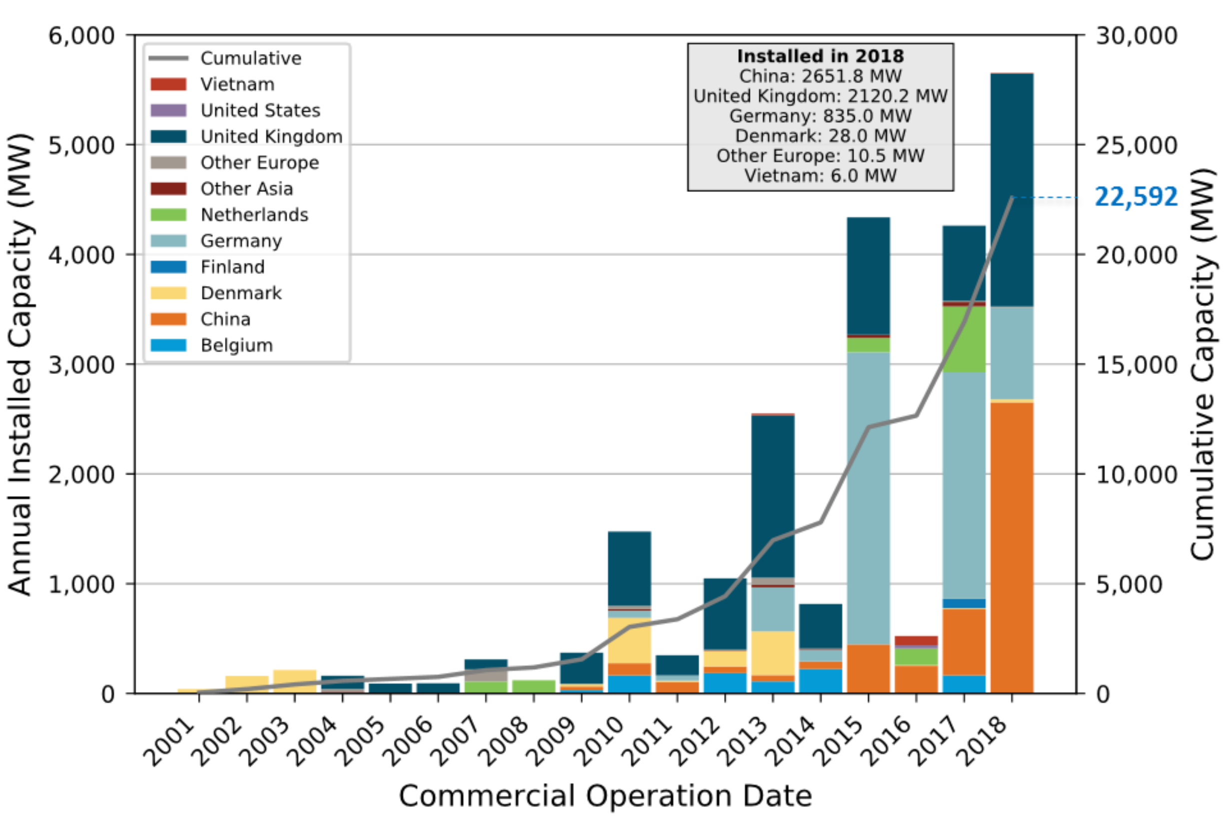


Figure 9. Global offshore wind in 2018 (annual installed capacity–left axis) (cumulative capacity–right axis)

The global offshore wind market is still centered in Europe, with approximately 17,979 MW of installed cumulative capacity. Asia is the second largest regional market, with 4,639 MW, and North America is the third largest market, with only 30 MW of capacity installed today. The OWDB indicates that future market growth will shift toward the Asian and U.S. markets.

Europe's large regional offshore wind market is sustained in part because it has the most transparent national offshore wind procurement schedules, regionally based original equipment manufacturers (OEMs) and installers, mature logistical and manufacturing supply chains, and strong research and development networks to support its development. In addition, Europe has had 28 years of offshore wind experience. However, the Asian offshore wind market may soon surpass the European market in terms of annual capacity additions, driven primarily by China's demand for renewable energy and the motivation to advance the country's domestic manufacturing capabilities. This shift is noticeable in the 2018 annual capacity additions. As shown in Figure 10, there were three main countries contributing to offshore wind capacity in 2018—China, the United Kingdom, and Germany.

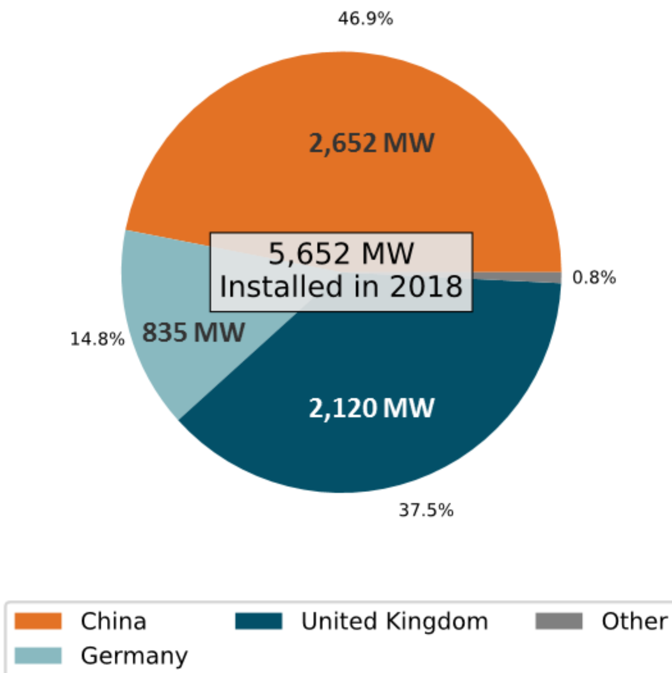


Figure 10. Installed offshore wind capacity by country in 2018

Of the 22,592 MW of cumulative offshore wind deployment recorded by the end of 2018, Figure 11 shows how that capacity is distributed among all countries. The United Kingdom continues to lead the world in terms of total deployment, with 35.2%, followed by Germany (27.4%), China (19.5%), Denmark (6.4%), the Netherlands (5%), and Belgium (3.9%).

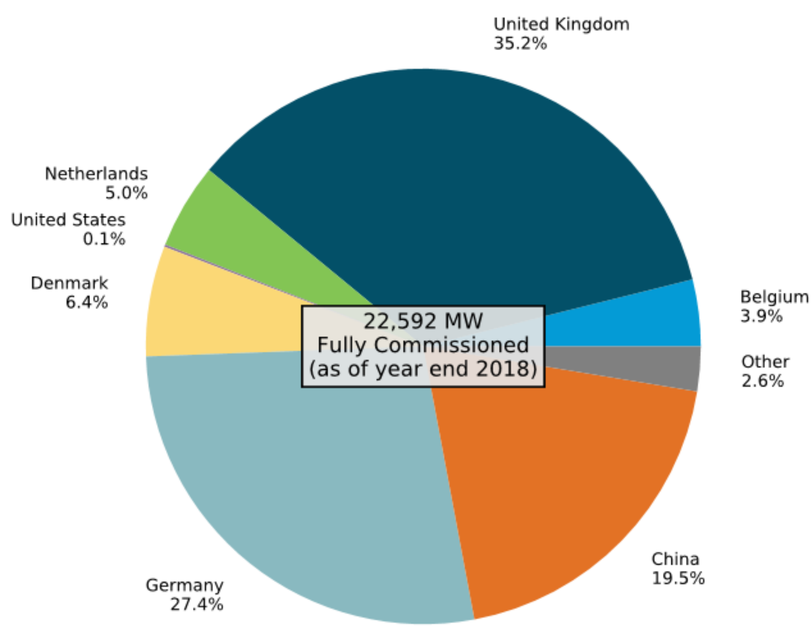


Figure 11. Cumulative offshore wind installed capacity by country

Figure 12 shows the same data plotted in Figure 9 but provides more insight into how the cumulative capacity changed by country.

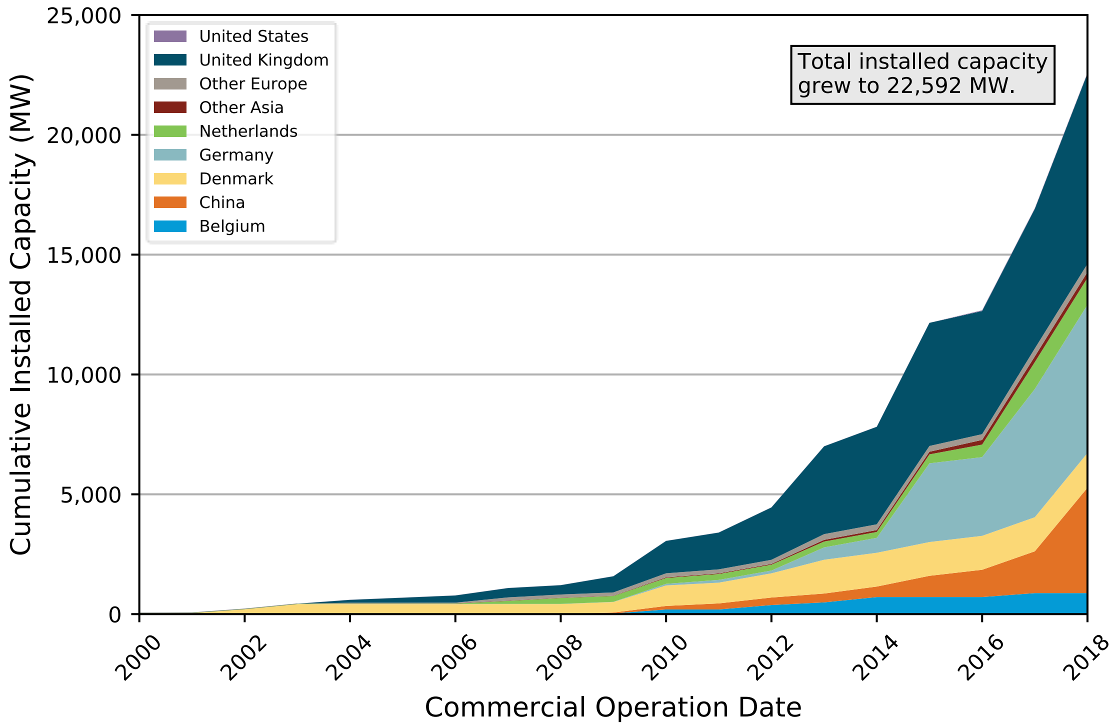


Figure 12. Cumulative installed offshore wind capacity by country over time

Historically, Denmark was clearly the first mover of the industry; however, being a small country, its long-term demand is smaller, and by 2010 the United Kingdom gained more total deployment. Germany began its transition to offshore wind around 2010 and has been increasing its deployment rapidly. Figure 12 also shows the sharp acceleration of the Chinese market, especially this past year—a trend that is likely to continue.

3.1.1 European Market Activities

As of December 31, 2018, 2,994 MW of additional offshore wind capacity was installed in Europe, bringing the total cumulative capacity to 17,979 MW. In 2018, Denmark installed 28 MW, France installed 2.2 MW, Germany installed 835 MW, Spain installed 5 MW, Sweden installed 3.3 MW, and the United Kingdom installed 2,120 MW. Table 9 provides a list of all the projects that reached commercial operation in 2018 by country. The table provides the project capacity values in megawatts and the name of the developer. Note that both of the French projects are subscale floating demonstration projects.

Table 9. European Projects Installed and Grid Connected in 2018

Country	Project Name	Capacity (MW)	Lead Developer
Denmark	Nissum Bredning Vind	28	Nissum Bredning Vindmallelaug
France	EOLINK 1/10 Scale Prototype	0.2	EOLINK
France	Floatgen	2	Ideol
Germany	Arkona	385	E.ON
Germany	Borkum Riffgrund 2	450	Ørsted
Spain	Elisa/Elican Demonstration	5	Elican and ESTEYCO
Sweden	Bockstigen	3.3	Momentum Gruppen A/S
United Kingdom	Aberdeen Offshore Wind Farm	93.2	Vattenfall
United Kingdom	Blyth Offshore Demonstration Array 2	41.5	EDF
United Kingdom	Galloper	353	Innogy
United Kingdom	Race Bank	573.3	Ørsted
United Kingdom	Rampion	400.2	E.ON
United Kingdom	Walney Extension	659	Ørsted

Looking beyond 2018, there has been a significant amount of additional offshore wind activity in Europe related to new policy, procurements, permits, and offtake agreements, indicating continued market growth. Some of the highlights of these activities by country include the following.

France. Although France initially implemented policies targeting 6 GW of offshore wind by 2020, disagreements over the feed-in tariff prices continually delayed commercial projects that had been approved in two tenders in 2012 and 2014. However, in June 2018, the French government finally approved the construction of six of the previously approved offshore wind projects after reducing the feed-in tariff.[41] Each project is expected to receive between 150 €/MWh and 200 €/MWh (Reuters 2018). The projects, all expected to come on line around 2022, are Saint-Nazaire (480 MW), Courseulles-sur-Mer (496 MW), Fécamp (498 MW), Dieppe-Le Tréport (496 MW), and Ile d'Yeu et Noirmoutier (496 MW) (Espérandieu 2018).

Germany. In April 2018, six projects with CODs from 2022 to 2024 were awarded grid connection in the second German offshore wind tender. The projects were Baltic Eagle (476 MW), Gode Wind 4 (132 MW), Kaskasi (325 MW), Arcadis Ost (248 MW), Wikinger Sud (350 MW), and Borkum Riffgrund West I (420 MW). The German Renewable Source Act drives the German offshore wind market and has targeted installing 6.5 GW by 2020 and 15 GW of offshore wind capacity by 2030. Because the German market is poised to achieve its offshore wind goals ahead of schedule, the German legislature initiated a grid reliability study to assess the feasibility of increasing the country's offshore wind goal to 20 GW by 2030 (Foxwell 2018b).

Poland. Poland held its first offshore wind tender in November 2018, awarding two projects the rights to connect to the grid. Additionally, the Polish Secretary of State announced the country was targeting 8 GW of offshore wind deployment by 2030 (offshoreWIND.biz 2018b).

Portugal. Portugal continues to support the development of the 25-MW floating WindFloat Atlantic project. The project is expected to reach financial close and initiate construction in late 2019 pending government

[41] A feed-in tariff guarantees the amount of compensation a developer receives for every megawatt-hour of electricity that their project supplies to the grid.

approval.

Spain. Spain deployed its first offshore wind project in the Canary Islands, the 5-MW Elisa/Elican, a novel gravity-base float-out system that can be fully assembled inshore, with a telescoping tower. According to 4C Offshore, the turbine became fully operational in March 2019. As such, this project will be counted toward the 2019 capacity additions (Skopljak 2019c).

United Kingdom. The United Kingdom continues to be the world leader in offshore wind, with over 7.9 GW of installed capacity. In November 2018, The Crown Estate announced the fourth round of offshore wind tenders would be held in May 2019 and subsequent tenders would occur every 2 years. Based on “market appetite,” the tender was increased from 6 to 7 GW, and wind development regions that were limited to 50-m depths were extended to 60-m depths (The Crown Estate 2018).

3.1.2 Asian Market Activities

By the end of 2018, 2,658 MW of new offshore wind capacity was added in Asia, increasing the region’s total cumulative installed capacity to 4,639 MW. In 2018, China added 2,652 MW and Vietnam added 6 MW. Table 10 provides a list of all of the Asian projects that reached commercial operation in 2018 by country.

Table 10. Asian Projects Installed and Grid Connected in 2018

Country	Project Name	Capacity (MW)	Developer
China	Fuqing Xinghua Bay - Phase 1	77.4	China Three Gorges New Energy Co.
China	Guodian Zhoushan Putuo District 6 Zone 2	252	GD Power Development Co.
China	Jiang Su Ru Dong Jiangjiasha H2	300	Shanghai Electric Power
China	Jiangsu Longyuan Chiang Sand H1	300	China Longyuan Power Group
China	Jiangsu Luneng Dongtai	200	Shandong Luneng
China	Laoting Bodhi Island Demonstration	300	Jointo Energy Investment
China	Longyuan Jiangsu Dafeng (H12)	200	China Longyuan Power Group
China	Longyuan Putian Nanri Island I	200	China Longyuan Power Group
China	SPIC Binhai North H2	400	State Power Investment Corporation
China	SPIC Jiangsu Dafeng H3	302.4	State Power Investment Corporation
China	Zhuhai Guishan Hai Demonstration - Phase 1	120	China Southern Power Grid
Vietnam	Ben Tre 10 – Phase 1	6	Mekong Wind Power

Looking beyond 2018, other significant offshore wind activities in Asia related to new policy, procurements, permits, and offtake agreements by country include the following.

China. China has a national offshore wind deployment goal of 5 GW by 2020; however, the rapid increase in the number of proposed projects has been driven by the individual province-level goals in Jiangsu (3.5 GW), Fujian (2 GW), and Guangdong (2 GW) (Deign 2019). In May 2018, China’s National Energy Administration determined that offshore wind power prices in 2019 and beyond will be set by competitive auctions instead of feed-in tariffs in an effort to increase competition and spur cost reductions in the industry (Recharge News 2018). These cost-reduction and province-level procurement targets, in conjunction with a rapidly maturing supply chain, are expected to dramatically accelerate the future deployment of offshore wind in China, potentially making it a world leader by 2030 (see Section 3.2).

Japan. In November 2018, the Japanese government passed a bill that created a national framework for offshore wind development. Under the law, the Japanese government will designate at least five offshore wind lease areas, hold competitive auctions, and award leases for 30-year terms. In January 2019, Tokyo Electric Power Company, Japan's largest utility, signed a memorandum of understanding with Ørsted to develop the Chosi project near Tokyo (Ørsted 2019). Although Japan still lacks firm government targets for offshore wind, outside analysts such as Wood Mackenzie predict that by 2028 the country will have 4 GW of offshore wind (Hill 2019).

Taiwan. Taiwan has a national goal to develop 5.5 GW of offshore wind capacity by 2025 (Jacobsen 2018). In April and June 2018, the government awarded the first tranche of projects (~3.5 GW) the right to connect to the grid. In late 2018, the Taiwanese government proposed to reduce its feed-in-tariff before some of the awardees could finalize their power purchase agreements. This uncertainty led some developers to question the bankability of their projects and temporally suspend project development. Ultimately, the government settled on smaller feed-in-tariff reduction that enabled all projects to stay economically viable. In early 2019, Ørsted reached financial close on Changhua 1 (605 MW) and Changhua 2 (205 MW), Wpd reached financial close on Yunlin (640 MW), and Northland Power reached financial close on Hai Long 2A (300 MW) (4C Offshore 2019a).

South Korea. Although no projects were commissioned in South Korea in 2018, land-use constraints are shifting the focus for renewable energy to offshore wind power. In 2018, the government set a 12-GW offshore-wind-capacity-by-2030 target to help the country meet a 20% renewable energy target set earlier in 2017. In June 2018, the government adjusted the RPS to increase the renewable energy certificate (REC) value for offshore wind because of economic efficiency and ability to meet policy goals (Linklaters 2019). Offshore wind REC values are attractive because they increase with the distance from the interconnection facilities (Linklaters 2019).

3.2 Offshore Wind Market Projections

This report contains both near-term (2024) and medium-term (2030) projections for the global offshore wind market. Near-term trends are based on NREL's OWDB and medium-term trends are based on a collection of outside sources, but primarily BNEF and 4C Offshore. These projections can help illuminate broad market trends, identify different national and regional deployment trajectories, and approximate the level of uncertainty in future deployment estimates.

3.2.1 Project Pipeline Through 2024

The near-term project projection is based on data obtained for NREL's OWDB and represents our best understanding of the global offshore wind market. Note that market dynamics, policies, and future technological innovations are always subject to change, and could impact these projections.

Near-term projections are based on industry data reporting their status in the pipeline and the developers' expected commercial operation dates. Projects that have made it past financial close have a much higher probability of being completed and a much lower uncertainty about when they will be completed. Figure 13 shows that 9,511 MW of new offshore wind is underway globally, which is broken down by key countries.

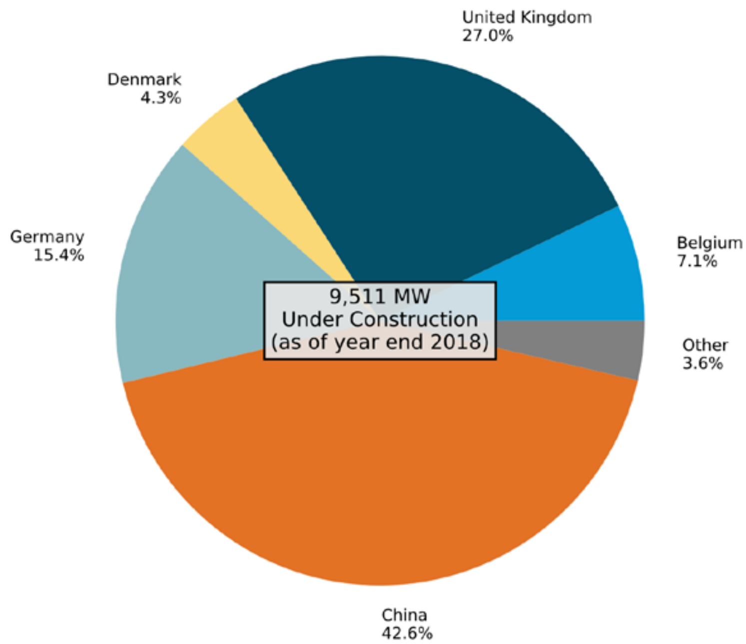


Figure 13. Offshore wind capacity under construction by country as of 2018

By the end of 2018, there were 12 European offshore wind projects under construction, representing 5,115 MW of new capacity to be commissioned.[42] The majority of ongoing construction in Europe is occurring in the United Kingdom (2,520 MW) and Germany (1,460 MW), with smaller amounts in Belgium (678.6 MW) and Denmark (406 MW). In Asia, 17 projects, with a combined capacity of 3,469 MW, are currently under construction. Of the projects under construction, 12 are located in China, three in Vietnam, one in Japan, and one in South Korea. The increased amount of construction in Asia, especially China, represents a new market segment that is expected to grow in future years.

In 2018, just over 10 GW of projects reached financial close. In Europe, 14 projects, representing 6,052 MW of capacity, reached financial close in 2018. In the Asian market, 17 projects, representing 4,178 MW of capacity, reached financial close. In total, there are about 19 GW of projects that have reached financial close or are under construction as of 2018.

Figure 14 provides a yearly estimate of new deployment based solely on the developer's estimation of when they expect their project to be commissioned. Although a project developer may not always be at liberty to disclose detailed updates or information related to their exact deployment schedule, the developer COD data is a rough proxy for near-term deployment. In 2019, annual capacity additions are expected to be dominated by the United Kingdom and China.

Although most deployments until 2024 are located in the United Kingdom and China, other European countries, such as Germany, the Netherlands, and Denmark, continue to approve new projects to meet their national renewable or offshore wind targets. Based on only the projects reporting COD dates in Figure 14, these new additions would result in approximately 44 GW of new capacity from 2019 through 2024.

[42] Generally, a project is assumed to be commissioned 2 years after construction begins.

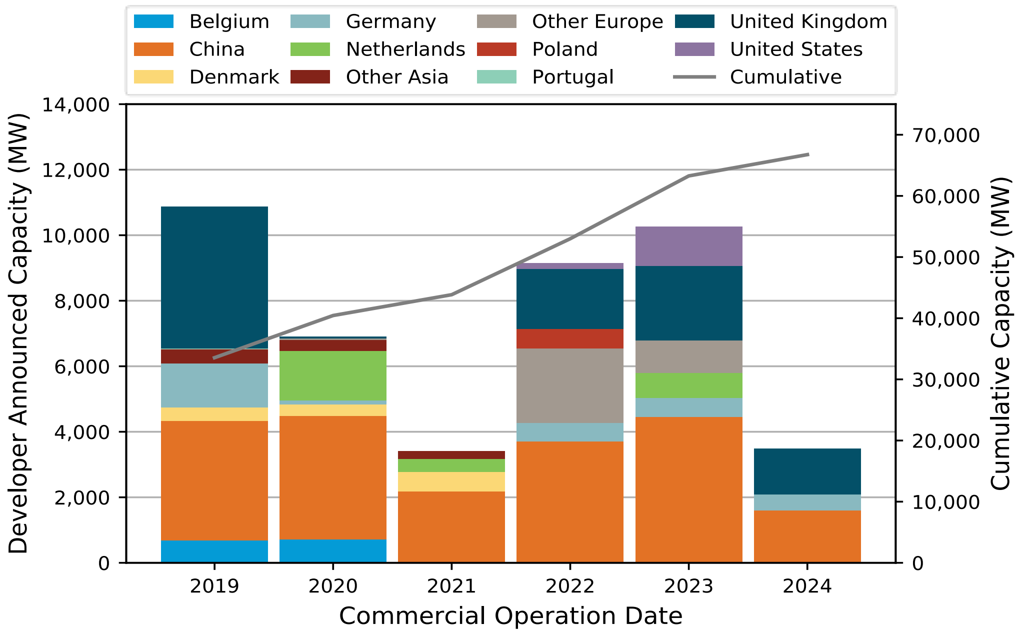


Figure 14. Developer-announced offshore wind capacity through 2024 for projects with financial close

Figure 15 extends Figure 12 beyond the present day using the data shown in Figure 14 as a proxy to estimate near-term offshore wind deployment through 2024.

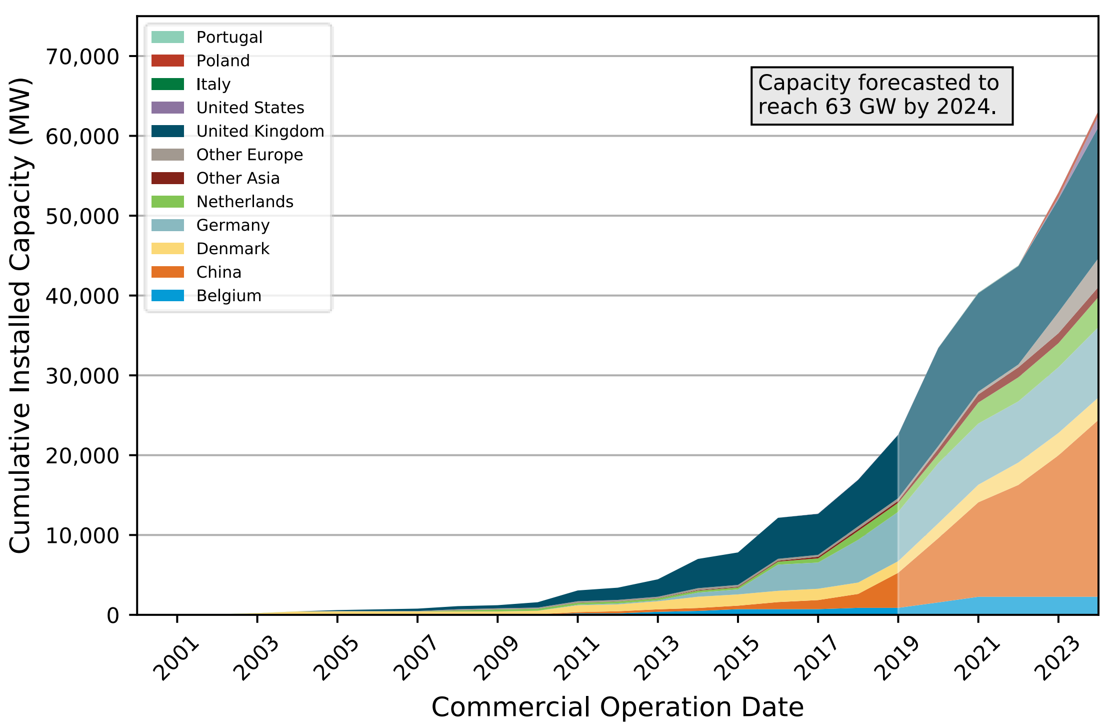


Figure 15. Estimated 2024 cumulative offshore wind capacity by country based on a developer-announced COD (shaded areas represent forecasted deployments)

The figure shows steady or accelerated growth for the next 5 years. Although new markets, such as Poland or Portugal, could help maintain the European share of total global offshore wind capacity, dramatic growth in Asian markets indicates that China may represent almost 50% of the cumulative global capacity in the next 5 years. In aggregate, cumulative global offshore wind deployment is expected to reach over 63 GW by 2024.

3.2.2 Total Global Pipeline

Figure 16 shows the global capacity of the operating and announced development pipeline for all offshore wind projects by region to be 272 GW, compared to approximately 230 GW in 2017. The uptick is primarily attributed to more Asian projects entering the planning phase. This figure does not provide information about the likely timing of developments within the long-term pipeline, but provides overall announced capacity for all active projects recorded in the NREL OWDB.[43] Generally, projects that are more advanced within the pipeline are more likely to reach COD and to be installed sooner than those at an earlier stage; however, international differences in regulatory structure can result in a wide range of development timelines. The global project pipeline illustrates that the majority of the world's installed projects and projects under advanced development are in Europe, but the majority of the world's potential future capacity is in Asia. Looking at project status, there are approximately 63 GW of approved projects in the global pipeline—roughly three times the amount of capacity currently installed today. If all of the approved capacity gets built, the dramatic expansion of the global market will require the further maturation of global supply chains, expansion of manufacturing capabilities, and new installation vessels.

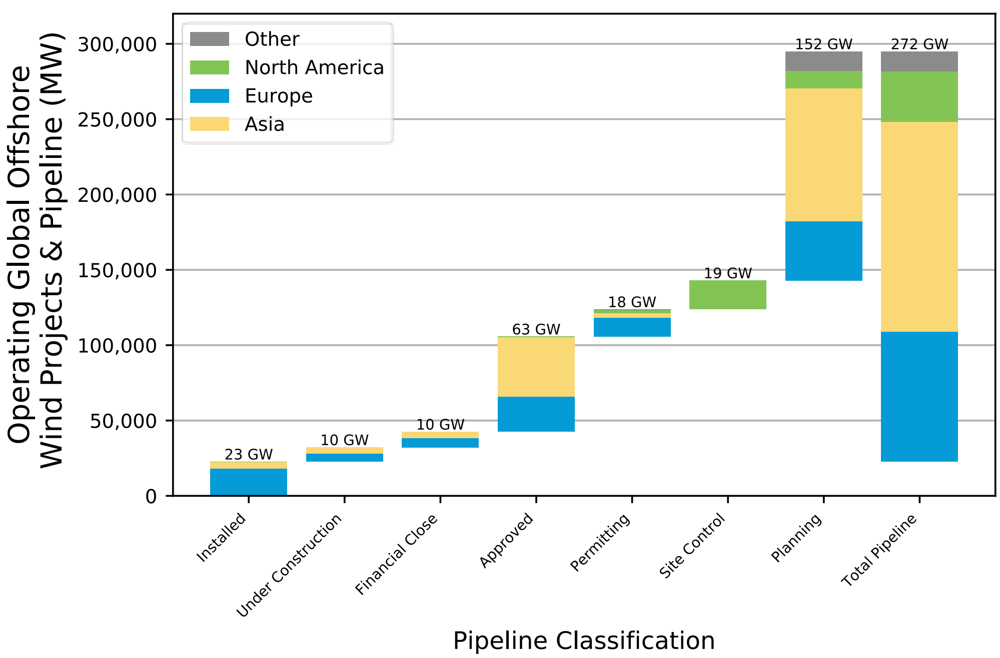


Figure 16. Total global pipeline by status

3.2.3 Medium-Term Projections

Figure 17 illustrates medium-term forecasts of global offshore deployment broken down by country from 2018 through 2030.

[43] The data in Figure 16 do not include projects that are dormant, cancelled, decommissioned, or development zones.

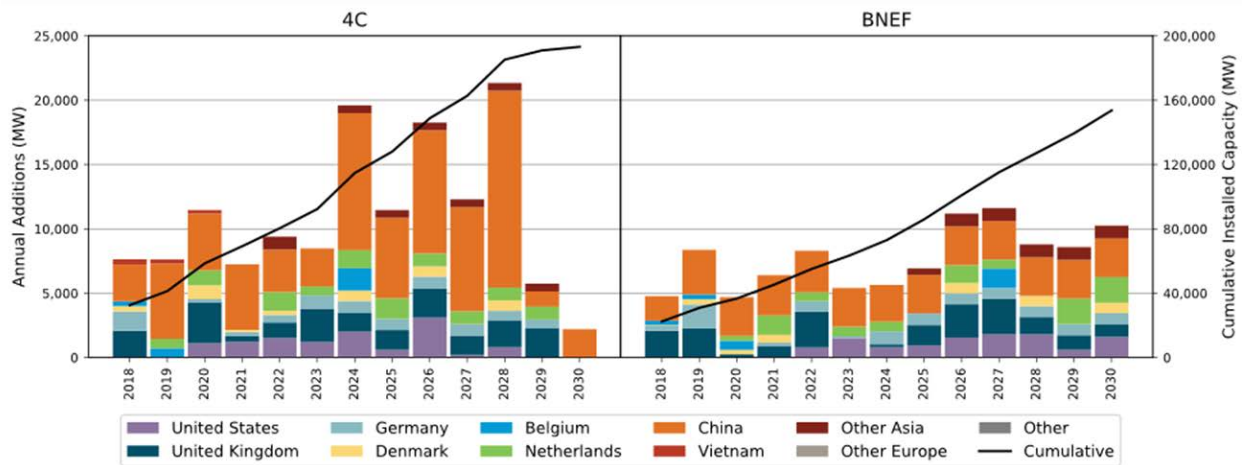


Figure 17. Medium-term wind capacity forecasts by country through 2030

In the figure, two independent forecasts are shown; one by BNEF (2018a) and one by 4C Offshore (2018), which estimate the future growth of the global offshore wind industry. BNEF forecasts offshore wind will reach 154 GW by 2030, whereas 4C Offshore estimates a projected deployment level of 193 GW by 2030. Both forecasts are provided to illustrate the variability and uncertainty associated with longer-range deployment estimates.

Like the near-term forecast to 2024, the most striking shift in offshore wind market dynamics in the 2030 forecast scenarios is the estimated growth of the Chinese market. Both forecasts expect China will cumulatively deploy between 41 GW and 84 GW by 2030. Forecasts also predict European developers will continue to incrementally build projects at a similar rate relative to today, with Europe holding roughly 47% of the total installed global offshore wind capacity by 2030. China itself is expected to represent 27% of the total 2030 installed capacity with the remaining other Asian countries (e.g., Korea, Japan, and Vietnam) accounting for 19%. Depending on the forecast scenario (4C Offshore or BNEF), the U.S. proportion of installed capacity could range from 6.5% to about 8.5% of the global total by 2030.

3.3 Floating Offshore Wind Market Trends

The floating offshore wind market is still driven by the prospect of accessing a much larger resource area with high-quality wind resources, but in water depths that are too deep (nominally greater than 60 m) for conventional fixed-bottom technologies. In the United States, more than 58% of the total technical offshore wind resource is located in water depths greater than 60 m, and in Europe that number is 80% (Musial et al. 2016; WindEurope 2018). Globally, the development of a floating offshore wind market is emerging quickly as experience and knowledge are gained from pilot projects in Europe, Asia, and North America. This pilot phase, which should be mostly operational by 2022, is expected to inform the development of cost-effective commercial-scale projects that may be possible by as early as 2025.

3.3.1 Existing Floating Projects

There are currently eight floating offshore wind projects installed around the world representing 46 MW of capacity. Five projects (37 MW) are installed in Europe and three (9 MW) are in Asia. There are an additional 14 projects representing approximately 200 MW that are currently under construction or have achieved either financial close or regulatory approval. Two projects (488 MW) have advanced to the permitting phase of development, and another 14 are in the early planning stages (4,162 MW). Overall, the 2018 global floating offshore wind pipeline represents approximately 4,888 MW of capacity, growing by 2,000 MW relative to the *2017 Offshore Wind Technologies Market Report Update*. Figure 18 illustrates the current offshore wind market pipeline in terms of market timeline, proposed project size, water depth, and host country. The figure illustrates how the floating offshore wind market evolved from small-scale, single-turbine prototypes (2009–2015) to multiturbine demonstration projects (2016–2022). Post-2022, the first large-scale floating projects are expected to become commercially viable.

Each of the 38 projects shown in Figure 18 are listed in Table 11, which also includes the project status, capacity developer, and substructure type.

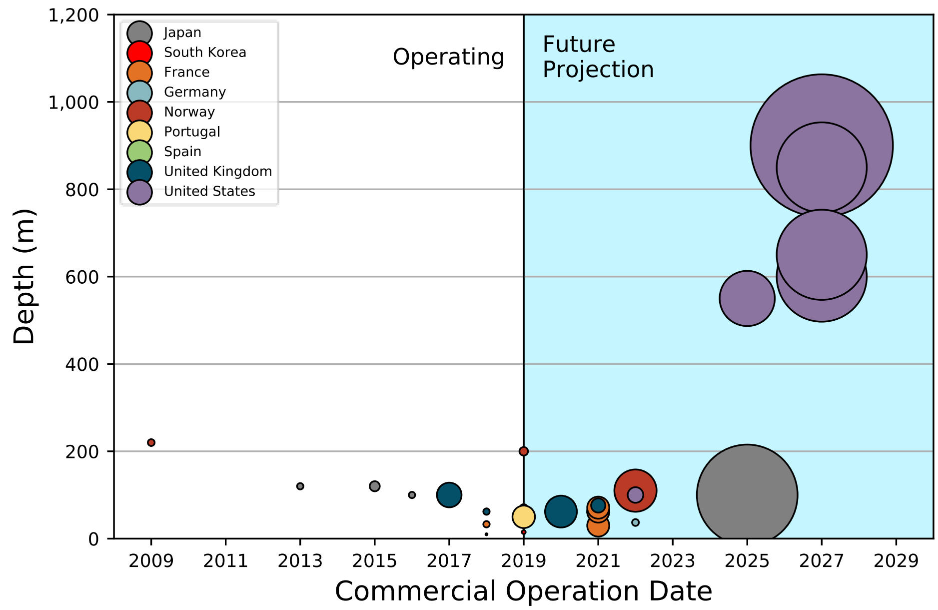


Figure 18. Global floating offshore wind pipeline

Table 11. Current Floating Offshore Wind Projects in Pipeline

Region	Project	Country	Pipeline Status	COD	Capacity (MW)	Water Depth (m)	Developer	Turbine Rating (MW)	Substructure
Asia	**Fukushima Floating Offshore Wind Farm Demo Phase 1**	Japan	Installed	2013	2	120	Marubeni Corporation	2	Semisubmersible
	Fukushima Floating Offshore Wind Farm Demo Phase 2	Japan	Installed	2015	5	120	Marubeni Corporation	5	Semisubmersible
	Sakiyama 2-MW Floating Wind Turbine	Japan	Installed	2016	2	100	TODA Corporation	2	Spar
	Kitakyushu – New Energy Development Organization (NEDO)	Japan	Under Construction	2019	3	70	NEDO/Ideol	3	Semisubmersible
	Hitachi Zosen	Japan	Permitting	2024	400	-	Equinor Hitachi	TBD	Semisubmersible
	Macquarie Japan	Japan	Planning	2025	500	100	Macquarie	TBD	TBD
	Ulsan 750-kilowatt Floating Demo	South Korea	Financial Close	2019	0.75	15	Consortium	0.75	Semisubmersible
	Donghae KNOC - Equinor	South Korea	Planning	2027	TBD	TBD	Equinor/KNOC	TBD	TBD
	Ulsan Shell, Coens, Hexicon	South Korea	Planning	2027	200	TBD	Shell/Coens/ Hexicon	TBD	Semisubmersible
	Ulsan Macquarie	South Korea	Planning	2027	200	TBD	Macquarie	TBD	TBD

Region	Project	Country	Pipeline Status	COD	Capacity (MW)	Water Depth (m)	Developer	Turbine Rating (MW)	Substructure
	Ulsan SK E&S - CIP	South Korea	Planning	2027	200	TBD	SK E&S/CIP	TBD	TBD
	Ulsan KFWind – Principle Power – Wind Power Korea	South Korea	Planning	2027	200	TBD	KFWind/PPI/WPK	TBD	Semisubmersible
	Floating W1N	Taiwan	Planning	2025	500		Eolfi/Cobra	TBD	TBD
Europe	**EOLINK 1/10-scale prototype**	France	Installed	2018	0.2	10	EOLINK S.A.S.	0.2	Semisubmersible
	Floatgen Project	France	Installed	2018	2	33	Ideol	2	Barge
	Groix Belle Ille	France	Approved	2021	24	62	EOLFI	6	Semisubmersible
	Provence Grand Large	France	Approved	2021	24	30	EDF	8	Tension Leg Platform
	Eolmed	France	Approved	2021	24	62	Ideol	6.2	Barge
	Les Eoliennes Flotant du Golfe du Lion	France	Approved	2021	24	71	Engie, EDPR, Caisse de Depots	6	Semisubmersible
	GICON Schwimmendes Offshore Fundament SOF Pilot	Germany	Financial Close	2022	2.3	37	GICON	2.3	Tension Leg Platform
	Hywind - Demo	Norway	Installed	2009	2.3	220	UNITECH Offshore	2.3	Spar
	TetraSpar Demonstrator	Norway	Financial Close	2019	3.6	200	Innogy, Shell, Stiesdal	3.6	Semisubmersible
	Hywind Tampen	Norway	Permitting	2022	88	110	Equinor	8	Spar
	NOAKA	Norway	Planning	2023	TBD	130	Equinor/Aker BP	TBD	TBD
	WindFloat Atlantic (WFA)	Portugal	Financial Close	2019	25	50	WindPlus S.A.	8	Semisubmersible
	DemoSATH - BIMEP	Spain	Approved	2020	2	68	Saitec Offshore Technologies	TBD	Semisubmersible
	X1 Wind prototype PLOCAN	Spain	Approved	2021	TBD	62	X1 Wind	TBD	Tension Leg Platform
	Floating Power Plant PLOCAN	Spain	Approved	2021	TBD	62	FPP	8 MW	Hybrid Wave Power Semisubmersible
	Hywind Scotland Pilot Park	United Kingdom	Installed	2017	30	100	Equinor	6	Spar
	Dounreay Tri	United Kingdom	Approved	2021	10	76	Hexicon	5	Semisubmersible
	Kinkardine Offshore Wind Farm Phase 1	United Kingdom	Installed	2018	2	62	Cobra	2 MW	Semisubmersible
	Kinkardine Offshore Wind Farm Phase 2	United Kingdom	Under Construction	2020	50	62	Cobra	9.5 MW	Semisubmersible
North America	**Castle Wind**	United States	Planning	2027	1,000	900	EnBW/Trident Winds	8+	Semisubmersible
	Redwood Coast Energy	United States	Planning	2025	150	550	EDPR/PPI	8+	Semisubmersible
	Aqua Ventus I	United States	Planning	2022	12	100	University of Maine	6+	Semisubmersible
	Oahu North	United States	Planning	2027	400	850	AW Wind	6+	Semisubmersible
	Oahu South	United States	Planning	2027	400	600	AW Wind	6+	Semisubmersible
	Progression Wind	United States	Planning	2027	400	650	Progression Wind	6+	Semisubmersible

3.3.2 Global Floating Market Assessment

The global offshore wind market continues to mature and show signs that it will accelerate its growth in the future. Major developments and trends in 2018 include the following.

- **Initial pilot and demonstration projects have validated functionality of floating technologies and encouraged further turbine upscaling**. Principle Power indicated that its 25-MW WindFloat Atlantic project in Portugal on its tri-hull asymmetrical semisubmersible substructures will be paired with three MHI Vestas V164-8.4 MW turbines, and the 50-MW Kincardine Floating Offshore Wind Park will use five MHI Vestas V164-9.5 MW turbines and one V80-2.0 MW turbine. Equinor also intends to deploy 8-MW (and above) turbines at its proposed 88-MW Tampen project aimed at powering two offshore oil and gas rigs in Norway. Similar to fixed-bottom technologies, floating systems seek larger turbines to help lower project costs (see Section 4).

- **Ideol installed a 2-MW demonstration project and France approved four demonstration projects**. Ideol's 2-MW Floatgen (dampening pool barge[44]) demonstration project was successfully installed 2 km off Le Crosic and connected to the grid in September 2018. The European Commission has offered financial support and the French government has approved four 24-MW demonstration projects: Groix Belle Ille in the Atlantic as well as Golfe du Lion, Eolmed, and Provence Grand Large on the Mediterranean (European Commission 2019).

- **Interest in offshore wind on the West Coast of the United States increased in 2018**. California's ambitious 100% renewable energy goals could necessitate the development of floating offshore wind projects in water depths up to 1,000 meters (m) (see Section 2). Two unsolicited offshore wind project applications have been filed with BOEM including Redwood Coast Energy (150 MW) and Castle Wind (1,000 MW). Because competitive commercial interest has been established, BOEM initiated three Call Areas (two are around these projects) and is accepting public comments on how to best shape potential future lease areas.

- **Nascent Asian markets showed strong interest in floating wind**. Japan has been interested in offshore wind since 2011 and installed some of the first prototypes using government funding appropriated after the Fukushima nuclear accident. New floating projects in Japan look increasingly promising now that the country has developed offshore wind deployment policies. In the near term, Japan's New Energy and Technology Development Organization announced that it is constructing a 3-MW demonstration project. Equinor has signed a memorandum of understanding with Korea National Oil Corporation to develop a floating project near the Donghae gas platform that is 58 km off the coast of Ulsan City, South Korea. Ulsan Metropolitan City and National Government also signed four memorandums of understanding with developers[45] to each develop 200-MW floating projects with a COD of 2023 (Quest Floating Wind Energy 2019).

---

[44] A dampening pool barge is a shallow-draft, buoyant foundation with a central opening that damps out platform motion caused by wave action.
[45] Developers include 1) Macquarie, 2) CIP and SK E&C, 3) PPI and Wind Power Korea, and 4) Shell, Coens, and Hexicon.

4 Offshore Wind Technology Trends

Technology advancements have played a key role in achieving the cost reductions experienced over the past few years that are enabling offshore wind energy to compete without subsidies in some energy markets. New technology and technical innovations are leading the industry to both lower costs and create new market regions. Continued cost reductions are allowing fixed-bottom offshore wind systems to compete in high-priced energy markets today, and floating wind technology, when matured, can open new regions that are currently inaccessible with existing technology (Gilman et al. 2016; WindEurope 2018). For many years, offshore wind technology advancements were measured by metrics, such as greater water depths and distances from shore (Beiter et al. 2016). More revolutionary technology advancements, such as floating wind turbines, promise larger payoffs in terms of dramatically greater siting options and wide-ranging increases in global electricity market penetration.

Using NREL's OWDB described in Section 1, this section relies substantially on empirical data for planned projects advancing through the pipeline to provide insight into global technology siting trends through 2024. The OWDB also provides insight regarding offshore wind turbine capacities, substructures, electric infrastructure, and logistical approaches for construction and maintenance activities. Much of the discussion is focused on fixed-bottom technologies, although floating technologies are also included.

4.1 Siting Trends for Global Offshore Wind Projects

Here we update trends observed in offshore wind fixed-bottom technology related to site characteristics of water depth and distance from shore. Figure 19 provides industry trends of four parameters—depth, distance, project status, and project size—and shows these trends for global offshore wind projects that have, at a minimum, advanced to the site-control phase. Global projects are color-coded by the project phase they have advanced to in the pipeline.

