2016 Offshore Wind Energy Resource Assessment for the United States

Walt Musial, Donna Heimiller, Philipp Beiter,
George Scott, and Caroline Draxl
National Renewable Energy Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

Technical Report
NREL/TP-5000-66599
September 2016

Contract No. DE-AC36-08GO28308

2016 Offshore Wind Energy Resource Assessment for the United States

Walt Musial, Donna Heimiller, Philipp Beiter, George Scott, and Caroline Draxl
National Renewable Energy Laboratory

Prepared under Task No. WE15.5C01

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

Technical Report
NREL/TP-5000-66599
September 2016

Contract No. DE-AC36-08GO28308

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

This report is available at no cost from the National Renewable Energy
Laboratory (NREL) at www.nrel.gov/publications.

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

Cover Photos by Dennis Schroeder: (left to right) NREL 26173, NREL 18302, NREL 19758, NREL 29642, NREL 19795.

NREL prints on paper that contains recycled content.

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 and Water Power Technologies Office. The authors would like to extend thanks to NREL technical staff who contributed to this study including Dylan Hettinger as well as Aaron Smith (now with Principle Power Inc.). We would like to thank the DOE Wind and Water Power Technologies Office staff and contractors including Alana Duerr, Patrick Gilman, Ben Maurer, and Jose Zayas for supporting this research and providing feedback throughout the process. Thanks also to Greg Matzat (New York State Energy Research and Development Agency) for his guidance at the early stages of this study. NREL would also like to thank the following peer reviewers and other contributors: Bruce Bailey (AWS Truepower, LLC), Chris Ziesler (AWS Truepower, LLC), Matt Filippelli (AWS Truepower, LLC), Darryl Francois (Bureau of Ocean Energy Management), and Bill White (Massachusetts Clean Energy Center). Technical editing was provided by Sheri Anstedt, Corrie Christol, and Tiffany Byrne.

Nomenclature or List of Acronyms

AEP	annual energy production
AWST	AWS Truepower
BOEM	Bureau of Ocean Energy Management
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
EEZ	Exclusive Economic Zone
EIA	Energy Information Administration
GCF	gross capacity factor
GIS	geographic information system
GW	gigawatt
GWh/yr	gigawatt-hour per year
LCOE	levelized cost of energy
m	meter
MERRA	Modern-Era Retrospective Analysis
m/s	meters per second
MW	megawatt
MW/km^2	megawatt per square kilometer
nm	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
OCS	Outer Continental Shelf
ReEDS	Regional Energy Deployment System
SLA	Submerged Lands Act
TW	terawatt
TWh/yr	terawatt-hours per year
WIND Toolkit	Wind Integration National Dataset Toolkit
WRF	Weather Research and Forecasting

Executive Summary

This report, the 2016 Offshore Wind Energy Resource Assessment for the United States, was developed by the National Renewable Energy Laboratory (NREL), and updates a previous national resource assessment study (Schwartz et al. 2010), and refines and reaffirms that the available wind resource is sufficient for offshore wind to be a large-scale contributor to the nation's electric energy supply. Experience from other renewable technologies, such as land-based wind and solar energy, indicates that offshore wind site development will likely be highly selective. Therefore, the resource potential needs to significantly exceed the anticipated deployment to allow for siting flexibility. When developers and regulators have more siting options, projects can be built in the most economical and least conflicted areas. Therefore, an abundant wind resource is one of the essential building blocks that compose the value proposition for offshore wind. As such, the study shows that to implement the U.S. Department of Energy's (DOE's) *Wind Vision* 86-gigawatt (GW) offshore wind deployment scenario for 2050 (DOE 2015a), it would require the United States to use about 0.8% of the gross resource area or about 4.2% of the total technical resource area.

Some of the significant highlights and updates featured in this report include:

- **Expansion of the gross resource area.** The previous resource assessment had a domain boundary of 50 nautical miles (nm) from shore because of limits on wind data availability. However, global industry data show that offshore wind projects are being developed at distances from shore that exceed 50 nm (Smith, Stehly, and Musial 2015). For this report, the domain boundaries were extended from 50 nm to 200 nm, the outer edge of the U.S. Exclusive Economic Zone (EEZ) [Musial and Ram 2010, page 135], utilizing wind speed data from NREL's Wind Integration National Dataset (WIND) Toolkit (Draxl 2015).
- **Turbine hub height.** The gross and technical potential resource was calculated using wind speed at a turbine hub height of 100 meters (m) (previously 90 m) to reflect market trends for the likely height of new offshore turbine installations in the United States over the next 5 years (Smith, Stehly, and Musial 2015).
- **Capacity array power density.** For calculating the gross and technical resource potential, the array power density of offshore wind installations was lowered from 5 megawatts per square kilometer (MW/km^2) to 3 MW/km^2 based on developer input for likely array spacing in U.S. projects (Musial 2013; Musial et al. 2013) and to provide consistency with the DOE *Wind Vision*.
- **Energy production potential.** The energy production potential was assessed using a representative 6-MW turbine power curve, including geospatial estimates of gross and net capacity factor for the entire resource area. Net capacity factor estimates considered wake losses, electrical losses, turbine availability, and other system losses.[1]
- **Technology exclusions.** For estimating the technical potential, technology exclusions based on maximum water depth for deployment, minimum wind speed, and limits to floating technology in freshwater surface ice were applied. In consultation with industry technology developers, excluded areas include water depths greater than 1,000 m (Arent

---

[1] Note that loss calculations in this resource assessment are not sufficient for site-specific annual energy production estimates.

et al. 2012), wind speeds lower than 7 m/s (Schwartz et al. 2010), and water deeper than 60 m in the Great Lakes.[2] These exclusions are intended to reflect the current state of offshore wind technology. However, with appropriate investments in the development of new technology, certain resource areas could be expanded to increase the resource estimates found in this report. For example, the development of ice-resistant floating foundations for water deeper than 60 m in the Great Lakes would extend the technical resource potential in this region. As an example of how the technical exclusions are applied, the dark blue shaded area in the map in Figure ES-1 shows the area that was excluded with water deeper than 1,000 m.

Figure ES-1. Gross potential resource area showing excluded water depths of more than 1,000 m in dark blue

- **Land Use and Environmental Exclusions.** Land-use and environmental exclusion areas, such as shipping lanes and marine protected areas, were deducted from the total technical potential resource area using a database developed by Black & Veatch (Black & Veatch 2010). These same exclusions were used to compute the energy supply curves in the *Wind Vision* study (DOE 2015a).

The analysis progression followed for this report is shown in Figure ES-2, which aligns with a new framework described by Beiter et al. (2016a). Figure ES-2 also shows the resource totals at each analysis step. The raw data for this study are tabulated in Appendix A through Appendix I.

---

[2] Water depths more than 60 m are assumed to require floating platform technology. As of this writing, there are no examples of floating systems of any kind that could be installed permanently in the Great Lakes during the winter season. New technology could be developed to overcome this barrier to add resource area to this region.

Figure ES-2. Progression of analysis for the *2016 Offshore Wind Energy Resource Assessment for the United States*

Through application of the analysis steps described in Figure ES-2, the gross resource potential area is reduced by approximately 75% to arrive at the technical resource potential area. The area is further reduced to include land-use and environmental exclusions. The final technical potential eliminates approximately 84% of the original gross energy supply but still has an energy potential that is twice as large as the electric energy demand for the United States (Energy Information Administration [EIA] 2015).

Regional assessments were carried out for the five U.S. regions defined in the *Wind Vision* study scenario. The gross resource potential was compared to the final net technical potential for both capacity potential in gigawatts and net energy potential in terawatt-hours per year (TWh/year) (Figure ES-3).

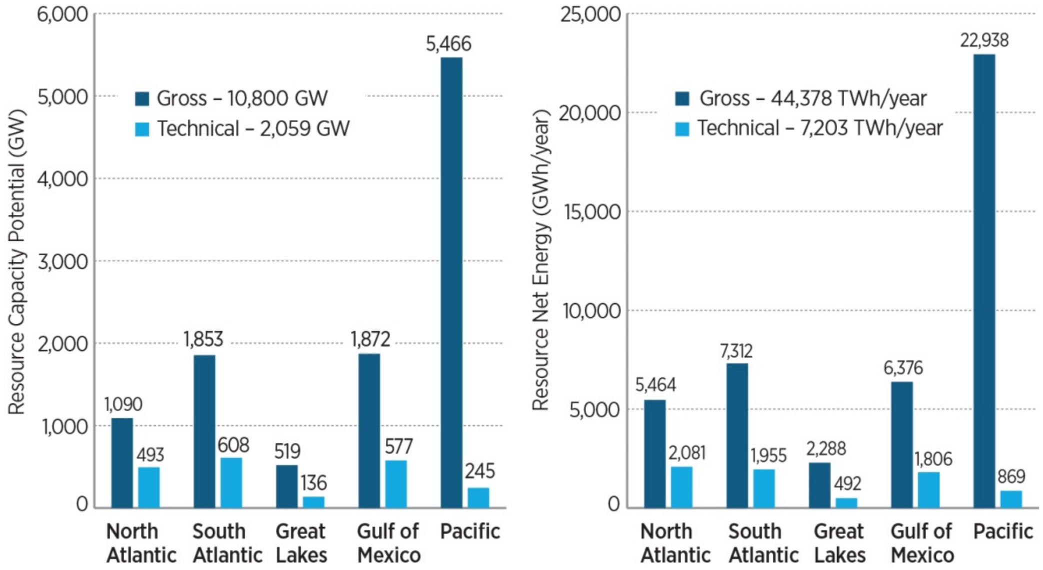


Figure ES-3. Capacity (left) and net energy (right) offshore gross resource (dark blue) and final net technical (light blue) potential estimates for five U.S. offshore wind resource regions

To reach the *Wind Vision* 2050 deployment scenario of 86 GW, approximately 4% of the technical resource area (about 0.8% of the gross resource area) would need to be developed. If developed, the energy produced would be approximately 7% of the U.S. electric consumption. Figure ES-3 shows the U.S. offshore wind technical resource potential and how it is distributed among all five U.S. regions. Each region is capable of contributing to a viable offshore wind industry by supporting significant deployment and participating in a robust offshore wind industrial supply chain and its supporting infrastructure.

Finally, state-by-state comparisons were made to determine geographically how the resource is distributed among the 29 offshore states examined (note that Alaska was not part of the study). Figure ES-4 shows this state-by-state comparison for two water depth classes: shallower than 60 m, and deeper than 60 m.