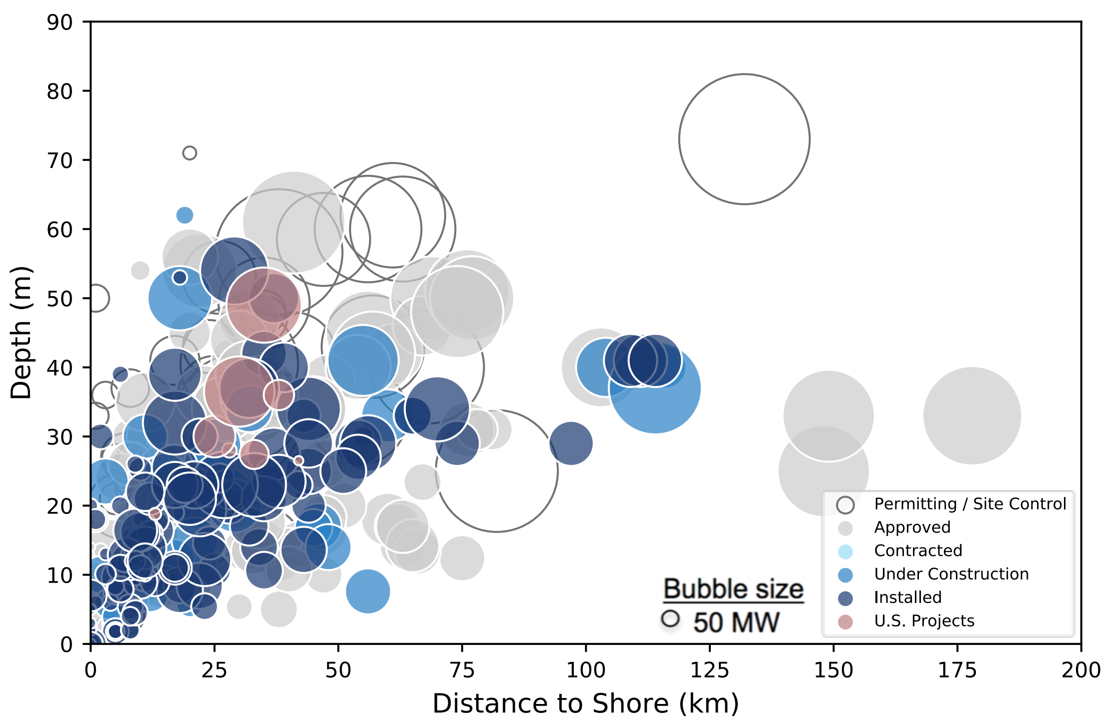


Figure 19. Fixed-bottom offshore wind project depths and distance to shore

In the figure, the project size is indicated by the diameter of the bubbles. The relative scale is shown with a representative 50-MW project in the key. This figure indicates a possible global trend toward larger projects (i.e., larger bubble sizes) sited farther from shore (i.e., the largest bubbles are at the 1,000-MW scale), particularly for those projects in the permitting and approval phase of development. Projects located further distances from shore (as far as 200 km) are enabled by the shallow bathymetry of the North Sea, where projects can be sited far from shore while still using fixed-bottom foundations.

Also included are the eight U.S. offshore wind fixed-bottom projects that have a viable pathway to an offtake agreement, have secured site control, and have significantly advanced in the permitting and regulatory process.[46] These projects have similar characteristics with respect to water depth and distance to shore; however, given the limited sample, it is difficult to judge longer-term trends. There are over 20 GW of capacity in the auctioned lease areas but distances from shore do not exceed 60 km in these areas and depths range from 20 to 65 m (Musial et al. 2013; BOEM 2019f).

Also, projects sited too close to shore can trigger public acceptance issues. Turbines sited beyond a certain distance from shore will generally be less visible and could raise fewer objections. This "acceptable" distance will vary depending on many factors including the land-based terrain and demographics, turbine scale, climate, and proximity to populations (Krueger et al. 2011). In the United States, public acceptance issues led to the demise of the first proposed commercial-scale U.S. project, Cape Wind, which may have contributed to BOEM's informal recommendation that new WEAs be at least 10 nautical miles (nm) from the shore (BOEM 2018). Therefore, with respect to distance from shore, near-term U.S. projects are likely to fall in a narrower vertical band (18–60 km depth) in Figure 19 than the global spread of distances. With respect to depth, some of the lease areas (e.g., Massachusetts WEA) have significant depths between 50 and 65 m, where projects will likely be built (Musial et al. 2013). Therefore, these depths up to 65 m in the existing WEAs will likely result in U.S. projects having slightly higher average depths than current European projects.

However, to judge a project's cost and complexity, it is more important to consider the distance to critical infrastructure than distance to shore. As more projects are permitted and built, developers may have more difficulty finding suitable grid connection points, thereby making export cable runs longer. Further, the cost of the electrical infrastructure for a wind project depends more on the length of the export cable than how far it is offshore. Similarly, the distance to construction and service ports will also be a strong cost factor, because turbine access, as well as construction and operation and maintenance (O&M) costs are directly related (Beiter et al. 2016).

As the industry matures, new technology and experience allows access to greater water depths, but projects with fixed-bottom foundations will pay a premium to access deeper water (Beiter et al. 2016). Floating foundations promise relief from water depth cost penalties, but it is still too early to fully understand these costs relative to fixed-bottom foundations on a commercial scale (Musial et al. 2016). However, if demand for offshore wind continues to increase, higher competing use constraints nearshore (e.g., fishing) may make it necessary to site some future Call Areas farther from shore, and therefore in deeper water where floating technology would be needed (Musial et al. 2016).

In Figure 19, the trends toward distance from shore or deeper water are not clear because new additions are difficult to track on a time-dependent basis. Figure 20 and Figure 21 show distance from shore and water depth as independent variables as a function of time (year of commissioning) for installed projects to help illuminate these trends better. These plots show the span of actual projects built for each year from 2000 to 2018, and projections that were made based on data from projects in the pipeline out to 2024. These data, provided for each year, indicate the capacity-weighted averages, and the range of all projects showing the highest and lowest values. For most years, the number of projects is too small to provide statistical significance, but the

[46] Note Aqua Ventus I is not shown because it is a floating project with different metrics for water depth.

overall trends out to 2024 can be inferred. Figure 20 indicates that the trend toward greater distances from shore may not be very strong. The data show there is a wider degree of variability from year to year, due, in part, to enabling technologies like high-voltage direct current (HVDC) transmission, which has been used in the North Sea to export power long distances to shore in several German projects.

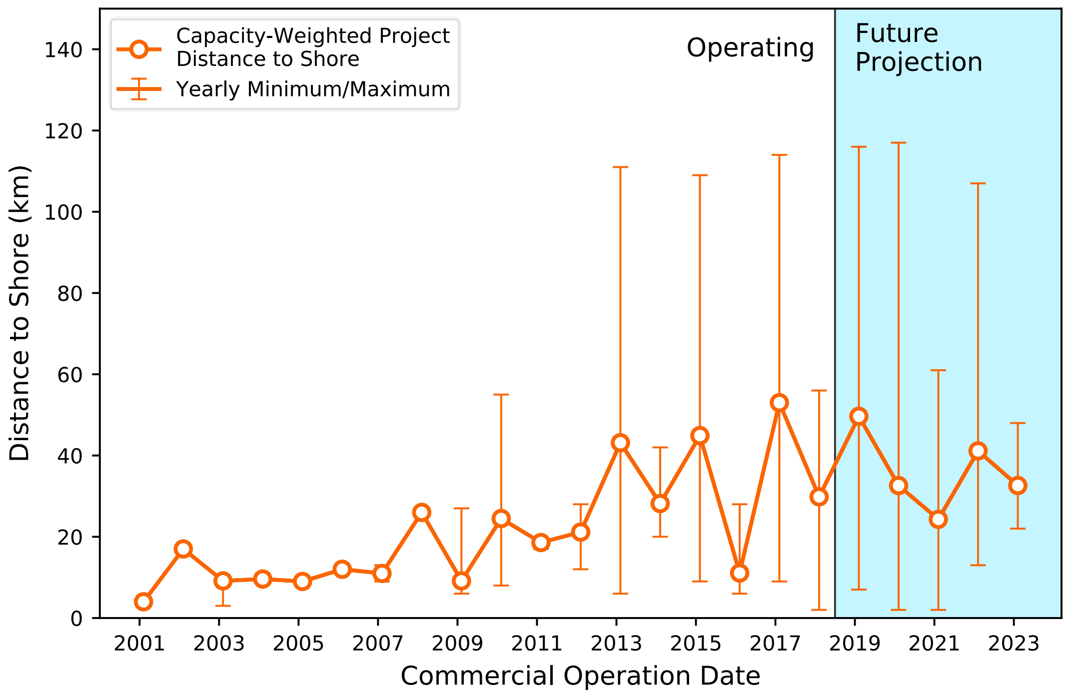


Figure 20. Project distance from shore trend to 2024

Similarly, Figure 21 shows the gradual trend in the global data toward greater water depths.

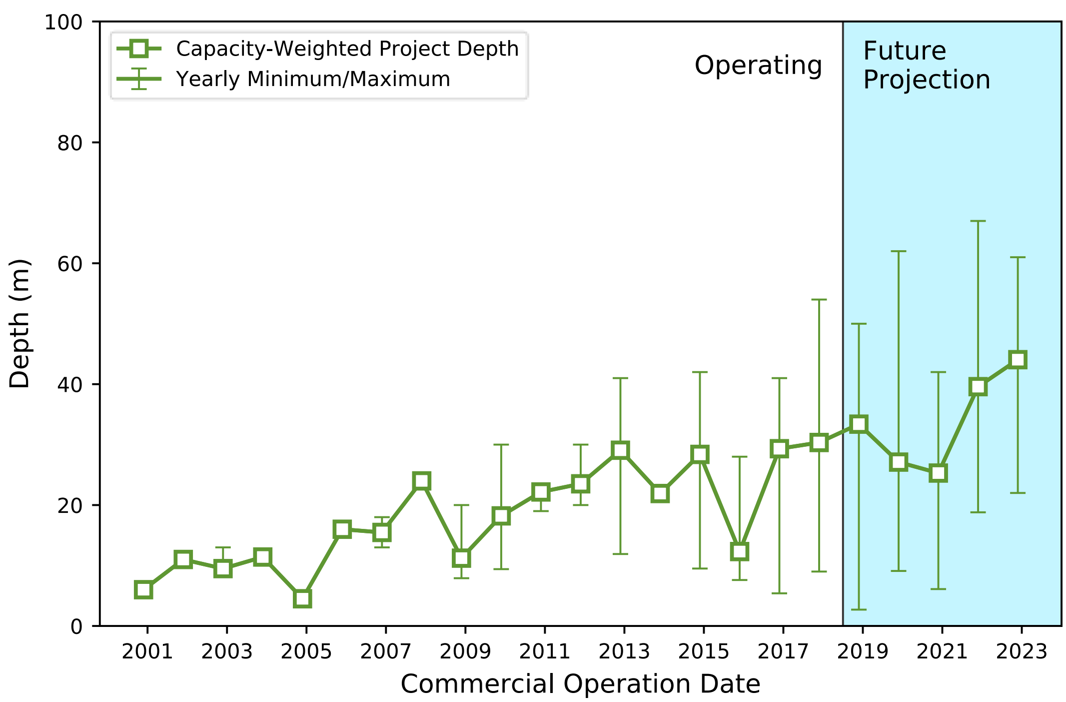


Figure 21. Project depth trend to 2024

The project trend toward deeper water is more defined than the trend toward greater distances to shore. Substructure designs have incrementally improved to overcome depth limits, thereby allowing access to more sites. Some deployments have already been successfully made at 50-m depths, and installations up to 60-m depths and beyond are planned before 2024 (The Crown Estate 2018). In the United States, some of the foundations at the Vineyard Wind site will be near a 50-m water depth (Vineyard Wind 2018a).

4.2 Offshore Wind Turbines

Here we address the trends in offshore wind turbine technology. In 2018, the industry's turbine manufacturers committed more confidently to increases in turbines size, indicating that a new 10-MW to 12-MW platform is under development for the next generation of turbines. This growth is being spurred by overall system cost reductions and energy production improvements associated with larger turbines. In addition, as the industry expands toward the Asian market (especially Taiwan, which committed to 5.4 GW earlier this year), turbine OEMs are beginning a serious effort to adapt turbines to extreme loads that may be generated by typhoons and seismic events.

4.2.1 Offshore Wind Turbine Technology

Offshore wind turbines are generally much larger than their land-based counterparts. Figure 22 shows global offshore wind turbine trends since 2000 along with the capacity-weighted[47] average turbine rating (blue bars; left axis), capacity-weighted average rotor diameter (green line; right axis), and capacity-weighted average hub height (orange line; right axis). Note that the future projection through 2023 for weighted average turbine capacity, rotor diameter, and hub height is based on only the subset of projects (21,037 MW) that have announced an agreement or partnership with a turbine OEM. These projections show that turbines are expected to continue to grow over time.

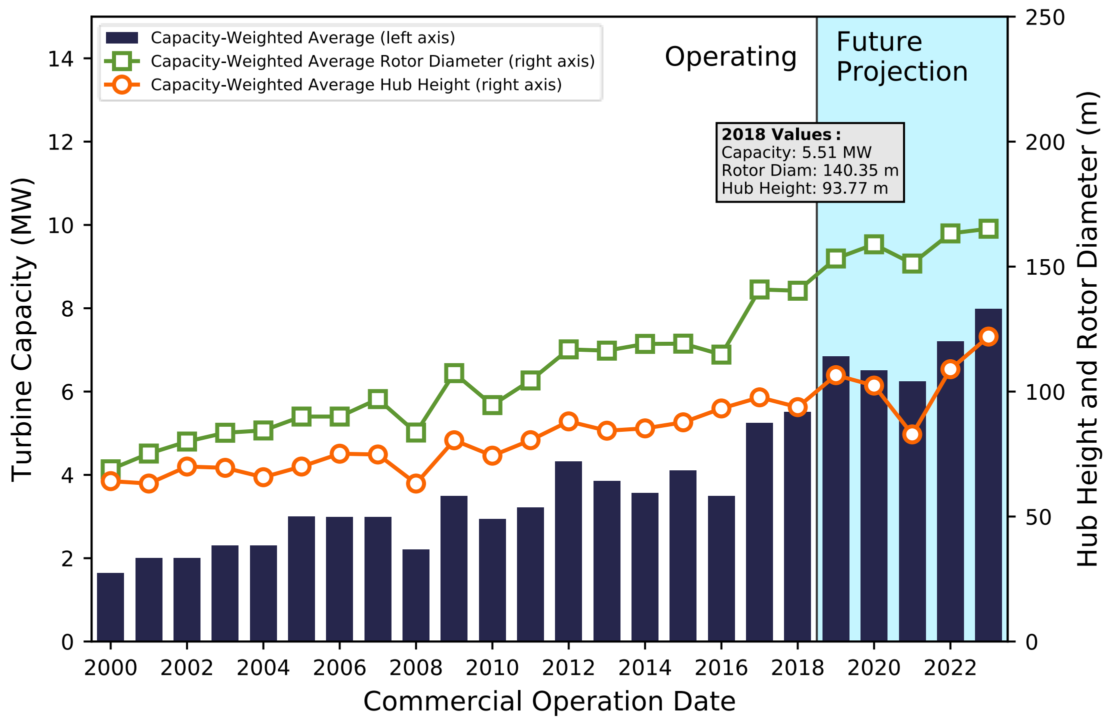


Figure 22. Offshore wind turbine rating, hub height, and rotor diameter

[47] A capacity-weighted average (weighted average) counts the contribution of a given characteristic (e.g., turbine rating) proportional to the amount of capacity (megawatts) the project delivers to the total capacity installed for a given year.

Although Figure 22 shows a steady turbine size growth trend, tracking the current and historical commercial deployments may not be the best way of predicting the absolute size of future wind turbines. To understand the cutting edge of new technology development, it is better to look directly at the turbine prototype development stage. This is especially important for offshore wind because the pace of turbine growth is much faster than land-based technology, and larger turbines are affecting all aspects of industry development including the economics, infrastructure, balance of plant, siting, and supply chain.

Increasing turbine size is one of the major factors that has been attributed to the sharp cost declines in offshore wind. Larger capacity turbines generally yield lower balance-of-plant costs, fewer and faster installations, and lower maintenance, as well as more energy per unit of area. Recent cost information also indicates that in addition to these project cost-scaling benefits, unit turbine costs may not be rising with turbine capacity as originally predicted by early models, such as the 2006 NREL Cost and Scaling Model (Fingersh 2006; for more recent assessments see Graré et al. 2018; Valpy et al. 2017; BNEF 2018e). In fact, a higher turbine rating may not result in an increase in per-unit turbine capital expenditures (CapEx) ($/kilowatt [kW]) at all. This new trend may potentially be a result of efforts by turbine manufacturers to manage increases in component mass using advanced engineering innovations and manufacturing methods, and through improved efficiencies in production and delivery. Therefore, a 6-MW wind turbine might have a similar cost per kilowatt as a 10-MW turbine. This trend may be incentivizing industry's push to further increase turbine capacity.

Because of these cost advantages, on a project level, developers will generally select the largest turbine available. At the end of 2018, the largest turbine installed was the MHI-Vestas V164–8.8 MW turbine at the Aberdeen Bay (European Offshore Wind Development Centre) project in Scotland, but the V174-9.5 is now available for commercial use and was ordered for the Baltic Eagle project in Germany. These Vestas turbines follow another industry trend to extend the nameplate power rating of the current turbine technology platforms for 6- and 7-MW turbines as high as possible by increasing drivetrain/generator capacities while maintaining rotor size. Most turbine manufacturers have conformed to this design approach over the past few years. In doing so, this has driven up the specific power rating[48] for these turbines, which could lower capacity factors in the interim while pushing the turbine technology platforms to their maximum energy extraction and load limits. These high specific power machines may still be well-suited for high wind sites in European waters but may not be the most efficient for lower wind speed sites in countries such as China, Japan, and Korea, and in the Great Lakes, mid-Atlantic, and South Atlantic regions of the United States.

In 2018, this trend in upscaling the existing turbine platforms was disrupted by the announcement of larger prototypes with increased rotor diameters—the next generation of offshore wind turbines on a new 10-MW to 12-MW technology platform. In March 2018, GE announced the 12-MW Haliade-X turbine, which has a prototype in production that is scheduled for installation in Rotterdam in 2019, and ready for market in 2021 (GE 2018b). The turbine is first in class, with a 12-MW direct-drive generator, 220-m rotor, and 140-m hub height. In January 2019, Siemens Gamesa announced the development of the SG10.0-193 DD turbine—a 10-MW direct-drive turbine with a 193-m rotor—which is planned to be ready for market in 2022 (Siemens 2019). This turbine would be a substantial departure from Siemens Gamesa's current SG 8.0-167 DD platform. Other manufacturers, such as Senvion (formally Repower), have been following suit with their own development plans for turbines in the 12- to 16-MW range (Foxwell 2018c). From recent industry trade press, it appears that the industry is likely to increase turbine size beyond 12 MW (Windpower Monthly 2018; Snieckus 2018).

To illustrate the pace at which turbines are growing in the offshore wind industry, Figure 23 shows the average turbine capacity growth from Figure 22 along with data contrasting the capacities of the largest prototypes available in the first year they were built since 2000. The turbine prototypes shown in Figure 23 were all later commercialized and have become part of the industry's commercial pipeline (e.g., blue bars).

[48] Specific power is the nameplate power rating of a turbine divided by its rotor's swept area in Watts/m^2.

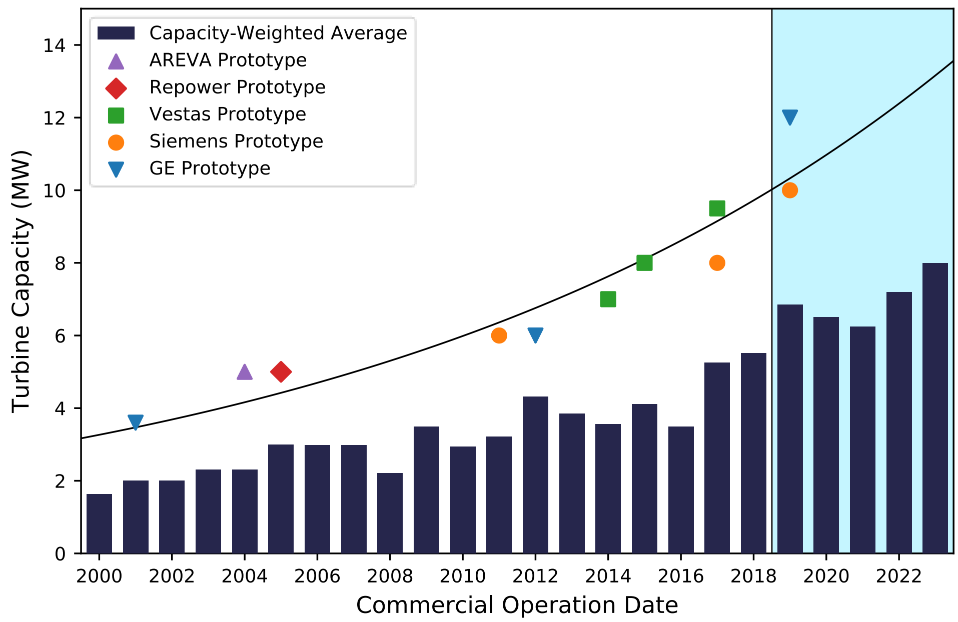


Figure 23. Average commercial offshore wind turbine rating compared to prototype deployment by year

Sources: Ragheb (2019), GE (2018), de Vries (2012), Composites World (2014), Adwen GmbH (2019),[49] Power Engineering (2005),[50] 4C Offshore (2017), Siemens (2013, 2019), Dvorak (2017)

From analysis of press releases, it takes at least 3 years for a turbine manufacturer to go from the first prototype to commercial production (GE 2018a; Siemens 2019). Historically, in many cases, this process is longer. Figure 23 shows that although offshore wind industry turbine size is indeed increasing, the maximum size of wind turbines that will be installed in later years is much larger than the weighted averages, and in 2018 there is no sign that offshore wind turbine growth is slowing down in spite of multiple logistical and infrastructure challenges. As shown, prototype capacity (shown in the colored symbols) has been consistently above the capacity of the weighted average turbine being installed.

4.2.2 Typhoons and Earthquakes

Offshore wind turbines are beginning to see more geographic diversity, especially as developers enter Asian markets wherein typhoons can bring extreme wave heights and wind speeds that exceed design specifications. Class 1A wind turbines are already designed to withstand wind gusts up to 70 meters per second (m/s) (156 miles per hour) but in these Asia-Pacific regions (and later in southern latitudes of the United States), the probability of major tropical cyclones (hurricanes) that produce loads exceeding the present design limits (set by International Electrotechnical Commission [IEC] standards) becomes more likely. Specialized hurricane-resilient designs are being developed to ensure that turbines, towers, blades, and substructures can withstand these extreme weather events.

Offshore wind turbines are currently designed using IEC 61400-01 and IEC 61400-03 standards, which define a 3-second maximum gust condition of 70 m/s (156 miles per hour) (IEC 2019a; 2019b). Oil and gas standards have been applied in the United States to manage the design of substructures. The recently released 2019 edition of IEC 61400-01 and 61400-03-1, the primary design standards for wind turbines, just added

[49] Note that AREVA is now a wholly owned subsidiary of Siemens Gamesa.
[50] Note that Repower now goes by the name Senvion.

provisions for a wind turbine typhoon class. Both Siemens Gamesa and Vestas have begun to ruggedize their turbine designs to adapt them to hurricane loading and comply with a more rigorous certification process to upgrade for the local conditions, particularly as they try and enter the Taiwan offshore wind market (Hill 2018). In some of these new offshore wind regions, there is also an increased threat of earthquakes; therefore, enhanced engineering activity to achieve seismic resilience has also been initiated.

4.2.3 Offshore Wind Turbine Manufacturers

Figure 24 shows the market share of each offshore turbine manufacturer for the cumulative installed capacity up to 2018, as well as the expected installations that have disclosed their intended turbine partner for near-term pipeline projects. After their merger, Siemens Gamesa continues to be the largest global supplier of offshore wind turbines, representing approximately 55% of installed capacity, or 12.3 GW, operating today. Siemens Gamesa is followed by MHI-Vestas, with just over 15% market share.

The right side of Figure 24 shows the OEM suppliers selected by developers for projects in the pipeline that have announced their turbine. The chart shows Siemens Gamesa's share of projected total global capacity is likely to grow to 60.3% for new projects, whereas Vestas is expected to hold on to about 14.5% total installed capacity. In addition, GE's share of total installed capacity is projected to grow to 8.9%. Other OEMs showing increased market share include Goldwind and Ming Yang, companies that are building strength in the emerging Chinese market.

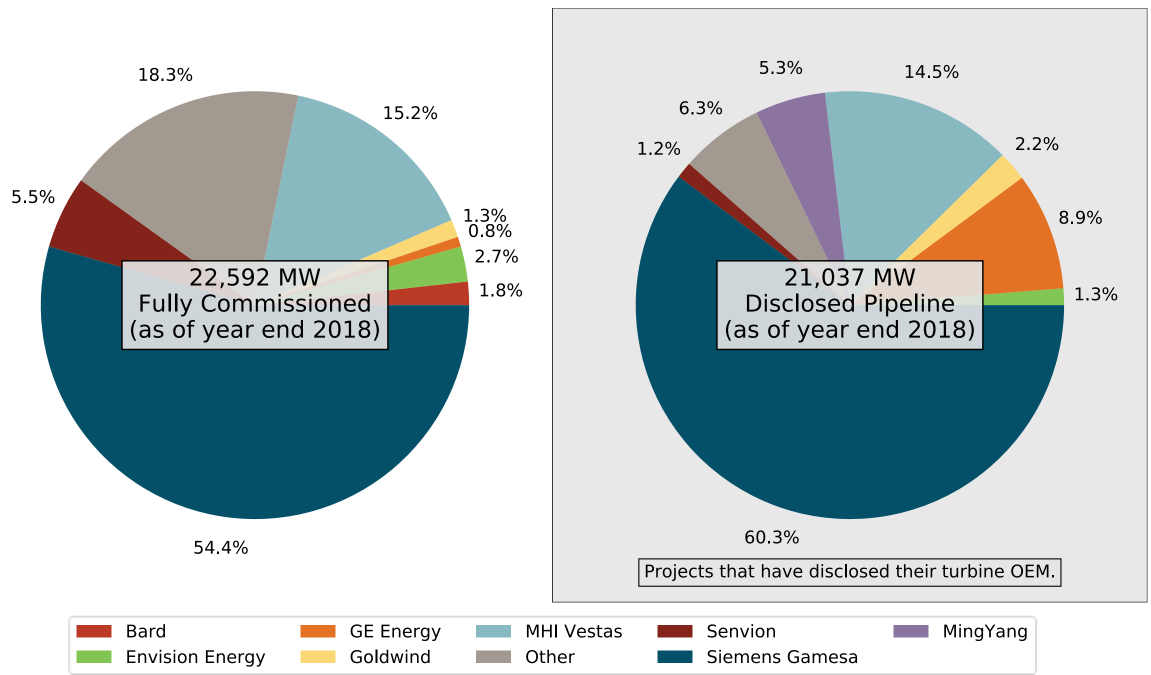


Figure 24. Offshore wind turbine manufacturers by market share for 2018 (left) and future (right)

4.3 Fixed-Bottom Substructures

Figure 25 shows the current mix of substructure types for fixed-bottom foundation projects operating at the end of 2018 along with the expected makeup of substructure types for the 37,203 MW of projects in the pipeline that have announced their intended substructure. In 2018, monopiles continued to dominate the operating fleet of global offshore wind turbines, representing 73.5% of the total market. Alternative substructure types, such as gravity-base, jacket, tripod, and floating foundations, each represent about 5% of the historical market share.

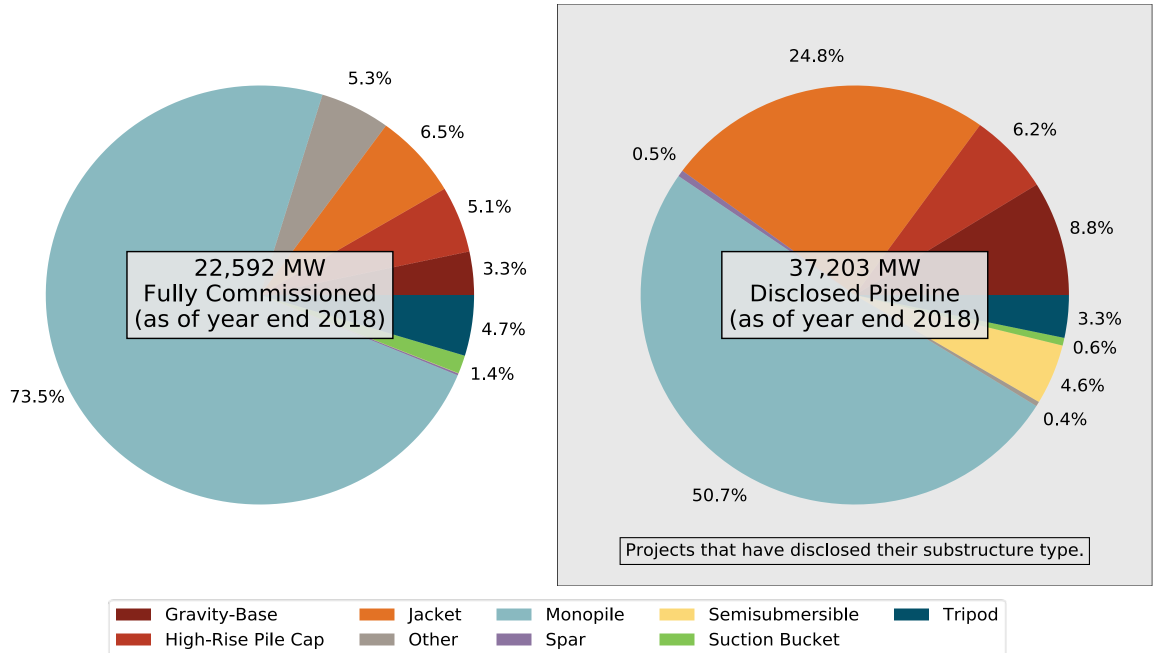


Figure 25. Offshore wind substructure technology trends in 2018[51]

Looking into the future, on the right side of Figure 25, developers have indicated they plan to increase the use of jackets by roughly fourfold. This change corresponds to projects being developed in deeper water depths and increased manufacturing options for jackets. Gravity-base foundations are also slowly increasing their market penetration because they do not require pile driving during installation, which eliminates underwater noise and potential negative impacts to marine mammals. Floating foundations are required for projects in water deeper than approximately 60 m and are discussed later in the report.

4.4 Electrical and Power System Technology

4.4.1 Array Cables and Substations

Buried, insulated, three-core copper cables are typically used for subsea array collector systems. Occasionally, aluminum cables are used as well. The array cables[52] are designed to meet the requirements on physical strength, flexibility, and temperature characteristics of the offshore site. Array cables also incorporate fiber-optic cables, plant control, and communications. Power conductor sizes for array cables are selected based on their current carrying capacity and location in a string of turbines. Array cable cross sections at the end of the string can be as small as 150 mm^2, and cables close to the substation can be 800 mm^2 or larger.

As shown in Figure 26, 42% of new intra-array cables energized in 2018 were supplied by Nexans, whereas JDR Cable Systems supplied 32.1% and Prysmian supplied 16.1%. These shares were calculated by counting the number of grid-connected turbines in each wind power plant during 2018 (WindEurope 2019).

[51] High-rise pile caps are offshore wind foundations that use a group of piles to support a flat, stable pad. The wind turbine tower is then installed on top of the pad. These foundations are primarily found in the Chinese market and deployed in shallow waters.
[52] Array cables are electrical cables that connect individual turbines to each other and an offshore substation or transmission cable.

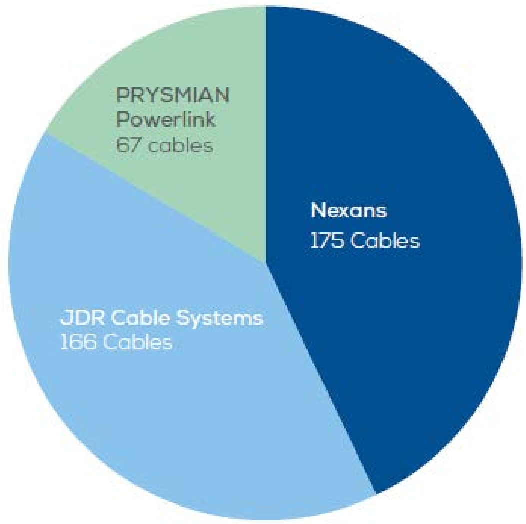


Figure 26. Number of turbines energized by supplier in 2018. *Chart courtesy of WindEurope 2019*

With the commissioning of the Aberdeen Bay offshore wind power plant in 2018, Nexans has now supplied two new offshore wind plants with its new 66-kilovolt (kV) cable technology (Nissum Brending Vind in Denmark and Aberdeen Bay in the United Kingdom). As rated power capacity of offshore wind turbines continues to grow, project developers and operators are increasing use of 66-kV cable technology instead of the conventional 33 kV. In 2018, there were three projects that used 66-kV array cables versus only one project in 2017. Operation at a higher voltage offers important life cycle cost-efficiency benefits, such as the possibility of reducing the number of offshore substations, decreasing the overall length of installed cables, and minimizing electric losses (Nexans 2018). During 2018, the advantages of 66-kV technology have been demonstrated by Nexans in three pilot projects: the Blyth Offshore Demonstrator (United Kingdom), Nissum Bredning Vind (Denmark), and Aberdeen Bay (United Kingdom) wind power plants. All these projects are currently connected to the grid and generating power. Nexans has also supplied a range of products and accessories including 66-kV sea cables (array and export cables), power cable accessories (e.g., equipment bushings, connectors, coupling connectors, surge arresters, dead-end receptacles, junction cabinets), GPH connection technology, and preassembled cables (Nexans 2018).

Continued development of several offshore projects in Southeast Asia has created new market opportunities for the undersea cable industry. For example, Formosa 1 is an offshore wind power plant being developed near Miaoli, Taiwan, by Formosa Wind Power Co in partnership with Macquarie Capital Group Limited, Ørsted, and Swancor Renewable. The 130-MW wind power plant will be Taiwan's first commercial-scale offshore wind project (Power Technology 2018). In 2018, JDR Cable Systems delivered 21 km of interarray cable, 13 km of export cable, and an additional 16 km of land cable to transmit power from the shore to the local substation. The 33-kV cables were manufactured at JDR's facility in Hartlepool, United Kingdom, before being shipped to Taiwan for installation by Jan De Nul. The project is targeted for completion in 2019 (JDR 2019).

4.4.2 Export and Land-Based Interconnect

The electrical grid connection contributes significantly to the cost of an offshore wind power plant. It includes both offshore and land-based infrastructure and connects the wind power plant to the land-based electricity grid. AC offshore substations contain the common busbar for cable termination, protection, and switchgear, transformers that step up the voltage from a 33-kV or 66-kV array level to a 132- to 220-kV export level, and reactive power compensation. There is normally more than one AC substation in a large wind power plant, thereby providing a higher level of reliability and redundancy in the electrical system to reduce the impact of a single point of failure. Similarly, DC offshore substations contain an AC busbar, protection, and switchgear; AC transformers; HVDC power electronic station; and DC terminals.

Typically, the AC export cables use conductor cores ranging from 600 mm^2 to 1,200 mm^2, although larger cross sections are possible. Various types of armoring can be used depending on seabed conditions, amount of vessel traffic, and water depth.

In terms of export cables in 2018, eight export cables manufactured by NKT Group were energized, representing 53.3% of the annual market. Prysmian, Ls Cable & System, and JDR Cable Systems each had about a 13.3% share, and Nexans represented the remaining 6.7%, as shown in Figure 27 (WindEurope 2019). When calculating these shares in Germany, the export cables are considered to be the cables connecting the offshore wind power plants to the land-based grid, whereas in other countries the export cables are considered to be the high-voltage, alternating-current cables only. Note that these market shares were calculated by considering only the export cables in operating wind power plants.

According to Market Research Consulting, the global submarine cable market accounted for $6.31 billion in 2017 and is expected to reach $25.56 billion per year by 2026 (Market Research Consulting 2018). Such growth is expected because of rising demand in both offshore wind and oil and gas operations. Increasing demand for HVDC submarine power cables is also one of the major electrical supply chain trends for offshore wind observed during the forecast period. By geography, several regions in Europe are dominating the offshore power cable market because of rapid growth in numbers of offshore wind projects and rising demand for intercountry submarine power transmission links. Some key players in the submarine power cable market include Furukawa Electric, General Cable Corporation, Hengtong Group, Hydro Group, KEI Industries, LS Cable & System, Nexans, NKT Holding, Prysmian Group, Sumitomo Electric Industries, Tele-Fonika Kable S.A, ZTT International Limited, and TE Subcom.

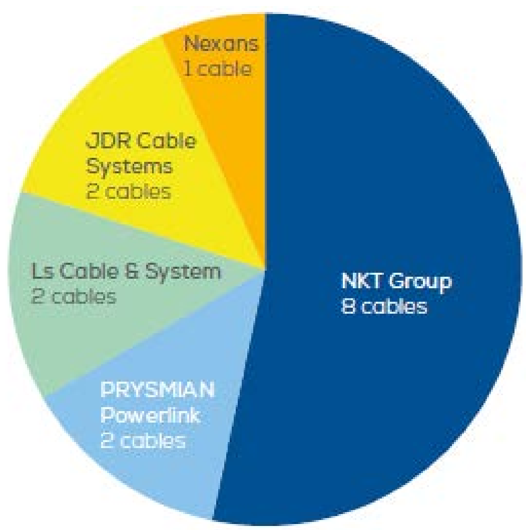


Figure 27. Share of energized export cables by supplier in 2018. *Chart courtesy of WindEurope 2019*

4.4.3 Transmission, Grid Integration, and Storage

As the role of wind energy grows in the U.S. power grid, there is increased interest and requirement for it to provide essential reliability services. These services are critical to maintaining the reliability and stability of the grid, and historically were provided by large synchronous generators, mainly from fossil-fueled and hydroelectric generators (Denholm, Sun, and Mai 2019).

In 2018 and early 2019, as state offshore wind policy commitments grew from near 5 GW to 20 GW by 2035, the challenge of integrating this amount of electricity into the existing land-based grid has begun to resonate as a high priority among the many developers, utilities, and state energy organizations (Business Network for Offshore Wind 2019). For some states like Massachusetts, New York, and New Jersey, injecting this amount of offshore wind represents up to 30% of their current electricity supply, which is likely to have significant impacts to the land-based grid and transmission system that have not been fully quantified. In the next year, the topic of offshore wind grid integration and grid planning is likely to gain more attention.

In most of today's power systems, wind (both offshore and on land) and solar generation still have a limited impact on grid operation because other generation sources can be dispatched. As the share of variable renewable generation becomes a major fraction of the total generation, electricity systems will need more flexibility services that can be potentially provided by the rapid response capabilities of electricity storage. The shift toward large-scale integration of energy storage into the power systems operation will need to be part of the energy planning process.

In 2018, Masdar and the Norwegian company Equinor (formerly Statoil) installed, and started testing, a new battery system designed to store electricity generated by the 30-MW Hywind Scotland, the world's first commercial-scale floating wind power plant. This battery energy storage system (BESS) project coupled with the offshore wind power plant is the first of its kind in the world. The goal of the project is to evaluate the capabilities of advanced storage technologies to optimize the release of electricity from renewable energy plants to transmission grids—from both a technical and commercial perspective. A conceptual diagram of interconnection between the offshore wind power plant located at a short distance from the shore and the land-based BESS is shown in Figure 28 (Equinor 2018b).

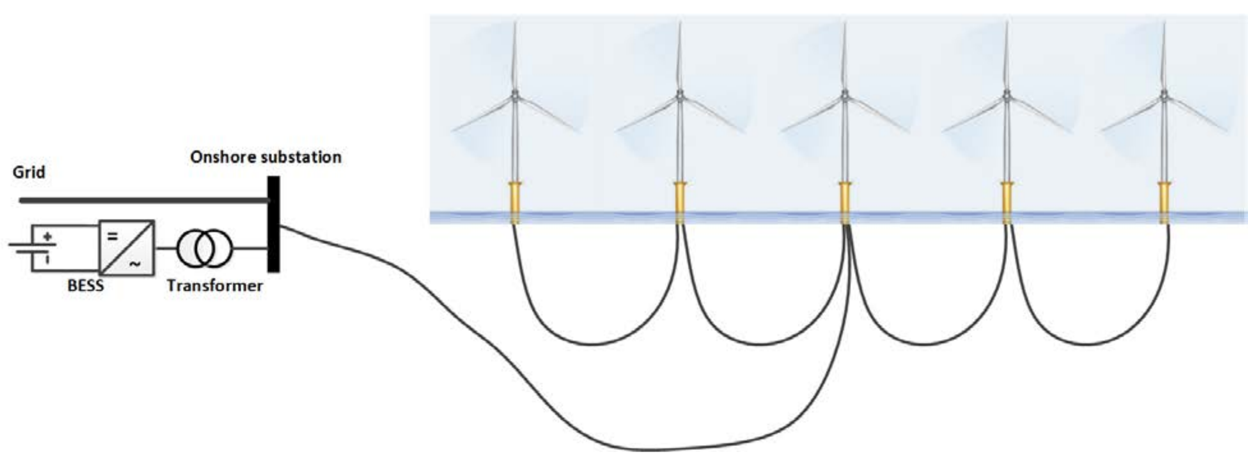


Figure 28. Near-shore offshore wind power plant operating with the land-based BESS. *Illustration by NREL*

The BESS technologies can provide a wide range of utility-controlled and self-directed services (Benson 2018).

4.5 Floating Technology Trends

Floating wind energy technology is advancing rapidly. Based on the resource capacity, the prospect for significant future deployment potential of floating wind seems similar to fixed-bottom wind but there are many technology challenges that must still be solved. Some of these unique technology challenges for floating wind are discussed in this section.

4.5.1 Floating Wind Turbines

Like fixed-bottom technology, developers of floating offshore wind projects generally want to use the largest commercial offshore turbines available on the market. For example, WindFloat Atlantic in Portugal is planning to install three MHI Vestas V164-8.4 MW turbines, and the Kincardine project in Scotland is installing five MHI Vestas V164-9.5 MW turbines (Froese 2018; 4C Offshore 2019; Davidson and Weston 2018). The motivation is the same for both floating and fixed-bottom foundations: project costs are lower with larger turbines. To date, all offshore wind turbines used in floating applications have been designed for fixed-bottom applications. Therefore, the market information for turbines on fixed-bottom foundations applies directly to floating systems. Floating-specific turbines have not yet been designed but conceptual engineering studies suggest a greater value proposition for lightweight turbine components, which may help reduce overall system weight. Because the floating wind pipeline is still small, the demand for these floating-specific offshore wind turbines is not high enough for OEMs to take the turbine development risk. More certainty in a large future floating wind market will be needed to motivate the first generation of customized floating wind turbines.

4.5.2 Floating Support Structures

The cost of a floating offshore wind project depends on the characteristics of the support structure it uses. The cost of the support structure itself is important, but so is the support structure's ability to help lower costs in other parts of the system, such as by enabling serial fabrication, inshore assembly, and commissioning, and by minimizing expensive offshore labor, including O&M. In addition, the coupled hydrodynamic-aerodynamic design of the floating system is the primary method for protecting the turbine from excessive loads and accelerations, especially under extreme conditions. Most floating projects in the pipeline plan to use semisubmersible substructures (see Table 11) because inherently, semisubmersible floating foundations have a shallow draft and are stable even after the turbine is installed. This allows for a full assembly and commissioning at quayside, and allows the full system to be towed from an inshore assembly port to an offshore station without the use of heavy-lift installation vessels.

Figure 29 shows a capacity-weighted average of the substructure choices for all floating projects in the NREL OWDB at the end of 2018.

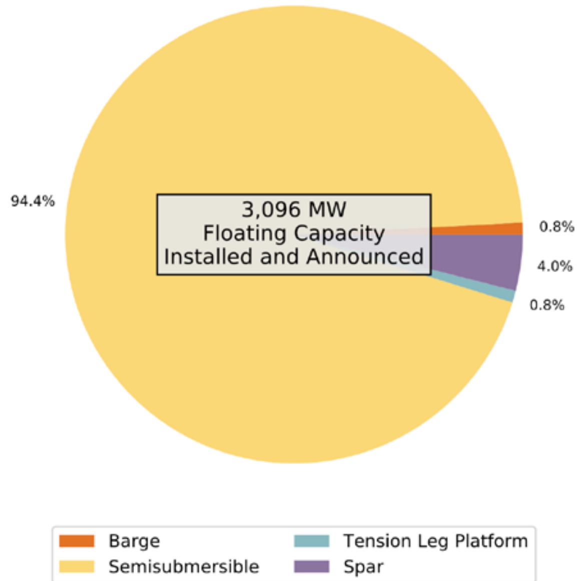


Figure 29. Capacity-weighted average of floating substructure selection for the global pipeline

The chart shows that 94% of projects in the floating wind pipeline plan to use semisubmersible substructures. Approximately 4% use or plan to use spar technology, like the substructures deployed by Equinor on the first commercial floating wind project, shown in Figure 30 (Equinor 2018a). The remaining substructures are tension leg platforms and barges.

As the industry deploys the next generation (second generation) of technology, new hybrid floating platform design concepts are being introduced that have desirable characteristics like the semisubmersible. In 2018, Stiesdal Offshore Technologies introduced the TetraSpar floater, which has a stable buoyant floating substructure with low draft to allow for inshore assembly but uses a flexible cable system to deploy a ballast weight at sea. The design incorporates a tubular steel base with a suspended underwater tetrahedral counterbalance. Innogy and Shell have partnered with Stiesdal to build a single turbine demonstration project in Norway that plans to use a 3.6-MW Siemens Gamesa turbine (Weston 2019). In November 2016, SBM Offshore won a contract to deliver three floating platforms for the 24-MW Provence Grand Large pilot wind energy project in the French Mediterranean. The SBM tension leg platform substructure design is unique because it is stable before attaching the mooring lines—an uncommon characteristic and one of the major drawbacks of conventional tension leg platforms. Both the TetraSpar and the SBM tension leg platform represent hybrid platform technologies that could challenge conventional semisubmersible technology for cost competitiveness and possible future market share. Figure 31 shows both designs.

Figure 30. A 6-MW floating wind turbine in Equinor's 30-MW array near Peterhead, Scotland, supported by a spar buoy floating platform. *Photo courtesy of Walt Musial, NREL*

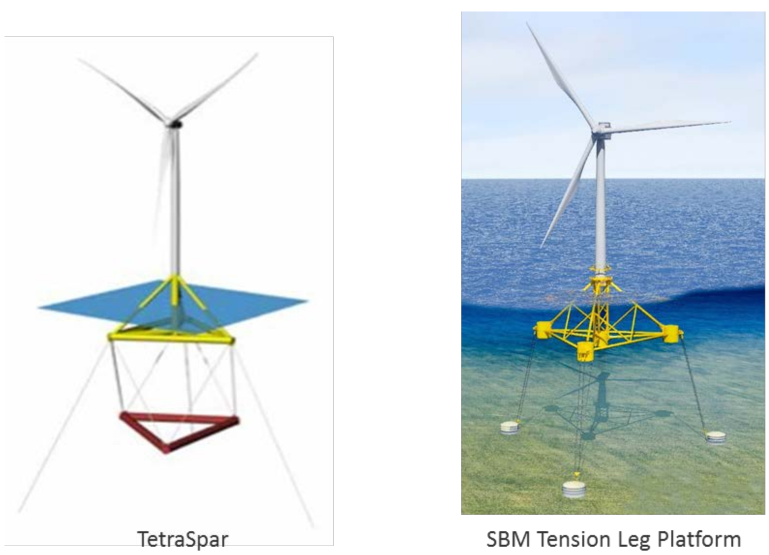


Figure 31. Second-generation floating wind concepts of alternative hybrid substructures. *Images courtesy of Stiesdal Offshore Technologies (left) and SBM Offshore (right)*

One concern for floating projects in the United States and likely other parts of the world is the design of mooring systems for the depth characteristics of the U.S. Outer Continental Shelf.

In the eastern United States, it is likely that floating technology could open large areas in the 60−100-m depth range for offshore wind development. Although this water depth is deep by fixed-bottom wind turbine standards, for floating, these depths are shallower than typical floating oil and gas rigs and are generally unique to offshore wind. Shallow water means shorter mooring lines, which act as shock absorbers to absorb hydrodynamic loading. If they are not long enough or heavy enough, platform loads could increase. New mooring system designs are needed to enable floating technology at shallow water depths. New designs are emerging already to allow projects to be sited in these water depths (4C Offshore 2019b). Conversely, because of the steep shelf on the Pacific Coast, floating projects will be located at sites with water depths up to 1,000 m or more. In these waters, the optimization of deeper water moorings is a different technology challenge because project developers are likely to be encouraged to reduce the footprint of their anchor circle and generally shorten the length of their mooring lines to minimize the impact to other users of the sea. In 2018, DOE and NYSERDA formed the National Offshore Wind R&D Consortium to address technical issues affecting developers in the United States and released a solicitation calling for engineering solutions to shallow and deep-water mooring design issues (NYSERDA 2019).

4.5.3 Electrical Power Systems

Floating turbines allow greater distances from shore, which can have several impacts on cost including the design of subsea electrical cabling and system configuration (e.g., consideration of HVDC) as well as logistical challenges during the project's construction and operation phases (e.g., transport time, effective length of working day).