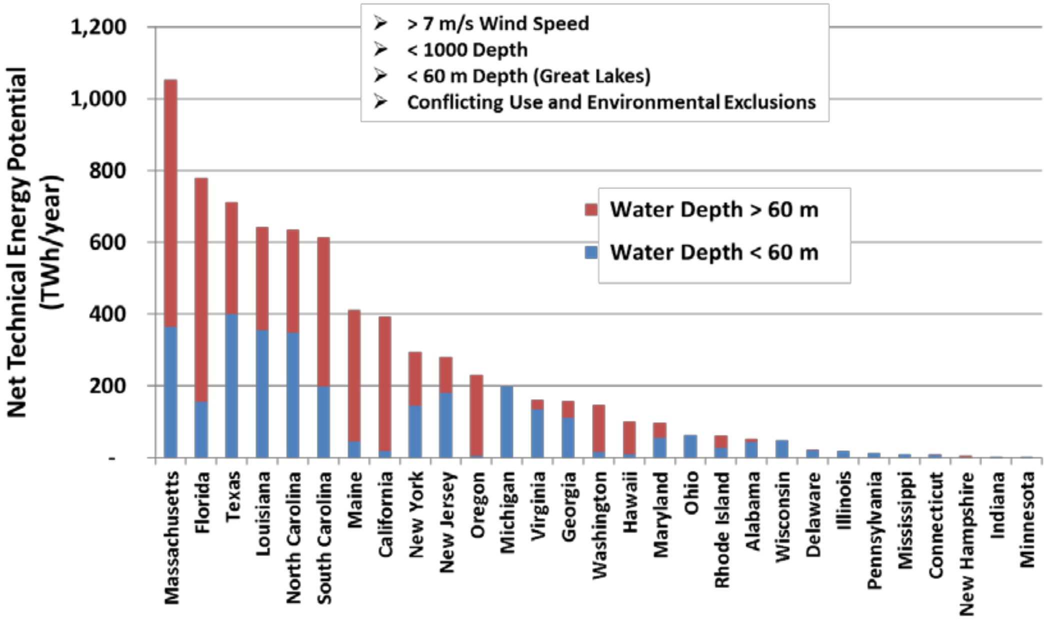


Figure ES-4. Offshore wind net technical energy potential (7,203 TWh/year) by state for depths of more than and less than 60 m

State-by-state comparisons indicate an abundance of resource potential in all U.S. regions relative to their electricity consumption. The best resource, based on quality and quantity, was found to be in northeast states such as Maine, Massachusetts, Rhode Island, New York, and New Jersey. Massachusetts has the highest technical offshore resource potential. Southern states such as Florida, Texas, and Louisiana all had large resource areas because of long coastlines and wider continental shelves, but the quality of their resource was lower due to lower wind speeds.

Using the most current industry knowledge, this updated U.S. offshore wind resource assessment has refined and reaffirmed the abundance of the available offshore wind resource. Moreover, it conforms to a new framework for resource classification that describes the offshore wind resources in terms that help promote consistency with broader renewable resource potential classification schemes (Beiter et al. 2016a; Lopez 2012) and other energy sources. This report does not cover the cost of offshore wind or the relative economic differences between sites. The analysis used to quantify the cost and economic potential is covered in a companion NREL report (Beiter et al. 2016b).

Table of Contents

List of Figures

List of Tables

1 Introduction and Background

This report updates and quantifies the U.S. offshore wind resource capacity and energy yield potential which is the foundation of the offshore wind value proposition. The U.S. offshore wind resource is robust, abundant, and regionally diverse, allowing for offshore wind development that can be located near congested load centers with some of the highest electric rates in the United States (Musial and Ram 2010). These coastal wind resources can provide local power generation, relief from transmission congestion, positive externalities including zero carbon emissions, energy diversity, and economic development, particularly in regions that depend on imports of traditional fossil-based fuels.

In March 2015, the U.S. Department of Energy (DOE) published *Wind Vision: A New Era for Wind Power in the United States* (DOE 2015a). The report examines a detailed, long-term, broad-reaching scenario for the United States to generate 35% of its electricity from wind energy by 2050, using both land-based and offshore wind. The *Wind Vision* scenario estimates that 86 gigawatts (GW) of offshore wind power capacity could be deployed in the nation by 2050 and provides a high-level road map of the actions necessary to realize this scenario. The *Wind Vision* highlights an offshore wind resource potential that can contribute to all regions of the United States, including the North and South Atlantic Ocean, the Gulf of Mexico, the Great Lakes, and the Pacific Ocean (including California, Oregon, Washington, and Hawaii).

This report updates the previous national resource assessment studies (Schwartz et al. 2010), and refines and reaffirms the adequacy of the available offshore wind resource to be a viable large-scale contributor to the electric energy supply. Experience from other renewable technologies, such as land-based wind and solar energy, indicates that site development will likely be highly selective. Therefore, the resource potential should ideally exceed the expected long-term deployment by a significant amount to allow for siting flexibility. When developers and regulators have more siting options, projects can be built in the most economical and least-conflicted areas.

The motivation for conducting this new offshore wind resource assessment was motivated by several factors including the:

- Availability of expanded, higher-quality wind resource data
- Need to keep pace with advances in offshore wind technology
- Need for improved consistency to allow comparison with other renewable and nonrenewable resources
- Anticipated release of an updated offshore wind strategy by DOE and the U.S. Department of the Interior in 2016.

This updated 2016 Offshore Wind Energy Resource Assessment for the United States conforms to a new framework for resource classification described in Section 4 and documented more fully by Beiter et al. 2016a, which describes the offshore wind resources in terms that help promote consistency with broader renewable resource potential classification schemes (Beiter et al. 2016a; Lopez 2012) and other energy sources.

2 Previous Resource Assessments, Changes, and Limitations

In 2010, the first comprehensive U.S. offshore wind energy resource assessment was documented by the National Renewable Energy Laboratory (NREL) (Schwartz et al. 2010). The Schwartz wind resource study quantified the gross offshore wind energy resource capacity for the contiguous United States and Hawaii[3] at about 4,150 GW. This gross resource potential (for the geographic domain extending from 0 to 50 nautical miles [nm] from the shoreline) provided a coarse evaluation of the quantity of ocean and Great Lake areas that would support offshore wind commercial development by state, sorted into discrete bands of water depth (0–30 meters [m]; 30–60 m; and more than 60 m), wind speed, and distance from shore (0–3 nm, 3–12 nm, and 12–50 nm). The 2010 study was effective in showing that the gross offshore resource potential was large relative to the U.S. energy consumption.[4] However, it did not quantify the gross or net energy production potential or losses; nor did it address the technically developable resource potential by excluding areas with apparent technology, environmental, and land-use conflicts.

Using Schwartz et al. (2010) as a point of comparison, several assumptions have changed in this report:

- Distance from shore is now extended from a 50-nm boundary to the edge of the U.S. Exclusive Economic Zone (EEZ), up to 200 nm
- Turbine hub height was changed from 90 to 100 m to reflect current technology trends
- Array power density was changed from 5 megawatts per square kilometer (MW/km^2) to 3 MW/km^2 to account for growth in rotor diameters and likely requirements for inter-array buffers
- Energy production is estimated over the entire domain and losses were calculated based on current wind turbine assumptions
- Technology exclusions were imposed to compute technical potential, acknowledging limitations in the current technology based on water depth, ice climate survival, and annual average wind speed
- Land-use and environmental exclusions were included based on data available from the *Wind Vision*.

---

[3] Alaska’s vast offshore wind resource is not yet counted. However, because of its extensive coastline and enormous wind-driven wave climate, it will likely have the largest gross resource capacity of any state (National Oceanic and Atmospheric Administration [NOAA] 2016; Previsic 2012; http://www.infoplease.com/ipa/A0001801.html)

[4] As evidence, in subsequent studies (e.g., *Wind Vision*), none of the offshore wind deployment scenarios in the Regional Energy Deployment System capacity expansion model were constrained by resource availability.

3 Applicable Uses and Limits

Although this report makes a significant stride forward in quality, consistency, detail, and applicability to the recent *Wind Vision* offshore resource data, it is important to note that this new database and resource classification are limited in their use applications.

Appropriately, these data are generally intended for quantifying offshore wind gross and technical resource potential at a state, regional, and national level for the purposes of:

- Identifying potential wind energy areas and evaluating the efficacy of one area relative to another on a global scale
- Establishing energy production estimates in the 14.6 GW of auctioned lease areas and other lease areas for early planning and energy policy decision-making
- Site prospecting analysis for developers seeking inputs for initial economic and energy estimation tools
- Alternative site analysis by regulators
- Local and regional policy decision-making for long-range energy planning.

The data in this assessment are not intended to support site-specific design and the due diligence efforts that are necessary to safely deploy an offshore wind facility. More rigorous analysis of wind characteristics and data validations will be necessary to complete a wind facility design and install and operate such a facility.

Although these data show resource areas that have been reduced to account for technology limits, these reductions were applied with broad criteria to allow for multiple solutions. These limits will vary widely depending on the technology and this study should not be used as a substitute for more rigorous engineering analysis.

Similarly, environmental and land-use exclusions were assumed to reduce the area of developable sea surface. However, this analysis makes no attempt to identify actual site locations. Moreover, it is certain that several land-use and environmental conflicts have not been fully identified or considered. As such, this study should not be used as a substitute for a rigorous marine spatial planning process.

4 Offshore Wind Energy Terminology Framework

The new offshore wind energy resource classification framework developed by NREL is shown in Figure 1. Generally, this terminology framework conforms to methods of renewable energy resource classification that have been developed by Lopez (2012) and which provide accepted conventions based on their regular appearance in congressional briefings on renewable energy resources (DOE 2013; Beiter et al. 2016a).

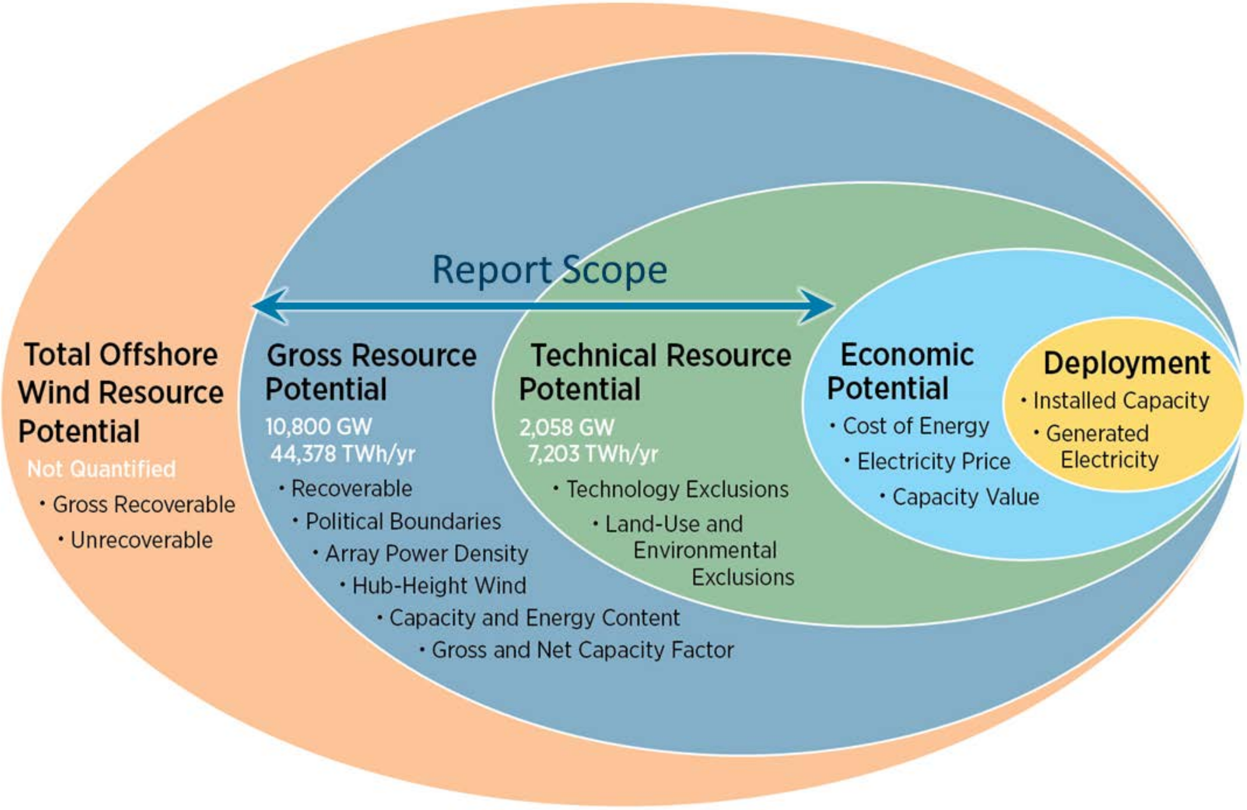


Figure 1. Offshore wind energy resource classification framework. *Illustration from Beiter et al. 2016a*

In Figure 1, all of the global resources are contained in the outer ellipse. As refinements and exclusion criteria are applied to the total resource, the potential resource supply is diminished, moving toward the inside. Each successive ellipse is a subset of the larger one it is part of. For instance, offshore wind "technical resource potential" is a subset of "gross resource potential," which in turn is a subset of "total offshore wind resource potential."

The total offshore wind resource potential includes the entire set of offshore wind resources (recoverable and nonrecoverable), regardless of whether the resource can be developed under presently available technological or commercial paradigms. In addition, all recoverable resource classes inside the total offshore wind resource potential in Figure 1 are also included in this resource class as well as unquantified and nonrecoverable offshore wind resources. For example, upper-air wind and high-seas wind (> 200 nm from shore) are considered unrecoverable using current technology. Similarly, the offshore wind resource potential inside the Alaskan EEZ (< 200 nm) is considered unquantified at this time. However, because of its remoteness from load centers, much of this vast energetic offshore wind may also be unrecoverable. Competing-use and environmental exclusions are not considered at all in this category. Generally, this study is only concerned with the gross recoverable resource potential and technical resource potential that is represented by the ellipses inside the total offshore wind resource potential.

The gross resource potential is limited to the boundaries of the U.S. EEZ (up to 200 nm from shore), assessed at 100 m above the sea surface, which is the average height of offshore turbine hubs expected to be deployed in the next 5 years. Because large arrays depend on the continuous replenishment of the kinetic energy in the free stream wind, gross resource potential must include some assumptions about how turbines are spaced within the array. Conflicting use and environmental exclusions are not considered.

The technical resource potential captures the subset of gross resource potential that may be commercially viable within a reasonable timeframe. It takes into account technical limits of offshore wind, including water depth, freshwater ice, and areas where winds are too low for consideration of large utility-scale projects. Generally, water depths less than 1,000 m and wind speeds greater than 7 meters per second (m/s) are included in the technical resource potential. In addition, technical resource potential excludes ice regions in the Great Lakes where depths are greater than 60 m—the depths at which floating technology is assumed to become the most viable option. To date, floating wind technology has not yet been developed that can survive in freshwater ice floes.

The economic resource potential is the available supply of offshore wind energy at a given site where a project's levelized cost of energy is equal to or below the expected levelized avoided cost of energy (Brown et al. 2015; Namovicz 2013; Beiter et al. 2016b). Economic potential can vary significantly depending on specific economic and market conditions including local incentive schemes, market barriers, competition among different technologies, electricity exports and imports, elasticity of demand, market failure, and the social cost of carbon, and forms of strategic market behavior and monopoly power. Market, policy, and economic factors that can change the economic resource potential of offshore wind vary considerably, and often within a shorter timeframe. By comparison, options to increase the technical potential of offshore wind are typically conducted over a longer timeframe.[5]

Deployment is simply the nameplate gigawatt capacity of the commissioned offshore wind installations or the quantity of electric energy delivered by those turbines (Smith, Stehly, and Musial 2015). The first offshore installation in U.S. waters is a 30-MW project that is scheduled to be commissioned in 2016 off Block Island (Rhode Island).

Note that the scope of this report is limited to the gross resource potential and the technical resource potential as shown in Figure 1. Further information about the economic potential of offshore wind is described in Beiter et al. 2016b.

The 2010 analysis performed by Schwartz et al. considered only the gross resource potential based on nameplate capacity. However, the nameplate power capacity is not the best indicator of potential from an energy production or economic perspective. Therefore, this analysis looks at resource potential based on energy production and nameplate capacity. The energy-based

---

[5] In a long-term perspective, research and development activities can be expected to increase offshore technical potential.

resource potential is derived from capacity factors associated with annual average wind speeds. Gross capacity factors (GCFs) are derived from defined power curves representative of 2015 technology. Losses and exclusions are applied to the gross potential to obtain the subset of gross resource potential that may be considered viable without considering technical, conflicting use, or environmental limits. This process is described in Section 5.

5 Progression of Analysis

The analysis method followed the progression shown in Figure 2 while conforming to the terminology framework in Figure 1. The analysis method was divided into two sections to differentiate between gross resource potential and technical resource potential.

5.1 Gross Potential Resource

The gross potential resource analysis method followed these steps:

1. **Define resource area.** First, the gross offshore resource domain area in square kilometers was defined and the total area was calculated using geographic information system (GIS) tools (Section 7.1). The gross resource areas data are provided in Appendix A.
2. **Calculate gross offshore wind resource capacity.** The gross offshore resource capacity in gigawatts was calculated by simply multiplying the gross domain area by the array power density (Section 7.2). These data are provided in Appendix B.
3. **Calculate gross offshore wind resource energy potential.** The gross offshore resource energy potential was calculated by applying the GIS-based wind resources to a representative power curve using the Openwind analysis program developed by AWS Truepower (AWST 2012) (Section 7.3). The gross resource energy data are provided in Appendix C.
4. **Calculate and apply losses.** The gross offshore resource energy potential including an estimate of likely losses caused by wakes, electrical, availability, and other normal losses was calculated from gross offshore resource energy potential using geospatial criteria to account for site conditions (Section 7.4.1). The gross resource energy data, with losses included, are provided in Appendix D.

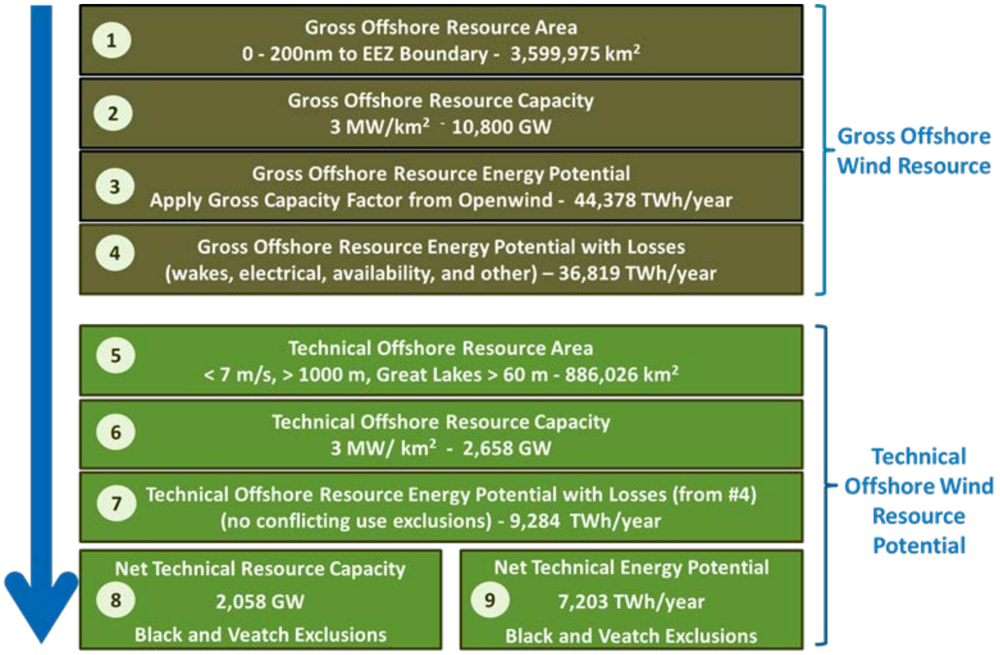


Figure 2. Progression of analysis for the 2016 Offshore Wind Energy Resource Assessment for the United States

5.2 Technical Potential Resource

The technical potential resource analysis method followed these steps:

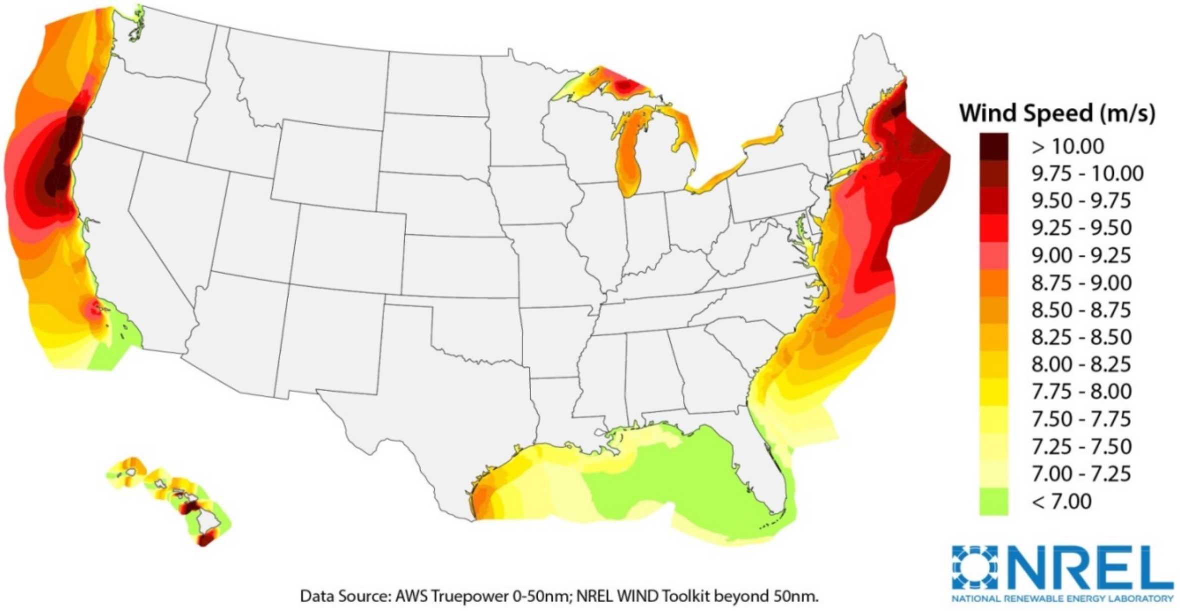
1. **Define technical resource area utilizing exclusion factors**. The technical potential area in square kilometers was calculated by reducing the gross potential area using the technology exclusion filters. These exclusions include area of wind speeds less than 7 m/s, water depths greater than 1,000 m, and water depths (in the Great Lakes only) greater than 60 m (Section 8.2). Note this technical potential area does not yet account for exclusions that are a result of conflicting industry use and environmental conflicts, which are applied later. The data for technical potential area are provided in Appendix E.
2. **Calculate technical offshore capacity**. The technical offshore capacity potential was calculated by multiplying the technical offshore resource area by the array power density (Section 8.3). Note the array power density is 3 MW/km^2 for all resource categories. The data for technical offshore capacity potential are provided in Appendix F.
3. **Calculate technical energy potential with losses**. The technical offshore energy potential (with losses considered) was calculated by using the gross offshore resource energy potential (step 4 in Section 5.1) and applying the same technology exclusions used to obtain the technical resource area in step 5 (Section 8.4). The data for technical offshore energy potential are provided in Appendix G.
4. **Apply industry use and environmental conflicts**. In the final step, the exclusions for industry use and environmental conflicts were applied. These exclusions assume that a percentage of the technical resource area will not be available for development. However, because of rigorous marine spatial planning activities underway, the study does not specify the exact location of the excluded areas (Section 8.5). These percentages are applied to the technical offshore capacity potential and the technical offshore energy potential (with losses), respectively, to obtain the final technical resource estimates. The data for technical offshore capacity potential and net technical energy potential are provided in Appendix H and Appendix I, respectively.