Floating offshore wind platforms are constantly moving with the waves and winds acting on the structure. As a result, the attachment point for the electric cable is in motion as well. For a fixed-bottom foundation, this attachment point is firmly secured. The dynamic nature of floating platforms will require developers and cable manufacturers to develop dynamic cable designs to ensure that cyclic loads and bends on the cable will not compromise the system. This approach is important for turbine systems as well as possible floating substations. In March 2019, Prysmian announced that it had developed a specialized submarine cable system specifically designed for floating offshore wind applications. The company plans to test their new cable on the 24-MW Provence Grand Large Demonstration in France (T&D World 2019).
JDR, a supplier of subsea power cables and umbilical cables to the global offshore energy industry, has been selected by WindPlus as the preferred cable supplier for the Windfloat Atlantic 25-MW floating wind power plant. The project—located off the coast of Viana de Castelo, Northern Portugal—will be the industry's first application of dynamic cables operating at 66 kV with V164 floating wind turbine generators (WireTech 2019).

In April 2019, the Carbon Trust announced the five winners of its dynamic export cable competition as a part of the Floating Wind Joint Industry Project, which aims to accelerate and support the development of commercial-scale floating wind power plants. The project is a collaboration between industry partners EnBW, ENGIE, Eolfi, E.ON, Equinor, Innogy, Kyuden Mirai Energy, Ørsted, ScottishPower Renewables, Shell, Vattenfall, and Wpd, with support from the Scottish government (Carbon Trust 2019).

4.5.4 Targeted Research in the United States

The U.S. offshore wind industry is poised for substantial deployment of over 10 GW of electric-generating capacity over the next decade, but with only 30 MW operating there is some uncertainty about the transfer of largely European-based technology to the United States. The physical and economic characteristics of U.S. sites, supply chains, and offshore resources may present unique issues that would require additional research conducted outside the scope of individual commercial projects. To help address this concern, a new national technical research consortium was formed in 2018 with the purpose of conducting new technology research to benefit the end users (developers) of the U.S. market. Under an open funding opportunity, DOE committed

$20.5 million in 2018 to NYSERDA to form a National Offshore Wind R&D Consortium. The corporation agreed to match the DOE contribution and launched a funding organization to make research and development awards on prioritized topics that will support developers in achieving their near-term deployment and cost targets. The first solicitation was released by NYSERDA on March 29, 2019, and the first awards are expected in 2019. As the organization matures, NYSERDA envisions that the consortium will become a nonprofit entity with a self-sustaining mission that extends well beyond the initial 4-year time frame (NYSERDA 2019).

5 Cost and Pricing Trends

The PPA and price schedule agreed upon between Vineyard Wind LLC and Massachusetts electric distribution companies in July 2018 offers the first market-based reference point for the price and cost of commercial-scale (800 MW) offshore wind generation in the United States. It suggests that the Vineyard Wind project off Massachusetts falls within the price range of European offshore wind projects, with an expected start of commercial operation between 2022 and 2023. This PPA was established against the backdrop of continued price and commensurate cost reductions in major offshore wind markets from 2016 to 2018. Section 5.1 provides a discussion of price trends for fixed-bottom projects, including an analysis of the PPA price point for the Vineyard Wind project. Section 5.2 summarizes LCOE trends for fixed-bottom projects, with subsections on the constituent parts of LCOE (i.e., CapEx [Section 5.2.2], turbine costs [Section 5.2.3], operational expenditures (OpEx) [Section 5.2.4], and financing [Section 5.2.5]. Section 5.3 summarizes cost trends for floating technology.

5.1 Fixed-Bottom Pricing Trends

Figure 32 shows (adjusted) strike prices from recent offshore wind auctions held in Germany, the United Kingdom, the Netherlands, Denmark, and the United States, for projects to be commissioned between 2017 and 2025.

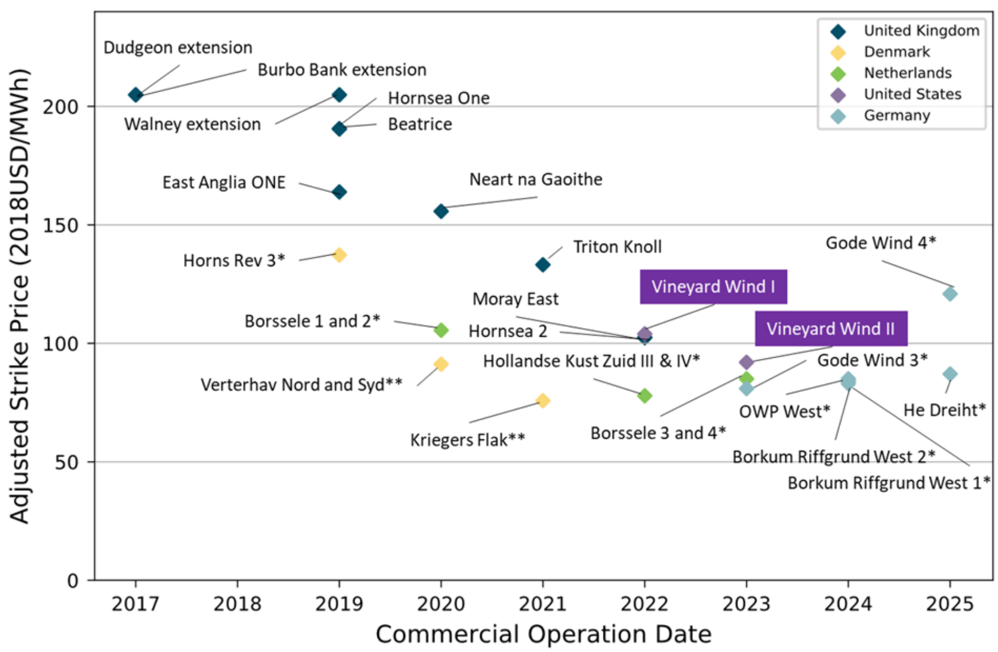


Figure 32. Adjusted strike prices from U.S. and European offshore wind auctions. *Reprinted from Beiter et al. (2019)*

Notes: *Grid and development costs added; **Grid costs added and contract length adjusted; includes data for commercial-scale projects only

The winning auction prices (commonly referred to as "strike prices")[53] that are shown in the figure were adjusted by NREL for contract length, grid connection, and revenue mechanism for an "all-in" price

[53] The strike price for an offshore wind project from an auction is usually the lowest bid price at which the offering can be sold. The strike price usually covers a specific contract term for which the project will be paid for the energy (and possibly other products or attributes) produced. The offeror of that

comparison (see Musial et al. 2017 for a more detailed description).[54] These adjustments were made to account for differences in project scope. For example, under German award terms, the project developer is only responsible for expenditures related to intra-array cabling and the offshore substation but not for the rest of the export cable system. Adjustments were made to the German projects to add the expected cost of the export cable and land-based grid connection back into the price.

The data suggest a trend of declining price levels from approximately $200/MWh (2017–2019 COD) to approximately $75/MWh for projects with a 2024–2025 COD.[55] These reductions in the prices for procuring offshore-wind-produced electricity were achieved through a combination of favorable siting characteristics; increased project size; continued optimization of technology and installation processes; improved market, regulatory, and auction design structures; increased competition within the supply chain; favorable macroeconomic trends; and strategic market behavior.

5.1.1 Vineyard Wind PPA (Lease OCS-A-0501) Analysis

On July 31, 2018, Vineyard Wind LLC and the Massachusetts electric distribution companies submitted a 20-year PPA for 800 MW of offshore wind generation and renewable energy certificates to the Massachusetts Department of Public Utilities for review and approval. The Vineyard Wind/Massachusetts PPA established a contract for procurement of electricity from two 400-MW facilities that enter commercial operation in 2022 (facility 1)[56] and 2023 (facility 2), respectively, at a specified pricing schedule (Massachusetts Department of Public Utilities 2018a, 2018b). Key contractual terms and project filings from the Vineyard Wind LLC Draft Environmental Impact Assessment (Vineyard Wind 2018a), construction and operations plan (Vineyard Wind 2018b), and the independent evaluator report (Peregrine Energy 2018) are shown in Table 12.

The documented first-year price for delivery of offshore wind generation and renewable energy certificates under the Vineyard Wind/Massachusetts PPA is $74/MWh (2022$) for facility 1 (400 MW) and $65/MWh (2023$) for facility 2 (400 MW), but these prices do not reflect all of the revenue that the project will generate, and are therefore lower than the data shown in Figure 32. To allow for a more accurate comparison with the adjusted European auction prices, Beiter et al. (2019) calculated a levelized PPA price, accounted for revenue streams outside of the PPA,[57] and excluded U.S. tax benefits (i.e., election of the investment tax credit [ITC]). The resulting (adjusted) PPA price was estimated to be $98/MWh (2018$).

Although this (adjusted) "all-in" price level of $98/MWh is significantly higher than the reported first-year PPA prices, the data in Figure 32 show that the project costs are in line with European project bids for the same time frame. This suggests that the generally anticipated price (and cost) premium for the nascent U.S. offshore wind industry in comparison to offshore wind projects in the established European markets might be much less pronounced than has widely been expected by many analysts. Earlier cost analyses estimated LCOE between $120/MWh and $160/MWh for a commercial-scale offshore wind project built in the northeastern

---

strike price is awarded the rights to develop a particular parcel under predetermined conditions set in the tender offer that may vary by country or market. The strike price should not be confused with levelized cost of energy, which may be calculated using different financing and cost assumptions.

[54] In general, these adjusted costs are higher than the unadjusted strike prices but still reflect a steep decline in price for European offshore wind projects installed out to the 2025 COD.

[55] Note that many of the projects shown in Figure 32 with future CODs have not yet reached the financial investment decision, and some caution is appropriate when determining whether these projects will reach COD.

[56] Vineyard Wind LLC has recently reported its intent for both facilities to be in operation by the end of 2022, ahead of the commercial operation date indicated on initial fillings (Vineyard Wind 2018c).

[57] One of the revenue streams outside of the PPA considered is sales into the ISO-New England (ISO-NE) Forward Capacity Market. Note that in its capacity auction FCA #13 held on February 4, 2018, Vineyard Wind did not qualify for the renewable technology resource exemption, which allows a resource to be exempt from the ISO-NE minimum-offer price rule. Vineyard Wind participated in the ISO-NE substitution auction and secured 54 MW of capacity. ISO-NE filed tariff changes on November 30, 2017, to allow offshore wind resources located in federal waters, including Vineyard Wind, to qualify for renewable technology resource treatment in future auctions. These tariff changes were approved by the Federal Energy Regulatory Commission on January 29, 2019 (ISO Newswire 2019).

United States in the early 2020s (see e.g., Beiter et al. 2017; Musial et al. 2016; Maness et al. 2017; Kempton et al. 2016).

Table 12. Vineyard Wind LLC/EDC PPA Contract Terms[58]

	PPA 1	PPA 2	Notes	Source
Capacity [MW]	400	400	N/A	a, b
Commercial operation date	January 15, 2022	January 15, 2023	N/A	a, b
Delivered product	Energy and renewable energy certificates		N/A	a, b
First-year PPA price [$/MWh]	74 $2022/MWh	65 $2023/MWh	N/A	a, b
PPA duration [years]	20		N/A	a, b
Escalation factor [%]	2.5		N/A	a, b
Vineyard Wind LLC Project Filings				
Wind speed [m/s]	9.3		Simple average of the entire Vineyard Wind lease area	c
Net capacity factor [%]	45		Average capacity factor reported by Vineyard Wind; assumed to be net capacity factor	d
Average water depth [m]	42		The construction and operations plan indicates water depths in the northern half of the lease area range from 35 to 49 m; 42 m is the average	d
Substructure type	Monopiles		Vineyard Wind has indicated that it prefers to use monopiles but may deploy jackets for up to 400 MW of capacity depending on seafloor conditions	d
Turbine rating [MW	8		Turbine rating will range between 8 and 10 MW	d
Export cable length [km]	69.2		Generator lead line proposal selected by buyer (Vineyard Wind LLC procures all cables from turbine to point of interconnection); point of cable landfall: New Hampshire Avenue	e
Land-based cable length [km]	9.65		Generator lead line proposal selected by buyer (Vineyard Wind LLC procures all cables from turbine to point of interconnection); interconnection point: Barnstable	e
O&M port distance [km]	60		O&M port: Vineyard Haven	d

[58] These terms are derived from the PPA contract between NSTAR Electric Company d/b/a Eversource Energy and Vineyard Wind LLC; similar contract terms apply to the other electric distribution companies that have separate contracts with Vineyard Wind LLC.

Installation port distance [km]	92		Installation port: New Bedford Commerce Terminal	d
ITC [%]	18	18	Assumes safe harbor provision through expense of 5% of the overall project cost by the end of 2018 (facility 1) and 2019 (facility 2)	f

Source: Reprinted from Beiter et al. (2019)

a Massachusetts Department of Public Utilities (2018a)
b Massachusetts Department of Public Utilities (2018b)
c Musial et al. (2017)
d Vineyard Wind (2018b)
e Vineyard Wind (2018a)
f Peregrine Energy (2018)

The following is a set of factors that may help explain how Vineyard Wind may have been able to achieve lower-than-expected prices, which are on par with the European price reductions shown in Figure 32:

- The ability to import major technology components from Europe and Asia (e.g., nacelles, blades, cables)
- Favorable offtake conditions for electricity produced by offshore wind in the United States (e.g., relatively low merchant risk compared to the terms of recent European tenders)
- Use of state-of-the art technology solutions expected from early U.S. projects (e.g., Vineyard Wind LLC has announced its intent to procure the V164-9.5 MW turbine [MHI Vestas 2018])
- Project size of 800 MW that is comparable to large European projects
- Developer's experience with installing and operating offshore wind plants globally
- Successful demonstration of offshore wind technology at the Block Island Wind Farm may have lowered some risk perceptions
- Strategic bidding by tender participants for entry into emerging U.S. market (e.g., to gain "first-mover" advantages)
- U.S. market pipeline visibility and growing state policies (see Section 2)
- Industry consolidation as evidenced by Deepwater Wind's acquisition by Ørsted in December 2018
- Intensified competition within the global and U.S. supply chain and among bidders.

This price signal from the Vineyard Wind/EDC PPA could be indicative of subsequent procurement prices of U.S. commercial-scale offshore wind generation in the 2020s. However, a combination of factors determines future price and cost levels (Musial et al. 2016). Massachusetts legislation H.4568 requires future offshore wind generation procured under its capacity mandate of 1,600 MW[59] to produce a price below the Vineyard Wind LLC/EDC PPA contract price.[60] This will require additional cost reductions amid a tax environment that is expected to become less favorable with the ITC phase-out underway (see Section 5.2.6). It is also possible that the Vineyard Wind LLC/EDC PPA price could have benefited from one-time effects, such as strategic

[59] Massachusetts legislation H.4568 mandates the procurement of 1.6 GW of offshore wind capacity by 2027.
[60] The Massachusetts legislature is considering a change to this requirement, which would adjust the procurement price of the previous solicitation for the availability of federal tax credits, inflation, and incentives (amendment 280 to H.3800; H.3801).

bidding behavior among market entrants to gain first-mover advantages for subsequent U.S. offshore wind tenders.

Beyond Vineyard Wind, there is only a limited number of price signals from U.S. projects but their project sizes are smaller than 250 MW. The prices for these small-to-medium size projects are shown in Section 2.4.

5.1.2 European Auction Results and Outlook

Major offshore wind auctions were held in Germany and the Netherlands during quarter 1 (Q1) and Q2 of 2018. Auction activity ceased during the second half of 2018. Table 13 lists the auctions held in European markets during 2018. These were described in greater detail in the *2017 Offshore Wind Technologies Market Update* (Beiter et al. 2018), as they all took place in early 2018.

Table 13. Offshore Wind Auctions During 2018

Project	Country	Auction	Award Date	Capacity (MW)	Auction Price (2016$/MWh)	Adjusted Auction Price Estimate (2016$/MWh)
Borkum Riffgrund West 1	Germany	Second Auction (§ 26 WindSeeG)	04/27/18	420	0	~79
Gode Wind 4				132	118	~115
Hollandse Kust Zuid III and IV	Netherlands		03/19/18	700	0	~74
Note: For more details on these auctions, see Beiter et al. (2018).						

In Germany, no further auction activity is expected for a 3-year period after conclusion of the country's first two rounds of auctions held under the §26 *Offshore Wind Act* (*WindSeeG*) during 2017–2018. Although the German coalition government signaled it may hold an extra tender, it has not formally proposed another auction round to date ahead of 2020 (Foxwell 2018a). Industry groups have requested to "advance grid expansion and optimization and reduce regulatory hurdles for sector coupling" (German Offshore Wind Energy Foundation 2019). After awarding Hollandse Kust Zuid I and II projects (700–750 MW) on March 19, 2018, in a zero-subsidy bid, no additional tender was conducted during 2018 in the Netherlands. Tenders for Hollandse Kust (zuid) wind farms III and IV (700 MW) are scheduled to be held in March 2019 with awarded projects expected to commercially operate by 2023. The United Kingdom will continue its tender activity with a third contract-for-difference allocation round ("AR3") in May 2019. The tender budget is specified at £ 60 million, with a delivery cap of 6 GW.[61] The last award in the United Kingdom was made during its contract-for-difference 2 round in 2017 ("AR2"). After inactivity during 2018, Denmark has selected the location of a new offshore wind facility (800 MW) off Nissum Fjord to be auctioned during 2019 with a COD between 2024 and 2027.

[61] Note that various technologies can bid under the United Kingdom tender scheme, including (but not limited to) offshore wind. However, in previous auctions, offshore wind was awarded the largest share.

5.2 Fixed-Bottom Offshore Wind Cost Trends

5.2.1 Levelized Cost of Energy

Offshore wind is among the renewable energy technologies that has experienced a rapid cost decline in recent years. It is commonly expected that this cost reduction trend will continue globally and will be realized in the United States as the market emerges. Figure 33 provides a survey of LCOE estimates and projections for fixed-bottom technologies from a variety of research organizations and consultancies.

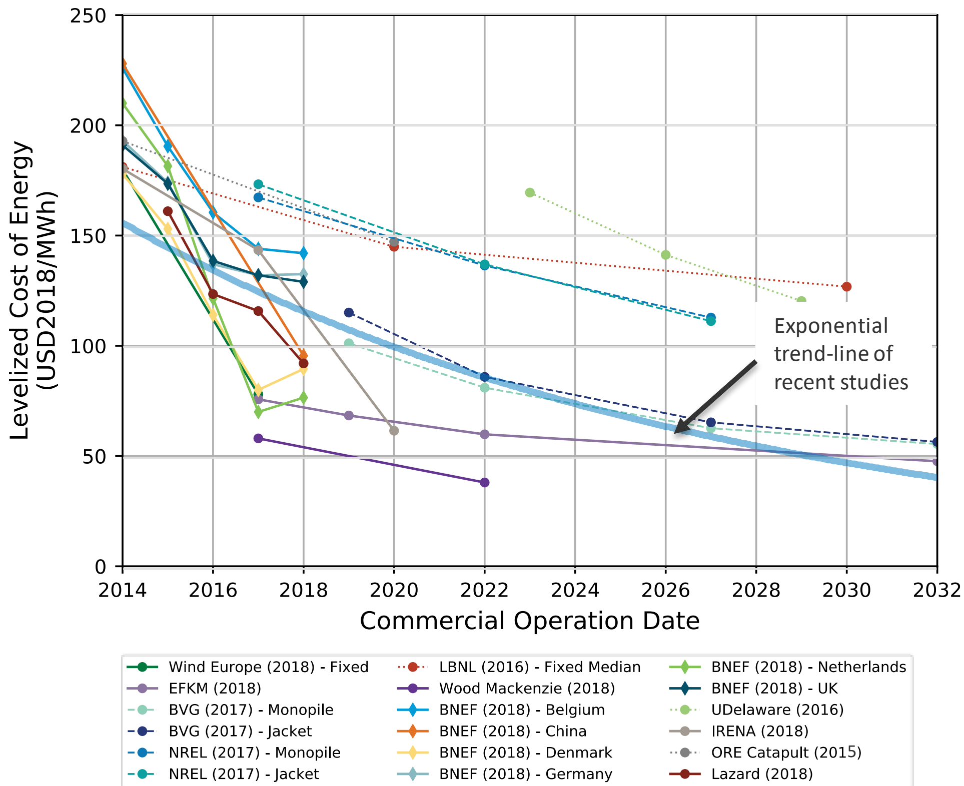


Figure 33. Global LCOE estimates for fixed-bottom offshore wind[62]

Sources: WindEurope (2018), Danish Ministry of Energy, Utilities and Climate (2018), Valpy et al. (2017), Beiter et al. (2017), Wiser et al. (2016), Barla (2018), BNEF (2018b, 2018c), Kempton et al. (2016), IRENA (2018), ORE Catapult (2015), and Lazard (2018)

In Figure 33, the 2018 cost projections are shown in solid lines, whereas earlier studies are plotted with dashed lines. The wide blue trend line represents an exponential fit of the most recent data from studies published in 2018, as well as Valpy et al. (2017) projections, which extend to 2032. This trend line suggests a decrease from LCOE levels of about $120/MWh in 2018 to $50/MWh by 2030. The trend line is meant to serve as a visual reference to focus on the most recent cost projections.

Projections informed by a learning curve approach offer a complementary method for forecasting future cost reductions (Wiser et al. 2016). Based on industry growth projections, the cumulative capacity of the global industry is likely to experience approximately three doublings, or a total growth of eight times its current

[62] "LBNL" in the figure refers to Berkeley Lab

capacity, by 2030. IRENA (2018) estimates a learning rate for offshore wind of approximately 14% per doubling over the period 2010–2020, which would indicate possible LCOE reductions of over 35% based on industry growth projections of 154–193 GW globally by 2030 (see Section 3.2.3).

5.2.2 Capital Expenditures

CapEx are the single largest contributor to the life cycle costs of offshore wind power plants and include all expenditures incurred prior to the COD. Figure 34 shows the reported CapEx over time for operational projects as well as for those in various stages of the near-term project pipeline globally. Each bubble represents the cost estimate (in terms of $/kW) for a single project and bubble size represents the project's capacity.

After a period of increasing project CapEx until 2014 (Musial et al. 2017), an industry trend of declining CapEx has developed, with a capacity-weighted average CapEx of $4,350/kW in 2018 globally. WindEurope reported a European project CapEx of $2,870/kW in 2019, a 45% reduction since 2015 (Brindley 2019). Reported project data suggest a gradual decline of CapEx to levels in the range of $2,500–$4,000/kW between 2020 and 2030. The underlying data for Figure 34 include considerable variation of CapEx within a given year. For projects with a COD in 2018, CapEx ranges from approximately $2,470/kW (Jiangsu Luneng Dongtai project, China [200 MW]) to $6,500/kW (Galloper project, United Kingdom [353 MW]) among projects with capacities greater than 100 MW. Several factors may possibly explain the variation in CapEx within a given year and over time (Smith, Stehly, and Musial 2015), including:

- Varying spatial conditions (e.g., water depth, distance to port, point of interconnection, and wave height of sites that affect technical requirements of installing and operating a wind farm)
- Project size
- Different levels of supply chain shortages (e.g., components, vessels, and skilled labor)
- Changing prices for commodities and energy
- Macroeconomic trends, such as fluctuating exchange rates
- A change in the appreciation of the costs and risks associated with offshore wind project implementation, which reflects in pricing strategies from equipment suppliers and installation contractors.

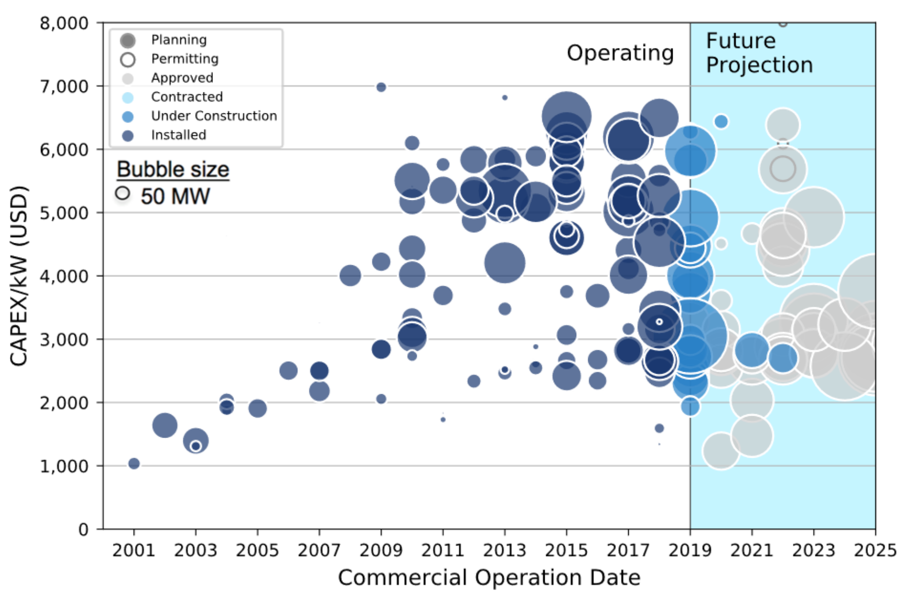


Figure 34. Capital expenditures of global offshore wind projects by commercial operation date and project capacity

Note: Only projects with CapEx greater than $800/kW included.

Note that only limited CapEx data are available for any given year before 2010 and after 2025. As a result of this relatively small sample, and the projects' early planning stages in which firm contracts for capital equipment have yet to be executed, the level of confidence is relatively low for some years.

CapEx has been reported for 67,185 MW of global offshore wind projects. Figure 34 shows the announced costs for 123 installed projects (20,198 MW), 21 projects (7,198 MW) that have started construction, 14 projects (4,848 MW) that have secured financial close, 56 projects (34,009 MW) that have received regulatory approval, 5 projects (575 MW) in the permitting process, 1 project (300 MW) that is still in the planning phase, and 8 projects (58 MW) that are decommissioned. These CapEx data have some uncertainty for various reasons: 1) the CapEx data are normally self-reported by developers and difficult to verify independently, 2) there is limited transparency into the financial impact of cost overruns, and 3) it is often unclear whether the reported CapEx fully captures the total cost of installing the project and connecting it to the grid.[63] When viewed together, though, these data can provide insight into the long-term cost trends. Generally, greater confidence can be placed in cost estimates that are in more mature stages of the project life cycle (i.e., costs for projects that have reached the financial investment decision are typically more accurate than for a project that has not yet received permits); however, preliminary estimates provide insight into developer expectations about cost trends.

5.2.3 Wind Turbine Cost

Offshore turbine costs are estimated to be between 30% and 45% of the total CapEx. Typically, turbine price data come from turbine supply agreements that are negotiated for each project, but because of their proprietary nature these data are very limited. Turbine prices may vary considerably among specific projects. Some of the factors in turbine pricing include delivery costs to the staging port, warranty period (typically 5 years), availability guarantees, project order size, turbine attributes (e.g., turbine rating and drivetrain topology), market competition, timing, and specific strategic market behavior (e.g., first-mover advantages, customer retention). Turbine CapEx has declined rapidly over the last few years, which has led to a considerable spread in price estimates found in publicly available literature sources. Figure 35 shows turbine CapEx estimates published between 2016 and 2019, which illustrate considerable variation yet a general trend of price decline in turbine CapEx between 2010 and 2030.

[63] For example, it is unclear if the announced capital expenditure values include soft costs, such as construction, financing, insurance, or fees.

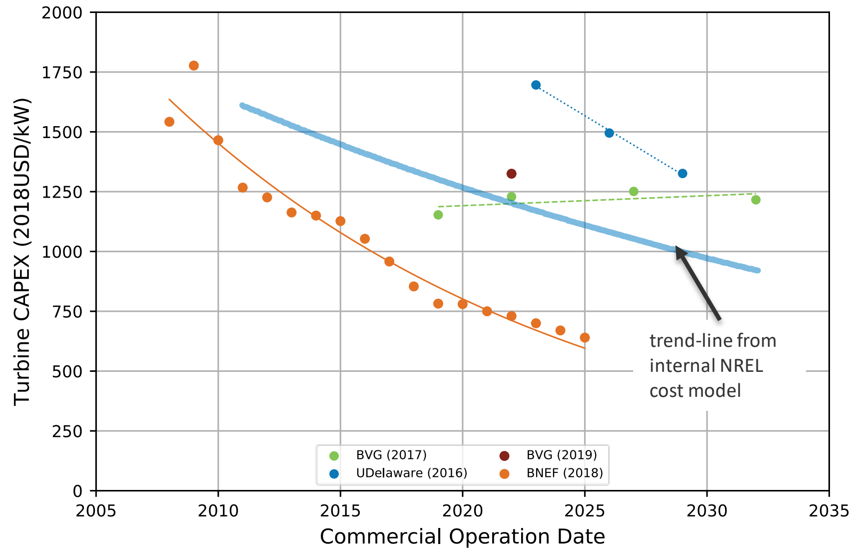


Figure 35. Turbine CapEx trend estimates

Sources: Valpy et al. (2017),[64] Kempton et al. (2016), BVG Associates (2019), and BNEF (2018e)

Available cost studies indicate that turbine CapEx could range between $800/kW and $1,200/kW in 2018–2019. BNEF (2018d) numbers were the lowest and estimate a reduction trend reaching $640/kW by 2025. Valpy et al. (2017) illustrates the impact from larger turbine ratings of 6 MW (2019), 10 MW (2022), and 12 MW (2027 and 2032) on turbine CapEx. The increase in turbine CapEx from Valpy et al. (2017) is found to be relatively small on a $/kW basis, which would allow for a significant decrease of total system costs on a $/MWh basis. Kempton et al. (2016) estimated considerably higher turbine CapEx from their 2016 study but show a similar cost reduction rate as BNEF (2018d).

The highest commercially available turbine rating is expected to grow from 9.5 MW in 2018[65] to 15 MW or higher over the next decade (see Section 4), which presents one of the primary areas for future cost reduction (e.g., Wiser et al. 2016). Using higher-rated turbines for a given project size reduces the number of turbines to be installed and serviced, effectively decreasing the unit costs for balance-of-station ($/kW) and O&M activities ($/kW/year). In addition, consultation with industry experts and turbine manufacturers suggests that higher turbine rating may not necessarily result in an increase in turbine CapEx ($/kW). Turbine manufacturers have reportedly been able to increase turbine rating without increasing the unit cost of the turbine ($/kW). Through continued innovations, such as the use of lightweight materials, advanced manufacturing methods, systemwide load control, and economies of scale in production and delivery, turbine manufacturers may be able to offset other cost increases (such as specific mass increases) caused by upscaling. Some evidence of this trend might be found in a review of the GE Haliade-X technical specifications by Pondera Consult, which reports only a slight increase in specific mass for the Haliade-X turbine at 68.8 tonnes per megawatt (t/MW)—including the nacelle, blades, and hub—compared to the Vestas V164-8MW specific mass of 62.5 t/MW. This

[64] Note: In contrast to the other sources, this estimate from Valpy et al. (2017) explicitly includes the impact from an increase in turbine rating (over time) on turbine CapEx ($/kW) (i.e., from turbine ratings of 8 MW [2018] up to 12 MW ([2027 and 2032]).

[65] MHI Vestas V164-9.5 MW turbine.

emerging trend in turbine lower mass/cost growth must be further validated but could provide a further economic motivation for upscaling to larger turbines (de Vries 2019).[66]

5.2.4 Operational Expenditures

OpEx cover all costs incurred after COD—but before decommissioning—that are required to operate the project and maintain turbine availability to generate power. These expenditures are generally thought to contribute between 20% and 30% to life cycle costs for offshore wind projects, depending on site characteristics. The strongest drivers are distance from the O&M port, accessibility limits related to local meteorological ocean conditions (e.g., wave height), and turbine rating (i.e., fewer, larger turbines suggest lower O&M costs per megawatt). To optimize the balance between OpEx and availability, operators adopt different logistical strategies for individual projects depending on site conditions (DNV GL 2013). OpEx for offshore wind projects are subject to considerable uncertainty because of a lack of empirical data. Although wind project owners commonly report CapEx, they rarely report OpEx.

5.2.5 Financing

In contrast to fossil-fueled power plants (e.g., natural gas or coal), variable costs of offshore wind plants are relatively small, and most lifetime costs are incurred up-front through CapEx for the development and construction of a project. These up-front expenditures generally require investment volumes of more than $1 billion for utility-scale projects (>200 MW).[67] The financing rate of a project, commonly expressed in terms of the weighted-average cost of capital,[68] has considerable impact on lifetime project costs (i.e., LCOE) because it determines the annual debt service and equity repayment for the initial (CapEx) investment.

During 2018, offshore wind projects in Europe and Asia continued to access low-cost capital, consistent with a broader trend of declining equity and debt rates for renewable energy asset financing in recent years. Nearly $12 billion was invested in new European offshore wind capacity (4.2 GW) during 2018, which comprised 24% of the total investment in new power generation assets in Europe.[69] Although the total investment volume is lower compared to the levels between 2015 and 2016, installed capacity levels were considerably higher "as a result of cost reductions and sector maturity, particularly for offshore wind" (Brindley 2019). In Europe, project finance dominated offshore wind investment transactions during 2018 with a share of 77%. This drastically reverses the trend of widespread balance-sheet financing from previous years and reflects growing comfort with the risks associated with constructing and operating an offshore wind plant, as well as the entry of smaller developers who can take advantage of a favorable lending market (Brindley 2019). Table 15 depicts financing conditions typical for European offshore wind projects between 2006 and 2018 (Guillet 2018). The share of debt in European project financing has been consistently at or above 70% since 2012, including in 2018. Brindley (2019) reports debt share of up to 90% for European offshore wind financing in 2018, exceeding those of land-based wind farms. These financing terms are generally expected to carry into 2019 (Brindley 2019).

Table 14. Typical Financing Conditions for European Offshore Wind Projects

Year	Debt-to-Equity Ratio	Pricing[70] (Basis Points)
2006–2007	60:40	150–200

[66] Note that the described trend between turbine rating and turbine CapEx may only apply to a certain range of turbine ratings.
[67] For instance, the 800-MW Vineyard Wind project has a reported investment volume of approximately $2 billion (Renewables Now 2018).
[68] Weighted-average cost of capital is the average cost of all sources of capital based on the percentage contribution to the total capital structure.
[69] Major offshore wind projects that reached their financial investment decision were Moray East and Triton Knoll (both in the United Kingdom) and Borssele III and IV (the Netherlands).
[70] Basis points are indicated above the London Interbank Offer Rate. One basis point is equal to 1/100 of a percent and 100 basis points equals 1%.

2009–2011	65:35	300–350
2012–2013	70:30	200–250
2014–2015	70:30	200–250
2016–2017	75:25	150–225
2018	70:30	120–175

Source: Reprinted from Guillet (2018)

Note: Year 2008 not available from source.

Debt

Debt rates for global offshore wind financing remain at historically low levels, ranging between 3% and 4% for 15-year debt terms (Guillet 2018). Debt maturity (post completion) ranged between 10 and 18 years, depending (among other factors) on the length and structure of the offtake conditions. These debt terms correspond to land-based wind financing in the United States (Wiser and Bolinger 2018). Consultation with industry experts suggests that debt financing rates for commercial-scale offshore wind projects will be similar to commercial-scale projects in the United States.

Equity

Driven by high demand for relatively predictable long-term cash flow and technology characteristics that are increasingly well-understood, equity rates for offshore wind have decreased in recent years. A greater variety of equity investor classes seems to be comfortable with the risk profiles of offshore wind, such as pension and insurance funds. Further, equity refinancing of operational projects has become more prevalent in established offshore wind markets. During 2018, the debt refinancing volume was nearly $10 billion for four European offshore wind farms completing their construction phase (Brindley 2019).

Emerging information for the U.S. market suggests that European financing terms are generally applicable to a U.S. project finance context. In the United States, it is generally expected that several different types of entities will participate in the financing of commercial-scale offshore wind projects, including commercial banks, export credit agencies, and institutional investors (e.g., pension funds, insurance funds, and infrastructure investors). The engagement of Copenhagen Infrastructure Partners in the Vineyard Wind project may indicate that major international infrastructure investors recognize the potential of the U.S. offshore wind market. A similar motivation might apply to the market entry of major oil and gas corporations as well as supply chain companies (i.e., manufacturers and marine contractors) acting as offshore wind investors globally and in the United States.

Important U.S.-specific financing considerations include, but are not limited to:

- **Tax Credits**. Offshore wind projects in the United States may currently elect the ITC or production tax credit. It is commonly expected that U.S. offshore wind projects will have a preference to elect the ITC; however, choosing between election of the ITC versus the PTC depends on a number of financial and legal considerations influenced by the anticipated energy production and operational risks. Pursuant to the Consolidated Appropriations Act, 2016 (P.L. 114-113), these tax credits are on a phase-down schedule (Table 15), thereby limiting the number of offshore wind projects that are expected to benefit from these tax provisions. Some large-scale projects have reportedly grandfathered their election of the ITC/production tax credit by commencing "physical work of a significant nature" on the facility or by incurring at least 5% of the total cost of the facility under the ITC phase-down rate schedule (Deloitte 2017). During 2018, some concerns were raised whether large-scale projects, such as the 800-MW

Vineyard Wind project, would be able to raise unprecedented volumes of tax equity financing for a single project of up to $600 million (Deepwater Wind 2018). Financial close of the Vineyard Wind project is expected during 2019 and will allow for a better understanding of whether enough tax equity is available at these investment levels. Election of these tax credit provisions influences the optimal financing structure of an offshore wind project with a higher share of equity and back-leveraged (i.e., the loan is collateralized by the sponsor's equity in the project), so that the benefits from the tax incentive can be fully utilized. As a result of the tax credit phase out, optimal offshore wind financing structures are expected to be impacted (i.e., lower equity share).

Table 15. ITC Phase-Down Rate Schedule

Construction Start Before	Applicable ITC Rate
1/1/2017	30%
1/1/2018	24%
1/1/2019	18%
1/1/2020	12%
On or after 1/1/2020	0%

Source: Reprinted from Deloitte (2017)

- **Installation and operation contingencies**. Consultation with industry experts suggests that early commercial-scale U.S. projects might expect higher contingency levels relative to the established European offshore wind markets. These serve to account for less experience in U.S. offshore wind power plant installation and operation with the risk of incurring delays and interruptions in the supply chain, marine logistics, and permitting processes.

- **Offtake mechanisms**. Current U.S. offtake mechanisms (Section 2.4.1) are generally seen as attractive to global offshore wind developers because of their relatively low merchant price exposure. Higher uncertainty in revenue streams and declining margins in established offshore wind markets in Europe and Asia might have been primary factors in yielding the high bid prices for lease areas auctioned during 2018.

- **Permitting**. In the United States, a federal, state, and local permit to construct and operate a wind power plant is not included in a lease award. This might introduce additional risk from legal action, permitting delays, and stranded assets compared to acquiring a fully permitted lease area.[71]

The Vineyard Wind PPA pricing suggests that there is only a small premium for "new market" risk (Beiter et al. 2019). Consultation with industry experts suggests that investors are available for the different types of risk profiles of each project phase (e.g., developers, private equity, independent power producers, utilities, tax equity, green banks, export credit agencies, manufacturers). A variety of financial vehicles could be utilized to mitigate the risk exposure of early projects, including tax incentives, bonus appreciation, loan guarantees, and financial hedging products. Coincident with the phase out of tax credits over the next few years, high RPS requirement levels are starting to take effect in coastal states, which might mitigate some of the lost tax benefits.

[71] For instance, in past German offshore wind auctions, prepermitted lease areas were awarded.

5.3 Floating Cost Trends

Although still in the precommercial phase of maturity, floating wind technology has gained greater mainstream recognition over the past year, partially because of Equinor's successful deployment and operation of the Hywind II pilot project near Peterhead, Scotland. Today, floating wind is generally considered a viable technology for the future of offshore wind. Figure 36 depicts LCOE trends estimated by various research organizations and consultancies that show a reduction from levels from above $175/MWh (2018) to $70/MWh (2030).

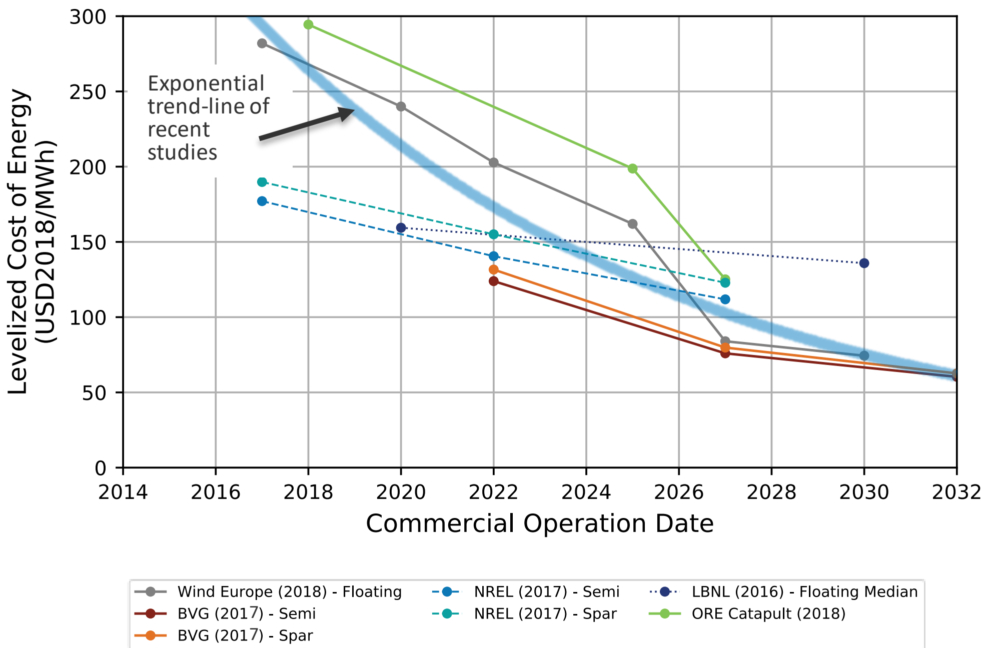


Figure 36. Global LCOE estimates for floating technology[72]

Sources: WindEurope (2018), Hundleby et al. (2017), Beiter et al. (2017), Wiser et al. (2016), ORE Catapult (2018)[73]

Note that the number of sources for floating wind cost is smaller than for the fixed-bottom trends. These estimates, except for those provided by ORE Catapult (2018) prior to 2027, assume commercial-scale floating wind plants and learning curve benefits commensurate with a mature industry. The blue trend line represents an exponential fit of the most recent studies from 2018. This trend line is meant to serve as a visual reference to focus attention on the most recent cost projections. Cost estimates assuming a commercial-scale floating project size, published prior to 2018, predict higher costs than those published more recently. This might reflect more accurate cost data and new data on anticipated fixed-bottom cost reductions that are applicable to floating systems, as well as increased optimism that technical challenges can be overcome.

The anticipated cost reductions between 2015 and 2030 are related to an expected floating deployment trajectory that spans from existing single-turbine demonstration projects (2015–2017) to multiple-turbine demonstration projects (2017–2022), and finally, to medium- to full-scale commercial projects (early to late 2020s). Globally, there is currently a wide range of floating technology concepts under consideration that are at the multiturbine demonstration phase.

---

[72] "LBNL" in the figure refers to Berkeley Lab

[73] Estimates from ORE Catapult (2018) were converted from £2012 to $2018 using 2012 exchange rates and applying a cumulative U.S. inflation factor of 9.4% for the period 2012–2018. The ORE Catapult (2018) estimates reflect demonstration (2018), precommercial (2025), and commercial status (2027).

The cost of floating wind technology is currently based on a small set of data from the first phase of prototypes and projects in the design or construction phase. Generally, the potential for cost reduction is high because early-stage technology advances usually result in significant cost reductions. In addition, technological and commercial developments from fixed-bottom wind systems might translate to floating wind systems. Cost estimates from NREL's geospatial analysis (Beiter et al. 2016; Gilman et al. 2016) indicate that floating costs may show a steeper rate of cost reduction than fixed-bottom systems, with the potential for cost parity over the next 10 years. The basis for technology-specific cost reduction potential comes from a range of factors, including (but not limited to) the ability of floating systems to:

- Leverage cost reductions, innovations, and experience from fixed-bottom systems
- Utilize existing supply chains
- Optimize using lighter components and increased modularity
- Reduce the number and complexity of construction steps at sea (e.g., by assembling the turbine and substructure at quayside)
- Automate production and fabrication of the floating platforms
- Access higher wind speeds sufficient to outweigh the higher O&M and installation costs associated with greater distances to shore and harsher meteorological conditions.

For a more detailed discussion of possible methods to reduce the cost of floating systems, see Beiter et al. (2016).

Primary Database Sources

- 4C Offshore. 2018. Offshore Wind Farms Intelligence. http://www.4coffshore.com/windfarms/request.aspx?id=owfdb.

- 4C Offshore. 2019. Global Offshore Wind Farms Intelligence. http://www.4coffshore.com/windfarms/request.aspx?id=owfdb.

- Bloomberg New Energy Finance. 2018. Renewable Energy Project Database. https://about.bnef.com/.
- MAKE Consulting. 2018. Global Offshore Wind Power Project Database. http://www.consultmake.com/research/databases.

- WindEurope. 2019. *Offshore Wind in Europe: Key trends and statistics 2018*. February 2019. https://windeurope.org/about-wind/statistics/offshore/european-offshore-wind-industry-key-trends-statistics-2018/.

References

The 100 Percent Clean Energy Act of 2018. Senate Bill No. 100. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB100.

4C Offshore. 2017. "Siemen's 8-megawatt wind turbine up and running." January 30, 2017. https://www.4coffshore.com/news/siemens-8-megawatt-wind-turbine-up-and-running-nid5241.html.

4C Offshore. 2018. Offshore Wind Farms Intelligence. http://www.4coffshore.com/windfarms/request.aspx?id=owfdb.

4C Offshore. 2019a. "Ørsted suspends Taiwan developments." January 21, 2019. https://www.4coffshore.com/news/%C3%B8rsted-suspends-taiwan-developments-nid11111.html.

4C Offshore. 2019b. "Kincardine Offshore Windfarm Project Offshore Wind Farm." https://www.4coffshore.com/windfarms/kincardine-offshore-windfarm-project-united-kingdom-uk2h.html.

Adwen GmbH. 2019. "Adwen (company)." Accessed April 26, 2019. https://en.wikipedia.org/wiki/Adwen_(company).

Barla, Sashi. 2018. "Global Wind Turbine Technology Trends." Market Report. Wood Mackenzie.

Bay State Wind. 2018. "Bay State Wind plans more than $2 million in environmental research grants." Press Release. April 10, 2018. https://baystatewind.com/News/2018/04/Bay-State-Wind-plans-more-than-2-million-in-environmental-research-grants.

Beiter P., W. Musial, A. Smith, L. Kilcher, R. Damiani, M. Maness, S. Sirnivas, T. Stehly, V. Gevorgian, M. Mooney, G. Scott. 2016. *A Spatial-Economic Cost Reduction Pathway Analysis for U.S. Offshore Wind Energy Development from 2015–2030* (Technical Report). NREL/TP-6A20-66579. National Renewable Energy Laboratory (NREL), Golden, CO (US). www.nrel.gov/docs/fy16/66579.pdf.

Beiter P., W. Musial, A. Smith, L. Kilcher, R. Damiani, M. Maness, S. Sirnivas, T. Stehly, V. Gevorgian, M. Mooney, G. Scott. 2016. *A Spatial-Economic Cost Reduction Pathway Analysis for U.S. Offshore Wind Energy*

Development from 2015–2030 (Technical Report). NREL/TP-6A20-66579. National Renewable Energy Laboratory (NREL), Golden, CO (US). www.nrel.gov/docs/fy16/66579.pdf.

Beiter, Philipp, Walter Musial, Levi Kilcher, Michael Maness, and Aaron Smith. 2017. *An Assessment of the Economic Potential of Offshore Wind in the United States from 2015 to 2030* (Technical Report). NREL/TP-6A20-67675. Golden, CO: National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy17osti/67675.pdf.
Beiter, Philipp, Paul Spitsen, Jake Nunemaker, Tian, Walter Musial, Eric Lantz, and Vahan Gevorgian. 2018. *2017 Offshore Wind Technologies Market Update*. Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency & Renewable Energy. https://www.energy.gov/eere/wind/downloads/2017-offshore-wind-technologies-market-update.

Beiter, Philipp, Paul Spitsen, Walter Musial, and Eric Lantz. 2019. *The Vineyard Wind Power Purchase Agreement: Insights for Estimating Costs of U.S. Offshore Wind Projects* (Technical Report). National Renewable Energy Laboratory (NREL), Golden, CO. NREL/TP-5000-72981. https://www.nrel.gov/docs/fy19osti/72981.pdf.