6 Data Sources

In developing this report, multiple data sources were required to conduct a thorough assessment of potential resource area, capacity, and energy production. The following sections identify the data sources utilized during the wind resource assessment and describe how they were used to shape the results of this assessment.

6.1 Wind Speed Data

Three primary sources contributed wind speed data for the wind resource analysis: AWS Truepower, the Wind Integration National Dataset (WIND) Toolkit, and Vaisala/3Tier. For the contiguous United States, the annual average wind speed data was adjusted to 100 m above the surface (data produced by AWS Truepower), at a distance of 0 to 50 nm from shore. WIND Toolkit data were utilized to extend the domain from 50 to 200 nm. For Hawaii, AWS Truepower 100-m wind speed data were used in the area of 0 to 12 nm from shore. To extend the domain to the 200-nm EEZ, 100-m data from Vaisala/3Tier[6] (extrapolated from 90-m data) were used in the area of 12 to 200 nm from shore. The composite map combining these data is shown in Figure 3.



Data Source: AWS Truepower 0-50nm; NREL WIND Toolkit beyond 50nm.

Figure 3. Offshore wind resource data (100 m) used for the 2016 offshore wind resource assessment. *Map provided by NREL, AWS Truepower, and Vaisala/3TIER*

---

[6] The Hawaii monthly offshore wind speed data set is available on Wind Prospector (https://maps.nrel.gov/wind-prospector). The resulting data set is intended to provide broad estimates of wind speed variation for the purposes of identifying possible wind energy sites. It is not intended to provide estimates of possible energy production for the purpose of investing in offshore wind projects or making financing decisions in specific locations.

6.1.1 AWS Truepower Data

The primary wind speed data for the regions between 0 and 50 nm from shore was licensed from AWS Truepower by NREL. AWS Truepower data were available for the contiguous United States and for Hawaii out to 12 nm. These data provided long-term annual average wind speeds (m/s) at a 100-m height above the surface. The data are output from a mesoscale model with nominal a 2-km spatial resolution, downscaled to a 200-m resolution (AWS Truepower 2012).

6.1.2 WIND Toolkit Data

To date, the WIND Toolkit contains the largest, publicly available grid integration wind dataset, with both meteorological and power values (Draxl 2015). DOE Wind and Solar Programs funded the WIND Toolkit data creation. The WIND Toolkit consists of a wind resource and forecast dataset with a 2-by-2-km grid and 20-m vertical resolution from the surface to a 200-m elevation. It includes meteorological and power data every 5 minutes. The data are based on the Weather Research and Forecasting (WRF) model, which incorporates 7 complete years of data from 2007 through 2013. Figure 4 shows the WRF modeling domains (gridded data is available for the innermost domain and metadata is available on Wind Prospector at https://maps.nrel.gov/wind-prospector).

Using the WIND Toolkit, the area of offshore resource domain was extended from 50 nm to 200 nm for this study.

Figure 4. Weather Research and Forecasting modeling domains for the WIND Toolkit

6.1.3 Vaisala/3Tier Wind Data

Vaisala/3Tier data, at a 90-m height above the surface were extrapolated to 100 m assuming a power law wind shear of 1/7, and were used to characterize the domain in Hawaii from 12 nm out to 200 nm. These data were joined with the AWS Truepower data that covered the region inside the 12 nm territorial sea boundary. Modeled mean wind speed data from Vaisala/3TIER were provided to NREL on a 2-km grid and were mapped onto the 1.2-by-1.2 km Bureau of Ocean Energy Management (BOEM) aliquot grid cells by assigning mean wind speeds corresponding to the nearest 2-km Vaisala grid cell. This process created a long-term, 17-year wind speed record for each aliquot.

6.1.4 Offshore Wind Alaska

A resource characterization has not been conducted for Alaska to date. Because of the state's enormously long coastline, it is expected that Alaska's offshore wind resources could far exceed their regional needs. Some general observations of the offshore wind characteristics in Alaska include:

- A coastline that is 6,640 miles long (longer than all other ocean coastal states combined [5,839 miles]) (Beaver 2006)
- The potential for being the windiest offshore state
- The potential for being the most remote offshore state with no economically viable means to export excess electric power (Johnson 2012).
- The inclusion of Alaska's offshore wind resource with the US offshore wind resources provided in this study would greatly inflate the total U.S. resource estimates of this report
- Alaska ranks second to the lowest state (49th out of 50 states) in electric energy consumption nationally.

A complete offshore wind resource assessment for Alaska is recommended for future work.

6.2 Bathymetry Data

Understanding the bathymetry of the entire Outer Continental Shelf (OCS) was essential to developing this resource assessment. Bathymetry data for this report came from the following National Oceanic and Atmospheric Administration (NOAA) resources:

- NOAA Coastal Relief Model and Great Lakes bathymetry data 3 arc-second (~100-m spatial resolution) where coverage existed (NOAA 2013, 2015, 2016).
- NOAA 1 arc-minute (~ 2-km spatial resolution) global bathymetry data where higher resolution data were not available (NOAA 2013, 2015, 2016).

Figure 5 shows the boundaries for gross and technical resource potential in the United States. The gross resource area is bounded within the 200-nm EEZ, shown by the red line Figure 5. The gross resource area is reduced by all of the dark blue area, representing water depths greater than 1,000 m, to limit the technical resource area.

Figure 5. Bathymetry map of contiguous United States and Hawaii showing areas with depths out to the U.S. EEZ

6.3 State Boundaries

The determination of offshore jurisdiction encompasses complex legal agreements between individual states, between the individual states and the federal government, and treaties between the United States and adjacent countries. Some of these boundaries are currently unresolved (e.g., New Jersey versus Delaware, Supreme Court Decision No. 134 Original, October Term 2007, and Thormahlen [1999]). The state/federal offshore boundary is determined by the Submerged Land Act (SLA) and individual Supreme Court decisions for Texas and Florida (Thormahlen 1999). Seaward of the SLA, BOEM for administrative purposes, has drawn border lines based on standard principles of boundary measurement (i.e. the use of equidistance) relative to the shorelines of two adjoining coastal states. These border lines extend from the SLA line to the limit of the United States' OCS based on the United Nations Convention on the Law of the Sea (Federal Register).

Landward of the SLA line, state boundaries are based on legal agreements dating back to the Colonial period. A national dataset of state boundaries is still under development by BOEM and NOAA. For this report, NREL constructed an offshore administrative boundaries dataset from BOEM, SLA, OCS, and OCS administrative boundaries, and individual state and local government administrative boundary datasets. Where there was no available state data landward of the SLA, NREL constructed lines from the SLA to the shoreline. The summary list of data sources used and a more detailed listing is provided in Appendix K. Figure 6 illustrates the offshore area for each state out to the 50-nm delineation that was used in Schwartz et al. (2010). Note, the colors are provided to differentiate between adjacent states and do not have any other significance. This analysis used a simple extrapolation to extend the Schwartz boundaries out to the 200-nm EEZ. However, it should be noted that the United States does not recognize a state offshore domain on the OCS outside of state territorial waters (0–12 nm). Therefore, state boundaries from 3 nm (9 nm offshore Texas and the west coast of Florida) to 200 nm used in this analysis are approximations and should only be used for illustrative and planning purposes.

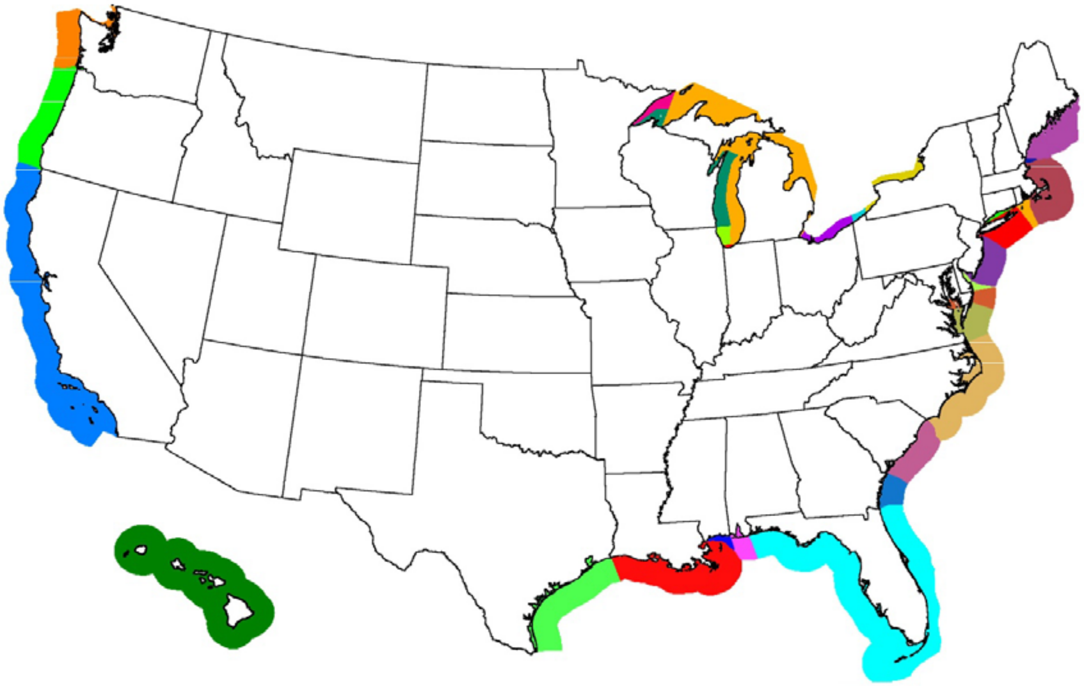


Figure 6. State resource areas at distances out to 50 nm. *Figure provided by Schwartz et al. 2010*

7 Gross Offshore Wind Resource

The gross resource was calculated for this study considering all coastal waters in the United States that have federal and state jurisdiction. The calculation of gross resource does not discriminate on the basis of possible technology, use conflicts, or environmental impacts. Therefore, it intentionally includes areas that might not be economical to develop or could be unsuitable for various reasons that normal site screening might eliminate using today's knowledge base. However, the assessment does take into consideration the experience and trends of the offshore wind industry over the past few decades to establish physical parameters for array power density and turbine height that are needed to limit power capacity and energy production. As such, the gross potential resource provides an upper bound on the maximum offshore wind potential but should not be used as a proxy for long-term deployment estimates.

7.1 Gross Resource Area

The gross resource area outlined in this report includes all offshore water area from the shoreline to the 200-nm EEZ using a 200-m-by-200-m grid cell. In the Great Lakes, the domain extends to the middle of the lakes where the U.S. and Canadian borders intersect. The U.S. gross resource area (excluding Alaska) was calculated for this study to be 3,599,975 km^2. Globally, offshore wind projects are now being installed more frequently at sites that are farther from shore than the 50-nm limit used by the Schwartz 2010 study, which limited the offshore wind resource to sites inside 50 nm. Projects have been proposed in Germany, for example, that are over 54 nm (100 km) from shore (Smith, Stehly, and Musial 2015). With high-voltage direct-current electric transmission technology maturing, and the desire for projects to be out of sight, project distances-to-shore may continue to increase even further (Figure 8).

7.1.1 Distance Zones

Within the total gross resource area domain, data were further classified into the following four distance zones.

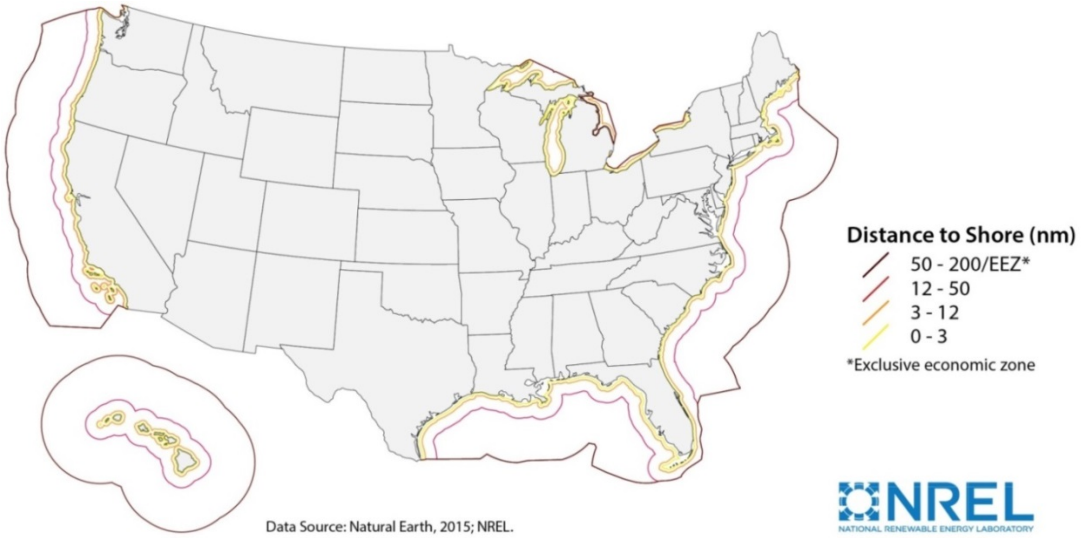
- **The 0-to-3-nm zone**. This zone is generally the area that contains state waters, but is outside BOEM's jurisdiction (Musial and Ram 2010).[7]
- **The 3-to-12-nm zone**. This zone extends to the territorial waters boundary at 12 nm. In this zone, conflicting-use impacts may be higher than in areas farther out. Some studies have found that opposition to offshore wind projects on the basis of view shed or aesthetics begin to decline rapidly beyond 12 nm (Lilley, Firestone, and Kempton 2010).
- **The 12-to-50-nm zone**. The 50-nm boundary was original selected to focus the effort of offshore wind resource evaluation on the near-shore area where access to grid and shore-based support services was more feasible (Schwartz et al. 2010). Subsequent assessments show that project feasibility is not necessarily limited to 50 nm. For this study, the 50-nm delineation was retained as a reference to help describe the differences between far-shore and near-shore impacts out to the 200-nm EEZ limit. For example, the *Wind Vision* study exclusions provided by Black & Veatch show a significant drop in use and environmental conflicts from the 12-to-50-nm zone to the 50-to-200-nm zone (from 21% to 8%, respectively).

---

[7] For Texas and the western coast of Florida, state waters extend to 9 nm (see Section 9.3). For the Great Lakes, all of the resource is in state waters (see Table 3).

- **The 50-to-200-nm zone**. This additional distance from shore was added to the gross resource area to provide the possibility of development beyond 50 nm where conflicts are lower and some regions have large areas of developable water with depths less than 1,000 m.

Figure 7 shows a map defining these distance zones.



Data Source: Natural Earth, 2015; NREL.

Figure 7. Gross offshore area map highlighting distance-to-shore zones

7.1.2 Depth Zones

The domain area was also classified separately in five water depth bands: 0–30 m, 30–60 m, 60–700 m, 700–1,000 m, and greater than 1,000 m. These depth-band classifications were approximately the same as the 2010 study except with additional break points added at 700 m and 1,000 m to allow for more realistic assessments of technology limits. Figure 8 shows the range of depth and distance from shore that offshore wind installations have been deployed and are being planned, but does not include any floating projects.

It is widely known that floating offshore wind technology cannot extend beyond some practical depth limit. However, there is no industry-wide consensus on the precise depth limit of floating wind plants. Researchers and developers interviewed for this study agree that the limit today should be between 700 m and 1,300 m, which is not a hard physical limit and is based mostly on economic criteria; however, there is some concern that electrical subsea cables may not be suitable below a 1,300-m depth. The *Wind Vision* study used a depth of 700 m to define the maximum deployment depth, but industry elicitation suggests that 1,000 m may be more appropriate. Both 700 m and 1,000 m were used as depth delineators for this study; however, 1,000 m was chosen as the maximum cut-off for U.S. technical resource potential to remain consistent with past work and to acknowledge industry trends that are indicating a deeper limit (Arent et al. 2012; Weinstein 2016; Campbell 2016).

Previous depth delineators for fixed-bottom technology of 30 m and 60 m appear to still be appropriate based on progress shown in European wind installations, and these delineators were retained for this study. The shallower 30-m depth cutoff is relevant as a shallower economic break point for earlier monopile and gravity-based foundation technology, whereas the 60-m depth seems to be a reasonable upper economic limit for fixed-bottom systems.

Furthermore, the resource area was geographically subdivided along the state boundaries assigned by NREL (see Section 6.3) to allow individual state resources to be approximated. The tabulated data for gross resource area by state, water depth, and distance to shore are shown in Appendix A.

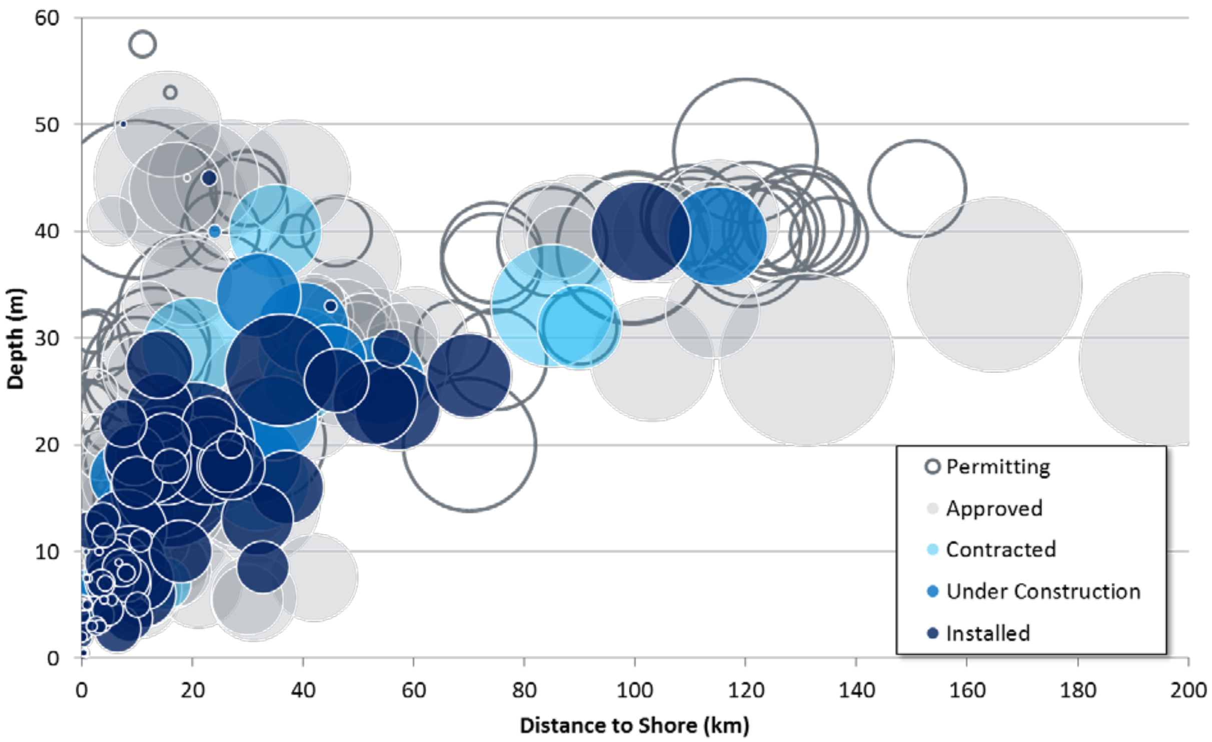


Figure 8. Offshore wind projects installed and under development as a function of depth and distance to shore. *Figure from Smith, Stehly, and Musial (2015)*

7.2 Gross Resource Capacity

The gross resource capacity was calculated in gigawatts by multiplying the gross resource area by the assumed nominal array power density of 3 MW/km^2, which results in a gross capacity of 10,800 GW for the entire United States, excluding Alaska. This is the theoretical recoverable resource based on turbine nameplate capacity that would be possible if wind turbines were installed everywhere on the OCS and Great Lakes without regard to technology and use limits (see Appendix B). In the previous study conducted by Schwartz et al. (2010), a higher array power density of 5 MW/km^2 was used. However, the lower density used for this analysis accounts for wider spacing to ensure reasonable wake replenishment with current turbine technology in large arrays. Note that today's turbines have lower specific power (larger rotors) than turbines 10 years ago, which naturally dictates wider turbine tower spacing. Optimum spacing will vary with atmospheric conditions, but an array power density of 3 MW/km^2 is more able to account for normal turbine spacing with internal wind plant buffers included, and is consistent with the density used in the *Wind Vision* (DOE 2015a).