Benson, J. 2018. "Future Grid - Sun, Wind and BESS." Accessed April 22, 2019. https://www.energycentral.com/c/cp/future-grid-sun-wind-and-bess.

Bloomberg New Energy Finance (BNEF). 2018a. 2H 2018 Offshore Wind Market Outlook. https://about.bnef.com/.

BNEF. 2018b. "Current LCOE by Technology." https://www.bnef.com/core/lcoe?tab=Current%20LCOE%20by%20Technology.

BNEF 2018c. "Historic LCOEs: 2H 2018." https://www.bnef.com/core/lcoe?tab=Historic%20LCOE.

BNEF. 2018d. "First Big U.S. Offshore Wind Farm Offers $1.4 Billion to Customers." Accessed November 2018. https://www.bloomberg.com/news/articles/2018-08-01/first-big-u-s-offshore-wind-offers-1-4-billion-to-customers.

BNEF. 2018e. "2H 2018 Wind Turbine Price Index." Accessed February 1, 2019. https://www.bnef.com/core/.

(BOEM) Bureau of Ocean Energy Management. 2018. "Renewable Energy Path Forward on the Atlantic." Request for Information. https://www.boem.gov/Renewable-Energy-Path-Forward.

BOEM. 2019a. "Massachusetts Leases OCS-A 0500 (Bay State Wind) and OCS-A 0501 (Vineyard Wind)." Accessed April 2019. https://www.boem.gov/commercial-wind-leasing-offshore-massachusetts/.

BOEM. 2019b. "New York Bight." Accessed June 2019. https://www.boem.gov/NY-Bight/.

BOEM. 2019c. "California Activities." Accessed June 2019. https://www.boem.gov/California/.

BOEM. 2019d. "Hawaii Activities" Accessed June 2019. https://www.boem.gov/Hawaii/.

BOEM 2019e. BOEM Environmental Studies. Accessed June 2019. https://www.boem.gov/Renewable-Energy-Environmental-Studies/.

Business Network for Offshore Wind. 2019. "Leadership 100 Work Plan." June 3, 2019. https://www.offshorewindus.org/wp-content/uploads/2019/06/L100WhitePaperJun.3.2019.pdf.

Brindley, Guy. 2019. *Financing and investment trends. The European Wind Industry in 2018*. WindEurope. https://windeurope.org/wp-content/uploads/files/about-wind/reports/Financing-and-Investment-Trends-2018.pdf.

BVG Associates. 2018a. *Offshore wind in Virginia: A vision*. September 2018. https://files.vasierraclub.org/oswvision.pdf.

BVG Associates. 2018b. *The Virginia advantage: The roadmap for the offshore wind supply chain in Virginia*. https://static1.squarespace.com/static/5b3cf461d274cb109aa488d8/t/5c23e225562fa7be221fe841/1545855531929/BVGA-20802-Report-r2-final-20181227.pdf.

BVG Associates. 2019. "Guide to an Offshore Wind Farm." Published on behalf of The Crown Estate and the Offshore Renewable Energy Catapult. https://www.thecrownestate.co.uk/media/2860/guide-to-offshore-wind-farm-2019.pdf.

Carbon Trust. 2019. "Carbon Trust's Floating Wind Joint Industry Project reveals winners of dynamic export cable competition." April 17, 2019. https://www.carbontrust.com/news/2019/04/winners-dynamic-export-cable-competition.

Commonwealth of Massachusetts. 2018. An Act to Advance Clean Energy (Bill H. 4857). 190th General Court of Massachusetts. August 9, 2018. https://malegislature.gov/Bills/190/H4857.

Composites World 2014. "Vestas 8-MW turbine begins operation." February 3, 2014. https://www.compositesworld.com/news/vestas-8-mw-turbine-begins-operation.

Connecticut General Assembly. 2019. House Bill 7156. June 6, 2019. https://www.cga.ct.gov/asp/cgabillstatus/cgabillstatus.asp?selBillType=Bill&which_year=2019&bill_num=7156.

The Crown Estate. 2018. "The Crown Estate shares further detail on plans for Round 4, including proposed locations to be offered for new seabed rights." Press Release. November 16, 2018. https://www.thecrownestate.co.uk/en-gb/media-and-insights/news/2018-the-crown-estate-shares-further-detail-on-plans-for-round-4-including-proposed-locations-to-be-offered-for-new-seabed-rights/.

Davidson and Weston. 2018. "Principle Power joins Senvion's 10MW project." *Windpower Offshore*. May 4, 2018. Accessed May 2018. https://www.windpoweroffshore.com/article/1463807/principle-power-joins-senvions-10mw-project.

Danish Ministry of Energy, Utilities and Climate. 2018. "Note on technology costs for offshore wind farms and the background for updating CAPEX and OPEX in the technology catalogue datasheets." https://ens.dk/sites/ens.dk/files/Analyser/havvindsnotat_translation_eng_final.pdf.

Deepwater Wind. 2018. "Case 18-E-0071 – In the Matter of Offshore Wind Energy. Comments of Deepwater Wind, LLC." http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BE296F037-4F08-4529-8892-7295F236F80E%7D.

Deloitte. 2017. "2017 Deloitte Renewable Energy Seminar." https://www2.deloitte.com/us/en/pages/energy-and-resources/events/deloitte-energy-and-resources-conferences-and-training-seminars.html.

Denholm, Paul, Yinong Sun, and Trieu Mai. 2019. *An Introduction to Grid Services: Concepts, Technical Requirements and Provision from Wind* (Technical Report). National Renewable Energy Laboratory (NREL), Golden, CO. NREL/TP-6A20-72578. https://www.nrel.gov/docs/fy19osti/72578.pdf.

de Vries, E. 2012. "Close up - Alstom Haliade 6MW prototype." *Windpower Monthly*. July 11, 2012. https://www.windpowermonthly.com/article/1140792/close---alstom-haliade-6mw-prototype.

de Vries, E. 2019. "Haliade-X Uncovered: GE Aims for 14MW." WindPower Offshore, March 4, 2019. https://www.windpoweroffshore.com/article/1577816/haliade-x-uncovered-ge-aims-14mw.

Deign, J. 2019. "China Set to Overtake UK as Offshore Wind Leader by 2021." *Greentech Media*. January 31, 2019. https://www.greentechmedia.com/articles/read/uk-set-to-lose-offshore-wind-crown-to-china-by-2021#gs.4ef3uj.

DNV GL. 2013. "A Guide to UK Offshore Wind Operations and Maintenance." London, UK: Scottish Enterprise and The Crown Estate. http://www.hi-energy.org.uk/Downloads/General%20Documents/guide-to-uk-offshore-wind-operations-and-maintenance.pdf.

DOE (U.S. Department of Energy). 2018. Tethys Database. https://tethys.pnnl.gov/.

DOE. 2019. "Offshore Wind Advanced Technology Demonstration Projects." Accessed April 29, 2019. https://www.energy.gov/eere/wind/offshore-wind-advanced-technology-demonstration-projects.

Durakovic, A. "North Carolina Governor Proposes Offshore Wind Study." *OffshoreWIND.biz*. March 12, 2019. https://www.offshorewind.biz/2019/03/12/north-carolina-governor-proposes-offshore-wind-study/.

Dvorak, P. 2017. "Inching toward 10 MHI Vestas unwraps a 9.5-MW design." *Windpower Engineering*. August 2017. https://www.windpowerengineering.com/design/inching-toward-10-mhi-vestas-unwraps-9-5-mw-design.

Energy Information Administration. 2019. "Maryland State Profile and Energy Estimates." Accessed April 2018. https://www.eia.gov/state/?sid=MD.

Equinor. 2018a. "World class performance by world's first floating wind farm." February 15, 2018. Accessed May 2018. https://www.statoil.com/en/news/15feb2018-world-class-performance.html.

Equinor. 2018b. "Equinor has installed Batwind - the world's first battery for offshore wind." June 27, 2018. https://www.equinor.com/en/news/26june2018-equinor-has-installed-batwind.html.

Espérandieu, M. 2018. "État des lieux des projets éoliens au large des côtes françaises." Mer et Marine. December 6, 2018. https://www.meretmarine.com/fr/content/etat-des-lieux-des-projets-eoliens-au-large-des-cotes-francaises.

European Commission. 2019. "State aid: Commission approves support for four floating demonstration offshore wind farms in France." European Commission Press Release. February 25, 2019. http://europa.eu/rapid/press-release_IP-19-1412_en.htm.

Eversource Energy. 2019. "Ørsted and Eversource Enter 50-50 Partnership Agreement on Key Offshore Wind Assets in the Northeast." Boston, February 8, 2019. Accessed July 2019. https://www.eversource.com/content/docs/default-source/investors/orsted-partnership-agreement.pdf?sfvrsn=736bcb62_0.

Fingersh, L., M. Hand, A. Laxson. 2006. "Wind Turbine Design Cost and Scaling Model" National Renewable Energy Laboratory (NREL), NREL/TP-500-40566. https://www.nrel.gov/docs/fy07osti/40566.pdf.

Foxwell, David. 2018a. “Germany back-tracks on commitment to offshore wind auction.” *Offshore Wind Journal.* November 1, 2018. https://www.owjonline.com/news/view,germanybacktracks-on-commitment-to-offshore-wind-auction_55731.htm.

Foxwell, D. 2018b. “20-GW reference gives German offshore wind industry greater cheer.” *Offshore Wind Journal*. December 4, 2018. https://www.owjonline.com/news/view,20gw-reference-gives-german-offshore-wind-industry-greater-cheer_56109.htm.

Foxwell, D. 2018c. “Senvion super-turbine could one day be capable of 16MW.” *Offshore Wind Journal*. July 23, 2018. https://www.rivieramm.com/news-content-hub/senvion-super-turbine-could-one-day-be-capable-of-16-mw-23945.

Foxwell, D. 2019. “Ørsted awards crew transfer vessel contract for US market.” *Offshore Wind Journal*. May 9, 2019. https://www.owjonline.com/news/view,rsted-awards-crew-transfer-vessel-contract-for-us-market_57772.htm.

Froese, M. 2018. “MHI Vestas to supply turbines for WindFloat Atlantic Floating Offshore Wind.” *Windpower Engineering & Development*. September 10, 2018. https://www.windpowerengineering.com/business-news-projects/mhi-vestas-to-supply-turbines-for-windfloat-atlantic-floating-offshore-wind/.

Froese, M. 2019a. “Responsible Offshore Science Alliance launches to advance research on fisheries and offshore wind.” *Windpower Engineering & Development*. April 9, 2019. https://www.windpowerengineering.com/business-news-projects/responsible-offshore-science-alliance-launches-to-advance-research-on-fisheries-offshore-wind/.

Froese, M. 2019b. “Equinor promotes collaboration between offshore wind and fishing industries.” *Windpower Engineering & Development*. February 27, 2019. https://www.windpowerengineering.com/business-news-projects/equinor-promotes-collaboration-between-offshore-wind-and-fishing-industries/.

GE (General Electric). 2018a. “GE announces Haliade-X, the world’s most powerful offshore wind turbine.” March 1, 2018. Accessed May 2018. https://www.genewsroom.com/press-releases/ge-announces-haliade-x-worlds-most-powerful-offshore-wind-turbine-284260.

GE. 2018b. “Haliade-X Offshore Wind Turbine Platform.” Accessed May 2018. https://www.ge.com/renewableenergy/wind-energy/turbines/haliade-x-offshore-turbine.

German Offshore Wind Energy Foundation. 2019. “Expansion of Offshore Wind Energy Successfully Continued in 2018 - Industry Sector Calls for Rapid Increase of Expansion Targets.” https://www.offshore-stiftung.de/en/expansion-offshore-wind-energy-successfully-continued-2018-industry-sector-calls-rapid-increase.

Gilman, P., B. Maurer, L. Feinberg, A. Duerr, L. Peterson, W. Musial, P. Beiter, J. Golladay, J. Stromberg, I. Johnson, D. Boren, A. Moore. 2016. *National Offshore Wind Strategy; Facilitating the Development of the Offshore Wind Industry in the United States*. DOE/GO-102016-4866. Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency & Renewable Energy; U.S. Department of the Interior. https://energy.gov/sites/prod/files/2016/09/f33/National-Offshore-Wind-Strategy-report-09082016.pdf.

Graré, V., F. Kühn, F. Küster, A. Schlosser. 2018. “The offshore-wind industry’s moment of reckoning.” McKinsey & Company. https://www.mckinsey.com/business-functions/sustainability/our-insights/the-offshore-wind-industrys-moment-of-reckoning?reload.

Guillet, Jerome. 2018. "Who will fund U.S. Offshore Wind–and on what terms?" Presented at the Offshore Wind Implementation Summit, Teaneck, New Jersey, September 7. https://green-giraffe.eu/presentations/who-will-fund-us-offshore-wind-%E2%80%93-and-what-terms.

Hill, J. 2018. "How To Typhoon-Proof Offshore Wind Turbines." *CleanTechnica*. October 7, 2018. https://cleantechnica.com/2018/10/07/how-to-typhoon-proof-offshore-wind-turbines.

Hill, J. 2019. "Japanese Offshore Wind To Hit 4 Gigawatts In 2028." *CleanTechnica*. February 19, 2019. https://cleantechnica.com/2019/02/19/japanese-offshore-wind-to-hit-4-gigawatts-in-2028.

House Bill 226: Maryland Offshore Wind Energy Act of 2013. General Assembly of Maryland. Accessed May 2018. http://mgaleg.maryland.gov/2013RS/bills/hb/hb0226E.pdf.

Hundleby, Giles, Kate Freeman, Andy Logan, and Ciaran Frost. 2017. "Floating Offshore: 55 Technology Innovations That Will Have Greater Impact on Reducing the Cost of Electricity from European Floating Offshore Wind Farms." KiC InnoEnergy and BVG Associates. http://www.innoenergy.com/new-floating-offshore-wind-report-55-technology-innovations-that-will-impact-the-lcoe-in-floating-offshore-wind-farms/.

International Electrotechnical Commission (IEC) 2019a. IEC 61400-1 Edition 3, *Wind turbines*—Part 1: *Design requirements.* https://www.iec.ch/dyn/www/f?p=103:23:27965083281002::::FSP_ORG_ID,FSP_LANG_ID:1282,25/.

IEC 2019b. IEC 61400-3 Edition 2, *Wind turbines*—Part 3: *Design requirements for offshore wind turbines.* https://www.iec.ch/dyn/www/f?p=103:23:27965083281002::::FSP_ORG_ID,FSP_LANG_ID:1282,25/.

International Renewable Energy Agency (IRENA). 2018. *Offshore innovation widens renewable energy options: Opportunities, challenges and the vital role of international co-operation to spur the global energy transformation*. Brief to G7 policymakers. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Sep/IRENA_offshore_wind_brief_G7_2018.pdf.

ISO Newswire. 2019. "An Update on Vineyard Wind's Participation in FCA #13." February 8, 2019. http://isonewswire.com/updates/2019/2/8/an-update-on-vineyard-winds-participation-in-fca-13.html.

Jacobsen, S. 2018. "Offshore wind power firms see Taiwan as a battleground to expand in Asia." Reuters. Accessed April 2018. https://www.reuters.com/article/us-taiwan-windpower/offshore-wind-power-firms-see-taiwan-as-a-battleground-to-expand-in-asia-idUSKBN1I11IV.

JDR. 2019. "JDR Wins Second Offshore Wind Contract For Major Project In Taiwan." http://www.jdrcables.com/jdr-wins-second-offshore-wind-contract-for-major-project-in-taiwan/.

Kempton, W., S. McClellan, and D. Ozkan. 2016. *Massachusetts Offshore Wind Future Cost Study*. Technical Report. Special Initiative on Offshore Wind. University of Delaware. https://www.ceoe.udel.edu/File%20Library/About/SIOW/MA-Offshore-Wind-Future-Cost-Study-rev-4-April-16.pdf.

Krueger, A. D., G. R. Parsons, and J. Firestone. 2011. *Valuing the Visual Disamenity of Offshore Wind Projects at Varying Distances from the Shore*. University of Delaware, Land Economics. 87 (2): 268–283, ISSN 0023-7639; E-ISSN 1543-8325. https://works.bepress.com/george_parsons/7/.

Lazard. 2018. "Levelized Cost of Energy Analysis, Version 12.0." https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf.

Lefevre-Marton, N., Saharia, R, Sellschop, R., and Tai, H. 2019. "Scaling the US East Coast offshore wind industry to 20 gigawatts and beyond." April 2019. https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/scaling-the-us-east-coast-offshore-wind-industry-to-20-gigawatts-and-beyond?reload.

Lillian, B. 2019. "Equinor Wind US Joins Effort To Protect Whales in New York Bight." *North American Wind Power*. April 9, 2019. https://nawindpower.com/equinor-wind-us-joins-effort-to-protect-whales-in-new-york-bight.

Linklaters LLP. 2019. "Korea Offshore Wind: Looking Ahead." Lexology. January 7, 2019. https://www.lexology.com/library/detail.aspx?g=32b9bb3f-1e68-4967-9b08-e71160308bdd.

Maness, Michael, Ben Maples, and Aaron Smith. 2017. *NREL Offshore Balance-of-System Model* (Technical Report). National Renewable Energy Laboratory (NREL), Golden, CO. NREL/TP-6A20-66874. https://www.nrel.gov/docs/fy17osti/66874.pdf.

Market Research Consulting. 2018. *Submarine Power Cable – Global Market Outlook (2017-2026)*. https://www.researchandmarkets.com/reports/4592698/submarine-power-cable-global-market-outlook.

Maryland General Assembly. 2019. Senate Bill 516. May 25, 2019. http://mgaleg.maryland.gov/2019RS/bills/sb/sb0516e.pdf.

Massachusetts Department of Energy Resources. 2019a. *Request for Proposals For Long-Term Contracts for Offshore Wind Energy Projects*. May 23, 2019. https://macleanenergy.files.wordpress.com/2019/05/83c-ii-rfp_finalpackage.pdf.

Massachusetts Department of Energy Resources. 2019b. *Offshore Wind Study*. May 31, 2019. https://www.mass.gov/files/documents/2019/05/31/OSW%20Study%20-%20Final.pdf.

Massachusetts Department of Public Utilities. 2018a. "Offshore Wind Generation Unit Power Purchase Agreement Between NSTAR Electric Company d/b/a Eversource Energy and Vineyard Wind LLC (Facility 1)." July 31, 2018. Redacted. Exhibit JU-3-A. https://eeaonline.eea.state.ma.us/EEA/FileService/FileService.Api/file/FileRoom/9676522.

Massachusetts Department of Public Utilities. 2018b. "Offshore Wind Generation Unit Power Purchase Agreement Between NSTAR Electric Company d/b/a Eversource Energy and Vineyard Wind LLC (Facility 2)." July 31, 2018. Redacted. Exhibit JU-3-B. https://eeaonline.eea.state.ma.us/EEA/FileService/FileService.Api/file/FileRoom/9676523.

Mass Live. 2018. "Vineyard Wind signs $9 million lease at New Bedford Commerce Pier." October 23, 2018. https://www.masslive.com/news/2018/10/vineyard_wind_signs_9_million.html.

McClellan. 2019. "Supply Chain Contracting Forecast for U.S. Offshore Wind Power," Special Initiative on Offshore Wind White Paper. Accessed July 2019. https://www.ceoe.udel.edu/File%20Library/About/SIOW/SIOW-White-Paper---Supply-Chain-Contracting-Forecast-for-US-Offshore-Wind-Power-FINAL.pdf.

MHI Vestas. 2018. "Vineyard Wind Selects MHI Vestas as Preferred Supplier for First Large-scale Offshore Wind Project in the United States." November 27, 2018. http://www.mhivestasoffshore.com/vineyard-wind-selects-mhi-vestas-as-preferred-supplier/.

Mills, J. 2019. "An Order Concluding the Maine Wind Advisory Commission and Wind Permit Moratorium." Office of the Governor. February 14, 2019. https://www.maine.gov/governor/mills/sites/maine.gov.governor.mills/files/inline-files/EO%20Wind.pdf.

Musial, W., Z. Parker, J. Fields, G. Scott, and C. Draxl. 2013. *Assessment of Offshore Wind Energy Leasing Areas for the BOEM Massachusetts Wind Energy Area* (Technical Report). National Renewable Energy Laboratory (NREL), Golden, CO. NREL/TP-5000-60942. http://www.nrel.gov/docs/fy14osti/60942.pdf.

Musial, W., D. Heimiller, P. Beiter, G. Scott, and C. Draxl. 2016. *2016 Offshore Wind Energy Resource Assessment for the United States* (Technical Report). National Renewable Energy Laboratory (NREL), Golden, CO. NREL/TP-5000-66599. http://www.nrel.gov/docs/fy16osti/66599.pdf.

Musial, W., P. Beiter, P. Schwabe, T. Tian, T. Stehly, P. Spitsen. 2017. *2016 Offshore Wind Technologies Market Report* (Technical Report). Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency & Renewable Energy. https://www.energy.gov/sites/prod/files/2017/08/f35/2016%20Offshore%20Wind%20Technologies%20Market%20Report.pdf.

New Jersey Board of Public Utilities. 2018. Docket No. Q018080843. December 18, 2018. https://www.bpu.state.nj.us/bpu/pdf/boardorders/2018/20181218/12-18-18-8H.pdf.

New Jersey Board of Public Utilities. 2019. *2019 Annual Report on New Jersey Offshore Wind and the Implementation of Executive Order No. 8*. NJ BPU. January 31, 2019. https://www.bpu.state.nj.us/bpu/pdf/publicnotice/2019%20ANNUAL%20EO8%20REPORT%2002082019%20FNL%20V2.pdf.

New Jersey State Legislature. 2018. "A3723." May 23, 2018. Accessed May 2018. http://www.njleg.state.nj.us/bills/BillView.asp?BillNumber=A3723.

New York State. 2019a. "2019 State of the State Budget Address." New York State Governor Andrew M. Cuomo. https://www.ny.gov/programs/2019-state-state-budget-address.

New York State. 2019b. *Climate Leadership and Community Protection Act*. June 18, 2019. https://www.nysenate.gov/legislation/bills/2019/s6599.

New York State Energy Research and Development Authority (NYSERDA). 2019. "National Offshore Wind R&D Consortium Research Solicitation (PON 4124)." https://portal.nyserda.ny.gov/CORE_Solicitation_Detail_Page?SolicitationId=a0rt000000beASkAAM.

Nexans. 2018. "Cable supplies for the world's first 66 KV offshore windfarms." September 2018. https://www.nexans.com/newsroom/news/details/2018/09/Supply-of-cables-for-the-first-66kv-offshore-windfarms.html.

National Oceanic and Atmospheric Administration (NOAA). 2019a. "Northeast Regional Ocean Council Data Portal." https://www.northeastoceancouncil.org/quick-links/.

NOAA. 2019b. "Mid-Atlantic Ocean Data Portal." http://portal.midatlanticocean.org/about-us/.

offshoreWIND.biz. 2018a. "Shell, EDF Acquire US Wind's New Jersey Lease Area." December 20, 2018. https://www.offshorewind.biz/2018/12/20/shell-edf-acquire-us-winds-new-jersey-lease-area/

offshoreWIND.biz. 2018b. "Poland Sets 8GW by 2035 Offshore Wind Goal." November 8, 2018. https://www.offshorewind.biz/2018/11/08/poland-sets-8gw-by-2035-offshore-wind-goal/.

ORE Catapult. 2015. "Cost Reduction Monitoring Framework: Summary Report to the Offshore Wind Programme Board." ORE Catapult and The Crown Estate.

https://ore.catapult.org.uk/app/uploads/2018/02/Cost-Reduction-Monitoring-Framework-2015.-Summary-report-to-the-OWPB.pdf.

ORE Catapult. 2018. "Macroeconomic Benefits of Floating Offshore Wind in the UK." Glasgow, UK: Crown Estate Scotland. https://www.crownestatescotland.com/maps-and-publications/download/219.

Orrell, A., N. Foster, S. Morris, J. Homer, D. Preziuso, R. Poehlman. 2019. *2018 Distributed Wind Market Report* (Technical Report). Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency & Renewable Energy. https://energy.gov/eere/wind/downloads/2018-distributed-wind-market-report

Ørsted. 2018. "Ørsted acquires Deepwater Wind and creates leading US offshore wind platform." Ørsted Press Release. August 10, 2018. https://orsted.com/en/Company-Announcement-List/2018/10/1819975.
Ørsted. 2019. "TEPCO and Ørsted sign MOU to work jointly on offshore wind projects."

Ørsted Press Release. January 18, 2019. https://orsted.com/en/Media/Newsroom/News/2019/01/TEPCO-and-Orsted-sign-MoU-to-work-jointly-on-offshore-wind-projects.

Peregrine Energy. 2018. "Independent Evaluator Report: On the Solicitation, Evaluation, and Bid Process Under Section 83C of the Green Communities Act." Accessed September 2018. https://eeaonline.eea.state.ma.us/EEA/FileService/FileService.Api/file/FileRoom/9685211.

Power Engineering. 2005. "REpower 5 MW turbines to power Borkum West offshore wind park." September 7, 2005. https://www.power-eng.com/articles/2005/09/repower-5-mw-turbines-to-power-borkum-west-offshore-wind-park.html.

Power Technology. 2018. "Formosa 1 Offshore Wind Farm." https://www.power-technology.com/projects/formosa-1-offshore-wind-farm/.

Quest Floating Wind Energy. 2019. "What Will Float in South Korea's Newly Announced Project." March 5, 2019. https://questfwe.com/what-will-float-in-south-koreas-newly-announced-project/.

Ragheb, M. 2019. *Modern Wind Generators*. http://mragheb.com/NPRE%20475%20Wind%20Power%20Systems/Modern%20Wind%20Generators.pdf.

Recharge News. 2018. "Chinese wind power faces switch to competition from 2019." *Recharge News*. June 5, 2018. https://www.rechargenews.com/wind/1504927/chinese-wind-power-faces-switch-to-competition-from-2019.

Renewables Now. 2018. "Vineyard Wind Faces Rhode Island Permitting Setback." November 22, 2018. https://renewablesnow.com/news/vineyard-wind-faces-rhode-island-permitting-setback-report-634128/.

Reuters. 2018. "France cuts tariffs on controversial offshore wind projects." Reuters. June 20, 2018. https://www.reuters.com/article/us-france-windpower-offshore/france-cuts-tariffs-on-controversial-offshore-wind-projects-idUSKBN1JG1N8.

Rhode Island Coastal Resources Management Council. 2019. "Agreements to Establish RI Fishermen's Future Viability Trust." February 21, 2019. http://www.crmc.ri.gov/windenergy/vineyardwind.html.

Richard, C. 2019. "MHI Vestas in line to supply first V174 turbines." *Windpower Offshore*. February 2019. https://www.windpoweroffshore.com/article/1525372/mhi-vestas-line-supply-first-v174-turbines.

Saltzberg, R, and B. Dowd. 2019. "RODA and Ørsted Strengthen Dialogue." *Martha's Vineyard Times*. January 18, 2019. https://www.mvtimes.com/2019/01/18/roda-orsted-strengthen-dialogue/.

Siemens. 2013. *Fact Sheet: The new SWT-6.0; The next-generation offshore wind turbine. Status: February 2013*. https://www.siemens.com/press/pool/de/feature/2013/energy/2013-01-rotorblade/factsheet-6mw-e.pdf.

Siemens. 2019. "Siemens Gamesa launches 10 MW offshore wind turbine; annual energy production (AEP) increase of 30% vs. predecessor." https://www.siemensgamesa.com/en-int/newsroom/2019/01/new-siemens-gamesa-10-mw-offshore-wind-turbine-sg-10-0-193-dd.

Skopljak, N. 2019a. "Vineyard Wind Commits to Whale Protection." January 24, 2019. https://www.offshorewind.biz/2019/01/24/vineyard-wind-commits-whale-protection/.

Skopljak N. 2019b. "Vineyard Wind Seeks Whale Protection Tech." May 22, 2019. https://www.offshorewind.biz/2019/05/22/vineyard-wind-seeks-whale-protection-tech/.

Skopljak, N. 2019c. "Spain's First Offshore Wind Turbine Goes Into Operation" March 18, 2019. https://www.offshorewind.biz/2019/03/18/spains-first-offshore-wind-turbine-goes-operation.

Smith, Stehly, and Musial. 2015. *2014-2015 Offshore Wind Technologies Market Report* (Technical Report). National Renewable Energy Laboratory (NREL), Golden, CO. NREL/TP-5000-64283. https://www.nrel.gov/docs/fy15osti/64283.pdf.

Snieckus. 2018. "Senvion offshore turbine will be 12MW+ model." *Recharge News*. June 19, 2018. https://www.rechargenews.com/wind/1515084/senvion-offshore-turbine-will-be-12mw+-model.

Stehly, T., D. Heimiller, G. Scott. 2017. *2016 Cost of Wind Energy Review* (Technical Report). National Renewable Energy Laboratory (NREL). Golden, CO. NREL/TP-6A20-70363. Accessed May 2018. https://www.nrel.gov/docs/fy18osti/70363.pdf.

Stehly, T., P. Beiter, D. Heimiller, G. Scott. 2018. *2017 Cost of Wind Energy Review* (Technical Report). National Renewable Energy Laboratory (NREL). Golden, CO. NREL/TP-6A20-72167. https://www.nrel.gov/docs/fy18osti/72167.pdf.

Sununu, C.T. 2019. "BOEM Renewable Energy Task Force for New Hampshire." Office of the Governor. January 2, 2019. https://www.governor.nh.gov/news-media/press-2019/documents/20190107-boem-offshore.pdf.

T&D World. 2019. "Prysmian to Develop Submarine Cable System for Floating Offshore Wind Farm." March 20, 2019. https://www.tdworld.com/renewables/prysmian-develop-submarine-cable-system-floating-offshore-wind-farm.

University of Delaware. 2016. "Massachusetts Offshore Wind Future Cost Study." March 2016. https://www.ceoe.udel.edu/File%20Library/About/SIOW/MA-Offshore-Wind-Future-Cost-Study-FINAL-14-Mar-16.pdf.

University of Delaware's Special Initiative for Offshore Wind. 2019. *Supply Chain Contracting Forecast for U.S. Offshore Wind Power*. March 2019. https://www.ceoe.udel.edu/File%20Library/About/SIOW/SIOW-White-Paper---Supply-Chain-Contracting-Forecast-for-US-Offshore-Wind-Power-FINAL.pdf.

United States Department of Labor Bureau of Statistics. 2019. "Overview of BLS Statistics on Inflation and Prices." https://www.bls.gov/bls/inflation.htm.

United States Treasury Bureau of Fiscal Service. 2019. "Treasury Reporting Rates of Exchange." https://www.fiscal.treasury.gov/reports-statements/treaury-reporting-rates-exchange/current.html.

Valpy, B. G. Hundleby, K. Freeman, A. Roberts, A. Logan. 2017. *Future renewable energy costs: Offshore wind; 57 technology innovations that will have greater impact on reducing the cost of electricity from European offshore wind farms*. InnoEnergy and BVG Associates. http://www.innoenergy.com/wp-content/uploads/2014/09/InnoEnergy-Offshore-Wind-anticipated-innovations-impact-2017_A4.pdf.

Vineyard Wind LLC. 2018a. *Vineyard Wind Offshore Wind Energy Project: Draft Environmental Impact Statement* (EEA#15787). https://www.boem.gov/Vineyard-Wind-EIS/.

Vineyard Wind. 2018b. "Plugging into a new industry." April 1, 2018. Accessed May 2018. https://www.vineyardwind.com/in-the-news/2018/4/1/plugging-into-a-new-industry.

Vineyard Wind. 2018c. "Project Update: Vineyard Wind Submits Supplemental Draft Environmental Impact Report for Additional Public Comment." September 4, 2018. https://www.vineyardwind.com/news-and-updates/2018/9/4/project-update-vineyard-wind-submits-supplemental-draft-environmental-impact-report-sdeir-for-additional-public-comment.

Vineyard Wind. 2018d. "Project Update: Vineyard Wind Submits Supplemental Draft Environmental Impact Report for Additional Public Comment." September 4, 2018. https://www.vineyardwind.com/news-and-updates/2018/9/4/project-update-vineyard-wind-submits-supplemental-draft-environmental-impact-report-sdeir-for-additional-public-comment.

de Vries, E. 2019. "Haliade-X Uncovered: GE Aims for 14MW." WindPower Offshore, March 4, 2019. https://www.windpoweroffshore.com/article/1577816/haliade-x-uncovered-ge-aims-14mw.

Walton, R. 2018. "FERC advances transmission line to serve Massachusetts' offshore wind industry." Utility Dive. Accessed May 2018. https://www.utilitydive.com/news/ferc-advances-transmission-line-to-serve-massachusetts-offshore-wind-indus/517125/.

Weston, D. 2019. "Steisdal's TetraSpar demo gets go-ahead." *Wind Power Offshore*. February 13, 2019. https://www.windpoweroffshore.com/article/1525677/stiesdals-tetraspar-demo-gets-go-ahead.

WindEurope. 2018. *Floating Offshore Wind Energy; A Policy Blueprint for Europe*. https://windeurope.org/wp-content/uploads/files/policy/position-papers/Floating-offshore-wind-energy-a-policy-blueprint-for-Europe.pdf.

WindEurope. 2019. *Offshore Wind in Europe: Key trends and statistics 2018*. February 2019. https://windeurope.org/about-wind/statistics/offshore/european-offshore-wind-industry-key-trends-statistics-2018/.

Windpower Monthly. 2018. "Who will pay for 15MW turbine?" March 2018. https://www.windpowermonthly.com/article/1457880/will-pay-15mw-turbine.

WireTech. 2019. "JDR selected as preferred cable supplier for Windfloat Atlantic project." http://www.wiretechworld.com/jdr-selected-as-preferred-cable-supplier-for-windfloat-atlantic-project/.

Wiser, R. M. Bolinger, G. Barbose, N. Darghouth, B. Hoen, A. Mills, J. Rand, D. Millsteing, K. Porter, K. Fisher, N. Disanti, F. Oteri. *2018 Wind Technologies Market Report*. Lawrence Berkeley National Laboratory. https://www.energy.gov/eere/wind/downloads/2018-wind-technologies-market-report

Wiser, R., K. Jenni, J. Seel, E. Baker, M. Hand, E. Lantz, A. Smith. 2016. *Forecasting Wind Energy Costs & Cost Drivers. The Views of the World's Leading Experts*. LBNL-1005717. Lawrence Berkeley National Laboratory. http://eta-publications.lbl.gov/sites/default/files/lbnl-1005717.pdf.

Wiser, Ryan, and Mark Bolinger. 2018. "2017 Wind Technologies Market Report." DOE/EE-1798. U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. https://emp.lbl.gov/sites/default/files/2017_wind_technologies_market_report.pdf.

U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

2018 **Offshore Wind Technologies Market Report**

For more information visit,
energy.gov/eere/wind

DOE/GO-102019-5192 • August 2019

Front cover photo from
Dennis Schroeder, NREL
Back cover photo from
Walt Musial, NREL

So Bright You Have to Wear Shades: PACE Financing for Solar Panels and Other Alternative Energy Facilities

So Bright You Have to Wear Shades: PACE Financing for Solar Panels and Other Alternative Energy Facilities

Mark Palmer

Introduction: As competition for tenants continues to heat up in the marketing of commercial, retail, office, multi-family, and other property types, borrowers are exploring new ways of reducing operating costs, including through the use of solar panels and other energy-generating or energy-saving facilities. Property Assessed Clean Energy (PACE) financing is becoming an increasingly popular and preferred means of financing such facilities, and the requirements and terms of such PACE financing present both opportunities and challenges for CMBS loan lenders and servicers.

Although significant savings and better property operating performance may be achieved by installing such facilities, any use of PACE financing involves potential risks that must be carefully considered, especially with respect to the requirement that mortgage liens be subordinated to PACE financing liens. As a result of such required mortgage lien subordination and other risks, loan servicers and rating agencies have been reluctant to consent to and provide no-downgrade confirmations for PACE financing, however, there is, at least on a limited basis, an ongoing re-evaluation of the manner in which PACE financing requests and the risks are being considered and how such risks may be mitigated.

This article focuses on those risks, potential mitigants and credit enhancements, and required consents, including the subordination of the mortgage lien, due on encumbrance and alterations terms, potential reductions in operating costs, and considerations related to foreclosures and REO sales.

PACE Financing: What is it? PACE financing has been established by statute in a majority of the states as a tool to provide access to capital for clean energy and energy-generating and energy-efficiency projects, such as solar panels, tankless water heaters, insulation improvements, electric vehicle charging stations, and upgrading heating and air conditioning systems with more efficient systems. The financing is typically funded by bonds secured by a voluntary assessment lien on the related real property, which is billed and collected as part of the property tax assessment and, like a property tax lien, a PACE financing lien is superior in priority to mortgage liens and other liens. The lien is "voluntary" because the property owner must request and agree to the PACE financing and the related assessment lien.

The term of PACE financing is customarily twenty years, with annual (or semi-annual, depending on the jurisdiction's method of collecting property taxes) fully amortizing payments. PACE financing interest rates are typically less than market rates offered by banks and other conventional lenders for similar projects, in part as a result of such financing being secured by a superior lien on the entire real property on which the facilities are installed. PACE financing cannot be accelerated upon a default, and any collection action or foreclosure of the lien is limited to the amount of the periodic payment or payments that are past due.

PACE financing requires an audit and a projection of savings in energy costs as a result of the energy generation or improved efficiency of the facilities to be installed and a demonstration of a net savings to the property owner after taking into account the cost and repayment of the financing. Annual savings are typically greater with PACE financing than any savings that could be achieved by installing the facilities using conventional financing because of the lower interest rates and extended terms available through PACE financing programs. The net-savings calculations are, however, determined based on assumptions related to the long-term future cost of traditional energy sources, and, especially in the current energy market with changes in pricing resulting from the discovery and use of new energy resources, the validity of such assumptions must be considered.

Additionally, because PACE financing is established at the state level, enabling legislation varies from state to state, and a loan servicer and its legal counsel should review the applicable statute.

Mortgage Subordination, Due on Encumbrance, and Alterations: As discussed above, assessment liens securing PACE financing projects are given the same priority as property tax liens and are, therefore, superior in priority to the liens securing mortgage loans. PACE financing liens and the related facilities to be installed require consent under customary loan document provisions relating to additional encumbrances and indebtedness. PACE financing also typically requires rating agency no-downgrade confirmations under pooling and servicing agreements, whether pursuant to specific terms related to PACE financing under more recent pooling and servicing agreements or, even if PACE financing is not specifically referenced, under the due on encumbrance provisions, as a superior lien, and under the consent and modification terms.

Borrowers sometimes encourage servicers to accept a PACE financing lien as an additional permitted encumbrance under loan documents in which permitted encumbrances include property tax liens. Such a position, however, should be rejected. Although PACE financing liens are similar to property tax liens and are billed and collected by the tax assessor as an additional assessment, they are different than property tax liens. Such liens are assessed and created only at the voluntary request of property owners and can be distinguished from property tax assessment liens even under vague permitted encumbrance terms of loan documents. Recent forms of CMBS mortgage loan documents typically expressly define and prohibit PACE financing without the prior written consent of the mortgage lender.

Additionally, PACE financing customarily requires the consent of mortgage lenders under the applicable statutory framework and PACE documentation (note, however, that the enabling legislation in Florida, among other jurisdictions, suggests that mortgage lender consent may not be required for certain PACE financing projects relating to single family residences, which is a topic of ongoing discussions in the applicable jurisdictions).

Because PACE financing is used to alter the collateral property, noteholder consent is also required under the alterations provisions of loan documents, subject to any permitted alterations and cost threshold terms that may be included as an exception to such consent requirements.

Underwriting, Mitigants, and Credit Enhancements: In addition to the usual underwriting performed in connection with requests to consent to an additional encumbrance, new indebtedness, and alterations projects, additional information relating to PACE financing includes the following, each of which must be reviewed by loan servicers and legal counsel: the state enabling legislation; the audit and projection of savings in energy costs; the company that will coordinate and administer funding and the bonding arrangements; and the requested mortgage lender consent form and other proposed PACE financing documentation. With respect to the audit and projection of savings in energy costs, in particular, the loan servicer must consider the reputation of the firm that prepared such audit and projection and the assumption statements included as part of the projected savings, and, in most situations, such firm must be acceptable to the applicable state or in compliance with any applicable requirements of the enabling legislation.

In discussions concerning underwriting and consideration of PACE financing requests, borrowers (at the urging of the private companies that administer and collect fees from PACE financing) often emphasize that PACE financing loans cannot be accelerated such that collection efforts and foreclosures are limited to the periodic payment or payments that are past due. While that is correct and does have some mitigating effect on the risks of PACE financing, be aware that such inability of a PACE financing lender to accelerate the debt does not mean that a foreclosing mortgage lender will only be liable for the periodic payments that may be past due under the PACE financing. Upon any mortgage loan foreclosure, the remaining balance of any PACE financing loan will remain due and payable and secured by an assessment lien on the collateral property, such that periodic payments must continue to be made by the property owner following any such foreclosure. The manner in which the non-acceleration aspect of PACE financing is described by consultants and others involved in PACE financing, while technically correct, can sometimes be interpreted by those not involved with PACE financing on a regular basis as suggesting that, upon a mortgage loan foreclosure, only the past due PACE financing payments are due and payable, which is incorrect.

As mentioned above, although special servicers and rating agencies have historically been reluctant to consent to and provide no-downgrade confirmations for PACE financing, there has been limited movement toward re-evaluating the manner in which PACE financing requests and the related risks are being considered and how such risks may be mitigated with credit enhancements and other conditions. In our practice, we have recommended and seen such credit enhancements and conditions include the following:

- New or adjusted reserves for deposit of PACE financing payments, often including an advance deposit and retention in the reserve of an amount equal to an annual payment due in connection with the PACE financing;
- A reserve in the full amount of the PACE financing loan though borrowers would typically elect not to undertake the PACE financing project if such a large reserve were required; and
- More recently, a guaranty from a borrower affiliate to cover any gap between the projected net savings to be achieved by the PACE financing project and the actual savings realized.

With such credit enhancement requirements to mitigate the PACE financing risks, special servicers and rating agencies have consented to and provided (or waived) no-downgrade confirmations to allow certain PACE financing projects to proceed. As a result of these more encouraging recent developments the future for PACE financing may indeed be bright.

Considerations Related to Foreclosure and REO: In considering borrower requests for PACE financing, also be aware that the effects of PACE financing on foreclosure and the eventual sale of the property as REO remain largely unknown. Proponents of PACE financing generally take the position that the related improvements financed on favorable terms with an interest rate of less than conventional financing market rates will be perceived as a benefit and add value because of the net savings in energy costs. The counter argument, however, is that potential buyers of REO may not accept the projections of continued savings as being reliable in a rapidly changing and fluctuating energy market and will focus instead on higher assessments relative to competing properties. As more PACE financing projects proceed, such effects will become more certain, but at this stage it remains an open matter.

Conclusion: As the use of on-site facilities for energy-generation and energy-savings increases, property owners are likely to explore PACE financing as a favorable means of financing the costs of such facilities. Although there are potential benefits in the nature of anticipated reductions in operating costs, the required mortgage lien subordination and other risks must be considered by loan servicers. Among other issues, the reliability of the projected savings in energy costs must also be evaluated in light of the instability of energy markets and prices and the difficulty of making accurate projections as to future energy costs.

Nonetheless, with suitable mitigants and credit enhancements, PACE financing and the related improvements may be appropriate for certain projects, and, with special servicers and rating agencies being willing to at least review borrower requests, each project and request should be considered rather than being dismissed or denied without further discussion and evaluation.

For more information, contact:

Mark A. Palmer
Kilpatrick Townsend & Stockton LLP
1100 Peachtree Street NE
Atlanta, GA 30309
t 404 815-6105
MPalmer@KilpatrickTownsend.com

MANAGED ENERGY SERVICE AGREEMENTS (MESAs)

Prepared By:
IMT
INSTITUTE FOR MARKET TRANSFORMATION

A Managed Energy Service Agreement (MESA) is a variation of an Energy Service Agreement (ESA). In an ESA, the provider develops, finances, owns, operates, and maintains all energy efficiency measures and equipment installed during the term of the project. A MESA differs from an ESA because the provider also assumes the broader energy management of a client's facility, including the responsibility for utility bills, in exchange for a series of payments based on the customer's historic energy use.

MESAs offer promise for retail energy retrofits when the customer is financially stable, but lacks the expertise or time to undertake the energy efficiency retrofit.

Why should you use it?

- Your company wants to pursue portfolio wide installations or retrofits, but does not have cash for additional capital investments.
- Your company is risk adverse and wants a third-party to take on underperformance risk and provide project management.
- Your company is interested in having a third-party manage your facility to ensure that it is operating as efficiently as possible during the contract term.

Who has used it in the past?

Although MESA is a relatively new market tool that retailers are just beginning to explore, there has been initial uptake in the commercial and higher education sectors.

In 2006, Corporate Office Properties Trust, a REIT based in Maryland, used a MESA to upgrade five buildings. In year one, they averaged over 26% energy savings and by year five, they averaged over 30% energy savings annually.

Drexel University used a MESA to reduce energy consumption by more than 25% in 430,000 square feet of building space. Conservation measures included demand controlled ventilation systems, replacement of the central air chiller, variable air volume units, cooling towers, and lighting controls.

Companies like SCIenergy and Metrus Energy offer MESAs and they report working with BAE Systems, Hyatt Hotels, and other Fortune 500 companies.

What are the advantages?

- **Avoided Capital Outlay** – MESA provider pays for all upfront project costs, enabling customers to conserve capital funds for investment in their core business.
- **MESA Payments Treated as an Operating Expense** – The MESA is designed to be an off-balance sheet financing solution.
- **Enhanced Reliability of Operations** – MESA providers pay for periodic maintenance services to ensure long-term reliability and performance of the project equipment. Customer has a single point of contact and a single payment for all utility expenses and the MESA provider actively manages energy consumption at the facility.
- **Energy Savings Pay for Projects** – The MESA enables customers to redirect a portion of their

Better Buildings® U.S. DEPARTMENT OF ENERGY

This resource was completed with support from the Department of Energy's Office of Energy Efficiency and Renewable Energy and the Better Buildings Initiative to highlight innovative proven energy solutions from market leaders in the Retail sector. Find more ideas at the Better Buildings Solution Center at betterbuildingssolutioncenter.energy.gov

current utility spending to pay for efficiency improvements; MESA payments are based on realized energy and operational savings.

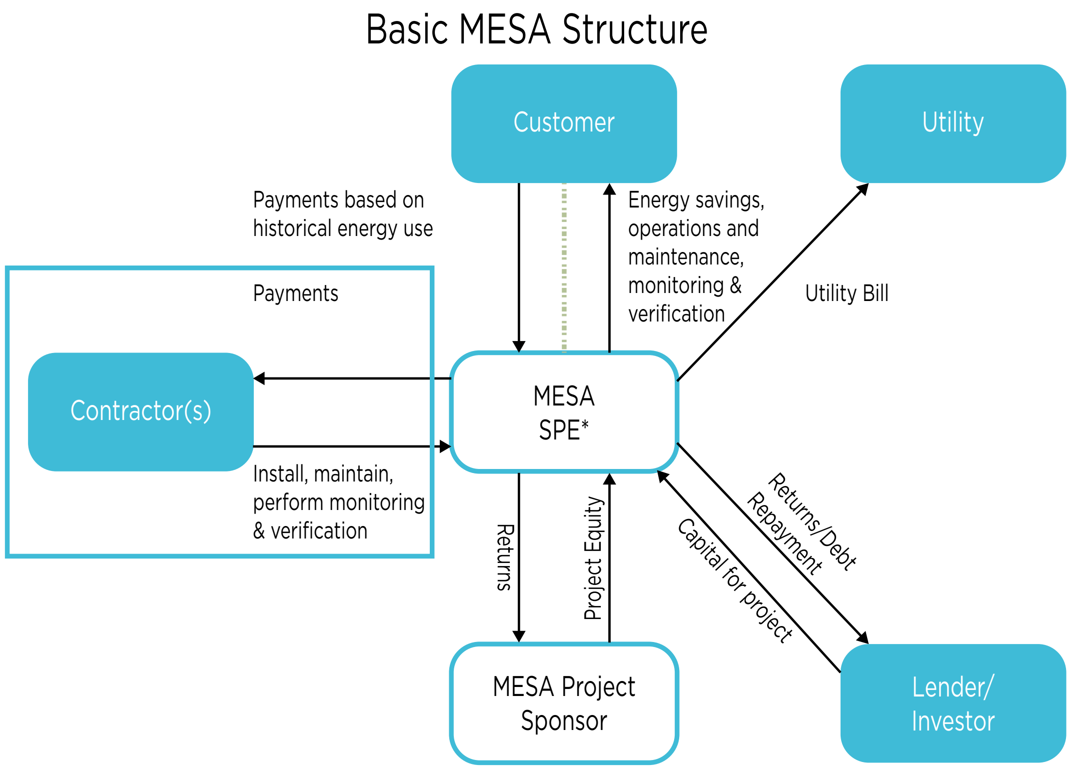
- **Flexible & Scalable Financing –** Under a MESA, as new opportunities for savings are identified they can be funded as they emerge, and rolled out to additional buildings across facilities. MESA providers can bundle together multiple sites that have smaller sized project opportunities ($500,000 or less) into a single MESA financing package (e.g., bundle 10 sites with $500,000 projects into a single $5 million MESA).