7.3 Gross Resource Energy

The gross resource energy potential was calculated over the entire gross resource area of 3,599,975 km^2 described in Section 7.1. Gross resource energy potential is reported in terawatt hours per year (TWh/year). This metric was not part of previous resource assessments (e.g., Schwartz et al. 2010). With no assumed technology, conflicting use, or environmental exclusions, and no performance losses (i.e., wakes, electrical), the gross U.S. offshore resource area can theoretically produce 44,378 TWh of energy each year (see Appendix C).

The gross offshore energy potential for a unit area was calculated using the following equation:

Gross Offshore Energy = Array Power Density x Gross Capacity Factor x 8760 hours per year (1)

The array power density was set to 3 MW/km^2 as described earlier. The GCF was calculated for each grid cell on the gross offshore resource area using Openwind. That analysis is described in the following sections.

7.3.1 Power Curve

To calculate the GCF, it was necessary to assume a wind turbine power curve that is representative of current technology in 2015. NREL created a generic 6-MW power curve that is based on typical commercial offshore wind turbines that were on the market in 2015. The wind turbine power curve used for this report was based on the inputs listed in Table 1 and is shown in Figure 9.

Table 1. Wind Turbine Power Curve Inputs

Turbine Characteristic	2015 Technology Value
Turbine Rated Power (MW)	6
Turbine Rotor Diameter (m)	155
Turbine Hub Height (m)	100
Turbine Specific Power (W/m^2)	318

Note that Figure 9 shows the power curve with Region 2 and Region 3 labeled. Region 2 is where the turbine is operating below rated power, in lower winds, and operation is controlled to maximize power production. Region 3 is the part of the power curve where power is regulated by the pitch actuators to maintain rated power (6 MW). These regions are referred to later in describing the relationship of wake losses to average annual wind speed.

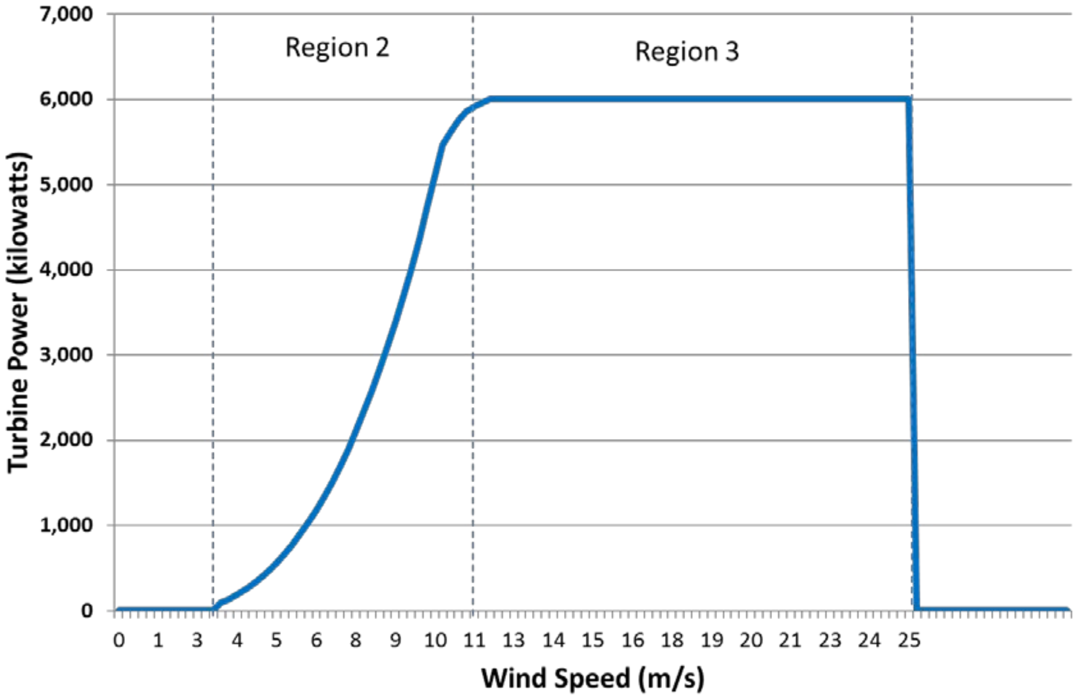


Figure 9. Generic 6-MW power curve for representative wind turbine technology available for commercial deployment in 2015 (assumed operation date of 2017)

Using this power curve, the gross energy production and GCF were calculated from Openwind analysis for distances from shore between 0 and 50 nm.

7.3.2 Evaluating Gross Capacity Factor

The Openwind Enterprise tool is a commercial wind energy facility design tool created by AWS Truepower and licensed to NREL. It has the capability to perform layout design, flow modeling, wake modeling, and energy assessment. Openwind Enterprise was selected for its interoperability with GIS data as well as its capability to model deep array wake effects.

One component of Openwind is the WindMap flow model, which is based on the NOABL code (Phillips 1979) and solves the conservation of mass equation to generate a three-dimensional wind flow map. The model accounts for moderate changes in terrain (for land-based applications) and surface roughness when used in conjunction with measured time series meteorological data.

The Openwind Deep Array Fast Eddy-Viscosity Wake Model was used to perform the wake loss analysis for this report. It enhances the open-source version of Openwind and provides additional accuracy in the modeling of the downwind effects of free-stream- and turbine-generated turbulence and predicts the recovery of the free-stream wind flow field in the array. The Deep Array Fast Eddy-Viscosity Wake Model (AWS Truepower 2010) is a combination of the open-source standard Eddy-Viscosity (EV) model and a roughness effect associated with each turbine.

The gridded turbine layer function within Openwind was used to create a standard 10-by-10 turbine array layout for 100 6-MW turbines. Wind turbine spacing was chosen to be 7 rotor diameters (D), corresponding to a turbine array density of 5.1 MW/km^2. This turbine density is about 70% greater than the array power density of 3 MW/km^2 used to calculate the resource for this report; however, the Openwind capacity factor analysis does not include array buffers and setbacks which would be needed under most development scenarios. Therefore, for the purposes of resource assessment, the resource capacity is represented more accurately by 3 MW/km^2. This standard layout is shown in Figure 10 which occupies a nominal area of 117 km^2. Note that this standard array configuration would be considered inefficient relative to today's optimized commercial array layouts, so wake losses calculations in this report would be expected to be higher than actual projects. This is offset to some degree by lower accounting for availability losses described in Section 7.4.1.

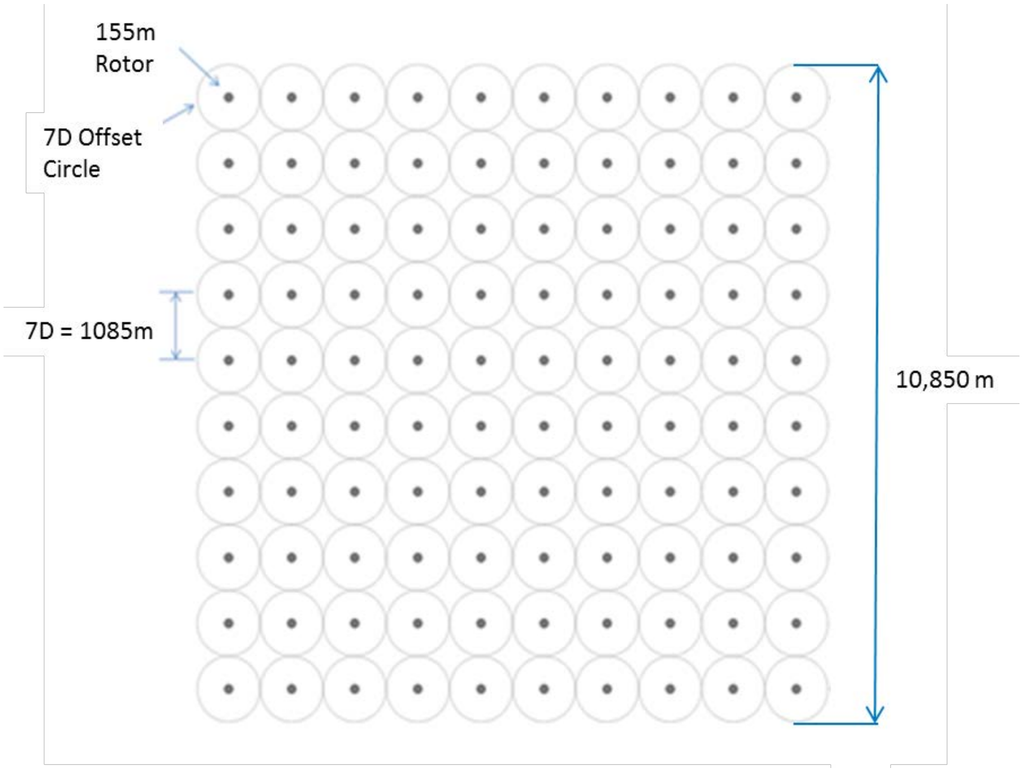


Figure 10. Unit 600-MW wind plant for Openwind energy and wake loss calculations using 7-by-7 rotor diameter (D) spacing and a generic 155-m rotor

The 5.1 MW/km^2 turbine array density of this 10-by-10 array is slightly lower than typical European offshore wind projects that have a mean turbine array density of 6.1 MW/km^2 as shown in Figure 11 (Musial et al 2013). These data were collected in 2013 for 18 European arrays, each of which have at least 200 MW of nameplate capacity.

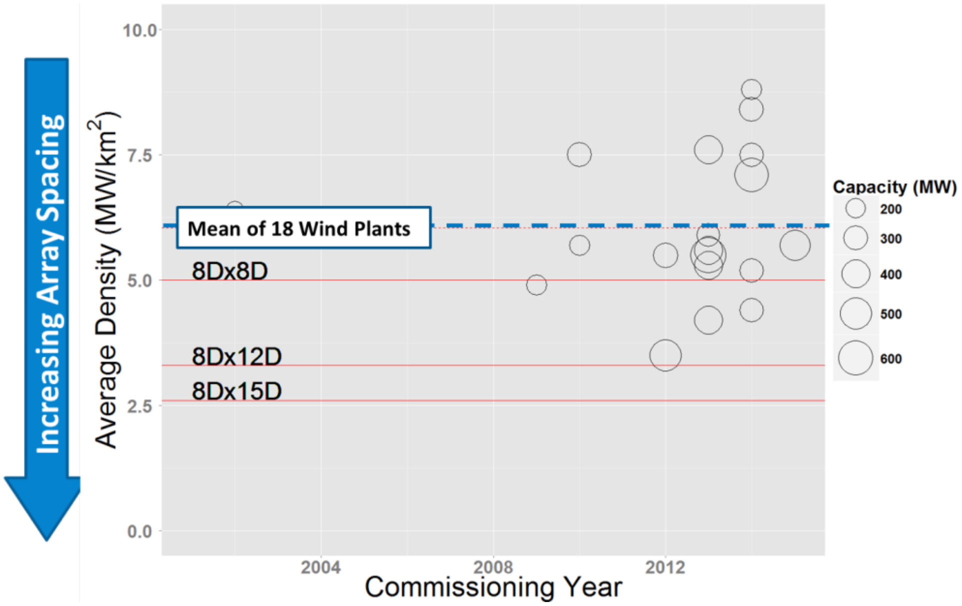


Figure 11. Turbine density for 18 large (> 200-MW capacity) offshore wind power projects showing turbine spacing scenarios for three reference configurations. *Figure from Musial et al2013*

The 600-MW 10-by-10 array shown in Figure 10 was replicated 7,159 times to cover the resource area from 0 to 50 nm without overlapping. Each 600-MW wind plant was modeled in Openwind individually on the GIS grid. No spaces were allowed between adjacent layouts. Although wake interactions were modeled inside each array, no wake interactions between layouts occurred because each wind plant was modeled independently without the presence of other arrays. The geographic area covered by this analysis is shown in Figure 12. Note that Hawaii and Alaska were not modeled in this analysis. For each location, Openwind calculated the energy yield and GCF, with and without wake losses.

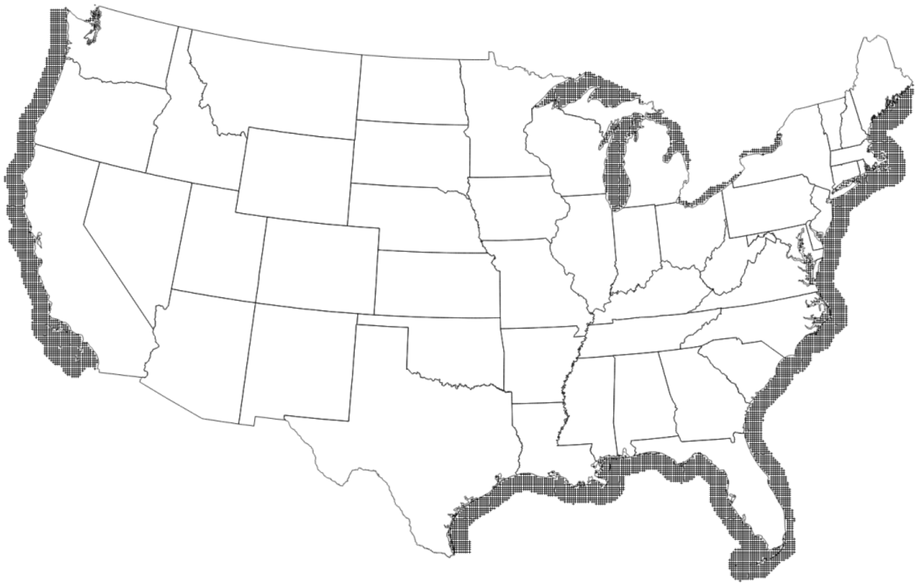


Figure 12. Using Openwind, 7,159-unit wind plants were modeled over the resource area of the continental United States from 0 to 50 nm

7.3.3 Calculating Gross Resource Energy Potential

Modeled hourly wind speed data from AWS Truepower was used with Openwind to estimate the GCF and wake losses using the NREL generic 6-MW wind turbine power curve for sites between 0 and 50 nm in the continental United States as described earlier.

This analysis was conducted before the decision to expand the gross resource area beyond the 50-nm boundary, established by Schwartz et al. (2010), was made. As shown in Figure 12, the analysis domain does not cover the entire gross resource potential area, which now extends to 200 nm and also includes Hawaii. Therefore, it was necessary to extrapolate the Openwind analysis data to generate the GCF for the regions between 50 and 200 nm and Hawaii. This was done by correlating the wind speed at each grid point with the GCF that was calculated in Openwind for that region. Areas beyond 50 nm were assigned a GCF and wake loss value based on the regional linear wind speed correlation. These linear correlations with Openwind data are shown in Figure 13 for the Atlantic, Gulf of Mexico, Great Lakes, and Pacific regions. Note that the Pacific region exhibited more scatter in the correlation and some nonlinear characteristics, especially at higher wind speeds. This unusual behavior is attributed to variability in Weibull k factors that tended to lower the energy production for the generic turbine at many West Coast sites.

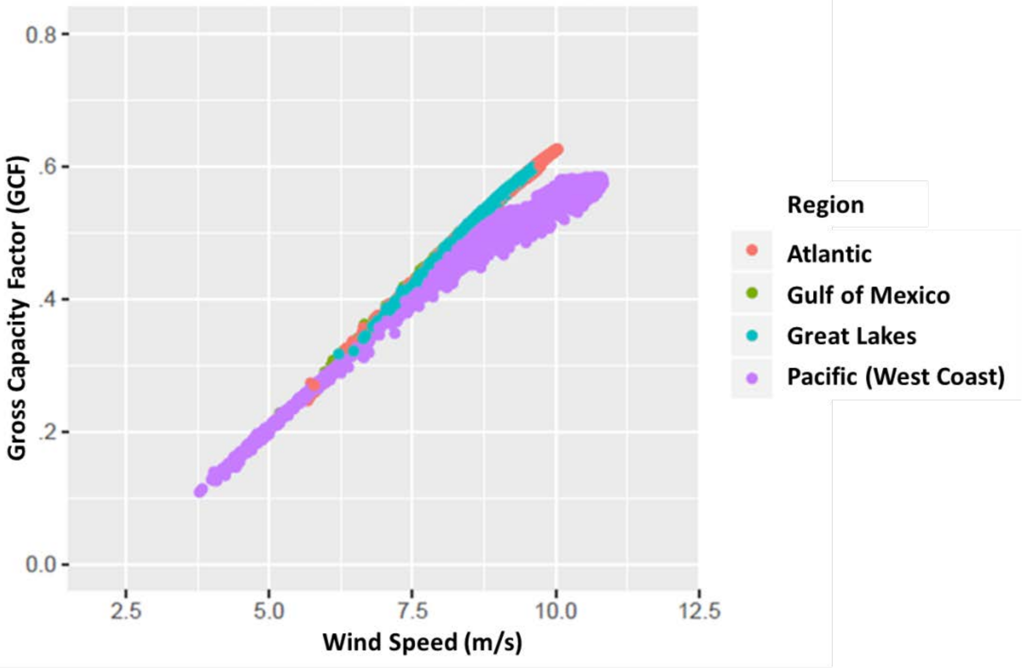


Figure 13. Gross capacity factor correlation with wind speed as derived regionally from Openwind data

This study found that when developing the GCF values for Hawaii that the Hawaiian Weibull characteristics do not correlate with the Pacific Weibull characteristics even though they are both in the Pacific region. When compared with other regions, the Hawaiian Weibull k values actually matched best with the Gulf of Mexico. Therefore, Hawaiian GCF values were assigned using correlations for the Gulf of Mexico Openwind data.

Relating the final GCF values at each grid point back to Eq. 1, the energy production potential was calculated at each grid point. As mentioned, the sum of all these energy values is 44,378 TWh/year, the theoretical gross energy resource potential for the United States, assuming no technology or use exclusions, and no losses. In the next section, losses will be applied to the gross energy resource without reducing the resource area.

7.4 Gross Offshore Energy Potential with Losses Included

To assess the realistic net energy available, losses must be considered to reduce the energy resource available by considering real-world operational effects. The losses considered in this study are only intended to reduce the GCF to nominal net energy levels and to approximate geographic biases as a result of wind speed and electrical transmission losses. This study does not provide a comprehensive assessment of losses on a site-specific basis and should not be used as a siting tool to determine net annual energy production (AEP). To perform these more rigorous analyses, refer to DNV KEMA (2013) and AWS Truepower (2014).

7.4.1 Losses

During modeling and analysis, the following resource assessment losses were deducted from the gross capacity factor values:

- Wake losses ranging from 4% to 12% were applied to the arrays via the Openwind analysis and regional correlations, using methodology similar to the methods described above for the GCF
- Electrical losses ranging from 1% to 5% were applied using a geospatial relationship that accounts for export cable length based on distance to shore and depth (Beiter et al 2016b)
- Availability losses were applied using a constant availability of 96% based on the *2014 Cost of Energy Review* (Mone et al. 2015)
- Other losses were assigned an additional constant 2%, based on internal NREL fixed/floating analyses (Beiter et al 2016b).

The AEP system losses were calculated using Eq. 2:

$$1 - (1 * (1 - \text{Electrical Losses}) * (1 - \text{Wake Losses}) * (1 - \text{Other Losses}) * \text{Availability}) \qquad (2)$$

The total losses assessed in this study over the entire resource area ranged from 12% to 23% depending on the site depth, distance from shore, and wind speed characteristics. However, the method of determining these losses would likely underestimate the total losses for a calculation of AEP when a full accounting of availability is conducted.

7.4.1.1 Wake Losses

The Openwind analysis described in Section 7.3.2 used to compute the GCF also computed the wake losses resulting from each of the 10-by-10 600-MW arrays. The Openwind data showed a strong correlation of wake losses with wind speed, where lower wind speeds generated higher wake losses. This outcome was expected because turbines sited in regions with low annual average wind speeds tend to run more often in Region 2 of the power curve (see Figure 9), where pitch systems cannot adjust for reduced wind speed. Figure 14 shows the regional correlations for the Atlantic, Gulf of Mexico, Great Lakes, and Pacific. In the chart, array efficiency is plotted against wind speed, where array efficiency is defined as the actual energy produced by the array, with wake losses present, divided by the energy production if each turbine were operating in unobstructed flow.

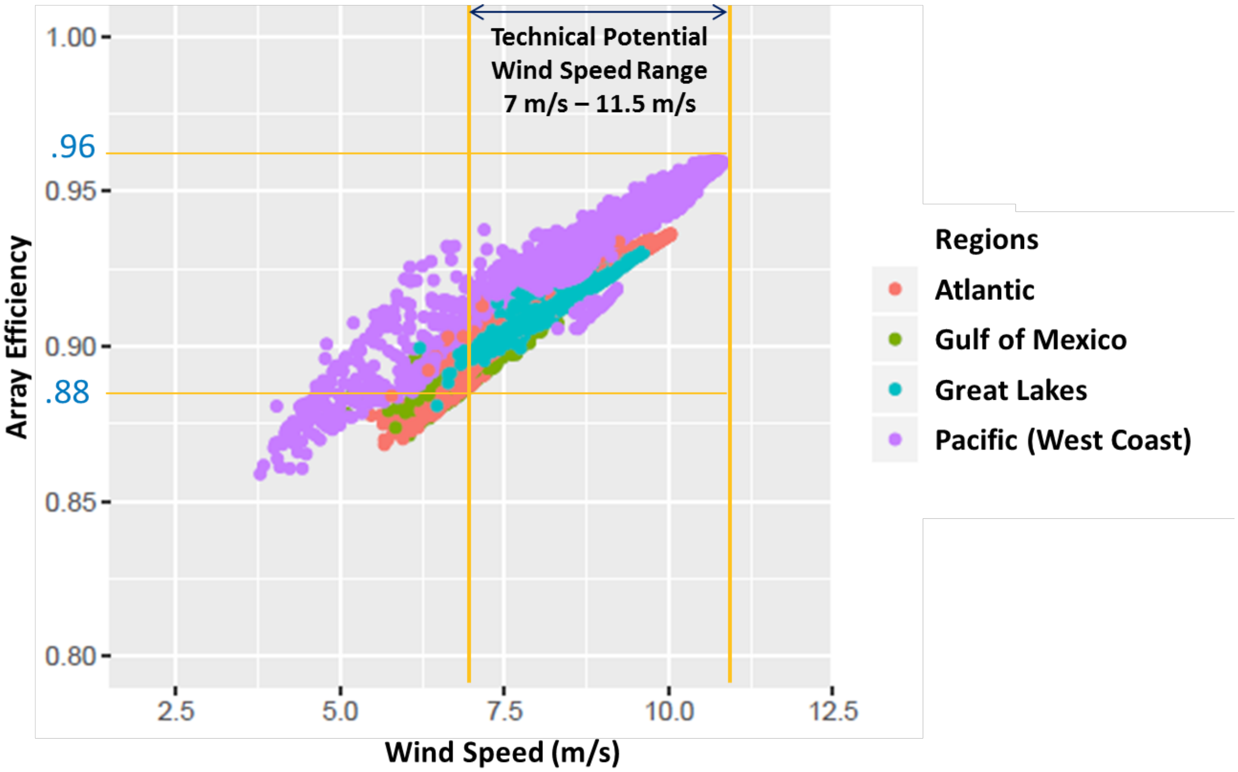


Figure 14. Array efficiency as a function of wind speed for four continental U.S. regions