What are the downsides?

- MESAs are typically reserved for larger projects ($500,000 and above).
- MESAs are only viable in leased space when the contract term matches the lease term.
- Transaction costs can be high if each deal is heavily negotiated; typical deals have a negotiation period of 9-24 months.

Who should you talk to next?

- Talk to your internal finance team to learn about the company's history and comfort working with energy service providers.
- Reach out to energy service providers like SCIenergy and Metrus Energy to learn more about how a MESA can help you meet your project goals.



Source: Wilson Sonsini Goodrich & Rosati, Innovations and Opportunities in Energy Efficiency Finance, Third Edition, May 2013
**SPE stands for Special Purpose Entity, which is typically the established entity that owns the installed equipment.*

MESAs IN THE MARKET

Managed Energy Service Agreements (MESAs) are contracts under which a third-party energy efficiency contractor assumes the energy management of a client's facility, including the installation of energy efficiency upgrades and responsibility for utility bills, in exchange for a series of payments based on the customer's historic energy use. MESAs offer a turn-key energy retrofit and financing approach that limits upfront costs and management burden.

The MESA contract in effect caps the customer's utility payments, while the contractor reaps all or part of the energy savings over the contract term. A MESA customer enjoys lower utility bills throughout the contract term, but does not own installed equipment unless they buy out the contract or purchase the equipment at fair market value at the end of the MESA contract.

More recently, the commercial sector has taken notice of the benefits that MESA provides and several deals have been executed. Corporate Offices Property Trust, a public REIT, utilized SCIenergy's MESA Capital product to retrofit five of its buildings in 2006. High efficiency lighting and HVAC systems coupled with digital controls on various systems, accounted for the majority of energy savings. In total, 479,420 square feet of space was made more efficient and by 2010, the energy savings were greater than the annual projected average of 30.8%.

Drexel University also worked with SCIenergy to fund $6.5 million worth of improvements in several facilities on campus. The overall reduction in energy consumption is expected to be more than 25% and will account for over 430,000 square feet of building space. The project includes installation of new control systems in 62 laboratories in three different buildings, which will save over 46% of the energy used to operate the lab spaces. Mechanical upgrades in another building include a new chiller, among other things, that will reduce the HVAC load by 35% resulting in $200,000 of savings per year.

While MESAs typically have long negotiation periods, they afford retailers flexibility with regard to site location, building type, and scalability. A MESA can be executed regardless of whether space is leased or owned, provided that the customer pays for their own utility consumption. In addition to improving the energy efficiency of retail stores, MESAs can also address the needs of warehouses, distribution centers, and corporate offices. A single MESA contract can be structured to span multiple locations, cover numerous facility types, and be executed in phases, allowing a customer to pilot a project before scaling it across their portfolio. Although the retail sector has not yet tested MESA as a viable external financing option, its spread into commercial real estate lays the foundation for uptake by retailers.

This material is based upon work supported by the Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), under Award Number DE-EE0007062.

LOCAL LAWS
OF
THE CITY OF NEW YORK
FOR THE YEAR 2019

No. 97

Introduced by Council Members Constantinides, The Speaker (Council Member Johnson) and Council Members Torres, Kallos, Rosenthal, Levin, Rivera, Koo, Powers, Levine, Reynoso, Richards, Salamanca, Menchaca, Chin, Lander, Ampry-Samuel, Ayala, Cumbo, Rose, Brannan, the Public Advocate (Mr. Williams), Espinal, Rodriguez, Lancman, Dromm, Gibson, Treyger, Cornegy, Van Bramer, Moya, Holden, Cohen, Eugene, Barron, Adams, Koslowitz, Cabrera and King.

A LOCAL LAW

To amend the New York city charter and the administrative code of the city of New York, in relation to the commitment to achieve certain reductions in greenhouse gas emissions by 2050

Be it enacted by the Council as follows:

Section 1. Chapter 26 of the New York city charter is amended by adding a new section 651 to read as follows:

§ 651. Office of building energy and emissions performance. a. There shall be in the department an office of building energy and emissions performance. The office shall be headed by a director, who is a registered design professional, who shall be appointed by and shall report to the commissioner. The duties of the office shall include, but not be limited to:

1. Overseeing implementation of building energy and emissions performance laws and policies for existing buildings, new construction and major renovations;

2. Establishing or administering protocols for assessing annual energy use in buildings;

3. Monitoring buildings' energy use and emissions, and reviewing building emissions assessment methodologies, building emissions limits, goals and timeframes to further the goal of *achieving a 40 percent reduction in aggregate greenhouse gas emissions from covered buildings by calendar year 2030, relative to such emissions for the calendar year 2005;*

4. Creating an online portal for the submission of annual building emissions assessments by owners;

5. Receiving and validating annual building emissions assessments;

6. Auditing building emissions assessments and inspecting covered buildings, as necessary, to ensure proper reporting;

7. Determining recommended penalties, including minimum penalties, for buildings that are noncompliant with applicable emissions limits;

8. Reviewing applications for alternative methods of compliance with building emissions limits, including adjustments of emissions limits, deductions for the purchase of greenhouse gas offsets or renewable energy credits, deductions for the use of distributed energy resources, and adjustments for special categories of buildings or for special use and occupancies;

9. Working in close coordination with the mayor's office of long-term planning and sustainability; receiving advice and recommendations, as applicable, from the advisory board established pursuant to section 28-320.2 of the administrative code; and

10. Ensuring the participation and cooperation of agencies, including but not limited to the department of environmental protection, the department of housing preservation and development and the department of citywide administrative services. Such participation and cooperation shall include, but not be limited to, detailing agency staff to assist office staff consistent with agency and office functions and reporting to the office on building energy performance issues and related enforcement efforts.

§ 2. Subdivision e of section 24-802 of the administrative code of the city of New York, as added by local law number 22 for the year 2008, is amended to read as follows:

e. "City government operations" means [operations described in the Government Inventory Methodology and the Government Inventory Results sections of the Inventory of New York City Greenhouse Gas Emissions, dated April 2007] *operations, facilities, and other assets that are owned or leased by the city for which the city pays all or part of the annual energy bills.*

§ 3. Paragraph (1) of subdivision a of section 24-803 of the administrative code of the city of New York, as amended by local law number 66 for the year 2014, is amended to read as follows:

(1) Reduction of emissions citywide. There shall be, at minimum, a [thirty] *40* percent reduction in citywide emissions by calendar year 2030, and an [eighty] *80* percent reduction in citywide emissions by calendar year 2050, relative to such emissions for the base year for citywide emissions.

§ 4. Subdivision b of section 24-803 of the administrative code of the city of New York, as added by local law number 22 for the year 2008, is amended to read as follows:

b. (1) Reduction of emissions from city government operations. There shall be, at minimum, a [thirty] *40* percent reduction in city government emissions by [calendar] *fiscal* year [2017] *2025, and a 50 percent reduction in city government emissions by calendar year 2030,* relative to such emissions for the base year for city government emissions.

(2) The emissions reduction required by paragraph [one] *1* of this subdivision shall be achieved through the applicable policies, programs and actions included in PlaNYC, *energy efficiency retrofits,* and any additional policies, programs and actions to reduce greenhouse gas emissions that contribute to global warming*, including methods to ensure equitable investment in environmental justice communities that preserve a minimum level of benefits for all communities*

and do not result in any localized increases in pollution. If the office determines that such emissions reduction is not feasible despite the best efforts of city government operations, such office shall report such findings and make recommendations with respect to policies, programs and actions that may be undertaken to achieve such reductions.

(3) Reduction of emissions by the New York city housing authority. The New York city housing authority shall make efforts to reduce greenhouse gas emissions by 40 percent by the year 2030 and 80 percent by the year 2050, relative to such emissions for calendar year 2005, for the portfolio of buildings owned or operated by the New York city housing authority. If the office determines that such emissions reduction is not feasible despite the best efforts of city government operations, such office shall report such findings and make recommendations with respect to policies, programs and actions that may be undertaken to achieve such reductions.

§ 5. Chapter 3 of title 28 of the administrative code of the city of New York is amended by adding a new article 320 to read as follows:

ARTICLE 320

BUILDING ENERGY AND EMISSIONS LIMITS

§ 28-320.1 Definitions. *As used in this article, the following terms shall have the following meanings:*

BUILDING EMISSIONS*. The term "building emissions" means greenhouse gas emissions as expressed in metric tons of carbon dioxide equivalent emitted as a result of operating a covered building and calculated in accordance with rules promulgated by the department in consultation with the mayor's office of long term planning and sustainability. The term "building emissions" shall not include greenhouse gas emissions emitted during a local state of emergency declared by the mayor pursuant to section 24 of the executive law or a state of emergency declared by the governor pursuant to sections 28 of the executive law, where such local or state emergency has an impact on building emissions.*

BUILDING EMISSIONS INTENSITY*. The term "building emissions intensity" means, for a covered building, the number obtained by dividing the building emissions by the gross floor area for such building, expressed in metric tons of carbon dioxide equivalent per square foot per year.*

CARBON DIOXIDE EQUIVALENT*. The term "carbon dioxide equivalent" means the metric used to compare the emissions of various greenhouse gases based upon their global warming potential as defined in the Intergovernmental Panel on Climate Change Fifth Assessment Report (2014).*

CITY BUILDING*. The term "city building" means a building that is owned by the city or for which the city regularly pays all of the annual energy bills.*

Exception*: The term "city building" shall not include any senior college in the city university of New York system.*

CLEAN DISTRIBUTED ENERGY RESOURCE*. The term "clean distributed energy resource" means a distributed energy resource that (i) uses any of the following sources to generate electricity: hydropower, solar photovoltaics, geothermal wells or loops, tidal action, waves or water currents, and wind; or (ii) is designed and operated to store energy, including, but not limited to, batteries, thermal systems, mechanical systems, compressed air, and superconducting equipment.*

COVERED BUILDING. *The term "covered building" means, as it appears in the records of the department of finance, (i) a building that exceeds 25,000 gross square feet or (ii) two or more buildings on the same tax lot that together exceed 50,000 gross square feet (9290 m^2), or (iii) two or more buildings held in the condominium form of ownership that are governed by the same board of managers and that together exceed 50,000 gross square feet (9290 m^2).*

Exceptions:

1. An industrial facility primarily used for the generation of electric power or steam.

2. Real property, not more than three stories, consisting of a series of attached, detached or semi-detached dwellings, for which ownership and the responsibility for maintenance of the HVAC systems and hot water heating systems is held by each individual dwelling unit owner, and with no HVAC system or hot water heating system in the series serving more than two dwelling units, as certified by a registered design professional to the department.

3. A city building.

4. A housing development or building on land owned by the New York city housing authority

5. A rent regulated accommodation.

6. The real estate owned by any religious corporation located in the city of New York as now constituted, actually dedicated and used by such corporation exclusively as a place of public worship.

7. Real property owned by a housing development fund company organized pursuant to the business corporation law and article eleven of the private housing finance law.

***DISTRIBUTED ENERGY RESOURCE**. The term "a distributed energy resource" means a resource comprised of one or multiple units capable of generating or storing electricity, all at a single location that is directly or indirectly connected to an electric utility distribution system. The resource may serve all or part of the electric load of one or more customers at the same location, and it may simultaneously or alternatively transmit all or part of the electricity it generates or stores onto the electric distribution system for sale to or use by other customers at other locations.*

***GREENHOUSE GAS**. The term "greenhouse gas" means a unit of greenhouse gas, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).*

***GREENHOUSE GAS OFFSET**. The term "greenhouse gas offset" means a credit representing one metric ton of carbon dioxide equivalent emissions reduced, avoided, or sequestered by a project from a measured baseline of emissions and which has been verified by an independent, qualified third party in accordance with offset standards referenced by rules of the department.*

***FINANCIAL HARDSHIP (OF A BUILDING**). The term "financial hardship (of a building)" means a building shall be considered to be subject to financial hardship where, for the combined two years prior to the application for an adjustment to annual building emissions limit pursuant to section 28-320.7, the building:*

1. Had arrears of property taxes or water or wastewater charges that resulted in the property's inclusion on the department of finance's annual New York city tax lien sale list;

2. Is exempt from real property taxes pursuant to sections 420-a, 420-b, 446 or 462 of the real property tax law and applicable local law and the owner had negative revenue less expenses as certified to the department by a certified public accountant, or by affidavit under penalties of perjury; or

3. Had outstanding balances under the department of housing preservation and development's emergency repair program that resulted in the property's inclusion on the department of finance's annual New York city tax lien sale list.

***METRIC TONS OF CARBON DIOXIDE EQUIVALENT**. The term "metric tons of carbon dioxide equivalent" means the global standard unit in carbon accounting to quantify greenhouse gas emissions, also expressed as tCO_2e.*

***RENEWABLE ENERGY CREDIT**. The term "renewable energy credit" means a certificate representing the environmental, social and other non-power attributes of one megawatt-hour of electricity generated from a renewable energy resource, which certificate is recognized and* *tradable or transferable within national renewable energy markets or the New York generation attribute tracking system. This term also means the environmental, social, and other non-power attributes of one megawatt-hour of electricity generated from a hydropower resource that does not trade or transfer renewable energy certificates for those hydropower resources in any renewable energy market or via the New York generation attribute tracking system, provided that the hydropower resource owner certifies the amount of energy produced in each reporting year and that it has not sold the non-power attributes equal to its energy production more than once.*

RENT REGULATED ACCOMMODATION. *The term "rent regulated accommodation" means a building (i) containing one or more dwelling units with a legal regulated rent pursuant to the emergency tenant protection act of 1974, the rent stabilization law of 1969 or the local emergency housing rent control act of 1962, (ii) containing one or more dwelling units required by law to be registered and regulated pursuant to the emergency tenant protection act of 1974 or the rent stabilization law of 1969, (iii) buildings developed with subsidies received pursuant to section 1701q of title 12 of the United States code and (iv) buildings participating in a project-based assistance program pursuant to section 1473f of title 42 of the United States code.*

§ 28-320.2 Advisory board*. There shall be an advisory board convened, by the office of building energy and emissions performance upon the effective date of this article, in January of 2029 and in January of 2039, to provide advice and recommendations to the commissioner and to the mayor's office of long term planning and sustainability relating to effectively reducing greenhouse gas emissions from buildings. Such recommendations shall include, but not be limited to:*

1. A report to be delivered to the mayor and 1. A report and recommendations to be delivered to the mayor and the speaker of the city council no later than January 1, 2023 for additional or improved approaches to assessing building energy performance. Such report shall include, but not be limited to:

1.1. An approach for buildings to submit energy use or greenhouse gas emissions and other information for the purpose of assessing energy performance of covered buildings;

1.2. A methodology that includes the metric of measure, adjustments to the metric, the approach to comparing the output to a benchmark, alternative compliance paths, credit for beneficial electrification and distributed energy resources, and an approach for a trading mechanism as described in section 28-320.11;

1.3. Recommendations for addressing tenant-controlled energy usage;

1.4. Recommendations for amendments to the audit required under section 28-308.2 of the administrative code, including consideration of whether such audit should be replaced by a capital plan;

1.5 Recommendations for reducing building emissions from rent regulated accommodations;

1.6 Recommendations for allowing additional time to comply with the emissions limits for buildings converting to a new occupancy group or use with lower emissions limits or some other change in status that would affect applicability of the provisions of this article;

1.7 An evaluation of the extent to which the mayor's 80x50 energy infrastructure pathways study is incorporated and addressed within the recommendations made pursuant to items 1.1 through 1.6 of this section; and

1.8 A reference guide to delineate the responsibilities of the building designer and owners to comply with emissions limits.

2. A report to be delivered to the mayor and the speaker of the city council no later than January 1, 2023, providing an analysis of, and any recommendations for improving, energy and emissions performance requirements for covered buildings. Such recommendations shall be targeted to achieve at least a 40 percent reduction in aggregate greenhouse gas emissions from covered buildings by calendar year 2030 relative to such emissions for the calendar year 2005. Such report shall include, but not be limited to assessments of:

2.1. Incentives for reduction of peak energy demand;

2.2. Methods to allow for staggered reporting cycles for compliance with energy and emissions performance improvements;

2.3. Methods for calculating penalties for non-compliance;

2.4. Estimated emissions reductions associated with any recommended energy performance requirements;

2.5. The economic impact, including benefits, of achieving the energy and emissions performance requirements;

2.6. Methods for achieving earlier or larger reductions from city-owned buildings;

2.7 Separate improvement targets for base building energy systems and tenant-controlled energy systems;

2.8 Methods for achieving emissions reductions from manufacturing and industrial processes; and

2.9 Methods for achieving emissions reductions from hospitals while maintaining critical care for human health and safety.

***§ 28-320.2.1 Advisory board composition.** Such advisory board shall be staffed with registered design professionals and be composed of 16 members including the chairperson, 8 of the members* *of such advisory board shall be appointed by the mayor or the mayor's designee, and 8 of the members of such advisory board shall be appointed by the speaker of the council. The mayor shall appoint one architect, one operating engineer, one building owner or manager, one public utility industry representative, one environmental justice representative, one business sector representative, one residential tenant representative, and one environmental advocacy organization representative. The speaker shall appoint one architect, one stationary engineer, one construction trades representative, one green energy industry representative, one residential tenant representative, one environmental justice organization representative, one environmental advocacy representative and one not for profit organization representative. The director of such office, or the designee of such director, shall serve as chairperson of the advisory board. The advisory board may convene in working groups. Such working groups may include individuals not on such advisory board to address the recommendations required by this article. The mayor shall invite the appropriate federal, state and local agencies and authorities to participate, including but not limited to the New York state energy research and development authority. Such advisory board shall convene a working group on hospitals that shall be composed of engineers, architects, and hospital industry representatives.*

§ 28-320.3 Building emissions limits*. Except as otherwise provided in this article, or otherwise provided by rule, on and after January 1, 2024 a covered building shall not have annual building emissions higher than the annual building emissions limit for such building as determined in accordance with this section based on the occupancy group of the building.*

§ 28-320.3.1 Annual building emissions limits 2024-2029*. For calendar years 2024 through 2029 the annual building emissions limits for covered buildings shall be calculated pursuant to items 1 through 10 of this section. For the purposes of such calculation the department shall provide a method for converting categories of uses under the United States environmental protection agency Portfolio Manager tool to the equivalent uses and occupancy groups set forth in this section. For a covered building with spaces classified in more than one occupancy group, the annual building emissions limit shall be the sum of the calculated values from items 1 through 10 of this paragraph, as applicable for each space.*

1. *For spaces classified as occupancy group A: multiply the building emissions intensity limit of 0.01074 tCO_2e/sf by the corresponding gross floor area (sf);*

2. *For spaces classified as occupancy group B other than as described in item 6: multiply the building emissions intensity limit of 0.00846 tCO_2e/sf by the corresponding gross floor area (sf);*

3. *For spaces classified as occupancy groups E and I-4: multiply the building emissions intensity limit of 0.00758 tCO_2e/sf by the corresponding gross floor area (sf);*

4. *For spaces classified as occupancy group I-1: multiply the building emissions intensity limit of 0.01138 tCO_2e/sf by the corresponding gross floor area (sf);*

5. *For spaces classified as occupancy group F: multiply the building emissions intensity limit of 0.00574 tCO_2e/sf by the corresponding gross floor area (sf);*

6. *For spaces classified as occupancy groups B civic administrative facility for emergency response services, B non-production laboratory, Group B ambulatory health care facility, H, I-2 and I-3: multiply the building emissions intensity limit of 0.02381 tCO_2e/sf by the corresponding gross floor area (sf);*

7. *For spaces classified as occupancy group M: multiply the building emissions intensity limit of 0.01181 tCO_2e/sf by the corresponding gross floor area (sf);*

8. *For spaces classified as occupancy group R-1: multiply the building emissions intensity limit of 0.00987 tCO_2e/sf by the corresponding gross floor area (sf);*

9. *For spaces classified as occupancy group R-2: multiply the building emissions intensity limit of 0.00675 tCO_2e/sf by the corresponding gross floor area (sf);*

10. *For spaces classified as occupancy groups S and U: multiply the building emissions intensity limit of 0.00426 tCO_2e/sf by the corresponding gross floor area (sf).*

§ 28-320.3.1.1 Greenhouse gas coefficient of energy consumption for calendar years 2024 through 2029. *The annual building emissions of a covered building in accordance with this section, greenhouse gas emissions shall be calculated as follows for calendar years 2024 through 2029:*

1. *Utility electricity consumed on the premises of a covered building that is delivered to the building via the electric grid shall be calculated as generating 0.000288962 tCO_2e per kilowatt hour, provided, however, that the department, in consultation with the office of long term planning and sustainability, shall promulgate rules governing the calculation of greenhouse gas emissions for campus-style electric systems that share on-site generation but make use of the utility distribution system and for buildings that are not connected to the utility distribution system.*

2. *Natural gas combusted on the premises of a covered building shall be calculated as generating 0.00005311 tCO_2e per kbtu.*

3. *#2 fuel oil combusted on the premises of a covered building shall be calculated as generating 0.00007421 tCO_2e per kbtu.*

4. *#4 fuel oil combusted on the premises of a covered building shall be calculated as generating 0.00007529 tCO_2e per kbtu.*

5. *District steam consumed on the premises of a covered building shall be calculated as generating 0.00004493tCO_2e per kbtu.*

6. *The amount of greenhouse gas emissions attributable to other energy sources, including but not limited to distributed energy resources, shall be determined by the commissioner and promulgated into rules of the department.*

§ 28-320.3.2 Building emissions limits for calendar years 2030 through 2034. *For calendar years 2030 through 2034 the annual building emissions limits for covered buildings shall be calculated pursuant to items 1 through 10 of this section. For the purposes of such calculation the department shall provide a method for converting categories of uses under the United States environmental protection agency Portfolio Manager tool to the equivalent uses and occupancy groups set forth in this section. For a covered building with spaces classified in more than one occupancy group, the annual building emissions limit shall be the sum of the calculated values from items 1 through 10 of this paragraph, as applicable for each space. The department may establish different limits, set forth in the rules of the department, where the department determines that different limits are feasible and in the public interest. Where such limits are set by rule, the average emission limits for all covered buildings shall not be less restrictive than the average emissions impact of the building emissions limits outlined in items 1 through 10 of this section. The advisory board and the office of long term planning and sustainability shall provide advice and recommendation regarding such limits.*

1. *For spaces classified as occupancy group A: multiply the building emissions intensity limit of 0.00420 tCO_2e/sf by the corresponding gross floor area (sf);*

2. *For spaces classified as occupancy group B other than as described in item 6: multiply the building emissions intensity limit of 0.00453 tCO_2e/sf by the corresponding gross floor area (sf);*

3. *For spaces classified as occupancy groups E and I-4: multiply the building emissions intensity limit of 0.00344 tCO_2e/sf by the corresponding gross floor area (sf);*

4. *For spaces classified as occupancy group I-1: multiply the building emissions intensity limit of 0.00598 tCO_2e/sf by the corresponding gross floor area (sf);*

5. *For spaces classified as occupancy group F: multiply the building emissions intensity limit of 0.00167 tCO_2e/sf by the corresponding gross floor area (sf);*

6. *For spaces classified as occupancy groups B civic administrative facility for emergency response services, B non-production laboratory, Group B ambulatory health care facility, H, I-2 or I-3: multiply the building emissions intensity limit of 0.01193 tCO_2e/sf by the corresponding gross floor area (sf);*

7. *For spaces classified as occupancy group M: multiply the building emissions intensity limit of 0.00403 tCO_2e/sf by the corresponding gross floor area (sf);*

8. *For spaces classified as occupancy group R-1: multiply the building emissions intensity limit of 0.00526 tCO_2e/sf by the corresponding gross floor area (sf);*

9. *For spaces classified as occupancy groups R-2: multiply the building emissions intensity limit of 0.00407 tCO_2e/sf by the corresponding gross floor area (sf);*

10. *For spaces classified as occupancy groups S and U: multiply the building emissions intensity limit of 0.00110 tCO_2e/sf by the corresponding gross floor area (sf).*

§ 28-320.3.2.1 Greenhouse gas coefficients of energy consumption for calendar years 2030 through 2034. *For the purposes of calculating the annual building emissions of a covered building in accordance with this section, the amount of greenhouse gas emissions attributed to particular energy sources shall be determined by the commissioner and promulgated into rules of the department by no later than January 1, 2023. The commissioner shall consult with the advisory board required by this article to develop such greenhouse gas coefficients for utility electricity consumption. When developing such coefficient, the commissioner shall consider factors including, but not limited to, the best available New York state energy research and development authority and State Energy Plan forecasts for Zone J for the end of the compliance period and beneficial electrification.*

§ 28-320.3.4 Building emissions limits for calendar years 2035 through 2050. *No later than January 1, 2023, the commissioner shall establish by rule annual building emissions limits and building emissions intensity limits applicable for calendar years 2035 through 2039 and building emissions limits and building emissions intensity limits applicable for calendar years 2040 through 2049. Such limits shall be set to achieve an average building emissions intensity for all covered buildings of no more than 0.0014 tCO_2e/sf/yr by 2050.*

§ 28-320.3.5 Building emissions limits on and after calendar year 2050. *No later than January 1, 2023 the commissioner shall establish by rule annual building emissions limits and building emissions intensity limits applicable for calendar years commencing on and after January 1, 2050. Such limits shall achieve an average building emissions intensity for all covered buildings of no more than 0.0014 tCO_2e/sf/yr.*

§ 28-320.3.6 Deductions from reported annual building emissions. *The department may authorize a deduction from the annual building emissions required to be reported by an owner pursuant to section 28-320.3 where the owner demonstrates the purchase of greenhouse gas offsets or renewable energy credits, or the use of clean distributed energy resources, in accordance with this section.*

§ 28-320.6.1 Deductions from reported annual building emissions for renewable energy credits. *A deduction from the reported annual building emissions shall be authorized equal to the number of renewable energy credits purchased by or on behalf of a building owner, provided (i) the renewable energy resource that is the source of the renewable energy credits is considered by the New York independent system operator to be a capacity resource located in or directly deliverable* *into zone J load zone for the reporting calendar year; (ii) the renewable energy credits are solely owned and retired by, or on behalf of, the building owner; (iii) the renewable energy credits are from the same year as the reporting year; and (iv) the building that hosts the system producing the energy does not receive a deduction under § 28-320.6.3. Covered buildings claiming deductions for renewable energy credits under this section must provide the department with the geographic location of the renewable energy resource that created the renewable energy credits. The department, in consultation with the mayor's office of long term planning and sustainability, shall promulgate rules to implement this deduction.*

§ 28-320.3.6.2 Deductions from reported annual building emissions for purchased greenhouse gas offsets. *For calendar years 2024 through 2029, a deduction shall be authorized for up to 10 percent of the annual building emissions limit. Such a deduction shall be authorized only where within the reporting calendar year, greenhouse gas offsets equivalent to the size of the deduction as measured in metric tons of carbon dioxide equivalent and generated within the reporting calendar year have been (i) purchased by or on behalf of the owner in accordance with an offset standard referenced by rules of the department, (ii) publicly registered in accordance with such offset standard, and (iii) retired or designated to the department for retirement. Such greenhouse gas offsets must exhibit environmental integrity principles, including additionality, in accordance with rules promulgated by the department in consultation with the office of long term planning and sustainability. For the purposes of this section, additionality means a requirement that an offset project is not already required by local, national or international regulations. Prior to the department promulgation of rules, the department shall consult the advisory board on environmental justice as established in local law 64 of 2017.*

§ 28-320.3.6.3 Deductions from reported annual building emissions for clean distributed energy resources. *For calendar years 2024 through 2029, a deduction from the reported annual building emissions shall be authorized based upon the calculated output of a clean distributed energy resource located at, on, in, or directly connected to the building subject to the report. The department shall promulgate rules to set forth how such deduction shall be calculated, in accordance with the following:*

1. *For a clean distributed energy resource that generates electricity, the department shall establish separate calculations for each type of commercially available clean distributed energy resource, which shall not be revised more frequently than once every three years.*

2. *For a clean distributed energy resource that stores electricity, the deduction shall be based on the size of the resource and its ability to reduce greenhouse gas emissions during designated peak periods.*

§ 28-320.3.7 Reports. *By May 1, 2025, and by May 1 of every year thereafter, the owner of a covered building shall file with the department a report, certified by a registered design professional, prepared in a form and manner and containing such information as specified in rules of the department, that for the previous calendar year such building is either:*

1. *In compliance with the applicable building emissions limit established pursuant to section 28-320.3; or*

2. *Not in compliance with such applicable building emissions limit, along with the amount by which such building exceeds such limit.*

§ 28-320.3.7.1 Extension of time to file report. *An owner may apply for an extension of time to file an annual report required by section 28-320.3.7 in accordance with this section and the rules of the department. An extension may be granted where the owner is unable to file the certified report by the scheduled due date despite such owner's good faith efforts, as documented in such application. An extension granted pursuant to this section shall not modify the owner's obligation to comply with the applicable emission limits for such calendar year.*

§ 28-320.3.8 Continuing requirements*. In 2055, the office of building energy and emissions performance shall prepare and submit to the mayor and the speaker of the council recommendations whether to repeal or amend any of the requirements of this article.*

§ 28-320.3.9 Extension for certain income-restricted housing. *This section is applicable to covered buildings that are owned by a limited-profit housing company organized under article 2 of the private housing finance law, or contain one or more dwelling units for which occupancy or initial occupancy is restricted based upon the income of the occupant or prospective occupant thereof as a condition of a loan, grant, tax exemption, or conveyance of property from any state or local governmental agency or instrumentality pursuant to the private housing finance law, the general municipal law, or section 420-c of the real property tax law. Such buildings are exempted from the annual building emissions limits set forth in section 28-320.3.1 and 28-320.3.2 and from any applicable reporting requirements.*

§ 28-320.3.10 Changes in building status. *The department may establish by rule procedures for a building to apply for additional time to comply with the emissions limits when such building converts to a new occupancy group or use with lower emissions limits, or undergoes a change affecting the applicability of this article to such building.*

§ 28-320.4 Assistance*. The office of building energy and emissions performance shall establish and maintain a program for assisting owners of covered buildings in complying with this article, as well as expand existing programs established to assist owners in making energy efficiency and renewable energy improvements. These programs shall be made available to assist building owners without adequate financial resources or technical expertise.*

§ 28-320.5 Outreach and education*. The office of building energy and emissions performance shall establish and engage in outreach and education efforts to inform building owners about building emissions limits, building emissions intensity limits and compliance with this article. The materials developed for such outreach and education shall be made available on the office's website. Such outreach shall include a list of city, state, federal, private and utility incentive programs related to energy reduction or renewable energy for which buildings reasonably could be eligible. The office of building energy and emissions performance shall also provide outreach, education, and training opportunities for buildings' maintenance and operations staff.*

§ 28-320.6 Penalties*. An owner of a covered building who has submitted a report pursuant to section 28-320.3.7 which indicates that such building has exceeded its annual building emissions limit shall be liable for a civil penalty of not more than an amount equal to the difference between the building emissions limit for such year and the reported building emissions for such year, multiplied by $268.*

§ 28-320.6.1 Determination of penalty*. In considering the amount of the civil penalty to be imposed pursuant to this article, a court or administrative tribunal shall give due regard to aggravating or mitigating factors including:*

1. *The respondent's good faith efforts to comply with the requirements of this article, including investments in energy efficiency and greenhouse gas emissions reductions before the effective date of this article;*

2. *The respondent's history of compliance with this article;*

3. *The respondent's compliance with the conditions of any adjustment to the applicable building emissions limit, issued by the department pursuant to section 28-320.7;*

4. *Whether the non-compliance was directly related to unexpected and unforeseeable events or conditions during the calendar year outside the control of the respondent;*

5. *The respondent's access to financial resources; and 6. Whether payment of such penalty would impact the operations of facilities critical to human life or safety .*

§ 28-320.6.2 Civil penalty for failure to file report*. It shall be unlawful for the owner of a covered building to fail to submit an annual report as required by section 28-320.3.7 on or before the applicable due date. An owner of a covered building subject to a violation for failure to file a report shall be liable for a penalty of not more than an amount equal to the gross floor area of such covered building, multiplied by $0.50, for each month that the violation is not corrected within the 12 months following the reporting deadline; provided, however, that an owner shall not be liable for a penalty for a report demonstrating compliance with the requirements of this article if such report is filed within 60 days of the date such report is due.*

§ 28-320.6.3 False statement*. It shall be unlawful to knowingly make a material false statement in a report or other submission filed with the department, pursuant to this article. A violation of this section shall be a misdemeanor and subject to a fine of not more than $500,000 or imprisonment of not more than 30 days or both such fine and imprisonment. A person who violates this section shall also be liable for a civil penalty of not more than $500,000.*

§ 28-320.6.4 Penalty recovery. *Civil penalties provided for by this article may be recovered in a proceeding before an administrative tribunal within the jurisdiction of the office of administrative trials and hearings. Administrative summonses returnable to such tribunal for violations of this* *article may be issued by the department or by an agency designated by the department. Civil penalties provided for by this article may also be recovered in an action by the corporation counsel in any court of competent jurisdiction.*

§ 28-320.7. Adjustment to applicable annual building emissions limit*. The department, in consultation with the mayor's office of long term planning and sustainability or any other agency designated by the mayor, may grant an adjustment of the annual building emissions limit applicable to a covered building in existence on the effective date of this article or for which a permit for the construction of such building was issued prior to such effective date, provided that the owner is complying with the requirements of this article to the maximum extent practicable.*

1. *Such an adjustment may be granted upon a specific determination that:*

1.1. Capital improvements are necessary for strict compliance with the limit set forth in section 28-320.3 and it is not reasonably possible to make such improvements due to (i) a constraint imposed by another provision of law including but not limited to designation as a landmark, landmark site, interior landmark, or within a historic district pursuant to chapter 3 of title 25 of the administrative code, or (ii) a physical condition of the building or building site including but not limited to lack of access to energy infrastructure, space constraints, or lack of access to a space within a building covered by a lease in existence on the effective date of this section;

1.2. The owner has made a good faith effort to purchase greenhouse gas offsets to comply with section 28-320.3 but a sufficient quantity is not available at a reasonable cost; and

1.3. The owner has availed itself of all available city, state, federal, private and utility incentive programs related to energy reduction or renewable energy for which it reasonably could participate.

2. *Such an adjustment may be granted upon a specific determination that:*

2.1. The cost of financing capital improvements necessary for strict compliance with the limit set forth in section 28-320.3 would prevent the owner of a building from earning a reasonable financial return on the use of such building or the building is subject to financial hardship as defined in this article. In evaluating the ability of an owner to earn a reasonable financial return, the department may consider future savings expected from such capital improvements;

2.2. The owner is not eligible for any program funded by the city or enabled by a local law that provides financing for the purpose of energy reduction or sustainability measures. Proof of ineligibility for financing must be demonstrated by rejection from any such program funded by the city or enabled by a local law or an affidavit explanation why such owner could not reasonably participate in such programs;

2.3. The owner has made a good faith effort to purchase greenhouse gas offsets or renewable energy credits to comply with section 28-320.3 but a sufficient quantity is not available at a reasonable cost; and

2.4. The owner has availed itself of all available city, state, federal, private and utility incentive programs related to energy reduction or renewable energy for which it reasonably could participate.

§ 28-320.7.1 Effective period. *An adjustment granted pursuant to item 1 of section 28-320.7 may be effective for a period of not more than three calendar years. An adjustment granted pursuant to item 2 of such section may be effective for a period of not more than one calendar year.*

§ 28-320.7.2 Application. *An application for such an adjustment shall be made in the form and manner determined by the department and certified by a registered design professional.*

§ 28-320.8 Adjustment to applicable annual building emissions limit for calendar years 2024-2029. *The department may grant an adjustment of the annual building emissions limit for calendar years 2024 through 2029 applicable to a covered building in existence on the effective date of this article where such covered building emissions in calendar year 2018 exceeds the building emissions limit as prescribed by section 28-320.3.1 by more than 40 percent, as reported to the department by a registered design professional. The adjustment shall result in a required building emissions limit that is 70 percent of the calendar year 2018 building emissions for the covered building. Such adjustment may be granted where:*

1. The owner of a covered building demonstrates that the building emissions in excess of the building emissions limit is attributable to special circumstances related to the use of the building, including but not limited to 24 hour operations, operations critical to human health and safety, high density occupancy, energy intensive communications technologies or operations, and energy-intensive industrial processes;

2. The owner of a covered building demonstrates that the energy performance of the covered building is equivalent to a building in compliance with the New York city energy conservation code in effect on January 1, 2015; and

3. The owner of the covered building has submitted a plan to the department setting forth a schedule of alterations to the covered building or changes to the operations and management of the covered building sufficient to ensure that the covered building will be in compliance with the annual building emissions limits for calendar years 2030 through 2034, as required by section 28-320.3.2.

§ 28-320.8.1 Effective period. *An adjustment granted pursuant to section 28-320.8 may be effective for the reporting years 2025 through 2030, as prescribed by section 28-320.3.7, provided that the certificate of occupancy has not been amended after December 31, 2018.*

§ 28-320.8.1.1 Extension of effective period. *The commissioner may also grant an extension of the effective period of the adjustment to applicable annual building emissions limit for calendar years 2030-2035, as prescribed by section 28-320.3.8. Such extension may be granted upon submission of a schedule of alterations to the covered building or changes to the operations and management of the covered building in accordance with section 28-320.8 sufficient to ensure that by 2035 the covered building will comply with a required building emissions limit that is 50 percent of the reported 2018 building emissions for the covered building.*

§ 28-320.8.2 Application. *An application for an adjustment shall be submitted to the department before July 1, 2021 in the form and manner determined by the department and certified by a registered design professional.*

§ 28-320.9 Adjustment to applicable annual building emissions limit for not-for-profit hospitals and healthcare facilities. *The department shall grant an adjustment of the annual building emissions limits for calendar years 2024-2029 and 2030-34 where:*

1. *The building is classified as a not-for-profit hospital, not-for-profit health center, or not-for-profit HIP center, in existence on the effective date of this article; and*

2. *By no later than July 21, 2021, the owner of the covered building submits an application to the department for such adjustment in a form and manner prescribed by the department.*

For calendar years 2024 through 2029, the adjustment shall result in the covered building being subject to an emissions limit that is 85 percent of the calendar 2018 building emissions for such covered building. For calendar years 2030 through 2034, the adjustment shall result in the covered building being subject to an emissions limit that is 70 percent of the calendar 2018 building emissions for such covered building.

§ 28-320.10 Fee schedule*. The department may establish by rule a schedule of fees that shall be paid upon the filing of a report or an application for an adjustment to the applicable building emissions limit pursuant to this article. Such schedule may include a fee for the late filing of a report.*

§ 28-320.11 Carbon trading study*. The office of long term planning and sustainability shall conduct a study on the feasibility of a citywide trading scheme for greenhouse gas emissions from buildings and submit a report and implementation plan with the findings of such study to the mayor and the speaker of the council no later than January 1, 2021. Such study shall include methods to ensure equitable investment in environmental justice communities that preserve a minimum level of benefits for all covered buildings and do not result in any localized increases in pollution. Such study shall also include an approach to a marketplace for credit trading, pricing* *mechanisms, credit verification, and mechanisms for regular improvement of the scheme. Such study should also consider the reports and recommendations of the advisory board.*

§ 6. Chapter 3 of title 28 of the administrative code of the city of New York is amended by adding a new article 321 to read as follows:

ARTICLE 321

ENERGY CONSERVATION MEASURE REQUIREMENTS FOR CERTAIN BUILDINGS

§ 28-321.1 Definitions. *As used in this article, the following terms shall have the following meanings:*

COVERED BUILDING. *The term "covered building" means a building (i) containing one or more dwelling units with a legal regulated rent pursuant to the emergency tenant protection act of 1974, the rent stabilization law of 1969 or the local emergency housing rent control act of 1962, (ii) containing one or more dwelling units required by law to be registered and regulated pursuant to the emergency tenant protection act of 1974 or the rent stabilization law of 1969, (iii) buildings developed with subsidies received pursuant to section 1701q of title 12 of the United States code and (iv) buildings participating in a project-based assistance program pursuant to section 1473f of title 42 of the United States code , (v) real estate owned by any religious corporation located in the city of New York as now constituted, actually dedicated and used by such corporation exclusively as a place of public worship and, as it appears in the records of the department of finance, (i) a building that exceeds 25,000 gross square feet or (ii) two or more buildings on the same tax lot that together exceed 50,000 gross square feet (9290 m^2), or (iii) two or more buildings held in the condominium form of ownership that are governed by the same board of managers and that together exceed 50,000 gross square feet (9290 m^2).*

Exceptions*:*

1. *Real property, not more than three stories, consisting of a series of attached, detached or semi-detached dwellings, for which ownership and the responsibility for maintenance of the HVAC systems and hot water heating systems is held by each individual dwelling unit owner, and with no HVAC system or hot water heating system in the series serving more than two dwelling units, as certified by a registered design professional to the department.*

2. *An industrial facility primarily used for the generation of electric power or steam.*

3. *A covered building as defined in article 320.*

§ 28-321.2 Required energy conservation measures for certain buildings. *A covered building must comply with either section 28-321.2.1 or section 28-321.2.2.*

§ 28-321.2.1 Energy compliant buildings. *The owner of a covered building shall demonstrate that, for calendar year 2024, the annual building emissions of such covered building did not exceed what the applicable annual building emissions limit would be pursuant to section 28-320.3.2 if such building were a covered building as defined in article 320 of this chapter.*

§ 28-321.2.2 Prescriptive energy conservation measures. *By December 31, 2024, the owner of a covered building shall ensure that the following energy conservation measures have been implemented where applicable:*

1. *Adjusting temperature set points for heat and hot water to reflect appropriate space occupancy and facility requirements;*

2. *Repairing all heating system leaks;*

3. *Maintaining the heating system, including but not limited to ensuring that system component parts are clean and in good operating condition;*

4. *Installing individual temperature controls or insulated radiator enclosures with temperature controls on all radiators;*

5. *Insulating all pipes for heating and/or hot water;*

6. *Insulating the steam system condensate tank or water tank;*

7. *Installing indoor and outdoor heating system sensors and boiler controls to allow for proper set-points;*

8. *Replacing or repairing all steam traps such that all are in working order;*

9. *Installing or upgrading steam system master venting at the ends of mains, large horizontal pipes, and tops of risers, vertical pipes branching off a main;*

10. *Upgrading lighting to comply with the standards for new systems set forth in section 805 of the New York city energy conservation code and/or applicable standards referenced in such energy code on or prior to December 31, 2024. This provision is subject to exception 1 in section 28-310.3, provided that July 1, 2010 is replaced by January 1, 2020 for the purposes of this section;*

11. *Weatherizing and air sealing where appropriate, including windows and ductwork, with focus on whole-building insulation;*

12. *Installing timers on exhaust fans; and*

13. Installing radiant barriers behind all radiators.

§ 28-321.3 Reports. *By May 1, 2025, an owner of a covered building shall submit a report to the department to demonstrate compliance with this section in accordance with section 28-321.3.1 or section 28-321.3.2.*

§ 28-321.3.1 Energy compliant buildings reports. *The owner of a covered building shall file with the department a report, certified by a registered design professional, prepared in a form and manner and containing such information as specified in rules of the department, that for calendar year 2024 such building was in compliance with the applicable building emissions limit established pursuant to section 28-320.3.2.*

§ 28-321.3.2 Prescriptive energy conservation measures reports. *A retro-commissioning agent, as defined in article 308, shall prepare and certify a report in a form and manner determined by the department. The report shall include such information relating to the completion of the prescriptive energy conservation measures as shall be set forth in the rules of the department including, at a minimum:*

1. Project and team information:

1.1. Building address.

1.2. Experience and certification of persons performing the prescriptive energy conservation measures and any staff involved in the project.

1.3. Name, affiliation, and contact information for persons performing the prescriptive energy conservation measures, owner of building, and facility manager of building.

2. Building information:

2.1. List of all HVAC, domestic hot water, electrical equipment, lighting, and conveyance equipment types serving the covered building.

§ 28-321.4 Penalties. *Penalties that may be assessed for violations of section 28-321.2 shall be determined by department rule.*

§ 7. This local law takes effect 180 days after it becomes law, except that prior to such effective date the department of buildings and the office of long term planning and sustainability may take such measures as are necessary for the implementation of this local law, including the promulgation of rules.

THE CITY OF NEW YORK, OFFICE OF THE CITY CLERK, s.s.:

I hereby certify that the foregoing is a true copy of a local law of The City of New York, passed by the Council on April 18, 2019 and returned unsigned by the Mayor on May 20, 2019.

MICHAEL M. McSWEENEY, City Clerk, Clerk of the Council.

CERTIFICATION OF CORPORATION COUNSEL

I hereby certify that the form of the enclosed local law (Local Law No. 97 of 2019, Council Int. No. 1253-C of 2018) to be filed with the Secretary of State contains the correct text of the local law passed by the New York City Council, presented to the Mayor and neither approved nor disapproved within thirty days thereafter.

STEVEN LOUIS, Acting Corporation Counsel.

E-CAPITAL
INSURANCE SERVICES

Overview of Energy
Project Performance Insurance (PPI)

Project Performance Insurance (PPI) policies are written to reduce the risk that the Return on Investment (ROI) promised by a Contractor Developer Team (CDT) to a building owner or financier investing in an energy-efficiency or renewable energy project (an Energy Conservation Measure or ECM), fails to materialize or doesn't live up to expectations.

By agreeing to pay for any performance shortfalls over the policy term, a PPI insurer mitigates the two principal barriers to investments in energy projects: (1) the risk of underperformance; and (2) disputes over project performance.

<u>Highlights & Benefits</u>

- PPI policies cover performance shortfalls that result from: improper ECM design; improper ECM installation; improper baseline energy consumption calculations; and improper "savings" (or "output") calculations. They can be tailored to fit a wide variety of technologies and complex projects with different performance metrics (e.g. kWhs, Gals, therms, BTU's etc.). "Soft savings" (e.g. reduced maintenance costs, renewable energy credits, etc.) may also be included within the limits.

- The PPI underwriting process is about validating and bulletproofing a project's internal economics, from an engineering and financial perspective. It forces the criteria for defining baseline energy-use levels and the amounts of "savings" (or "output") to be transparent and explicit for all of the stakeholders in the project, and provides important third-party review of: the engineering design, the consistency and accuracy of energy data and projections, and the methodologies and protocols for ongoing Measurement and Verification of the energy "savings" (or "output").

- PPI policies typically run for terms of five (5) to ten (10) years. Premiums are 3.0%-6.0% of the total amount of energy "savings" (or "output") to be insured during the policy period. Rates will vary for each project, depending upon: the experience level and performance history of the CDT; the types of ECM's to be installed; the *insured amount vs. the total expected amount* of energy "savings" (or "output) for the project; and the policy structure (i.e. the level of Self-Insured Retention or SIR, deductible, coinsurance percentage, etc.).

Claims Process and Policy Exclusions

- PPI carriers employ engineering experts to analyze the actual energy performance data (through Measurement and Verification) during the covered performance period in order to pre-empt and remediate any claims that may arise.

- Typically, the project's performance is "trued-up" on an annual basis, and potential claims are reviewed to determine the actual cause(s) of loss and if such loss is covered under the PPI policy.

- Measured performance may be subject to adjustments for excluded events that may have caused or contributed to reduced levels of "savings" (or "output"), such as: changes in weather or commodity pricing, physical damage to ECM's or building systems, improper maintenance, changes in building occupancies or operations, etc.

Underwriting and Marketing Considerations

- PPI carriers provide important screening and validation of CDT's. Their underwriting process is similar to qualifying for a conventional Construction Bonding line.

- Once a CDT has been fully qualified by a PPI carrier, it is in a position to market investment-grade "Guaranteed Outcomes" and "Insured Services" to its customers, while transferring most of the liabilities for such guarantees to the insurer.

- CDT's should attempt to limit the amount of performance that they are willing to guarantee to customers to the amount (or some fraction of the amount) that the PPI carrier is willing to insure. This both reduces the CDT's exposure, and also helps to set the customer's expectations as to what levels of performance should be considered "realistic", "achievable", and "safe".

- With a PPI policy in place, a CDT does not have to engage outside counsel or engineers to defend itself against real or perceived claims from a customer for disputed energy performance.

- PPI policy costs are usually minimal as compared to a project's total return over the life-cycle of the ECM's. If a CDT properly prices all of the PPI policy costs into the project's economics, then it is the *customer* that will ultimately be paying for the coverage to backstop the project's income projections.

Using PPI to Enhance Project Development

Sample Solar Lease Project:

Equipment life-expectancy of 25 yrs.; 10-yr. "Simple Payback"; Estimated "output" of 25 yrs. @ $172k/yr. = $4.3M. [This assumes that panel degradation and utility rate increases more or less offset each other.]
7 yrs. lease payments @ $164k/yr., then 3 yrs. buyout @ $150k/yr. ($1.6M in total cash outlays over 10-yrs.). Project cash-flow is positive from day one; large savings to begin in 11th year. Net gain is $2.5M+ over the 25-yr. system life. Annual Return of 15%+.
Customer needs a production guarantee to cover all cash outlays. A PPI policy was structured to backstop 10-yrs. of "output" @ $1.6M. This project's internal economics support the $65k PPI policy premiums and/or a reserve fund to cover SIRs/deductibles. The CDT's SIR exposures under the PPI policy could range from zero to $160k, as negotiated between the parties.

Sample LED Project:
Cash Price $105k; equipment life-expectancy of 10 yrs. 3-yr. "Simple Payback"; Estimated "savings" of 10 yrs. @ $37k/yr. = $374k;

– Funding Option 1: Cash (Self-funded): The net gain to customer over 10 yrs. = $270k. Annual Return of 25%+:
– Funding Option 2: Debt (Loan or Leasing): Depending upon interest rates, net gain to customer over 10 yrs. = $230k to $250k; Annual Return of 15% - 20%;
– Funding Option 3: ESA (Shared-Savings): Customer pays $26k/yr. (or 70% of the annual "savings") to an investor for 7 yrs. (total of $182k). Net gain to customer over the life cycle of the system is $150k to $175k, *plus* free lighting for 10 yrs., off-balance sheet, and no up-front capital outlay.

Attaching an investment-grade performance guarantee to the project adds important security in all of the above funding situations. A PPI policy can be written to cover:
a) 10-yr. total "savings" of $374k for a premium of $12k; or
b) "savings" of $120k to $140k during repayment of a loan or lease, for a premium of $6k; or
c) "savings" of $105k over the "Simple Payback" period, for a premium of $4k.
This project's internal economics support the PPI premiums and/or a reserve fund to cover SIRs/deductibles. The CDT's SIR exposures under the PPI policy could range from zero to $37k, as negotiated between the parties.

E-CAPITAL
INSURANCE SERVICES
A DIVISON OF E-CAPITAL DEVELOPMENT INC.

Project Risks and Available Coverage

Equipment Exposures

Policy	Coverage	Estimated Cost
Manufacturer's Product Warranty	Manufacturer's warranty risk of product repair or replacement.	Provided by each Manufacturer.
Manufacturer's Output Performance Warranty	Insures against Project's underperformance from Manufacturer's design, and calculation errors.	4.0% to 6.0% of the Project's Guaranteed Energy Output.

Contractor/Construction Exposures

Policy	Coverage	Estimated Cost
Construction Bond	Guarantees satisfactory completion of a project by a Contractor.	0.5% to 2.0% of Contract Cost.
General Liability	Insures (and defends) against claims or third-party suits arising from construction or ongoing operations.	1.0% to 3.0% of field payroll. Varies with trade type and operating location.
Builders Risk	Insures against physical damage or losses to the materials, fixtures and/or equipment used during construction/renovation.	0.1% to 0.3% of Final Construction Cost.
Workers' Compensation and Employer's Liability Insurance	Insures against injuries to employees during ongoing construction or operations	0.5% to 1.5% of field payroll. Varies with trade type and operating location.
Professional Liability / Errors & Omissions	Insures (and defends) against claims or third-party suits arising from negligent acts, errors, or omissions in design or professional services.	0.1% to 0.3% of Sales. Included in Energy Savings Performance Insurance coverage.
Automobile Liability Insurance	Insures (and defends) against claims or third-party suits arising from ownership, maintenance or use of motor vehicles.	Varies with vehicle types and operating location.

Contractor's Pollution Liability Insurance	Insures (and defends) against claims or third-party suits arising from the release, discharge, or dispersal of pollutants.	0.1% to 0.3% of Contract Cost.

Project Owner/Operator Exposures

Policy	Coverage	Estimated Cost
Property Insurance	Insures against physical damage or loss to the premises or business equipment.	0.5% to 1.0% of the Total Property limits to be insured.
Business Interruption / Equipment Breakdown Insurance	Insures against loss or delay of income from physical damage to the premises or breakdown of the business equipment.	0.1% to 0.3% of the Business Interruption / Equipment Breakdown limits to be insured.
Energy Savings Performance Insurance	Insures against Project's underperformance from Contractor's design, or the implementation of energy saving measures and does not require physical damage to have occurred to the equipment.	2.0% to 5.0% of the Project's Guaranteed Energy Savings.
General Liability	Insures (and defends) against claims or third-party suits arising from construction and/or ongoing operations.	Varies with site operation, type and location.
Site Pollution Liability Insurance	Insures (and defends) against claims or third-party suits arising from the release, discharge, or dispersal of pollutants.	Varies with site operation, type and location.

If you have any questions, please feel free to give me a call at any time.

Marshall Haimson, President
E-Capital Insurance Services
+1-516-546-1106
Marshall@E-CapitalDevelopment.com

Quantifying the Financial Value of Insurance for Energy Savings Projects

Richard B. Jones and David R. Tine, Hartford Steam Boiler Inspection & Insurance Co.

ABSTRACT

Insurance is often viewed as an expense applied solely to meet investor, bank lending or regulatory requirements. In the energy savings performance contracting industry, engineers manage performance risk by providing comprehensive investment grade audits, robust designs, project implementation best practices, measurement and verification (M&V) plans, and reasonable energy savings deductible levels. Historically, insuring energy savings has not been widely adopted as a cost effective practice considering the guarantees offered by energy service companies (ESCOs). And from a lender's or investor's risk analytic perspective, the financial value of insurance has not been previously quantified.

This paper combines the financial-risk engineering of lending institutions with the energy-risk engineering of an insurer. It describes three models: a graphical/visual method, a theoretical solution and also a practical stochastic model that computes the credit risk reduction offered by insuring a fraction of the projected savings revenue stream. The work demonstrates the credit enhancement from the projected energy savings stream with and without insurance. An actual building retrofit project is used as an example to demonstrate the analysis model and the value created by energy savings insurance. The paper also demonstrates a methodology that connects the reduction in credit risk to an improvement in credit quality. For example, energy savings insurance can be applied to make a sub-investment grade loan appear, from an equivalent credit risk perspective, as an investment grade transaction.

Introduction

With about 49% of all energy used and 75% of all electricity consumed in the United States in buildings (EIA) the energy profiles of these structures represent a significant opportunity to increase grid reliability and reduce emissions, energy production, and costs. There are four basic pathways to achieve these goals as our economy and population grows:

- Building owners can retrofit the structures with new materials, windows, energy efficient equipment, and distributed generation
- Legacy energy production can be replaced or supplemented with cleaner or renewable sources.
- Building users can change their energy use behaviors.
- Ensure that newly constructed buildings incorporate best practices in energy efficiency design and are integrated with power production.

The diverse building marketplace of residential, commercial and institutional structures is composed of several underlying markets and segments and there is no one-size-fits-all approach. However, there are several options available to building owners to improve energy efficiency. The materials, equipment, and energy engineering knowledge are available today. And also due to the rapid increase in internet supported control, monitoring and operational systems, there is a rich selection of affordable aggregation and reporting tools to support dynamic energy management (US DOE Smart Grid). In other words, the practical engineering solutions to radically reduce building energy demand and consumption exist today.

New building construction provides a significantly improved level of energy efficiency over older structures simply because contemporary equipment and materials are manufactured to higher energy efficiency standards. However, the real potential for energy efficiency is in upgrading pre-existing buildings to contemporary standards. For example, Figure 1 shows, in part, the magnitude of this opportunity in the US and UK (US DOE 2010 and DECC 2012):

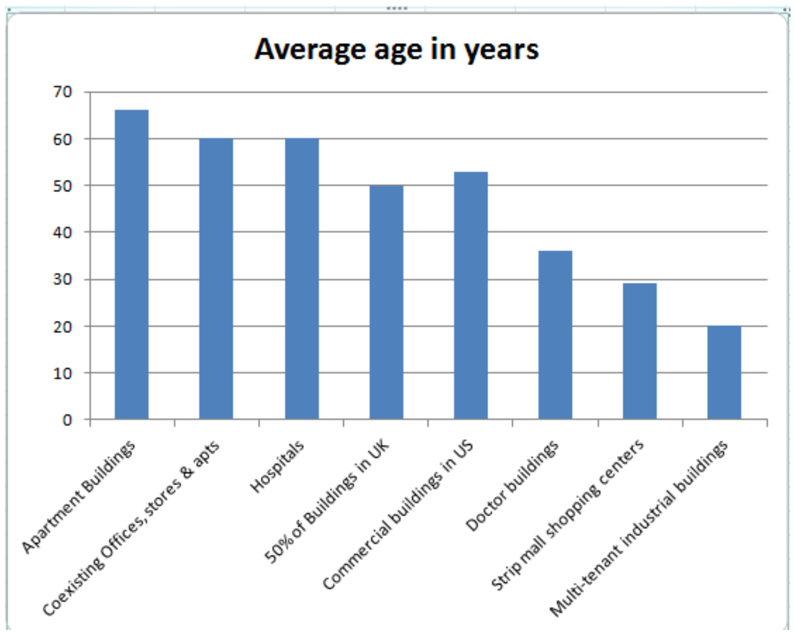


Figure 1. Average age in years of US and UK buildings.

So it is not surprising see that the global building retrofit market valued at $80.3 billion in 2011, is forecasted to grow to $151.8 billion by 2020(Navigant Research). Most of the new investments will be made by ESCOs and other energy engineering companies through the sale of equipment and technical services.

Yet, in spite of the purported long and short term money saving benefits and the proven engineering means to radically improve building energy efficiency, there still remains formidable barriers to the widespread deployment and implementation of actual programs. Regardless of the estimated annual energy savings, building retrofits are capital intensive projects that are executed in a relatively short period, usually less than a year. It is impractical to do these types projects gradually over several years; a compressed schedule is typically required in order that buildings and services remain functional throughout. Consequently, a significant capital expense is incurred by the building owner at the beginning of the project. The sources of this funding, for both the public and private sectors, generally fall into the following categories (ACEEE 2011):

Cash Flows

If the cash flows from the building are large enough, the project can be funded directly from this source. While this option is certainly convenient it implies that the cash flows can be diverted from their previous destination. In some structured finance situations, cash flow allocations are not discretionary, but in others this may be a viable option.

Parent Company Debt

A corporate owned building can borrow funds from internal sources for better than market interest terms. While this approach clearly streamlines the acquisition of capital, the corporation's financial data must reflect this debt which can influence trading values and company valuations.

Acquire Debt

If the building is completely owned, then this option is viable. However, for building owners with mortgages, there are often mortgage covenants that restrict debt accumulation and overriding these agreements can be difficult. Also many mortgages are part of larger security structures which complicates the approval process even further.

Utilize ESCOs & Energy Service Agreements (ESAs)

There are two major versions of a model where the project's capital expense will not be placed on the building owner's balance sheet: (1) The ESCO can create a Special Purpose Vehicle that will own and operate the energy-related equipment in the building. Essentially, the building owner outsources all energy-related operations. The reduction in energy costs pays for the O & M costs plus the ESCO's profit in addition to providing the building owner with lower energy expenses. (2) In the second model, the ESCO funds the project and is paid back over time through the energy savings.

These models have been used in specific market segments and there are many variations in how ESCOs can work. Generally ESCOs are not a source of funding as much as a way of structuring the financial arrangements of projects and whose direct loans and packaged capital are seen as expensive in some segments.

Rebates & Subsidized Capital Resources

Utilities have special programs and equipment rebates that can offset some of the equipment upgrade capital expense but their value does not offset all project costs. State, municipal, and federal programs offer tax incentives for renewable energy investments. But it is our belief that these programs are highly regionalized and are not necessarily long-term benefits, since they are subject to political factors.

Yet, even with the many positive accomplishments (ACEEE 1980-2012) of the building retrofit industry; there still remain several barriers to achieving the anticipated scale and demand for projects. These barriers reflect primarily the complexity of the residential, commercial and industrial building marketplace. On the demand (buyer) side (McKinsey & Company 2009):

- Retrofit projects usually require large upfront costs to achieve the savings annuity
- Savings incentives of energy consumption can be structured differently for tenants and owners, causing confusion.

- Building owners may not fully comprehend (or believe) the retrofit financial benefits.
- Sales cycle for retrofit projects of 9-12 months is too long to keep owner interest.

And on the supply (seller) side, the diversity and large size of the marketplace brings its own challenges. For in order to acquire the scale that is suggested by the overall technical and financial opportunities, the project development and financing need to become more standardized, simplified, and designed to directly address balance sheet requirements.

To deal with these issues, new financial structures have been created and others have been streamlined. Each of the major types listed below have advantages and disadvantages, but together they provide a solid basis to develop a list of financial options that can, hopefully in the near future, begin to penetrate the scale barriers (World Economic Forum 2011):

- Property Accessed Clean Energy (PACE) – regional & regulatory
- Energy Service Agreements (ESA) –special purpose vehicle
- On-Bill Loan – utility
- Government-owned development bank – some non-US markets
- Equipment Lease Finance
- ESCO business model
- Endowment and revolving funds

These finance structures are designed to manage the expense of building retrofits projects relative to the efficiency savings over time. They all involve the transfer for funds (or loans) for project implementation and include accounting of accumulated energy savings. These types of transactions possess two major forms of risk: loan default and asset performance. Default (or credit risk) is assessed and underwritten by the lending institution but the valuation or credit enhancement of insurance related to asset performance is not included in aforementioned financing models. The exception to this statement is the credit enhancement association with government-owned developmental banks.

Credit Enhancement of Asset Performance Insurance

Credit enhancement of a project loan transaction is protection in the form of financial support to cover loan losses under default or other adverse conditions. For energy efficiency projects there are two levels of financial support that generally can be interpreted as credit benefits:

- the new effective revenue stream from the efficiency improvements, and,
- insurance that some or all of the calculated reduction in energy use will be realized.

Many projects require property, casualty, and builder's risk insurances as part of the structured financial arrangement so these products are already being used as standard requirements for project lending. However, the financial benefits of insuring asset performance are just beginning to be explored.

Asset performance insurance is financial support, subject to the terms and conditions of the policy, to insure that the annual savings for a project will not fall below some prescribed level. From one perspective this provides a valuable benefit to mitigate risk in that the lenders (and the credit rating agency) will be assured of a minimum cash flow at the credit rating of the insurer.

For this analysis we define credit risk as the expected loss or recovery due to default for a loan of principal $\hat{P}$, for a term of 'n' years at an interest rate 'i.' These calculations are standard in lending activities but for energy efficiency loans there is another variable that also needs to be considered. This is the anticipated savings from lower energy demand and consumption costs. There may be additional savings (or costs) in maintenance and operations but generally these values are not considered when developing loans for efficiency projects.

Insuring a part of the annual savings provides a key benefit in that the total amount insured is backed by the credit rating of the insurer rather than the credit rating of the borrower. Credit rating enhancement insurance for energy efficiency needs to conform to three basic tenets (Puccia 2004):

- If a shortfall in aggregate savings occurs, the insurance company pays the claim within a pre-set period of time regardless of the cause. Any claim-related legal issues are secondary to claim payment.
- Claims settlement follows an approved formula known at the beginning of the policy.
- No additional legal or administrative charges will be assessed to the insured party.

In other words, if there is a claim for a given year, the insurer must quickly pay the claim amount to the policy holder and then pursue recovery or other subrogation measures independent of the insured. The major exception is fraud.

Given that asset performance insurance prescribes to these tenets, the question remains, "how to quantify the credit enhancements of this type of risk transfer"? Energy savings can be viewed as a new revenue stream that offsets the legacy expenses and improves cash flows that are necessary for loan repayment. From this perspective the certainty and size of the energy savings relative to the periodic loan payments should change the default probability for a given loan.

For example, consider the credit worthiness of two loans each for $1,000,000 for 5 years at an interest rate of 6%. The annual payment for this loan is $230,974.80. Each borrower is required to pay this amount each year. However, if borrower #1 is using the money for property improvements (e.g. a new roof) there probably are no annual savings. However, if borrower #2 is using the loan for an energy efficiency project with an annual savings of $100,000 per year, the financial stress to repay the loan is less, suggesting borrower #2 should have a lower default probability and therefore a higher effective credit rating.

Traditionally, lending companies or banks cover default risk and specialty insurers cover asset performance risk (related in this case to energy efficiency). To determine a project rating, analysts consider many project variables associated with default and asset performance, (Mandel, Morgan, and Wei 2012) including sovereign, business & legal, and force majeure risks. At a project level, rating analysis is divided into contract design, technology, construction, operation, competitiveness, legal structure, financial strength, and others. For energy efficiency projects, the major risks usually rest in the adequacy of the engineering design, performance of the technology to achieve the targeted efficiencies, the measurement and verification plan, and whether operational best practices are followed to maintain the saving levels. These risks can be addressed by energy efficiency insurance. Subsequently, as rating agencies begin to study these specialized projects types, more rating benefits of asset performance insurance may emerge.

In this paper we present a qualitative, theoretical, and numerical simulation examples, of methods designed to measure the credit rating enhancement potential for energy efficiency projects. The work does not replace a credit rating analysis done by a rating agency, lender, or investor but it does supply some insights on the amount of credit enhancement that is possible under certain conditions. A secondary application of this paper is to provide a framework that hopefully can be developed to provide a level of uniformity and standardization to financing and rating energy efficiency project loans.

Graphical Depiction of Credit Enhancement with Asset Performance Insurance

To understand how insurance can enhance a loan transaction credit rating, we begin by showing the results of a standard credit risk model. The multi-year default probabilities are taken from S&P's CDO Evaluator Code (CDO Evaluator Engine) and annual interest rates by rating category are estimated from S&P's 2013 literature (Rigby 2013). Since interest rates vary over time and default probabilities are re-published periodically, the objectives of this analysis are to:

- Demonstrate the methodologies that can be applied to value asset performance insurance in structured finance and
- Provide approximate estimates of how risk transfer through insurance can create savings for building energy-efficiency projects.

Figure 2 shows the average default loss or average credit risk associated with borrowing $1,000,000 and $500,000 (each paid back in five annual payments) as a function of the credit rating of the borrower.

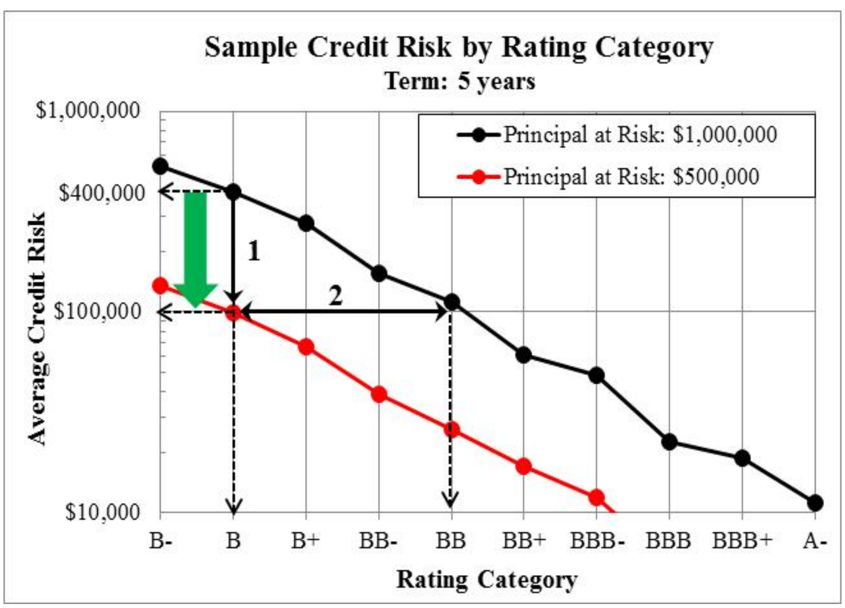


Figure 2. Credit risk enhancement from risk transfer conceptual description.

Both lines show how the default loss decreases as the borrower's credit rating improves. The only difference between the two lines is the principal at risk. The dotted horizontal line shows that the B rated company borrowing $1M has an average credit risk of $400,000. However, if $500,000 is insured, the principal at risk is reduced to $500,000, and the red curve (following the direction indicated by "1" in Fig. 2) applies. However, following "2" horizontally to the right, we see that this value is approximately equal to the credit risk of $1M for a BB rated borrower. Therefore from a credit risk perspective, a $1M loan to a B-rated borrower with $500,000 insured, is equivalent to a $1M transaction over the same time period to a BB rated borrower. In other words, the $500,000 insured value decreases the loan credit risk and therefore increases the loan credit rating; technically in this case from a "B" to a "BB." The difference in credit risk (shown by the green arrow) depicts about a $300,000 credit risk savings associated with insuring $500,000.

This methodology illustrates how asset performance insurance applied to the risk transfer of building energy efficiency savings can be used as a credit enhancement tool by investors, lenders, and rating agencies. There are several assumptions that are inherent in the method as described in Figure 2 that will be explored in the following theoretical and stochastic models.

Theoretical Model Credit Enhancement with Asset Performance Insurance

In this analysis, we describe a model for computing the credit enhancement from insuring a fraction of the loan principal associated with energy efficiency projects. The major approximations or assumptions are in the actual insurance coverages relative to what is needed by rating agencies and lenders to quantify the financial value of energy efficiency insurance in practice.

The situation being modeled is a building energy efficiency project where the implementation time is relatively short compared to the loan period so we ignore implementation delays relative to the loan payment period.

Let

Q_x	(x=1) - the credit rating of the borrower (x=2) - the achieved equivalent rate
L_x	the total amount loan including principal and interest (x = 1, 2)
M_x:	the annual (or periodic) loan payment (x = 1, 2)
$\hat{P}$	loan principal
$P_d(k, Q_x)$	the default probability in year k for a borrower with credit rating Q_x, (x = 1, 2)

For this model we repay the loan with interest in 'n' years with annual payments. The credit risk or default loss recovery for a loan, C_1, for 'n' years at an interest rate i_1 for a borrower with credit rating 1 (say "B") is:

$$C_1 = \sum_{k=1}^{n} P_d\,(k, Q_1)(L_1 - k * M_1) \tag{1}$$

The annual loan payment M_l can be written in terms of the loan principal, $\hat{P}$, interest rate, i_l, and loan term, n, as:

$$M_1 = \hat{P} * \frac{i_1}{(1-(1+i_1)^{-n})} = \hat{P} * I_1 \tag{2A}$$

$$\text{and} \qquad L_1 = n * M_1 = n * \hat{P} * I_1 \tag{2B}$$

The basic descriptions of M_l and L_l in terms of the interest, principal and loan term are helpful in simplifying the final equations.

Let's assume that the principal and interest required for loan repayment are determined for the borrower at their initial credit rating taking into consideration the insured energy efficiency savings amount, *S*. And the credit risk of *S* is measured at the insurer's credit rating. The resulting total credit risk is the sum of the reduced borrower's credit risk for (L_l-*S*) and the insurer's credit risk for *S*:

$$\sum_{k=1}^{n} P_d(k, Q_1)(n-k)(\hat{P} - S)I_1 + \sum_{k=1}^{n} P_d(k, Q_I)(n-k)SI_I \tag{3}$$

We now need to find the new state (denoted by the subscript 2) where this amount of credit risk is equal to a higher credit rating and lower interest rate for the full loan amount $\hat{P}$.

$$\sum_{k=1}^{n} P_d(k, Q_1)(n-k)(\hat{P} - S)I_1 + \sum_{k=1}^{n} P_d(k, Q_I)(n-k)SI_I = \sum_{k=1}^{n} P_d(k, Q_2)(n-k)\hat{P}I_2 \tag{4}$$

The left-hand side of Equation 4 describes the situation where the lender gives the borrower full benefit of the energy efficiency insurance. The insurance covers the asset performance or energy efficiency savings designed to produce at least *S* dollars of savings over the policy term and the default risk for this portion of the principal is rated at the insurer's credit rating.

This scenario implies that default and energy efficiency savings risk associated with the amount, *S*, is completely transferred to the insurer. In general, default risk coverage is not included in the same policies that cover asset performance. However, the effective new revenue stream from the efficiency savings, the insurer's additional technical project review, and the additional oversight through the policy term intuitively decrease default risk.

Also there is a basic difference between default and energy efficiency insurance that is a significant issue from the lender's perspective. If a borrower defaults the bank can lose the outstanding repayments. However, financial support for energy efficiency insurance is not a strict guarantee. There are terms and conditions that must be satisfied in order for the policy to respond to any revenue shortfall. So lenders cannot be 100% confident that the insurance will provide the needed financial support. Insurance is generally not an unconditional financial guarantee and rating agencies have indicated that energy efficiency policies must respond quickly and unilaterally if any credit enhancement is to be achieved(9). To address this important issue, new energy efficiency policy language is being developed in cooperation with interested investors, contractors, and building owners to ensure that the policy language provides the maximum credit enhancement benefits from this type of insurance.

Using Equation 4, it can be shown that the maximum credit enhancement possible is equal to the insurer's credit rating. If for example, an insurer covers the entire principal in its performance-related coverage then S = $\hat{P}$ which mathematically states this result. Solving Eqn. 4 for ($S/\hat{P}$) we compute a formula than can be used to determine how much credit enhancement is obtained by insuring a given percentage of the principal, $\hat{P}$.

$$\frac{S}{\hat{P}} = \frac{I_1 \sum_{k=1}^{n} P_d(k, Q_1)(n-k) - I_2 \sum_{k=1}^{n} P_d(k, Q_2)(n-k)}{I_1 \sum_{k=1}^{n} P_d(k, Q_1)(n-k) - I_I \sum_{k=1}^{n} P_d(k, Q_I)(n-k)} \tag{5}$$

Equation 5 has several variables that need to be known before the ratio can be computed: loan term, n, credit rating of the insurer, and the enabled credit enhancement '2.' To demonstrate the results that can be computed from Eqn. (5), we consider the example used in the previous section with the additional piece of data required being the credit rating of the insurer. For this example we will assume the insurer is 'A' rated by S&P.

Table 1. Maximum credit rating enhancement from insuring percentage of loan amount (S / $\hat{P}$)

		Achieved Credit Rating								
		B	**B+**	**BB-**	**BB**	**BB+**	**BBB-**	**BBB**	**BBB+**	**A-**
Initial Credit Rating	**B-**	22%	47%	58%	67%	80%	88%	94%	96%	98%
	B		32%	46%	58%	74%	85%	92%	95%	98%
	B+			21%	39%	62%	77%	88%	93%	97%
	BB-				23%	52%	71%	85%	92%	96%
	BB					39%	63%	80%	89%	95%
	BB+						40%	68%	82%	93%
	BBB-							47%	71%	88%
	BBB								45%	77%
	BBB+									58%

Table 1 is interpreted as follows: if the borrower was rated at a B-, then insuring 22% of the loan principal is required in order for the loan to have the same credit risk as a B rated loan for the total principal $\hat{P}$. In other words, insuring 22% of the principal has the potential to improve the credit rating of the loan transaction from a B- to a B. The biggest credit improvement comes for the non-investment grade rating categories (< BBB-) where the default probabilities and interest rates are considerable higher relative to the highly rated insurance company. As the borrower credit rating improves, the difference in credit risk between the borrower and the insurer decreases thereby diminishing the value of the insurance.

Stochastic Model for Energy Efficiency Insurance Valuation

In Figure 2 the credit benefit of insurance was demonstrated by reducing the principal at risk by a fixed amount – namely the insured amount of the project total efficiency savings. Yet, in building energy efficiency projects the actual amount of annual of savings is a stochastic variable subject to variation from a large number of internal and external factors. Energy efficiency loans are generally paid off by project cash flows where savings is seen effectively as new revenue stream compared to pre-retrofit operations. Therefore from an insurance and lending perspective there are two components that reduce the principal at risk: (1) the stochastic new revenue stream created by the efficiency upgrades and (2) the deterministic efficiency insurance which supports a minimum level of savings.

Intuitively, a company with an energy efficiency savings revenue stream is more likely not to default than an equivalent company that does not have this benefit. Yet rating agencies and lenders do not generally consider savings cash flows as a new revenue stream for providing credit enhancement benefits. Insurance, depending on the coverage details, can be considered a credit enhancement instrument.

There are several factors that can influence loan default rate. For example, a corporation which owns many buildings can be forced into loan default due to external factors related to their business that have nothing to do with local project cash flows. Yet for the single building owner where energy efficiency projects are viable, the efficiency savings stream can have direct revenue value in the long term project cash flows. To provide some insight on how these cash flows can influence the credit risk of loans, a stochastic model was developed that incorporates the stochastic distribution of potential efficiency savings with the additional option of augmenting this distribution with insurance.

To demonstrate the application of the model, consider an energy efficiency retro-fit project for an office building located in Connecticut. The project is composed of 12 energy conservation measures (ECMs) related to HVAC, building envelope, and control system upgrades. The total project costs are $2.5M with an expected annual energy savings of $185,000.

Performing a risk analysis from the audit reports, baseline, and engineering data, a range of possible ECM outcomes are computed and correlations between ECMs are assessed. From this data a project level savings distribution is computed as shown in Figure 3.

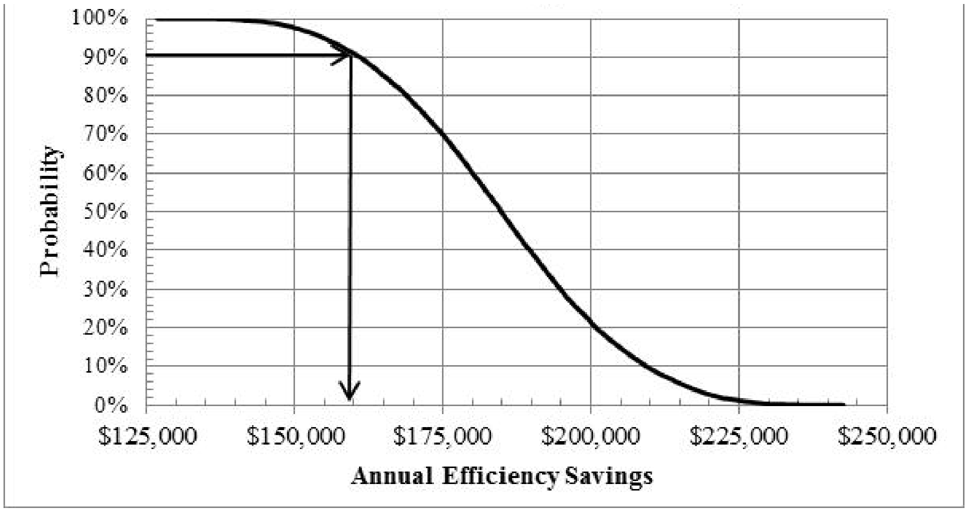


Figure 3. Distribution of annual efficiency savings for Connecticut Office Building Retrofit Project.

According to Figure 3, there is a 90% chance of the annual efficiency savings will exceed about $160,000 and a 20% chance that the savings amount will exceed $200,000. This curve represents valuable quantitative information that can be used to reduce the real income required to repay the loan. Let's consider a 10 year loan for the full project costs of $2.5M. To measure the credit enhancement value of the efficiency revenue stream and the additional value of insurance, we set the insured annual savings at the 10% deductible level from the expected savings estimate of $185,000 which corresponds to $166,500. The insurance company is assumed to be AA rated. Table 2 shows the credit enhancement potential that is obtained from:

- insuring $1,665,000 (10x$166,500) at the insurer's credit rating with the remaining part of the principal financed at the borrower's credit level, and
- the stochastic new revenue stream from the annual efficiency savings distribution shown in Figure 3

Table 2. Credit enhancement potential

		Achieved Credit Rating								
Initial Credit Rating	**Insurance?**	**B**	**B+**	**BB-**	**BB**	**BB+**	**BBB-**	**BBB**	**BBB+**	**A-**
B-	**No**	**98%**	**98%**	**35%**	**20%**	**---**	**---**	**---**	**---**	**---**
	Yes	**98%**	**98%**	**98%**	**35%**	**---**	**---**	**---**	**---**	**---**
B+	**No**	**---**	**---**	**98%**	**98%**	**40%**	**2%**	**---**	**---**	**---**
	Yes	**---**	**---**	**99%**	**98%**	**98%**	**10%**	**---**	**---**	**---**
BB+	**No**	**---**	**---**	**---**	**---**	**---**	**98%**	**12%**	**5%**	**---**
	Yes	**---**	**---**	**---**	**---**	**---**	**98%**	**98%**	**28%**	**6%**

In Table 2, three initial credit rating examples are shown with and without the energy efficiency insurance. The percentages refer to the probability of exceeding a level of credit enhancement. Notice the new revenue stream from the energy efficiency savings alone is sufficient to reduce the credit risk to gain two credit rating improvement in two cases and a single level of improvement for the highest initial credit rating, BB+. The value of the insurance is shown in all three examples by comparing the probability of exceeding the credit rating level as shown in the three circles. For example the B- borrower has only a 35% chance of exceeding the BB- level but with insurance this confidence is improved to 98%.

The value created by insuring a minimum level of savings provides a marginal increase in credit enhancement that is difficult to quantify in general. It is the lender's decision as to how much influence will be given to the effective revenue stream and to the insurance since all models contain assumptions and limitations. The revenue, while very real, is difficult for a lender to value because:

- From a securitization perspective there are no accounting rules as to how to value a stochastic energy efficiency savings distribution,
- Lenders generally do not have the engineering knowledge to assess the financial risk of the proposed energy efficiency revenue stream, and
- Energy price market risk over the loan term can influence the financial results.

Insurance is a financial risk transfer instrument that is well understood from a coverage perspective, but as this paper discusses, there can be additional project value created by reducing the effective credit risk which can be realized as a credit enhancement. The value created from this process is project dependent but the general categories are:

- Lower interest rate for the borrower: A credit enhancement can be translated into a basis point reduction in loan interest. This calculation and judgment is a function of the lender's view of the project. Mills (2003) describes the interest cost savings of energy-savings insurance versus a traditional savings guarantee. Our analysis shows the cost of the insurance is small in comparison to the financial benefit associated with the credit enhancement. Figure 4 shows a case study example, based on data from an energy efficiency project in Connecticut that highlights the lower interest rate for borrower, 4.0% versus 5.5%, due to insurance.

Loan Amount:	$1,992,683		**With Energy Efficiency Insurance: Years 1-5**	
Rate:	5.50%		Annual Insured Energy Efficiency Amt:	$164,489
Term (mo)	240		*(Insured Amt = Annual Debt Service)*	
			5 Year Insured Total:	$822,445
Without Energy Efficiency Insurance				
Monthly Payment	$13,707		Monthly Payment for first 5 years@ 4.0%:	$15,147
	x240		Monthly Payment for remaining 15 years@ 5.5%:	$9,562
Total Term Payout	$3,289,779		Time averaged monthly payment:	$10,958
			Total Term Payout:	*$2,629,922*
			Insurance Value = (Payout w/o ins - Payout w/ins)	***$659,857***

Figure 4. Lower interest payment for borrower because of insurance.

- Lower reserves for the lender: The quantification of the reduction in credit risk as shown in the stochastic model can be applied to reduce loan loss reserves which can enable the lender to make more loans.
- Intangible borrower assistance: It is possible that the insurance can improve a loan to make the loan appear as an investment grade transaction. This fact can help the borrower improve its marketplace perception, for example in the acquisition of capital funding, bond development, and stock performance.

Summary

The Introduction discussed the large potential for the building retrofit industry and that the financial community and building owners have yet to develop a systematic and standardized approach to streamline financing. While the technical and business justifications for these types of projects do exist, there are still roadblocks to large scale implementation. The authors speculate that as energy prices, emissions, and grid reliability become more important issues, retrofit projects will become more prolific. And the need to include insurance as a viable risk management instrument can be an important component of the financing equation – not just for better loan terms but also to possibly make more project capital available. The availability of insurance will increase the number of energy efficiency projects in two ways. First, level the playing field for contractors that are unable to provide a guarantee of energy savings due to constrained balance sheets. This will increase the selection pool for owners and increase competitiveness in the market. Second, as discussed in this paper, reducing credit terms will free up capital and in turn make projects more affordable and increase the likelihood of implementation.

Three methods of how insurance and energy efficiency savings can improve the credit worthiness of building retrofit projects have been discussed. The visual method provides a qualitative description regarding how insurance can reduce the effective principal at risk and how the net credit risk of this transaction is equivalent to the full principal loan credit risk at a higher credit rating. The principal of equivalent credit risk is the basis for credit enhancement. The theoretical approach shows that the limiting credit enhancement possible is the credit rating of the insurer. The method also assumes that project risk and default risk are covered by the insurance company. This is generally not currently the case in that insurers provide project performance protection and not default coverage. Project performance risk is generally the highest risk in retrofit projects in that lenders have good experience and expertise in assessing default risk but little to no experience in assessing performance risk which is exactly the cover that is being added by the insurance discussed here.

The stochastic model uses the basic visual model approach but instead of considering a fixed decrease in the principal at risk, the decrease is a probability distribution corresponding to the annual building efficiency savings distribution computed from a risk analysis of the energy efficiency project. In the stochastic model this distribution is modified to include a minimum level of savings. This patented methodology (Jones and Barats 2012) provides a practical method to assess project specific credit rating enhancement benefits as a function of the credit rating of the borrower and the other loan terms.

References

ACEEE - Energy Efficiency Finance 101: Understanding the Marketplace, Aug 2011, Joel Freehling, http://aceee.org/white-paper/energy-efficiency-finance-101.

ACEEE - *Major Accomplishments: 1980-2012*, http://www.aceee.org/about/accomplishments

CDO (Collaterized Debt Obligations) Evaluator Engine, http://www.standardandpoors.com/products-services/CDO-Evaluator-Engine/en/us.

DECC "The energy efficiency opportunity in the UK" Nov 2012 https://www.gov.uk/government/publications/energy-efficiency-opportunities-in-the-uk.

EIA (Energy Information Administration) Commercial Building Energy Consumption Survey (CBECS) http://www.eia.gov/consumption/commercial/.

Jones, Richard B., G. Barats, "Insurance Product, Rating System and Method," U.S. Patent #8,544,588, Issued June 5, 2012.

Mandel, Benjamin H., D. Morgan, and C. Wei. July 2012. "The Role of Bank Credit Enhancements in Securitization," Federal Reserve Bank of New York, Economic Policy Review.

McKinsey & Company "Unlocking energy efficiency in the US economy" July 2009 http://www.mckinsey.com/client_service/electric_power_and_natural_gas/latest_thinking/unlocking_energy_efficiency_in_the_us_economy.

Mills, Evan. 2003. "Risk Transfer via Energy Savings Insurance." *Energy Policy,*31:273-281. LBNL-48927. http://evanmills.lbl.gov/pubs/pdf/energy_savings_insurance.pdf

Navigant Research "The Market for Energy Efficiency Retrofits in Commercial Buildings will Nearly Double by 2020, Reaching $152 Billion Worldwide" http://www.navigantresearch.com/newsroom/the-market-for-energy-efficiency-retrofits-in-commercial-buildings-will-nearly-double-by-2020-reaching-152-billion-worldwide.

Puccia, Mark, Financial Enhancement Ratings, Global Credit Portal, Standard & Poor's, December 10, 2004.

Rigby, Peter, "Is 2013 the Year Interest Rates start Rising on U.S. and European Bonds?," Ratings Direct®, Standard and Poor's Rating Services, January 18, 2013.

US DOE (United States Department of Energy) 2010 Builders Energy Data Book http://buildingsdatabook.eren.doe.gov/default.aspx.

US DOE (United States Department of Energy) Smart Grid program. www.smartgrid.gov.

World Economic Forum, *A Profitable and Resource Efficient Future: Catalysing Retrofit Finance and Investing in Commercial Real Estate.* Geneva, Switzerland. October 2011, http://www.weforum.org/reports/profitable-and-resource-efficient-future-catalysing-retrofit-finance-and-investing-commercial.

urban green

80x50 BUILDINGS PARTNERSHIP

August 2018

BLUEPRINT FOR EFFICIENCY

We thank the following foundations for their generous support of the 80x50 Buildings Partnership:

THE NEW YORK COMMUNITY TRUST

DORIS DUKE CHARITABLE FOUNDATION

CONTENTS

Buildings over 25,000 square feet account for nearly 60 percent of the city's building area. With the right planning and support, upgrades over the next 10 years will put them on track for 80 percent carbon savings by 2050.

ABOUT THIS REPORT

We know how to dramatically reduce carbon pollution in New York City. We'll need to make major efficiency upgrades to our buildings. We'll eventually need to transition our heating and hot water systems from burning fossil fuels to using electricity. And we'll need to develop a greener electrical grid, with much more solar, wind and other sources of carbon-free electricity.

The stakes couldn't be higher: Sea levels along the coast have risen a foot in the past century. Spring begins a week earlier. Heat waves and superstorms—like Sandy and Irene—are becoming more frequent. And scientists project increasing impacts in the decades ahead, bringing enormous costs, heat waves, blackouts and floods that put vulnerable populations at greater risk.

Fortunately, New York City has made great progress. The green skyscraper was conceived by NYC developers, born on NYC drafting boards, and built with NYC labor. So much innovative policy was born here. New York was the first city to legislate LEED for city-funded construction, and now requires that new city-owned buildings be designed to use 50 percent less energy than used today. The city also recognized the importance of large buildings in solving climate change and developed groundbreaking policies for lighting upgrades, building tune-ups, and data-gathering under the Greener Greater Buildings Plan. Our energy codes continue to break new ground. The result? Even while the city's population has grown, emissions from large buildings have dropped 14 percent since 2010.

But the pace of these efforts must accelerate to achieve the city's goal of reducing greenhouse gas emissions 80 percent by 2050 (80x50). Getting there will require more than what existing regulations and voluntary, market-driven decisions will deliver. We need a bigger down payment on this transformation: a world-leading energy performance policy to drive efficiency in our large buildings.

Collaboration is key for a policy of this scale, with a multi-decade horizon and far-reaching implications for about 50,000 buildings. Mayor de Blasio laid a thoughtful climate planning foundation in *One City Built to Last* (2014) and *New York City's Roadmap to 80x50* (2016). The City Council galvanized action with Local Law 66 of 2014, committing NYC to 80x50. The vision took further shape with a bold efficiency proposal in fall 2017 for NYC's large buildings, carried forward by legislation sponsored by

Environmental Protection Committee Chair Costa Constantinides. And it continues with the 80x50 Buildings Partnership, an unparalleled collaboration of building and energy stakeholders convened by Urban Green.

This report is the result of a consensus-based process involving more than 70 participants from the real estate, labor, energy efficiency, nonprofit and government sectors. The varied knowledge and experience—and, ultimately, the buy-in—of these stakeholders was crucial to creating *Blueprint for Efficiency*.

This plan addresses New York City's large buildings (those over 25,000 square feet), which represent 57 percent of the city's built area. Upgrading these buildings takes time and money, but it also brings great opportunity. With the right financing and schedule, many efficiency improvements are highly cost effective. And this transformation will usher in new jobs, industry expertise and building technology to make New York City a healthier, more sustainable city in the years ahead.

Blueprint for Efficiency provides a workable policy **framework** to reduce emissions by 2030 and keep us on the path to reaching 80x50. It addresses **special cases**, like affordable housing and nonprofits, that will require unique treatment. It explores ways to allow **flexibility** for building owners to find the lowest-cost path to compliance. And it outlines the need for a major expansion of support services and financing to **make efficiency easier**.

The result is an ambitious but achievable plan to deliver 20 percent energy savings in large buildings from 2020 to 2030, with recommendations to guide future phases. Together with reductions made to date, this strategy will take NYC buildings a third of the way to 80x50. Equally important, New York City will have an infrastructure to deliver building energy improvements at scale. Finally, the hard work of the Partnership shows that consensus climate solutions are within reach, paving the way for other cities.

Note: This report contains brief summaries of the proposals. Additional details on each are available at ***urbangreencouncil.org/BlueprintForEfficiency.***

STATEMENT OF SUPPORT

The organizations listed below participated in a collaborative stakeholder process leading to the recommendations in this summary report. These organizations accept the core ideas expressed here, even though some may not agree with the specifics of certain recommendations. For many, consent to certain recommendations is contingent on other recommendations. Whether an organization will ultimately support a new law depends on many issues that will be determined during the legislative process.

32BJ SEIU

AIA New York

ALIGN: The Alliance for a Greater New York

American Council of Engineering Companies of New York

ASHRAE New York

Bright Power, Inc.

Brookfield Properties

Catholic Community Relations Council

CodeGreen Solutions

The Community Preservation Corporation

Council of New York Cooperatives & Condominiums

The Durst Organization

Edison Energy

Empire State Realty Trust

EnergyWatch Inc.

Enterprise Community Partners

Environmental Defense Fund

JLL

Jewish Community Relations Council of New York

Local Union No. 3 I.B.E.W.

Natural Resources Defense Council

New York League of Conservation Voters

New York University

New York Working Families

New York Communities for Change

Partnership for New York City

Real Estate Board of New York

Realty Operations Group

Related Companies

Rent Stabilization Association

Rudin Management Company, Inc.

SL Green Realty Corp.

Steven Winter Associates

Sustainable Energy Partnerships

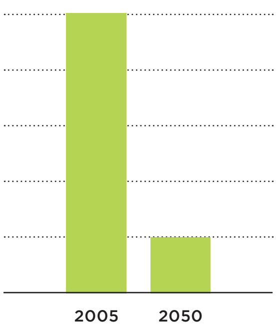
UA Plumbers Local Union No.1

Vornado Realty Trust

What does 80x50 mean for NYC?

Together with other leading world cities, NYC has pledged to cut its greenhouse gas emissions

80%
BY 2050



Two-thirds of citywide carbon emissions come from buildings, so they are central to achieving this goal.

REPORT HIGHLIGHTS

Major Impacts

20%
BUILDING ENERGY REDUCTION BY 2030

Balancing current costs with future uncertainties, these proposals will set large buildings on a realistic path to 80x50.

36%
PROGRESS TO 80x50

NYC buildings will be a third of the way to their 2050 CO_2 goal.

Key Proposal Elements

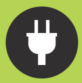
PROPOSAL 2:
Use a made-in-NYC metric to set realistic emissions targets for individual buildings.

PROPOSAL 5:
Focus fixes where needed most by requiring more of less-efficient buildings.

PROPOSAL 10:
Leading by example, city-owned buildings must hit 20% savings five years earlier.

Government Support

PROPOSAL 16:
Make efficiency easier by expanding services for building owners.



PROPOSAL 18:
To help tenants use just what they need, align energy use with energy bills.

50K
BUILDINGS AFFECTED

All buildings over 25,000 square feet will be included.

PROPOSAL 7:
Require less of rent-stabilized housing to limit rent hikes in these buildings.

PROPOSAL 11:
Let owners trade efficiency credits to deliver carbon savings at the lowest cost.

PROPOSAL 13:
Encourage beneficial electrification to reward early adopters of efficient solutions.

PROPOSAL 19:
Shorten the NYC heating season to match warmer spring temperatures.

PROPOSAL 20:
Speed up upgrades by facilitating access to tenant spaces for retrofit work.

PROPOSAL 21:
Lower the burden of façade inspections for buildings with good track records.

What went into creating this report?

42
ORGANIZATIONS
joined together to form the 80x50 Buildings Partnership, a collaboration of key building and energy stakeholders.

70
EXPERTS
contributed time and ideas to these recommendations, lending insight from fields as diverse as real estate, labor, energy efficiency, government and nonprofit.

8
MONTHS
of discussions and over 1,300 meeting hours went into shaping these recommendations.

Steam is used in 80 percent of large multifamily buildings. Many older steam systems are inefficient and offer abundant opportunities for energy savings.

CREATE A SMART FRAMEWORK

Building efficiency policies are becoming the norm. Many cities now have laws directing owners to measure annual energy use. A few, like New York and Los Angeles, mandate building system inventories and tune-ups. The energy code requires better boilers and more insulation when equipment is replaced or a building is renovated. Under NYC's Carbon Challenge, over 100 participants have volunteered to cut building emissions 30 percent over ten years.

But there is no playbook for an efficiency policy of the magnitude proposed here. The right framework must drive cost-effective carbon savings that will ultimately reach the city's 80x50 goal. It needs to align these goals with the practical realities of buildings and their management. It should balance present knowledge with future uncertainty, including changes to technology and the electrical grid. It must be fair to the many owners who have already made efficiency upgrades, while not penalizing buildings for density or other features that cannot or should not be changed. It must work across a great variety of buildings and make sense on a 30-year time horizon.

So, we built a novel policy structure from the ground up.

This chapter outlines the key elements of the policy framework: Start with ambitious but feasible sector-wide energy savings targets, measuring energy from its source in order to deliver the greatest carbon reductions. Develop a new performance metric that gauges the relative efficiency of similar buildings, based on NYC data. Assign building-level reduction targets that get smaller as performance scores increase, so that less-efficient buildings do more. And allow an initial ten-year compliance timeline so upgrades can align with financing, equipment replacement, and tenant turnover.

1

Cut Citywide Building Energy 20 Percent by 2030

ISSUE

Reaching 80x50 means making major reductions in building energy in the coming decades. We must balance the need to act soon with cost, the limits of existing practice and technology, housing affordability, and the uncertainty of more-distant timelines.

RECOMMENDATION

Require large buildings to save 20 percent from 2020 to 2030 in aggregate, with each building sector contributing its proportional share. By 2020, establish default targets for 2040 and 2050 consistent with achieving 80x50, with review and update every 5 years.

2

Use a Made-in-NYC Metric

ISSUE

Buildings use energy differently because of differences in construction, operations and occupancy. To accurately compare buildings, an energy metric must account for these variations.

RECOMMENDATION

Develop a metric based on EPA's Energy Star rating tool that is calibrated with NYC building data and reflects the downstate grid.

3

Measure Energy at its Source

ISSUE

Energy is measured either solely at the building level (site energy) or by also including energy used to generate and transport power to the site (source energy). Site energy is what owners control directly but source energy reflects energy's full environmental impact and is used for benchmarking. Source energy changes as the grid changes, which could mean a shifting metric for owners.

RECOMMENDATION

Use source energy to measure energy consumption. Base the source energy calculation on the local grid composition in 2020 so owners don't face a moving target in 2030. Adjust that calculation for future compliance periods based on the changing grid.

4

Combine All Building Energy in One Requirement

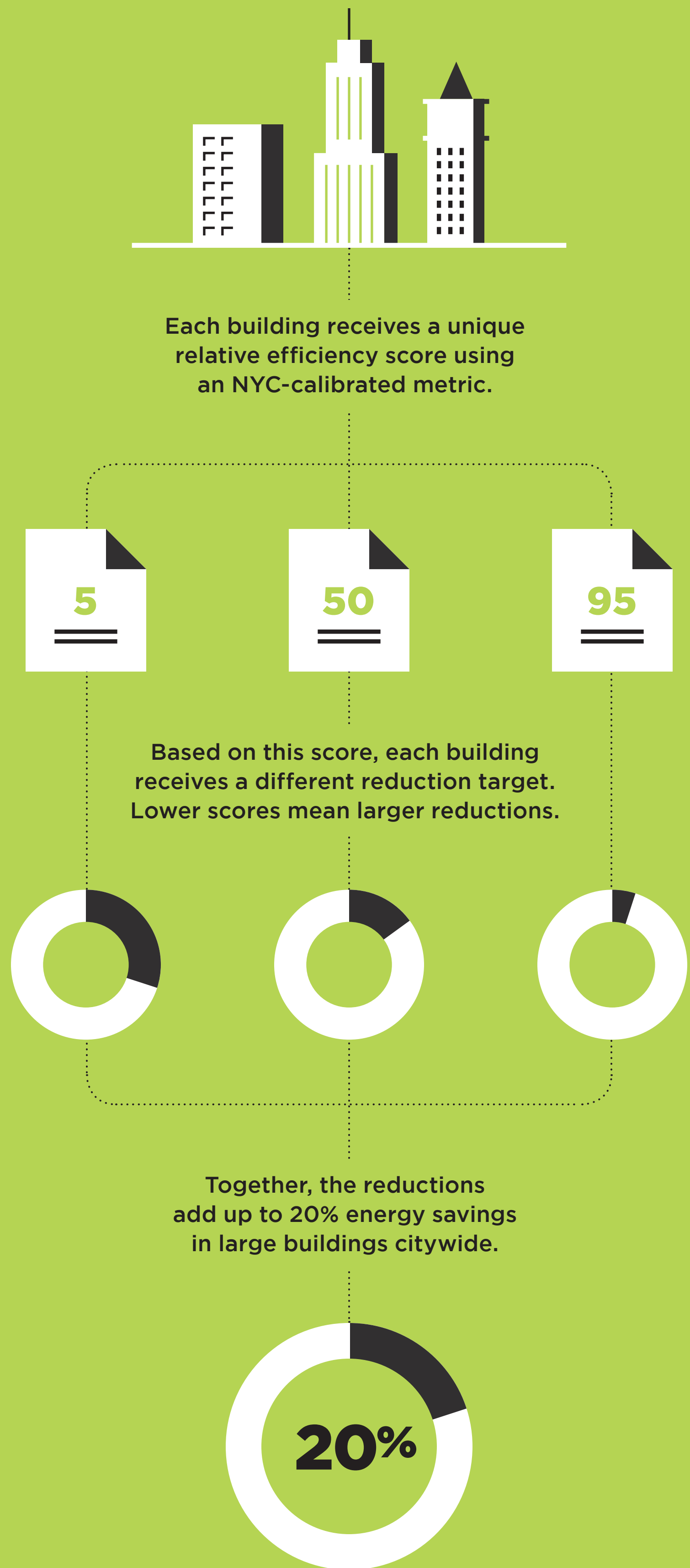
ISSUE

Buildings use many sources of energy, including electricity from the grid and oil and gas burned on site. Separately regulating each source would increase certainty about future emissions but add red tape and reduce flexibility for owners.

RECOMMENDATION

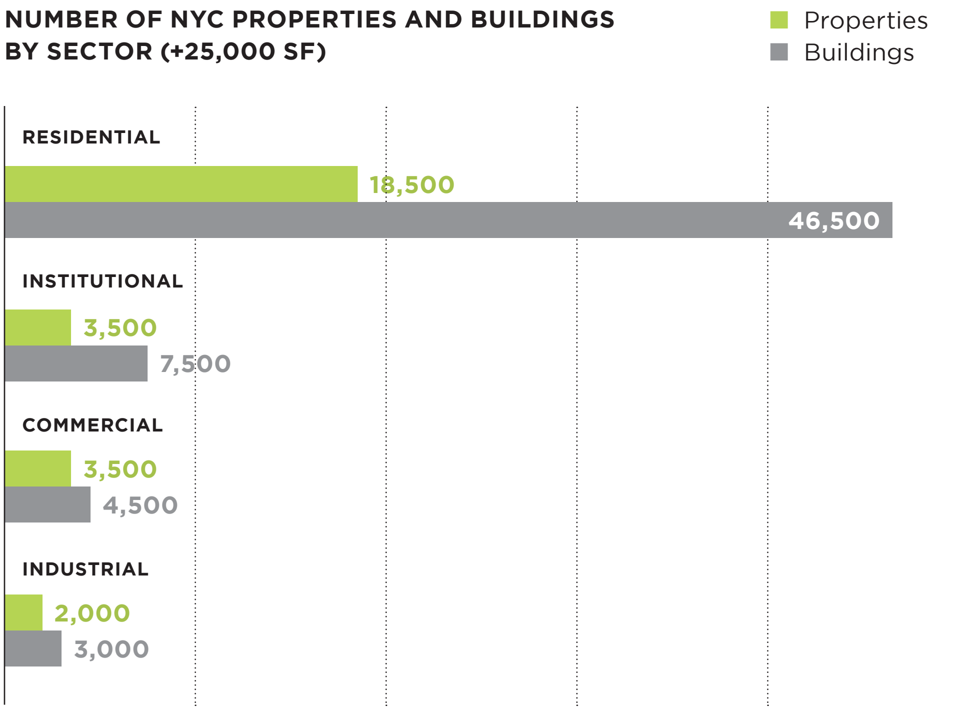
Regulate all energy sources together in a single, whole-building requirement. In the alternative, supplement with a cap on fossil fuels burned by the least-efficient multifamily buildings.

Together, the framework proposals outline a fair and effective approach to setting building energy reduction requirements.



The most efficient buildings, like PS 62, a Net Zero school on Staten Island, would be exempt from compliance in 2030.

NUMBER OF NYC PROPERTIES AND BUILDINGS BY SECTOR (+25,000 SF)



Many NYC properties have more than one building. Some smaller buildings on large properties may not be affected by this policy. Ultimately, the number of buildings covered will depend on legislative definitions.

5
Require Less-Efficient Buildings to Reduce More

ISSUE
Two core reduction strategies were considered for most buildings: cap a building's energy use, or require all buildings to reduce energy by a percentage. A one-cap-fits-all approach doesn't account for how different buildings use energy, while leaving those under the cap untouched. But using the same percentage reduction for all buildings may require too much from top performers and not enough from the least efficient.

RECOMMENDATION
Require most buildings to meet percent reductions that are smaller the more efficient a building is.

6
Avoid a Compliance Pile-up

ISSUE
A distant compliance date could delay upgrades. That means less carbon saved in the interim and a potential rush near 2030 that could overwhelm the workforce.

RECOMMENDATION
Develop a phased timeline to avert a 2030 pile-up. Options include multiple compliance years, an interim capital plan, and incentives for early compliance.

After a recent lighting upgrade, 160 LED bulbs illuminate the sanctuary at Our Lady of Mount Carmel, a Romanesque Revival church in the Bronx.

ADAPT FOR SPECIAL CASES

No two buildings and no two owners are the same. Some sectors face greater challenges than others when implementing efficiency upgrades and will require more support or tailored solutions. Proposals in this chapter focus on identifying these sectors and adapting the framework accordingly.

Perhaps the toughest nut to crack in developing this policy is the rent-stabilized multifamily sector. Housing affordability is a critical issue for NYC. Complicated state rules allow the costs of many major building upgrades to be passed on to tenants through permanent rent increases. Owners need to find a way to pay for upgrades, but efficiency requirements shouldn't drive rent increases on low- and moderate-income tenants. Until state rules are changed, this sizable sector requires a different path, one that spurs action but avoids affordability impacts.

Owners of other affordable housing—and there are many types—often struggle with thin margins and have difficulty accessing financing. So, too, do many nonprofit organizations, like houses of worship and social service organizations, or schools that may have limited staff and no experience with energy management. With a public-interest mission, these sectors warrant a bigger helping hand: dedicated financing, technical support and streamlined access to incentives or subsidies.

On the other hand, city-owned buildings can do more. The city should lead the way by upgrading public buildings sooner rather than later. Doing so will provide a critical place for industry to learn and innovate, encourage the development of a qualified workforce, and drive demand for energy efficiency products and services.

7

Keep Affordable Housing Affordable

ISSUE

The cost of “Major Capital Improvements” (MCIs), like boiler replacements, can often be passed on to tenants in rent-stabilized apartments, who may not be able to afford the resulting permanent rent increases. Nonetheless, owners need a way to pay for efficiency improvements. The rent-stabilized sector accounts for about 40 percent of large multifamily building space, so it’s essential to get it right.

RECOMMENDATION

Require low-cost, energy-saving measures that don’t qualify as MCIs for the rent-stabilized sector, instead of the percent reductions applicable to other sectors. Require adjustments to this approach if MCI rules or their interpretations change. And provide support and incentives so that the rent-stabilized sector can achieve the same efficiency gains as market-rate buildings.

How are MCIs approved?

Owners apply to New York State to raise rents based on the costs of MCIs. To qualify, an improvement must be building-wide, benefit all tenants, and typically replace an item past its "useful life."

8

Lend a Bigger Hand Where It’s Most Needed (Part 1)

ISSUE

Affordable housing owners often face thin margins, financing challenges, and a backlog of upgrades to implement. Without help, they may struggle to achieve required energy savings.

RECOMMENDATION

Help affordable housing owners by expanding support programs, improving access to financing, and coordinating with NY State programs to achieve energy savings on par with market-rate buildings.

9

Lend a Bigger Hand Where It’s Most Needed (Part 2)

ISSUE

Efficiency upgrades may be challenging for many nonprofit organizations. They often have constrained finances, limited staff, difficulty accessing available resources, and minimal experience with energy management.

RECOMMENDATION

Provide dedicated financing and technical support for nonprofits and religious organizations, including streamlining access to incentives.

10

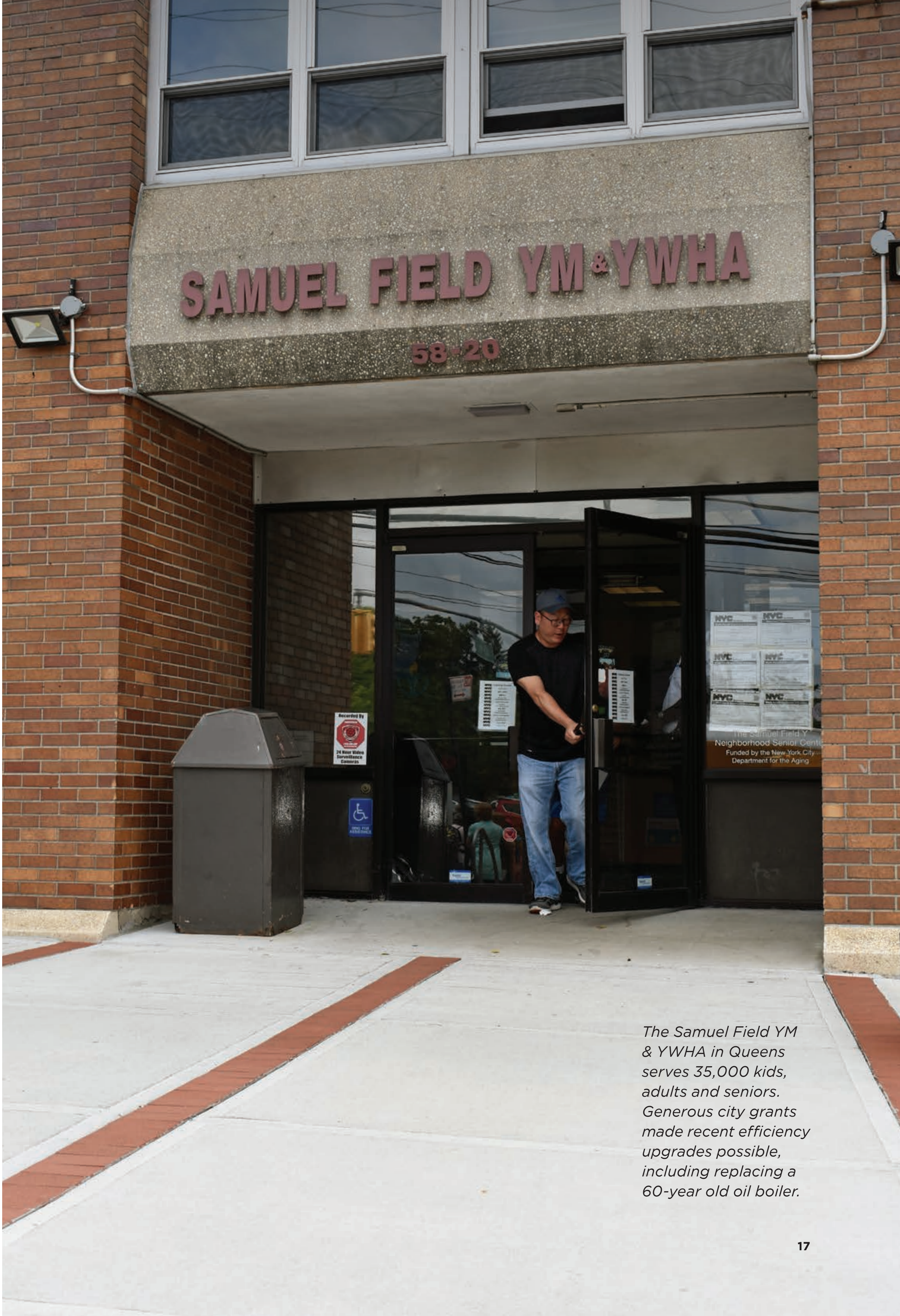
Lead the Way with City Buildings

ISSUE

Scaling retrofits in NYC requires a proving ground so designers and contractors can experiment, shedding light on costs, risks, and solutions. City buildings have long paved the way for green building innovations.

RECOMMENDATION

Require city-owned buildings over 10,000 square feet to reduce energy consumption 20 percent by 2025 (twice as fast as private sector buildings) and reduce fossil fuel consumption. Publish case studies with lessons learned on deep retrofits and new technology pilots.



The Samuel Field YM & YWHA in Queens serves 35,000 kids, adults and seniors. Generous city grants made recent efficiency upgrades possible, including replacing a 60-year old oil boiler.

Building management systems can help maximize efficiency. At One Battery Park Plaza, ventilation and cooling automatically adjust to the number of occupants, avoiding energy waste.

ALLOW FLEXIBILITY

The ideal building retrofit policy will deliver the largest carbon savings at the lowest cost. That doesn't just make sense for building owners. It also makes sense for everyone who lives and works in New York City, as we will ultimately benefit when energy efficiency is reflected in real estate prices. Proposals in this chapter explore ways to allow—and place reasonable limits on—flexibility in compliance to achieve that end, including adjustments that advance long-term carbon goals.

The cost of efficiency upgrades varies across sectors, building types and owners. And efficiency work is most cost-effective when aligned with equipment life, tenant turnover and normal financing cycles. Allowing owners to trade efficiency credits and purchase green power to achieve some portion of compliance would introduce flexibility, including some breathing room if retrofits underdeliver. But both options need more analysis and planning to advance.

From a policy perspective, two long-term 80x50 goals require some flexibility.

First, how can we encourage early adopters to replace fossil-fuel based heating and hot water systems with highly efficient electric systems? Doing so will help the market learn what works over the next decade and be ready to scale beyond 2030.

Second, what's the right balance to strike on credit for efficiency achieved through new, gas-fired cogeneration plants? Placing a limit will ensure that this policy drives the on-site efficiency improvements that are critical to reaching 80x50.

11
Let Owners Trade Efficiency

ISSUE
Every building has a different cost for energy savings. Allowing buildings to bundle together or trade efficiency “credits” would give owners flexibility and reduce the cost of cutting carbon.

RECOMMENDATION
Develop an optional efficiency trading program, enabling owners to reach their energy reduction targets by buying energy savings from upgrades in other buildings. Consider providing greater credit for efficiency improvements in the nonprofit and affordable housing sectors.

Tokyo Cap-and-Trade

In 2010, Tokyo became the first city in the world to use a cap-and-trade program to reduce CO_2 emissions. The program covers about 1,300 large buildings and has driven more than 25 percent emissions savings to date. Lessons learned in Tokyo should inform a New York efficiency trading program, including the importance of strict third-party verification and strategies for addressing high credit prices.

12
Include Flexibility to Buy Green Power

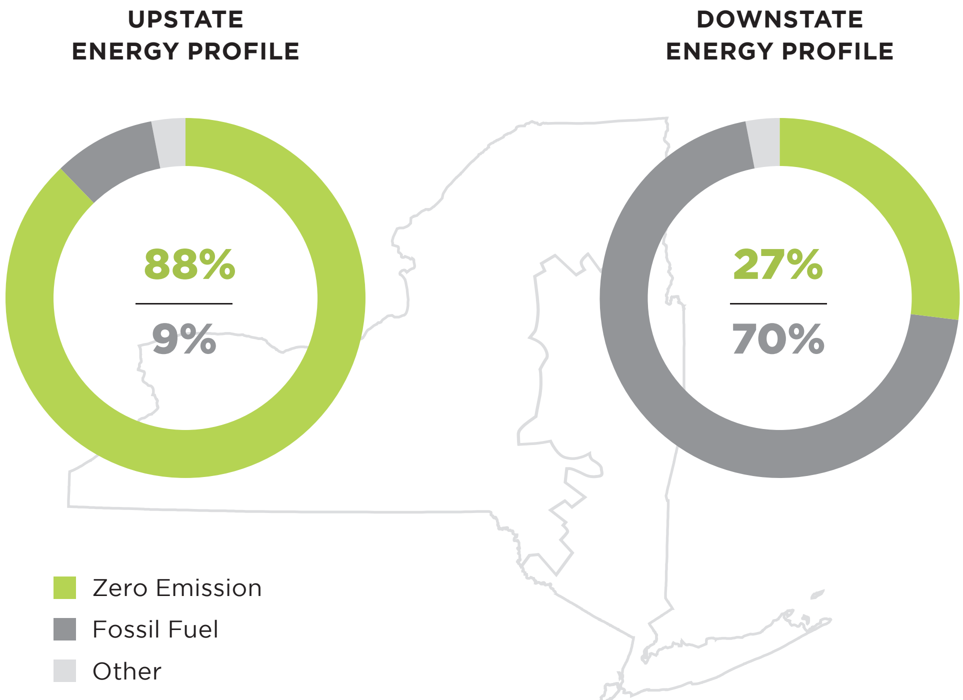
ISSUE
Financing cycles, equipment life and tenant turnover may make 2030 compliance especially challenging for some buildings. Allowing owners to defer some energy savings by buying green electricity would provide helpful flexibility. But not all green power is created equal. If used, it must not undercut efficiency as the top priority.

RECOMMENDATION
Allow owners to buy new, additional green power to defer a small portion of their required energy savings. Limit the option in quantity and duration, and prioritize New York green power.

13
Encourage Beneficial Electrification

ISSUE
To achieve 80x50, buildings must reduce their fossil fuel consumption and eventually begin using electricity for heating and hot water. Electric heat pumps are a likely solution. High electricity prices make them more expensive to operate now, but early adopters can help pave the way for taking them to scale.

RECOMMENDATION
Encourage heat pump pilots and installations by reducing the energy savings requirement for buildings that convert to high-efficiency electric heat or hot water systems.



Although New York state generates a lot of carbon-free electricity, constraints in transmission limit how much clean energy makes it to New York City.

14
Cap the Efficiency Credited to New Cogeneration

ISSUE

Cogen plants generate electricity from natural gas and then use exhaust heat that is normally wasted. It's a carbon benefit whenever the downstate grid is "dirty." Once the grid is clean, burning gas on site will mean more emissions than electricity from the grid. Investment in new cogen should be valued now, but not at the expense of building efficiency.

RECOMMENDATION

Limit the amount of new cogen that counts toward reduction requirements. Develop rules that require metering for new cogen and a transparent calculation for the efficiency credit. If a fossil fuel cap is included, exempt gas burned in cogen plants in the near term. But end that exemption once gas no longer dominates the downstate grid.

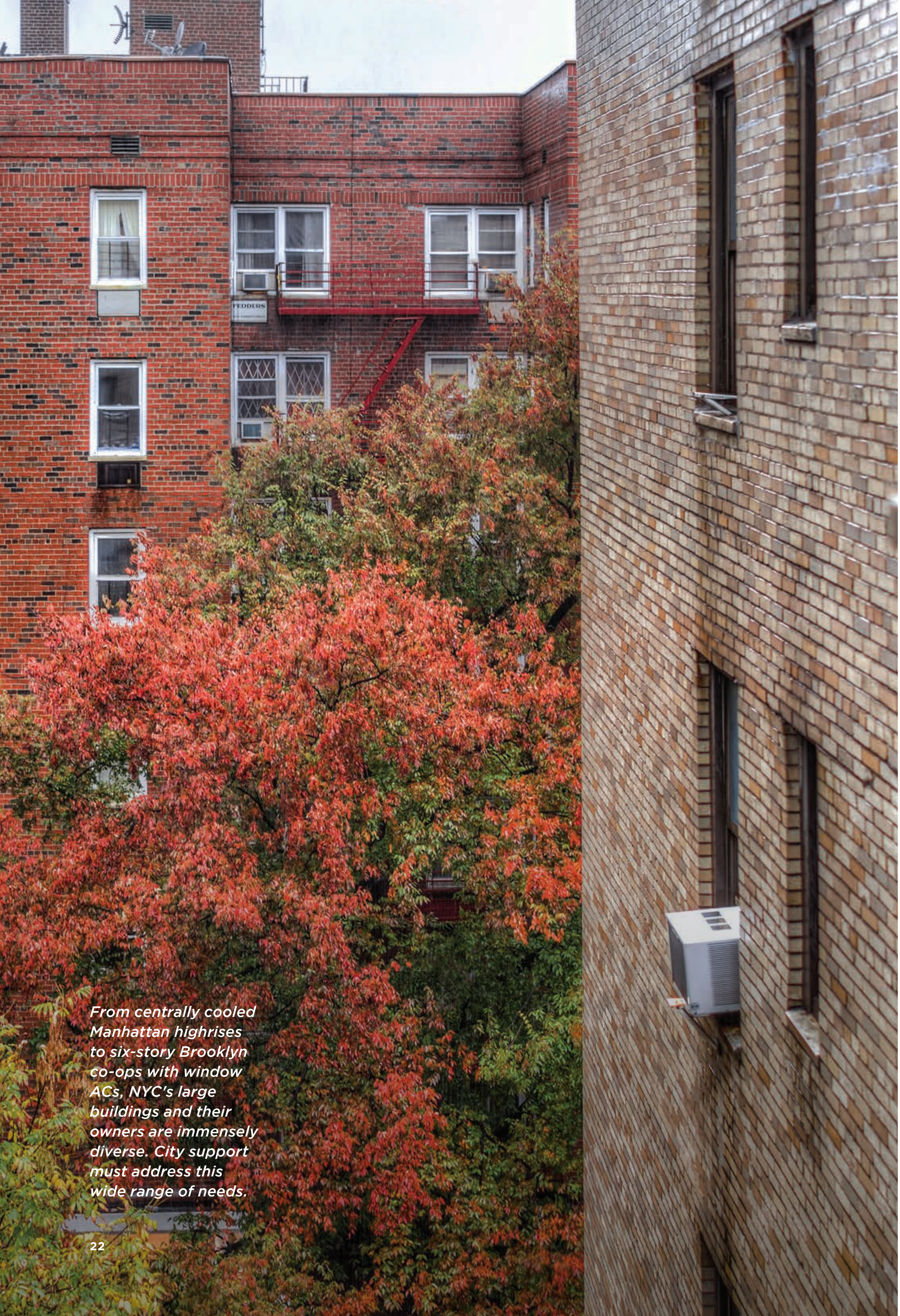
15
Reward Peak Demand Savings

ISSUE

The electrical grid is sized to meet a very small number of hours of maximum demand each year. A kilowatt-hour saved at 3AM in winter is worth much less for reducing carbon and air pollution than a kilowatt-hour saved at the peak of a hot summer day, when the least efficient power plants are firing.

RECOMMENDATION

Evaluate options to account for the carbon benefits of peak demand savings without undercutting permanent energy reductions.



From centrally cooled Manhattan highrises to six-story Brooklyn co-ops with window ACs, NYC's large buildings and their owners are immensely diverse. City support must address this wide range of needs.

MAKE EFFICIENCY EASIER

Construction in New York City is no cakewalk. It's more expensive to build here than anywhere else: 50 percent above the national average and 20 percent higher than major cities like Chicago, Los Angeles and Boston. In New York City, a typical project may require approvals from half a dozen city agencies, all important but adding time and cost.

Urban density places limits on noise and working schedules and makes it hard to deliver and store materials. And the high cost of living and a tight market for skilled labor translate to higher soft costs.

Given these high costs, building owners need support to comply with this plan. Many buildings—like most co-ops and condos—have minimal experience integrating efficiency upgrades into capital planning. They will need help doing so.

About 50,000 buildings are covered under the policy. Currently, big retrofit consulting firms might complete 50 large-building retrofits annually, while the city's Retrofit Accelerator targets 1,500 "projects" over three years (whether stairway lighting upgrades or full retrofits). We will require a support infrastructure more than ten times larger than what exists now.

Proposals in this chapter focus on providing owners with the technical and financial resources to make implementation easier. We need a huge expansion of programs to help owners with upgrades, prioritizing assistance to those with fewer resources and less technical ability. We also need to streamline existing financing options, better integrate efficiency in conventional lending, and enact new funding streams like commercial PACE. Some proposals also focus on lightening the regulatory burden for owners. As we add expenses through a major new policy, it makes sense to look for feasible ways to reduce costs elsewhere.

16
Make Efficiency Easier through Expanded Services

ISSUE
The proposed policy would impact about 50,000 buildings. Yet, most building owners are not proficient in energy efficiency or accessing financing for retrofits. Owners will require a lot of help for the policy to be successful, including engaging tenants whose energy use drives the energy profile of many buildings.

RECOMMENDATION
Dramatically expand the scope and capacity of the city's Retrofit Accelerator or other entities and approaches to support owners undertaking retrofits. Prioritize assistance to owners with fewer resources and less technical ability, including smaller buildings and nonprofits. Assist owners with strategies to reduce tenant energy use. Align with state and utility efficiency initiatives to maximize impact.

17
Bolster Financing Initiatives

ISSUE
Many buildings will require specialized financing to undertake energy retrofits, including on schedules that don't align with mortgage refinancing. And straightforward efficiency financing is not yet readily available through the traditional lending process.

RECOMMENDATION
Align and streamline existing financing resources. Simultaneously, enact C-PACE financing legislation, opening a new funding stream at attractive terms and rates. Encourage support for efficiency in conventional underwriting, while advancing other financing options to support retrofits.

18
Align Energy Use with Energy Bills

ISSUE
People tend to waste things that are free. When electricity is included in rent, apartment dwellers use about 20 percent more than when the tenant foots the bill. And metering and billing for water has saved 35 percent in some buildings. While more direct billing is possible now, regulatory hurdles mean it's cumbersome. Any change must be equitable for tenants in affordable housing.

RECOMMENDATION
Convene a task force with NY State to implement electric and cold water submetering and simplify regulatory requirements. When metering occurs in rent-stabilized units, ensure it is cost-neutral for tenants through rent reductions. Experiment with heat submetering, and later assess the potential to mandate.

19
Shorten the NYC Heating Season

ISSUE
NYC classifies October 1 to May 31 as the "heating season," when owners must maintain certain indoor temperatures. This means heating systems can only be upgraded or repaired during four months of the year. Over the last 20 years, the temperature has stayed above 50 degrees for 70 percent of days in May.

RECOMMENDATION
Reduce the heating season by four weeks, shifting it to October 1 to April 30.

20
Facilitate Access for Retrofits

ISSUE
Many efficiency improvements require work within tenant apartments, like upgrading radiators or insulating exposed pipes. Owners need predictability, while building service workers need clear access guidelines. Skipping work in just a few apartments can have an outsized impact on the cost, timeline and energy savings of a retrofit. But any changes must continue to protect tenant rights.

RECOMMENDATION
Explore the feasibility of facilitating access to tenant spaces for legitimate efficiency upgrades, while balancing the need to protect tenants. Options include developing a form letter from the city and guidelines for service workers to clarify the rules for access.

21
Lower the Burden of Façade Inspections

ISSUE
Since 1980, the façades of buildings affected by Local Law 11 have been thoroughly inspected eight times. Regulations and industry customs make these inspections the single largest expense for many buildings.

RECOMMENDATION
Require less-frequent inspections for buildings with clear track records. Reduce other cost factors by creating a role for drones or cameras, allowing reports to be filed despite open permits and clarifying rules for site-safety inspectors.

The Partnership held over 85 meetings and will continue to convene during the legislative process to advance our recommendations.

ABOUT THE 80x50 BUILDINGS PARTNERSHIP

The 80x50 Buildings Partnership is a collaboration between NYC's leading building and energy stakeholders to develop smart climate change policies. First convened by Urban Green Council in November 2017, the Partnership included more than 70 individuals from over 40 organizations representing the real estate, labor, energy efficiency, nonprofit and government sectors.

This report is the Buildings Partnership's inaugural project. In developing our recommendations, we followed the successful approaches of Urban Green's prior major convenings, the Green Codes Task Force (2008-2010) and Building Resiliency Task Force (2013).

Buildings Partnership participants were organized into five Working Groups, each led by a chair or co-chairs and focused on a different aspect of the policy: Framework, Requirements, Affordable Housing, Alternate Compliance, and Red Tape & Optimization. The Working Groups identified key issues and questions. Subgroups then analyzed and developed answers and potential solutions, collaborating on detailed proposals. The full Buildings Partnership reconvened throughout to review and comment on high-priority issues and finalize the ultimate recommendations.

Over the course of eight months, we held 85 meetings, with participants donating 1,300 pro bono hours of meeting time—and that doesn't include tremendous additional volunteer time spent drafting and reviewing detailed proposals. The substantial time and effort contributed by partnership members, all experts in their fields, was essential to the outcome. Urban Green is grateful for the knowledge, experience and dedication of all those who made this report possible.

The work of the Buildings Partnership will continue. Details of many proposals must be worked out during the legislative process, and we will continue to convene and help shape the final policy. Then there will be rulemaking. Beyond the legislation, we will work to ensure the development of the support services that will be essential for successful implementation.

In addition, entirely new 80x50 policy challenges await, such as addressing energy use in buildings under 25,000 square feet. Stakeholder input is critical to a successful policy, and the 80x50 Buildings Partnership will continue to drive consensus solutions to NYC's energy and climate challenges.

CONTRIBUTORS

Working Group Chairs

Russell Unger, *Chair*
Urban Green Council

Christopher Halfnight, *Vice Chair*
Urban Green Council

Chris Cayten
CodeGreen Solutions

David Downs
Enterprise Community Partners

Dan Egan
Vornado Realty Trust

Saverio Grosso
Edison Energy

Arthur Klock
UA Plumbers Union Local No.1

Charlotte Matthews
Sidewalk Labs

Jared Rodriguez
Realty Operations Group

Dana Schneider
JLL

Contributors

Barry Abramson
Servidyne

Andy Anderson
EnergyWatch Inc.

Gene Boniberger
Rudin Management Company, Inc.

Jonathan Braman
Bright Power, Inc.

Chris Coll
New York State Energy Research and Development Authority

Elias Dagher
American Council of Engineering Companies of New York

Elizabeth Kelly
Community Preservation Corporation

Emily Dean
New York State Energy Research and Development Authority

Donna DeCostanzo
Natural Resources Defense Council

Lisa DeVito
Consolidated Edison Co. of NY Inc.

Stephan Edel
New York Working Families

Evin Epstein
SL Green Realty Corp.

Adriana Espinoza
New York League of Conservation Voters

Jonathan Flaherty
Tishman Speyer

Nicholas Giannasca
Davis Wright Tremaine LLP

Greg Hale
New York State Energy Research and Development Authority

Adam Hinge
Sustainable Energy Partnerships

Jason Hochman
Consolidated Edison Co. of NY Inc.

Carl Hum
Real Estate Board of New York

Brook Jackson
Partnership for New York City

Ilana Judah
AIA New York

Laurie Kerr
LK Policy Lab

Richard Leigh
Pratt Institute

Michael Lipitz
Vornado Realty Trust

Charlie Marino
AKF Group
ASHRAE New York

David Pollock
Jewish Community Relations Council of New York

Marc Rauch
Environmental Defense Fund

Frank Ricci
Rent Stabilization Association

Lindsay Robbins
National Resources Defense Council

Adam Roberts
AIA New York

Joseph Rosenberg
Catholic Community Relations Council

Mary Ann Rothman
Council of New York Cooperatives & Condominiums

Stephan Roundtree
WE ACT for Environmental Justice

Cecil Scheib
New York University

Pete Sikora
New York Communities for Change

Maritza Silva-Farrell
ALIGN: The Alliance for a Greater New York

Isabelle Silverman
Environmental Defense Fund

Phil Skalaski
The Durst Organization

Brett Thomason
ALIGN: The Alliance for a Greater New York

Adrian Tuluca
Vidaris, Inc.

Marianna Vaidman Stone
Gehl Institute

Samantha Wilt
Natural Resources Defense Council

Michael Yee
Local Union 3 I.B.E.W.

Alvis Yuen
SL Green Realty Corp.

Marc Zuluaga
Steven Winter Associates

Urban Green Council Staff

Russell Unger
Executive Director

Christopher Halfnight
Manager, Policy

Nicole Pavia
Buildings Partnership Fellow

Christina Anjesky
Managing Director

Sheena Thiruselvan
Manager, Communications

Sean Brennan
Associate Director, Research

Anna Weingord
Coordinator, Research

Chloe Woodruff
Associate, Communications

Marcel Howard
Policy Intern

NOTES & CREDITS

Notes

Report Highlights

Analysis of CO_2 impact based on NYC energy benchmarking data and Property Land Use Tax Lot Output (PLUTO) data, using Energy Star scores in place of an NYC-calibrated metric. Baseline electric grid fuel mix adapted from New York City's Roadmap to 80x50 with accelerated closure of Indian Point Energy Center.

Analysis of number of buildings affected based on NYC's 2017 Primary Land Use Tax Lot Output (PLUTO) dataset and calculated using the definition of "covered building" from the NYC Benchmarking Law. Analysis excludes buildings likely to be under 25,000 square feet on large properties.

Create a Smart Framework

Analysis of number of NYC properties and buildings based on NYC's 2017 Primary Land Use Tax Lot Output (PLUTO) dataset.

Allow Flexibility

Upstate energy profile and downstate energy profile based on the New York Independent System Operator (NYISO) *2018 Power Trends*.

Photography & Design

8: Claire Taylor Hansen

12: ©James Ewing/OTTO

14: Gerri Hernández

17: Jared Mintz

18: Bessie Weisman

26: Matt Bookhout

Graphic Design: Rebecca Hume

Urban Green Council
55 Broad Street
9th Floor
New York, NY 10004

urbangreencouncil.org

Unlock energy savings and convert them into "bankable" income-producing assets.

E-CAPITAL
DEVELOPMENT

Marshall Haimson, President
323 Merrick Avenue, North Merrick, NY 11566
Tel: 516-445-2200 marshall@e-capitaldevelopment.com

Energy-Efficiency Projects Are Solid Investments with Desirable Characteristics

- **ROI's are high:** 10% to 30% (or more);
- **Payback Periods** are relatively short;
- **Payout Periods** are relatively long;
- **Yields:** Predictable, **Measureable**, **Verifiable**;
- **Cash flows:** Can be **Guaranteed, Insured**
- **Credit Enhancement:** The retrofit itself makes it easier to pay for the project, while also raising the value of the underlying Real Estate asset;

SIZE MATTERS: The largest impact is often from higher-cost ECM's with longer useful life-cycles and paybacks.

Recommended ECM's	Useful Life (yrs)	ECM Cost	Annual Savings*	Simple Payback (yrs)	Life Cycle Savings	Savings / Cost Ratio
Lighting	7.0	$ 80,000	$ 77,500	1.0	$ 542,500	6.78
BMS (Controls)	12.0	$ 125,000	$ 85,000	1.5	$ 1,020,000	8.16
HVAC System	25.0	$ 300,000	$ 78,000	3.8	$ 1,950,000	6.50
Insulation	20.0	$ 95,000	$ 9,500	10.0	$ 190,000	2.00
Boiler / Heating	30.0	$ 400,000	$ 75,000	5.3	$ 2,250,000	5.63
TOTAL "BUNDLE" OF ECM'S:		*$ 1,000,000*	*$ 325,000*	*3.1*	*$ 5,952,500*	*5.95*

Non-Cash Benefits from Retrofits

- Upgrading to the newer technologies
- Increased efficiencies in daily operations
- No disruptions from system breakdowns
- Better working / tenant conditions
- Attracting better tenants / higher rents
- Higher NOI's mean higher RE values

Motivating CEO's & CFO's to do what's best for both themselves and the environment

Sticks and Carrots…

NYC’s “Greener, Greater Buildings Plan” (2009)

Local Law 84 – Benchmarking: Requires owners of large buildings (i.e. over 25,000 gross ft.^{2}) to annually measure their energy / water consumption and submit these data to the City.

Local Law 85 - NYC Energy Conservation Code (NYCECC): Requires buildings to meet the most current energy codes for any renovation or alteration project (incl. 2010 Energy Conservation Construction Code of New York State (ECCCNYS), Local Law 85 of 2009, Local Law 48 of 2010 and Local Law 1 of 2011.

Local Law 87: Energy Audits & Retro-Commissioning: Mandates that all large buildings to undergo periodic energy audits, to perform retro-commissioning measures and to submit these data to the City.

Local Law 88 - Lighting Upgrades & Sub-Metering: Requires all large buildings to upgrade their lighting in compliance with NYCECC; to install electrical sub-meters for each non-residential tenant space over 5,000 gross ft.^{2} ; and provide monthly energy statements. The compliance deadline for both the lighting and sub-metering requirements is 2025.

NYC's "Climate Mobilization Act" (2019)

Local Laws 92 & 94 – Green Roofs & Solar PV: Requiring green roofs solar PV systems on certain new construction and renovation projects.

Local Law 95 – Building Labeling: Adjusting metrics used for letter grades assessing building energy performance.

Local Law 96 – PACE: Establishing clean energy financing tools for building owners (more on this below).

Local Law 97 – Emissions Limitations: First-of-its-kind legislation placing emissions limits on NYC's large buildings, both commercial and residential.

Local Law 98 – Wind Energy: Obliging the Department of Buildings to include wind energy generation in its toolbox of renewable energy technologies.

NYC's Local Law 97 – Emissions Limitations

Emissions reduction targets represent a **40% carbon reduction by 2030** and an **80% carbon reduction by 2050** relative to 2005 levels. Limits are assigned according to building occupancy type, with accommodations made for energy-intensive facilities involved in healthcare. Emissions limits for both the first and second compliance periods may be adjusted through the **rulemaking process**. Limits become much more stringent during the second compliance period.

ANNUAL BUILDING EMISSIONS LIMIT 2024-2029		Carbon Limit (KgCO2e/sf)*	
Occupancy Group(s)	Space Use	2024-2029	2030-2034
B- Ambulatory Health	Medical Office, Labs	23.81	11.93
M - Mercantile	Retail	11.81	4.03
I-1 - Facilities	Care & Rehab facilities	11.38	5.98
A - Assembly	Assembly	10.74	4.2
R-1 - Hotel	Hotel	9.87	5.26
B - Business	Office	8.46	4.53
E - Educational & I4 - Custodial Care	School, Daycare	7.58	3.44
R-2 - Residential	Multi family housing	6.75	4.07
F - Factory	Factory	5.74	1.67
S - Storage & U - Utility	Storage/Warehouse	4.26	1.10

*converted from metric tons to kilograms for easier reading

NYC's Local Law 97 – Penalties for Non-Compliance

- Failure to submit an annual report (by a "qualified energy professional") for a covered building will result in a penalty of $.50 per square foot for each month the violation is not corrected.
- False reporting will result in a penalty of $500,000 per violation.
- If your building emissions per square foot in a particular year are higher than the allowable limit set forth in the law, you are subject to a penalty of $268 per square foot multiplied by the difference between the emissions limit and your reported emissions.

For example, a 1,000,000 square foot commercial office building (group B), has an emissions limit of .00846 tCO_2e/sf/yr in 2024. If the actual reported emissions is .009729 (15% higher), then the annual penalty is $340,092.

NYC's "Climate Mobilization Act" (2019)

<u>Queens Chamber of Commerce panel on 'Climate Mobilization Act' (7/31/19):</u>

"If you're a building owner here today, and you're worried about fines, I don't want your money. I want your carbon," Councilmember Costa Constantinides told the audience.

Constantinides, who led the charge on the set of climate bills, has made climate change one of his signature issues, and is chair of the Council's Environmental Protection Committee.

NYC's "Climate Mobilization Act" (2019)

These laws are so ambitious, they're sparking an "Energy Gold Rush" and exposing clients to lots of new risks.

Legal and risk management professionals will play a key role in implementing these new laws effectively and safely.

Mitigating Risks and Maximizing Returns

<u>Clients and advisors must focus on</u>:

- **Upgrading Equipment** (paid for through savings)
- **Solid Projects** (hard numbers - not "Gut Feel Factor")
- **Large Life-Cycle Savings** (vs. Simple Payback)
- **Investment Returns** (not just the incentives)
- **Guarantees / Insurance** (protecting the cash flows)
- **Strong Teams** (Professionals, Contractors, Financiers)

ENERGY PROJECT PERFORMANCE INSURANCE

"This is Physics, not Metaphysics"

ASTM INTERNATIONAL

<u>BENCHMARKING / ASSESSMENTS</u>:
ASTM is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services.

ASHRAE

<u>METHODS FOR AUDITING / SAVINGS CALCULATIONS</u>:
A.S.H.R.E.A. (American Society of Heating, Refrigeration and Air-Conditioning Engineers)

EVO®
EFFICIENCY VALUATION ORGANIZATION

<u>PERFORMANCE MEASUREMENT & VERIFICATION</u>:
International Performance Measurement and Verification Protocol ("IPMVP")

"An Insurable Project is an Investable Project"

- ✓ **Insurer validates project's economics and engineering**
- ✓ **Large balance sheet to backstop savings guarantees**
- ✓ **Performance shortfalls resolved as insurance claims**
- ✓ **Economic analysis becomes a "Line-Item" Decision**

Potential Project **Insured Project** **Implemented Project**

SOLAR SHORTFALL INSURANCE

Securing a Solar Future for 930 Families

Georgetown Mews Co-op (Flushing, NY) - 1.55 MW
Backstopped by 5-Year Solar Shortfall Policy

SOL ALLIANCE

Energy Services Agreements (ESA's)
Portfolio of Small- to Mid-Sized Business

- **Install new Energy Management System, lighting, HVAC.**
- **Systems are connected to the internet and remotely accessible.**
- **Includes an operating system that learns from its environment.**
- **Used to maximize systems' performance, efficiency, productivity.**
- **ECM installations are paid for by rebates and future savings.**
- **JouleSmart owns the ECM's until fully repaid.**
- **No out-of-pocket for owners.**
- **Future savings are guaranteed and insured.**

JouleSmart℠

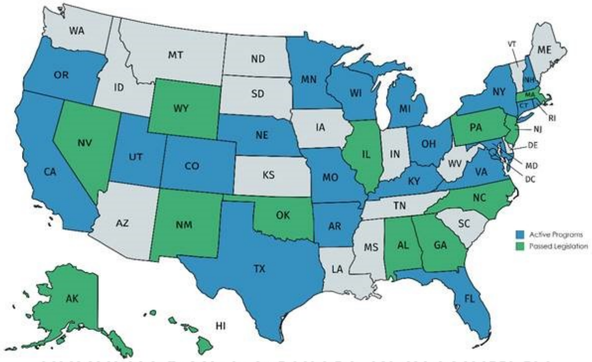
Local Law 96: P.A.C.E. (Property-Assessed Clean Energy)

City or county creates type of land-secured financing district or similar legal mechanism

Property owners voluntarily sign-up for financing and make energy improvements

Proceeds from revenue bond or other financing provided to property owner to pay for energy project

Property owner pays assessment through property tax bill (up to 20 years)



Resources

- https://www1.nyc.gov/site/buildings/codes/local-laws.page
- https://be-exchange.org/insight/the-climate-mobilization-act-int-1253/
- https://dsllp.com/content/pdfs/Climate_Mobilization_Act_White_Paper.pdf
- https://queenseagle.com/all/queens-chamber-of-commerce-hosts-panel-on-climate-mobilization-act
- https://www.tandfonline.com/doi/abs/10.1080/10406026.2017.1415074?scroll=top&needAccess=true&journalCode=becj20
- https://www.pacenation.org/wp-content/uploads/2018/04/CMBS-Article.pdf

E-CAPITAL
DEVELOPMENT

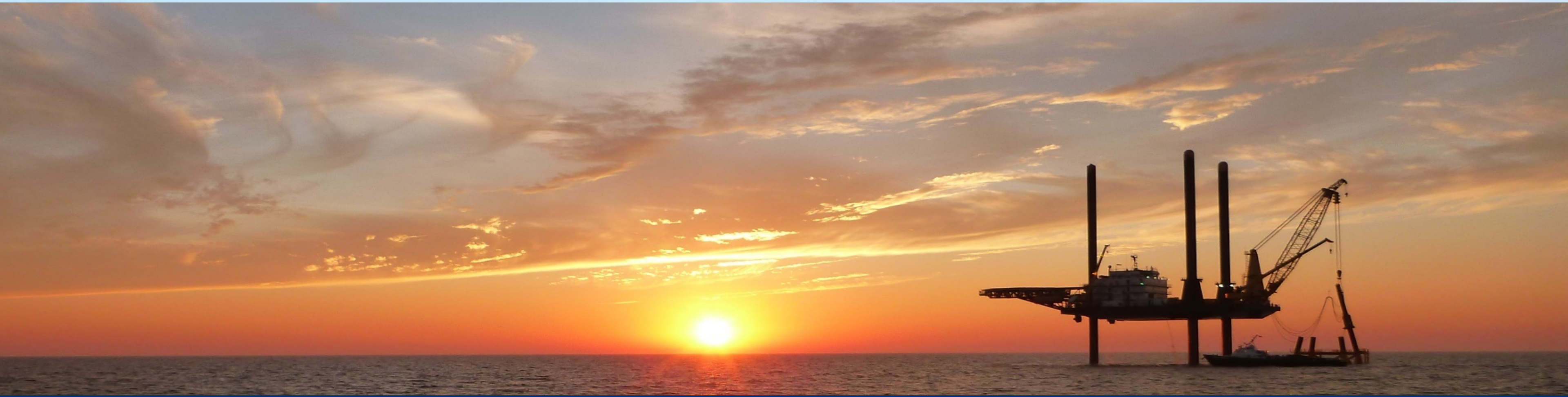
marshall@e-capitaldevelopment.com

Tetra Tech Offshore Wind Project Support

New York State Bar Association

Environmental and Energy Law Section Fall Meeting

September 23, 2019



offshorewind@tetratech.com

U.S. OFFSHORE WIND POTENTIAL
25,824 MEGAWATTS (MW)

- 30 MW of installed capacity
- 2,043 MW of capacity with site control and offtake pathways
- 19,151 MW of potential capacity (developers have exclusive site control)
- 2,250 MW of potential capacity in unleased wind energy areas (North Carolina)
- 2,350 MW of potential capacity in unsolicited project applications (Pacific region)

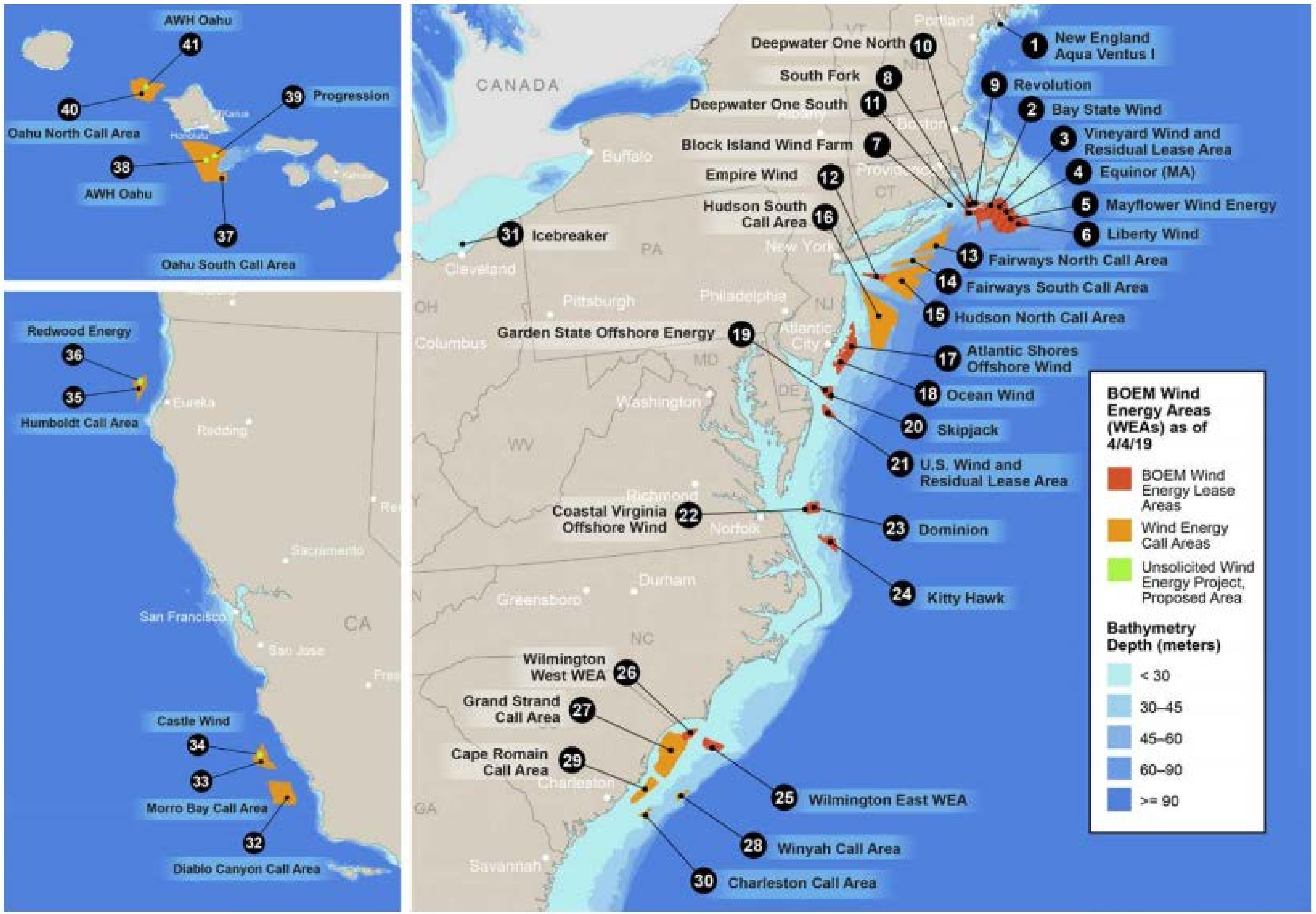
Federal Activities

- DOE released "Offshore Wind Technologies Market Report"
- Increased competition at auctions for new renewable energy lease areas. Three lease areas in Massachusetts were each sold for $135 million, more than tripling the previous highest winning bid.
- Department of Interior's Bureau of Ocean Energy Management (BOEM) considering establishment of an Intergovernmental Task Force for New Hampshire.
- BOEM is examining new "Call Areas" for offshore wind development.
    - Assessed commercial interest in multiple Call Areas in the New York Bight (2018). Final WEA expected in fall 2019. Lease auction expected in 2020.
    - Designated Call Areas along central and northern California coast (2018). Lease auction expected in 2020.

State Activities

- State-level policies continue to drive the U.S. market.
- State offshore wind targets increased to 11,468 MW to be operating in 2030 and 19,968 MW to be operating by 2035 (as of June 2019).
- 4 projects awarded offshore wind renewable energy certificates (US Wind Maryland project, Deepwater Wind Skipjack project) or a power purchase agreement (PPA) (Deepwater Wind South Fork project)

U.S. OFFSHORE WIND DEVELOPMENT ACTIVITY



Source: NREL 2019

NEW YORK AND OFFSHORE WIND

What is the driver?

- Climate Leadership and Community Protection Act
  - 100% zero-carbon electricity by 2040
  - 70% of state's electricity from renewable sources by 2030
  - 9,000 MW of offshore wind by 2035, enough to power up to 6 million homes

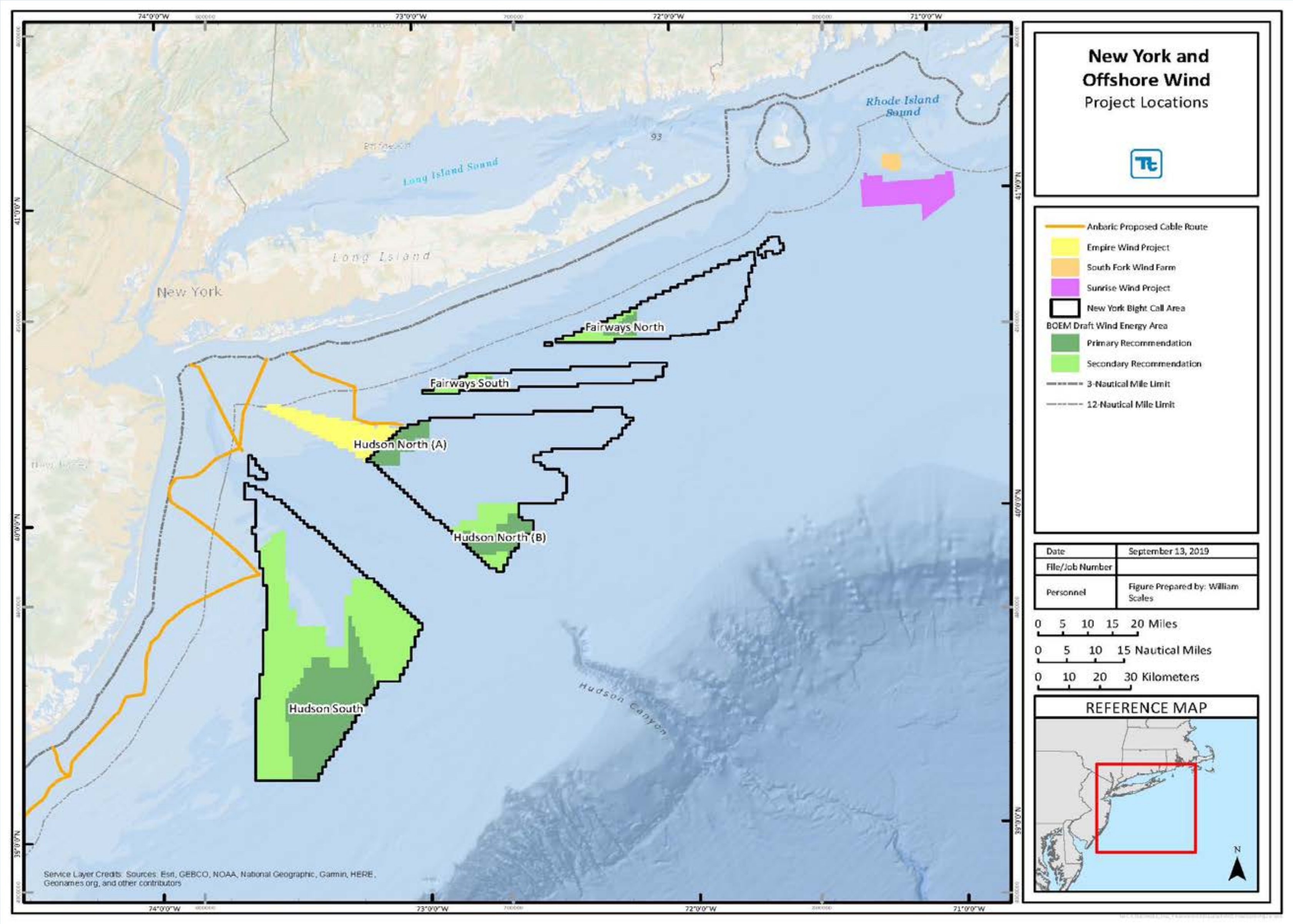
What is the status of projects?

- **South Fork Wind Farm**: Ørsted U.S. Offshore (Deepwater Wind) and Eversource Energy
  - 132 MW, enough to power 70,000 homes
  - 35 miles east of Montauk Point, Long Island
  - Operational by 2022
- July 2019—NYSERDA negotiated 25-year offshore wind RECs for 2 offshore wind farm projects
  - **Empire Wind**: Equinor
    - 816 MW of capacity
    - 14 miles southeast of Manhattan
    - Operational by 2024-2025
  - **Sunrise Wind**: Joint venture between Ørsted U.S. Offshore and Eversource Energy
    - 880-MW project
    - 30 miles east of Montauk Point, Long Island
    - Operational by 2024
  - Combined capacity to produce 1,700 MW of electricity (enough to power 1 million homes), or 20% of Gov Cuomo's goal for offshore wind.
  - 1,600 jobs and $3.2 billion in economic activity

What is next?

- Final NY Bight Wind Energy Areas to be announced by BOEM

NEW YORK AND PROPOSED OFFSHORE WIND PROJECTS



OFFSHORE WIND PROJECT ELEMENTS

Site Control
- Lease from BOEM

Offtake Agreement
- Revenue stream for power produced
- Unlocks development funding

Financing
- Investor or bank funding to construct

Permits
- NEPA process through BOEM
- Federal, state, and local permits

Marine Surveys
- Geophysical & Geotechnical
- T&E Species
- Cultural Resources

Subsea Cable Design and Installation
- Technology providers
- Owner's engineer
- Installation contractors

Marine Construction and O&M

PERMITTING PROCESS IN THE UNITED STATES

- Lead Federal Agency: Bureau of Ocean Energy Management (BOEM)
  - 3 nautical miles to U.S. Exclusive Economic Zone
  - Responsible for NEPA review for <u>all</u> project infrastructure from sea to point of interconnection
- State Lead would be site specific

PROJECT COMPONENT[1]	STATE	FEDERAL
Wind turbine array		X[2]
Offshore substation(s)		X[2]
Submarine transmission cable	X	X
Onshore transmission cable	X	X[3]
Tie-in to existing transmission system (e.g., substation and port upgrades)	X	X[3]

[1]Assumption is that offshore wind energy facilities are located on the Outer Continental Shelf ([OCS] federal waters).
[2] State Coastal Zone Management Agency must, however, issue a Consistency Certification for any project if it will "directly, indirectly, or cumulatively affect any natural resources, land uses, or water uses in the coastal zone."
[3] Depending on existing conditions along proposed route (e.g., wetlands, protected species habitat), federal jurisdiction may apply and require a permit (e.g. U.S. Army Corps of Engineers).

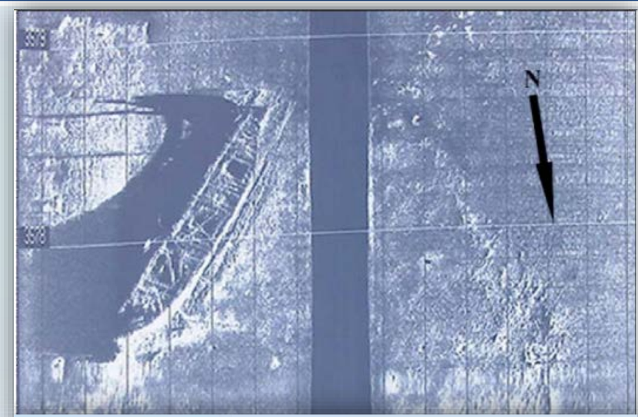



FEDERAL AUTHORITIES

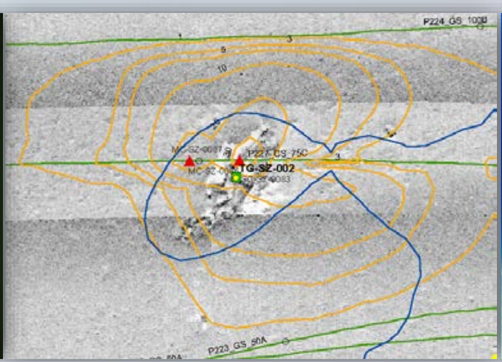
- National Environmental Policy Act
- Endangered Species Act
- Marine Mammal Protection Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Marine Protection, Research, & Sanctuaries Act
- National Marine Sanctuaries Act
- E.O. 13186 (Migratory Birds)
- Coastal Zone Management Act
- Clean Air Act
- Clean Water Act
- Marking of Obstructions
- E.O. 13007 (Indian Sacred Sites)
- E.O. 13547 (Stewardship of the Oceans, Our Coasts and the Great Lakes)
- Ports and Waterways Safety Act
- Rivers and Harbors Appropriation Act
- Resource Conservation and Recovery Act
- National Historic Preservation Act
- Archaeological and Historical Preservation Act
- American Indian Religious Freedom Act
- Federal Aviation Act
- Federal Power Act

MARINE ISSUES

- Impacts to marine mammals, fish, and avian species
- Disturbance of benthic habitat
- Suitable substrate (engineering and permitting)/ construction methodology
- Avoidance of sensitive cultural resources
- Avoidance of dumping grounds and UXO
- Minimize impact to Essential Fish Habitat (EFH)
- Water quality and air impacts during construction
- User conflicts especially with fishing interests and commercial shipping interests





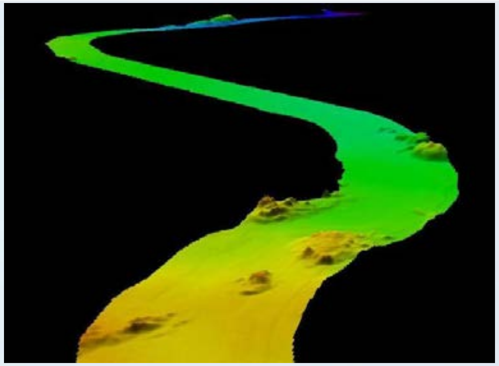


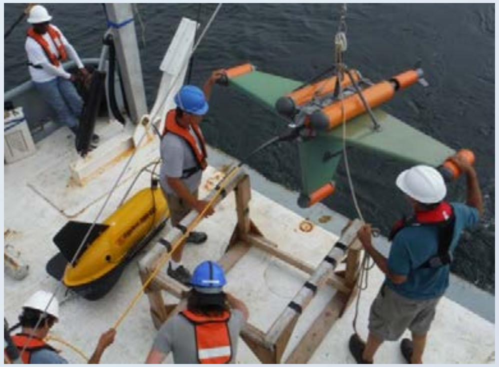

TERRESTRIAL ISSUES

- Sensitive coastal/near shore habitats
- Threatened and endangered (T&E) species
- Wetlands
- Coastal consistency
- Compatibility with existing land use and the power grid (use of existing infrastructure is best whenever possible)
- Submerged aquatic vegetation
- Sensitive cultural resources
- Structures
- Archaeological
- Noise (construction)

SURVEYS AND DESKTOP ANALYSIS

- Marine Geophysical and Shallow Geotechnical Surveys
- Marine Cultural Survey
- Marine Benthic Site Characterization
- In-Air and Underwater Noise Modeling
- Electromagnetic Field Assessment
- Visual Impact Assessment
- Navigational Safety Assessment
- Marine Mammal and Sea Turtle Assessment
- T&E Species Assessment
- Fisheries Assessment
- Air Emissions Analysis
- Sediment Dispersion Modeling
- Historic Properties Surveys





OVERVIEW OF BOEM PERMITTING PROCESS

Wind Energy Area Identification

- Intergovernmental Task Force--BOEM works with federal and state stakeholders to find potential areas with few environmental/user conflicts
- BOEM conducts an Environmental Assessment on lease execution and site assessment
- Request for Information or Call for Information and Nominations

2-3 years

Auction/Lease Execution

- BOEM determines competitive interest in designated wind energy area
- BOEM qualifies interested developers to participate in auction
- Auction winner(s) signs lease(s) including terms and conditions

1-2 years

Where Tetra Tech gets involved

Lease Preliminary Term (1 year)

- Begins on effective date of a lease
- Conduct site characterization surveys for buoy/meteorological tower deployment
- Submit a Site Assessment Plan (SAP) to BOEM for approval

1 year

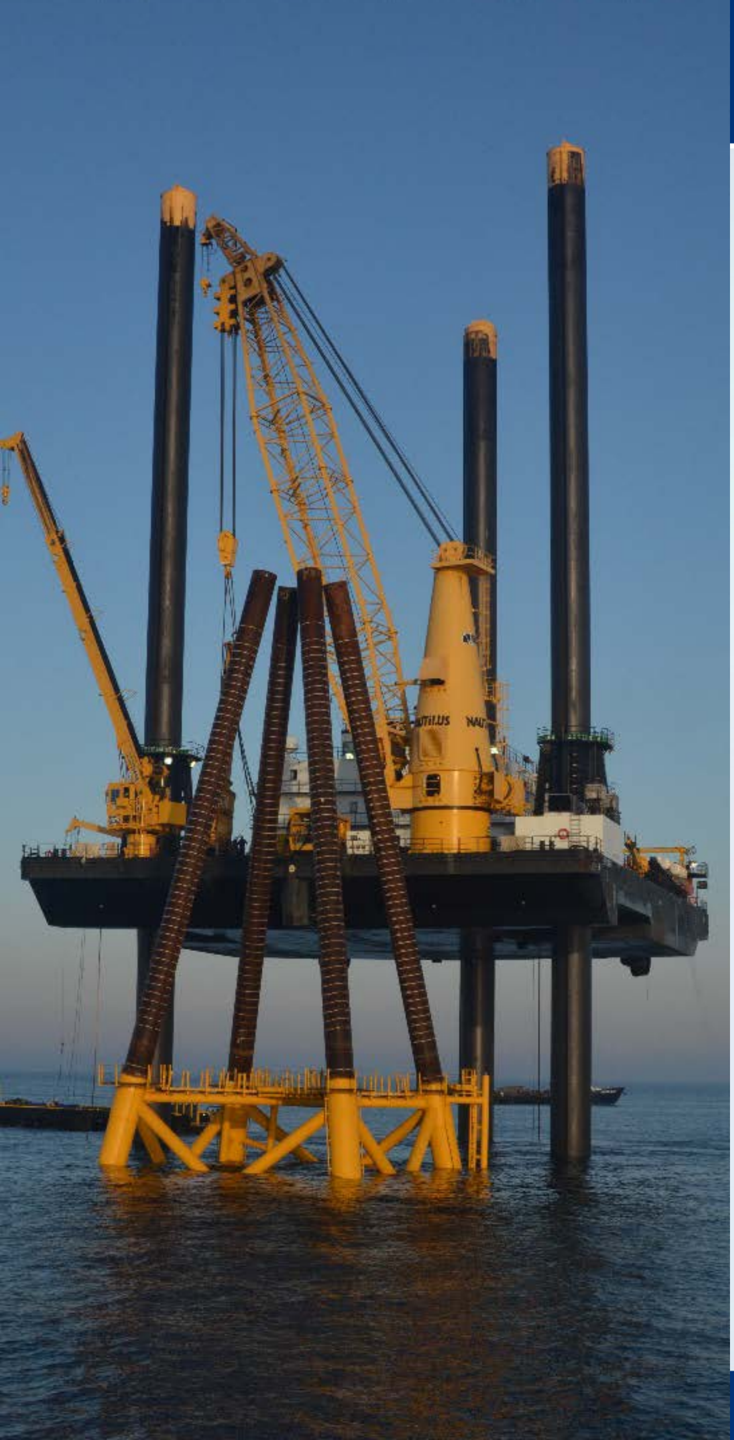
Lease Site Assessment Term (1 to 5 years)

- Begins when SAP approved by BOEM
- Deploy environmental monitoring equipment
- Conduct site surveys for wind project area
- Submit Construction and Operations Plan (COP) to BOEM for approval

2 years

Lease Operations Term (25+ years)

- Begins when COP approved by BOEM
- Construction, commissioning, and operations

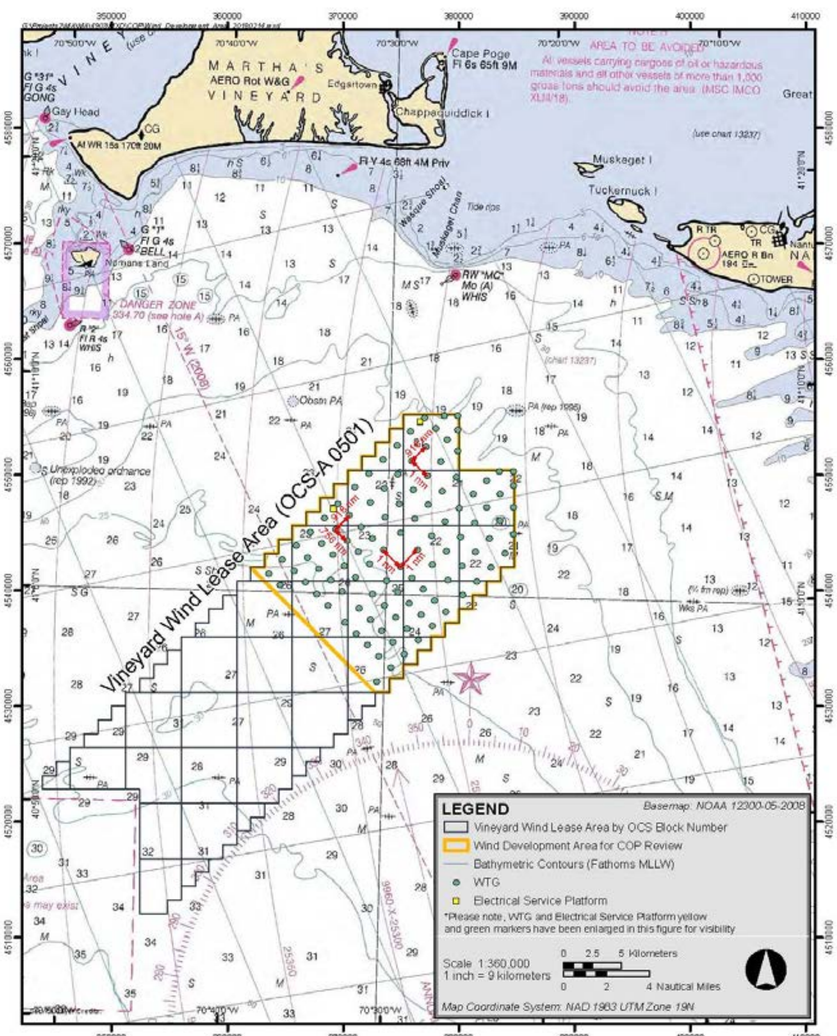


COP – NEPA REVIEW

- Agency scoping meetings (BOEM/USACE/USFWS/NOAA/EPA/USCG)
- Publish Notice of Intent to initiate scoping period in *Federal Register*
- Agencies’ public notice, public meetings, and comment period
- Third-party contractor prepares Draft Environmental Impact Statement (EIS) for agency review and public comment period.
- Third-party contractor prepares Final EIS for agency review
- BOEM issues Final EIS
- Issuance of Record of Decision (ROD)

CASE STUDY: VINEYARD WIND PROJECT

- 50-50 partnership between Copenhagen Infrastructure Partners and Avangrid Renewables
- $2.8 billion, 800-MW project (energy for over 400,000 homes) 15 miles south of Martha's Vineyard, MA with a transmission system at the Barnstable 115-kV substation
- 2 400MW Power Purchase Agreements (PPAs) approved by MA Dept of Public Utilities:
  - Phase 1: $74/megawatt-hour (MWh)—COD 2022
  - Phase 2: $65/MWh—COD 2023
  - Utilities have agreed to purchase 100% of energy and RECs generated and delivered by the project over a 20-year term
- Fishing conflicts
  - Vineyard Wind reduced project footprint by 20% and changed wind turbine generator layout to E-W alignment.
- Secretary of the Interior David Bernhardt has ordered additional study due to public comments requesting a more robust **cumulative impacts analysis** of offshore wind capacity buildout.
- BOEM is extending the mandatory environmental review in a **Supplemental EIS** (March 2020).
- Onshore construction expected in 2019; first phase of the project was expected to come online in 2022.
  - Qualification for 12% Investment Tax Credit being called into question



Vineyard Wind Project

VINEYARD WIND

Figure 3.1-2b
Wind Development Area for COP Review

EARTH, WIND & FIRE, "GOT TO GET YOU INTO MY LIFE" – CLEANER AND COST-EFFECTIVE ENERGY

Monday, September 23, 2019
9:50-11:05 AM (ET)
Mohonk Mountain House
New Paltz, NY

NYSBA

NEW YORK STATE BAR ASSOCIATION
ENVIORNMENTAL & ENERGY LAW SECTION

Earth, Wind & Fire, “Got to Get You Into My Life” – Cleaner and Cost-Effective Energy

- Panel Chair:
  - Gregory M. Brown, Esq. Brown Duke & Fogel, P.C
- Panelists:
  - Julia Pettit, Esq. Senior Counsel EDF Renewables

    Large Scale Solar and on-shore Wind
  - Megan Higgins, Director of Offshore Energy, Tetra Tech, Inc. Sciences

    Offshore Wind
  - Marshall Haimson, President, E Capital Development

    Storage, Transmission and Financing Energy Projects

Climate Leadership and Community Protection Act

Statewide Greenhouse Gas Emission Limits

- Limits (ECL 75-0107) Percentage of 1990 emissions:
  - 2030- 60%
  - 2050 – 15%
- Enforceable Regulations no later than 4 years – (ECL 75-0109) shall:
  - Include “*enforceable limits, performance standards, or measures or other requirements*” to control (exception for livestock emissions)
  - Considerations: equitable, minimize cost, maximize total benefits to NY, verifiable, permanent, enforceable
  - Limited use of offset projects as alternative compliance mechanism – electric generation sector not eligible to use offset mechanism.

Introduction

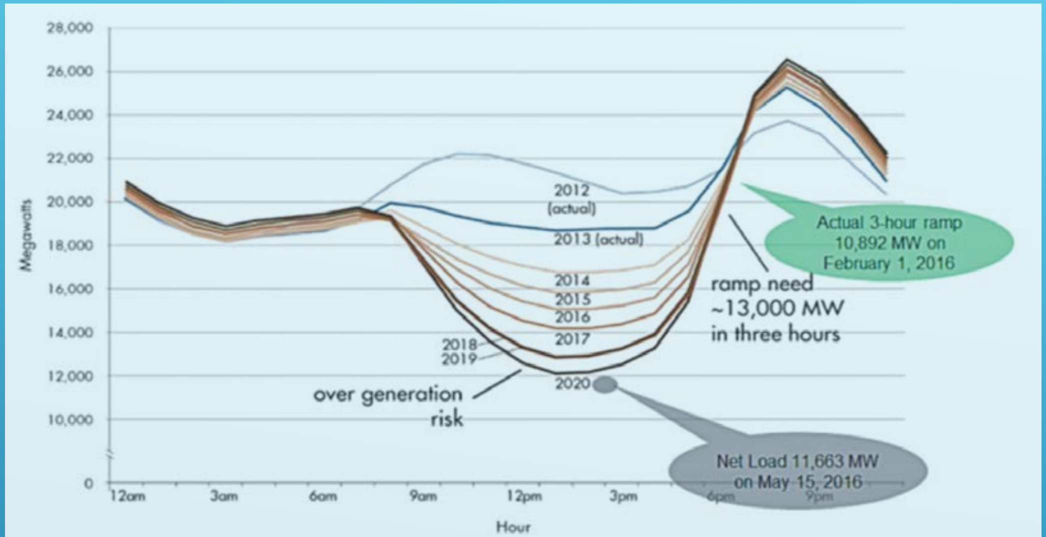
Climate Leadership and Community Protection Act cont.

Climate Action Council - 22 members – and advisory panels

- Timing:
  - 2021 – draft scoping plan – recommendations for attaining limits and beyond
  - 2022 – final scoping plan – recommendations to be incorporated into state energy plan
  - Updates at least once every five years
- “Just transition Working Group”
- Environmental Justice Advisory Group
- Must include measures to achieve – by 2025:

- 6 Gigawatts distributed solar
- 9 Gigawatts Offshore Wind
- 3 Gigawatts energy storage by 2030
- Displace fossil-fuel fired electricity with renewable or energy efficiency

Brown Duke & Fogel, P.C.



NEW YORK STATE BAR ASSOCIATION
ENVIORNMENTAL & ENERGY LAW SECTION
September 23, 2019

ENERGY STORAGE

Energy Storage

- '"[Q]ualified energy storage system' shall mean commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy using mechanical, chemical, or thermal processes to store energy that was generated at one time for use at a later time" (PSL § 74).
- Electric Storage Resource: "a resource capable of receiving electric energy from the grid and storing it for later injection of electric energy back to the grid" (18 C.F.R. § 35.28; Order No. 841, 162 FERC ¶ 61,127 at P 29).

Public Service Commission to establish an energy storage goal and policy by end of 2018 (PSL § 74.2)

- 3,000 MW of qualified storage energy systems by 2030,
- interim objective of deploying 1,500 MW of energy storage systems by 2025

Case 18-E-0130 *Matter of Energy Storage Deployment Program*, Order Establishing Energy Storage Goal and Deployment Policy, Dec. 13, 2018.

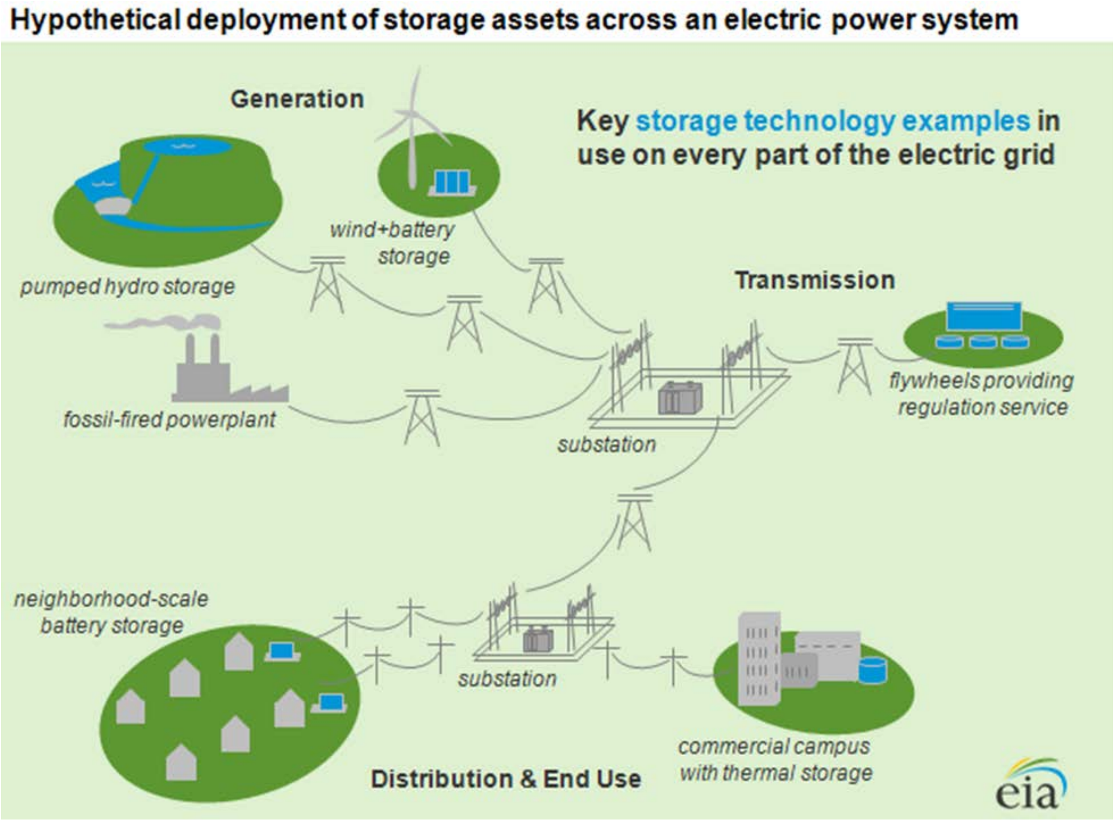
Energy Storage

NYSERDA Announces Completion of Largest Battery Installation in the State – 20MW - September 12, 2019

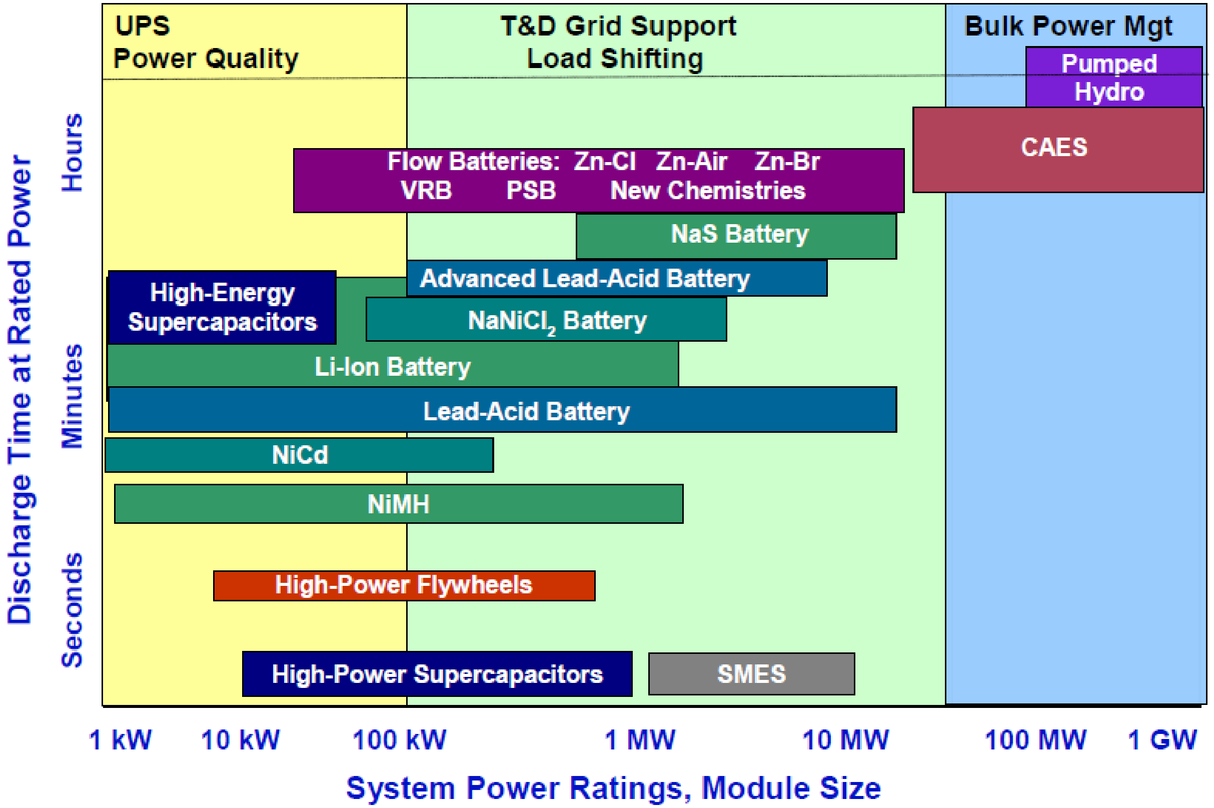
NY Power Authority - Blenheim-Gilboa Pumped Storage Project -1,400MW

Energy Storage

Technologies



- ## Characteristics



Energy Storage

Resources:

- U.S. Energy Information Administration (https://www.eia.gov/todayinenergy/detail.php?id=6910)
- International Energy Agency, Technology Roadmap, Energy Storage (https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapEnergystorage.pdf)
- Sandia National Laboratories, DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA (https://www.sandia.gov/ess-ssl/lab_pubs/doeepri-electricity-storage-handbook/

Energy Storage

Public Service Commission

- **Bulk Storage Dispatch Rights Contracts** - investor owned utilities required to competitively bid specified quantity to provide fixed revenue stream for up to seven years. (ConEd 300MW, other IOU's 10MW each)
- **Market Acceleration Incentives** - NYSERDA to develop incentives
- **Wholesale and Retail Market Reforms** - DPS to study and make proposals (VDER docket)
- **Evaluate storage in connection with Peaker Rule**

Case No. 18-E-0130 – *In the Matter of Energy Storage Deployment Program*, Order Establishing Energy Storage Goal & Deployment Policy (Dec. 13, 2018)

Energy Storage

Public Service Commission

Retail Storage Incentive

(bill savings or credits under IOU tariff - totaling $130 million)

Eligibility Up to 5MW – allocated blocks of MWh by region

- Retail demand metered customers standalone or paired with on site-generation (e.g. solar)
- Standalone or paired connected directly to distribution system compensated under VDER Value Stack Tariff
- Resource operated primarily for electric load management or shifting electric generation to more beneficial time periods while operating in parallel with the utility grid

Energy Storage Market Acceleration Incentives Implementation Plan (NYSERDA August 1, 2019) (filed in Case 18-E-0130)

Retail Energy Storage Incentive Program Manual (August 2019)

Updated amounts available: www.nyserda.ny.gov/All-Programs/Programs/Energy-Storage/Developers-Contractors-and-Vendors/Retail-Incentive-Offer/Incentive-Dashboard

Energy Storage

Public Service Commission

NYSERDA Bulk Storage Block Incentive($150 million)

Eligibility Up to 5MW – allocated blocks of MWh by region

- ❑ Above 5 MW providing wholesale energy, ancillary services, and/or capacity services
- ❑ Commercially available chemical, thermal, or mechanical systems physically located within New York State and interconnected into New York's bulk transmission system or an IOU's transmission or distribution system
- ❑ In Stage 9 in the NYISO interconnection queue or later (see NYISO's OATT 22 Attachment P – Transmission Interconnection Procedures) or have begun the equivalent distribution utility study if connecting directly into the distribution system

❑Executed agreement demonstrating site control for the duration of the project's lifespan

❑Completed draft Environmental Impact Study with a negative declaration as evidenced by meeting minutes of the local government or written approval

❑If applicable (*i.e.*, project includes new or expanded generation =>25MW), proof that the required Article 10 Application has been deemed compliant

ConEd RFP with NYSERDA Incentive Agreement and Storage Services Agreement at https://www.coned.com/en/business-partners/business-opportunities/bulk-energy-storage-request-for-proposals

Energy Storage

NYSDEC/ Public Service Commission

PEAKER RULE

- Renewable energy/storage output averaging as compliance alternative:

Effective Rate= Mass NOx / $\sum$ MWh(turbine, renewables, storage)

- DPS Evaluated Storage as Substitute for Peaking Units

Proposed Subpart 227-3, Ozone Season Oxides of Nitrogen (NOx) Emission Limits for Simple Cycle and Regenerative Combustion Turbines (comment period extended to Oct. 7, 2019)

The Potential for Energy Storage to Repower or Replace Peaking Units in New York State, filed in Case No. 18-E-0130 Matter of Energy Storage Deployment Program (July 2, 2019)

Energy Storage

FERC Order 841

- FERC held Regional Transmission Organization and Independent System Operator market rules are unjust and unreasonable in erecting barriers to the participation of electric storage resources.
- Directed RTO/ISO to revises tariffs establish a participation model consisting of market rules that, recognizing the physical and operational characteristics of electric storage resources, facilitates their participation in the RTO/ISO markets.

Order 841, 162 FERC ¶ 61,127 (2018) & Order 842, 167 FERC ¶ 61,154 (2019)

Electric storage resources tariff provision requirements at 18 C.F.R. § 35.28(9)

- NYISO Compliance Filing and Intervention and Protests by PSC, NYC, industry, NGOs

Energy Storage

FERC Order 841

- NYISO Request compliance no earlier than May 1, 2020
- Issues Raised by Intervenors
  - ❑ Buyer-Side Mitigation (BSM)
  - ❑ Dual Participation in Wholesale and Retail

- Considerations
  - ❑BSM assessment done with interconnection class year process – substantially delay entry in NYC
  - ❑IOU 300MW procurement of dispatch rights and $310 million market acceleration bridge – disputed impact on capacity prices

Energy Storage

Public Service Commission

- Ravenswood 316 MW Energy Storage Project
  - Petition for Certificate of Public Convenience and Necessity
  - Article 10 Not Applicable Per Prior Declaratory Ruling

- Expanded EAF
  - Existing Generation Site
  - Noise Study
  - Coastal Consistency

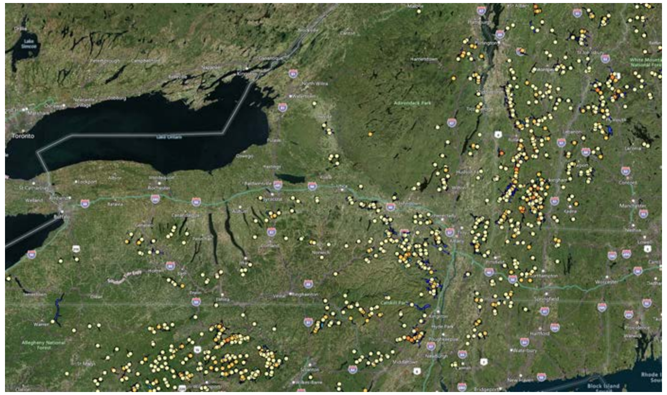
Case No. 19-E-0122, Petition of Ravenswood Development, LLC for Original Certificate of Public Convenience and Necessity (filed Feb. 21, 2019)

Energy Storage

Pumped Storage

Potential

- 530,000 potential pumped hydro storage sites globally(1)
- 100 x more than required for 100% global renewable electricity system(1)
- DOE forecasted new domestic 36 GW of pumped storage(2)



Australia Renewable Energy Mapping Infrastructure Project /https://www.nationalmap.gov.au/renewables/)

1 Australia National University

2. Hydropower Vision (DOE 2016)

Forecasted Pumped Storage

- DOE Energy Vision 2016

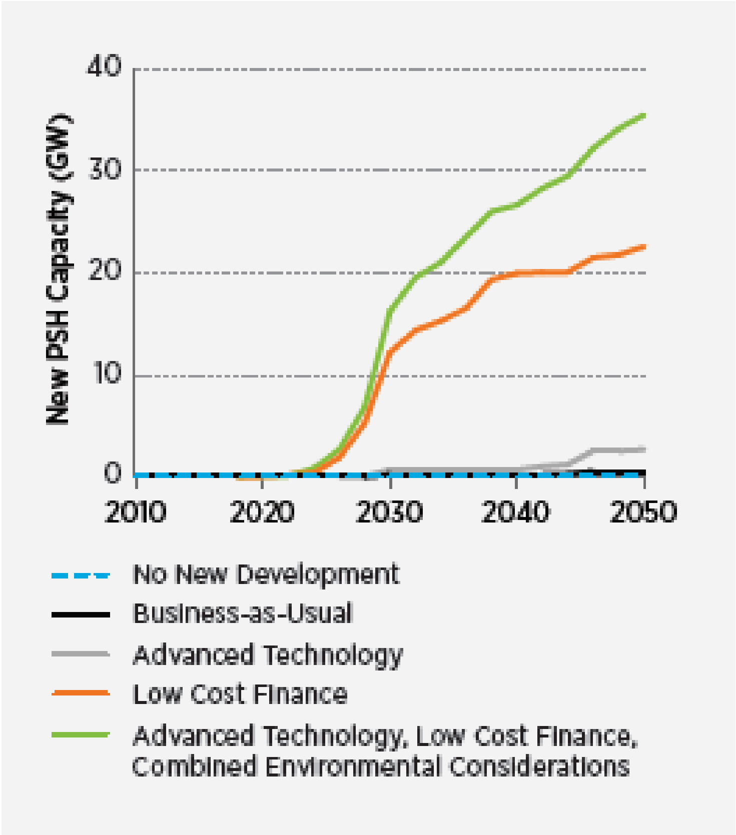


Figure ES-7. ReEDS modeled deployment of new pumped storage hydropower capacity, selected scenarios, 2017–2050 (GW)

Energy Storage

Pumped Storage

➢ Status[1]

- Licensed pumped storage – 19,769MW
- Preliminary Permitted – 20,041MW
- Pending preliminary permit applications – 19,020MW

(1) *https://www.ferc.gov/industries/hydropower/gen-info/licensing/pump-storage.asp*

1 Australia National University

2. Hydropower Vision (DOE 2016)

➢ America's Water Infrastructure Act of 2018

- ❑ FERC to issue rules establishing expedited processes for closed-loop pumped storage projects
- ❑ Goal- final decision no later than two years after receipt of a completed application

16 U.S.C. § 823f Closed-loop pumped storage projects

Energy Storage

Pumped Storage

Jurisdiction

- "[T]he term waterway as used in the FPA is sufficiently broad to include groundwater." Eagle Crest Energy Co., 153 FERC ¶ 61058 (2015)
- Commission may issue and amend licenses, as appropriate, for closed-loop pumped storage projects. 16 USCA § 823f(a)(1)

Statutory Criteria for Expedited Treatment[1]

- cause little to no change to existing surface and ground water flows and uses; and
- is unlikely to adversely affect species listed as a threatened species or endangered species under the Endangered Species Act of 1973

16 U.S.C. § 823f(g)

Energy Storage

Pumped Storage

Rulemaking/ Guidance

- ## Pumped Storage Eligible for Expedited Treatment Defined:

  “pumped storage projects that: (1) cause little to no change to existing surface and groundwater flows and uses; (2) are unlikely to adversely affect species listed as a threatened species or endangered species, or designated critical habitat of such species, under the Endangered Species Act of 1973; (3) utilize only reservoirs situated at locations other than natural waterways, lakes, wetlands, and other natural surface water features; and (4) rely only on temporary withdrawals from surface waters or groundwater for the sole purposes of initial fill and periodic recharge needed for project operation.”

➢ Procedures

- Application for expedited treatment
- If accepted, order issued establishing schedule

18 C.F.R. § 7.6

➢ Abandoned Mine Sites –

Commission directed to issue guidance to assist applicants for licenses or preliminary permits for closed-loop pumped storage projects at abandoned mine sites

16 USCA § 823f(f)