Because no other losses are considered in the Openwind analysis, the computed array efficiency is directly related to wake losses. Within the relevant range of wind speeds, between 7.0 m/s and 11.5 m/s for the continental United States, Figure 14 shows that array efficiency varies from 0.88 at a 7.0-m/s wind speed to 0.96 for the highest wind speeds. This range corresponds to wake losses of 4% to 12%, respectively. Note that significant scatter is present in the Pacific region, but for the other regions the array efficiency shows stronger linear correlation, with regional differences attributed to variations in Weibull k and c parameters.

As with the GCF analysis, the Openwind wake loss analysis, represented in Figure 14, does not cover the expanded gross resource area out to 200 nm, or the Hawaiian Islands. As with the GCF, regional correlations with wind speed were conducted to assign wake losses to these areas. As with the gross capacity factor analysis, the Weibull k factors for the Gulf of Mexico were applied to Hawaii as they fit to the Hawaiian wind characteristics the best.

Losses other than those caused by the wake effects were accounted for more directly through generalized constants or by deriving values from other GIS layers.

7.4.1.2 *Electrical Losses*

The electrical system loss analysis used in the resource assessment was based on NREL offshore wind cost studies, which take into account how electrical system losses change with respect to the projects' distance from the point of cable landfall (Beiter et al. 2016b). Electrical system losses were calculated to account for the increased cable lengths as sites become deeper and more remote. Electrical losses are assumed to be primarily a function of distance from the point of interconnection (D_{StoL}) and water depth (WD), and are represented by Eq. 3:

$$\text{Electrical Losses} = \frac{\left[\begin{array}{c}(2.073 + (0.073 \times D_{S_{to_L}}) + (-0.002 \times D_{S_{to_L}}{}^{2}) + (1.712E - 5 \times D_{S_{to_L}}{}^{3}) + (-8.563E - 08 \times D_{S_{to_L}}{}^{4}) + \\ \left(1.570E - 10 \times D_{S_{to_L}}{}^{5}\right) + 0.001 \times WD + (-4.85E - 6 * WD^{2}) + (8.158 \times E - 08 \times WD^{3}) + (-4.131E - 12 \times WD^{4})\end{array}\right]}{100} \tag{3}$$

Figure 15 is a graphical representation of this equation, showing the lowest losses nearshore and in shallow water as predicted from these assumptions and this equation.

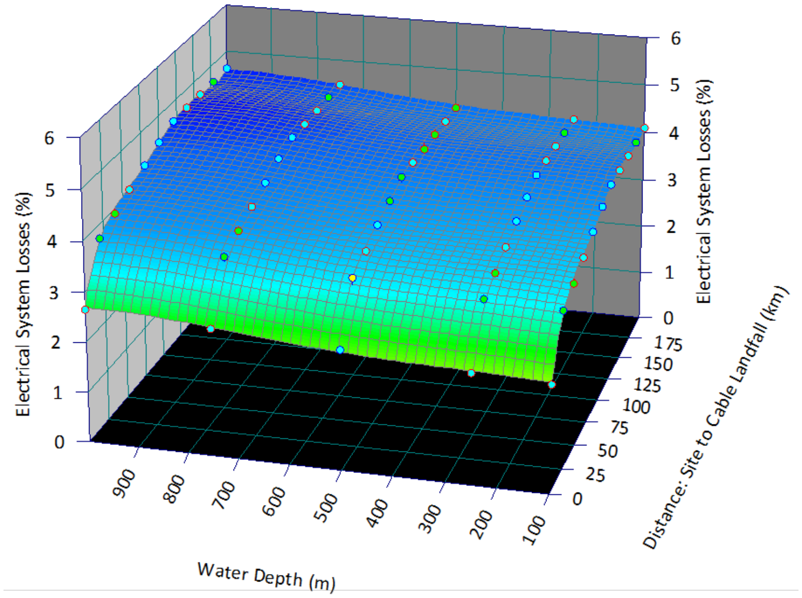


Figure 15. Electrical system losses from the offshore to the land-based substation

These system losses are based on the assumption that the least cost technology will be selected to transmit the power and are described more fully by Beiter et al. (2016b). The data represented in Figure 15 illustrate that these system electrical losses range between 1% and 5%.

7.4.1.3 Availability and Other Losses

The assessment of availability for offshore sites is highly dependent on meteorological ocean conditions, availability of service equipment, and the maturity of the land-based infrastructure. In this study, no attempt was made to disaggregate these variables. Instead, a nominal availability of 96% was chosen for all sites in the resource area. This value is based on the *2014 Cost of Energy Review* (Mone et al. 2015). Further analysis on availability would be necessary on a site-specific basis, but for the purpose of conducting this resource assessment, the constant value is considered sufficient.

A wide range of other additional losses are normally considered as well. These losses relate to turbine underperformance, curtailments, and environmental factors. A detailed assessment of these losses is not part of the scope of this study, however, they were addressed by assuming an additional 2% energy reduction for all grid points within the gross resource area. This value is also consistent with other recent NREL cost analysis (Beiter et al. 2016b).

7.4.2 Gross Offshore Resource Energy Potential with Losses

Gross offshore resource energy potential was calculated within the domain boundaries of 0-200 nm, which do not change when the losses are applied. With losses from wakes, electrical, availability, and other loss types, the gross offshore wind energy resource is reduced to 36,819 TWh/year (see Appendix D). When losses are included, the net capacity factor is calculated. These net capacity factors are mapped in Figure 16 for the entire gross offshore resource domain. This map is considered a relevant intermediate step toward calculating the technical energy potential, but the net capacity factor values in regions where the technology is not suitable have little value. The next section describes the technical resource potential for the United States.

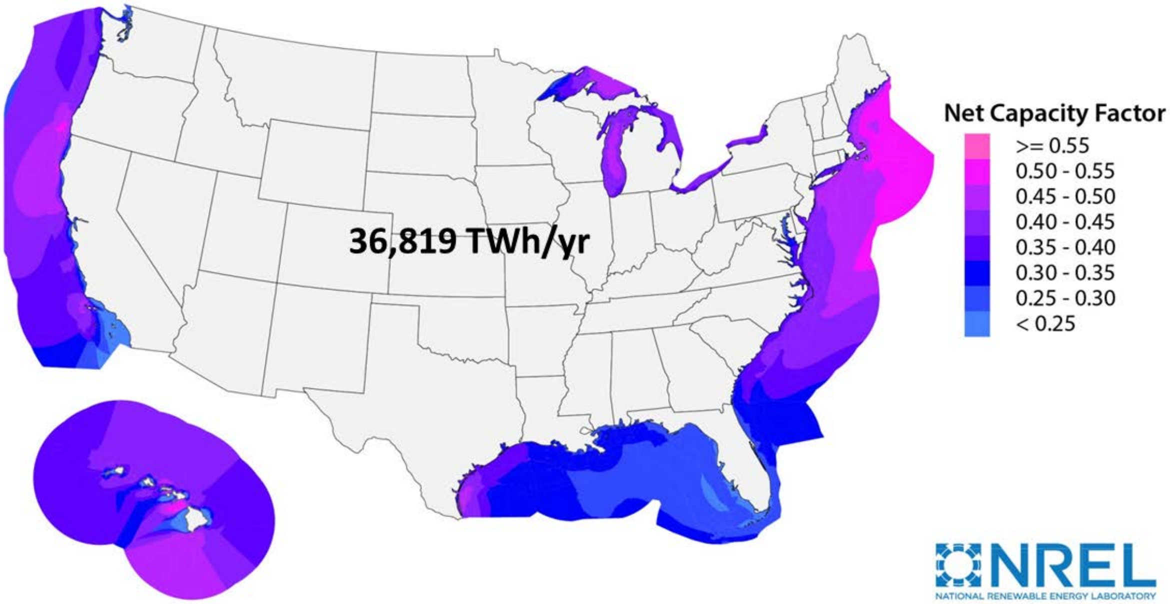


Figure 16. Net capacity factor for gross offshore wind resource area with losses

8 Technical Resource

The technical resource potential of offshore wind captures the subset of gross offshore wind resource potential that can be considered recoverable using available technology within reasonable limits. It also considers nominal land-use and environmental siting constraints without specifying specific site locations, which are defined as a percentage of the available area. It takes into account technical limits of offshore wind, including system performance and loss criteria, conflicting use and environmental constraints, and technology limits. The technology filters are generally applied as a function of precise geographical location and are considered in Section 8.1 through Section 8.4, whereas conflicting land-use and siting constraints are considered as a percentage of the remaining area (Section 8.5).

8.1 Technology Exclusions

Technology exclusions were applied to the gross resource potential to effectively restrict the resource area to geographic locations that are suitable for the technology based on industry experience to date. These technology exclusions are not intended to limit development or restrict innovation. In fact, it is expected that the boundaries used for technical potential in this report will change as new technology is developed and more experience is gained. Three technology filters were used to reduce the gross resource area for offshore wind to new boundaries defined for technical offshore wind resource potential. The technical resource area limits water depth to less than 1,000 m and wind speeds to areas with an annual average that is greater than 7 m/s, and excludes ice regions in the Great Lakes where depths are greater than 60 m, because floating wind technology has not yet been developed for platforms to survive in freshwater ice floes.

8.1.1 Water Depth Greater Than 1,000 m

Areas with a water depth greater than 1,000 m were excluded from the technical potential assessment. In consultation with global floating offshore wind technology developers, the 1,000-m depth was a reasonable cutoff for the resource assessment using current technology and industry experience, although no hard limits to deploying the technology in deeper waters were identified. This depth limit increases the cutoff that was used in the *Wind Vision* study scenario from 700 m to 1,000 m, but for this report, the 700-m delineation was retained so resources could be quantified at different depths. NREL cost models indicate that there will be some economic penalty in going to deeper water with floating wind technology but the cost relative to depth is mostly caused by increased mooring line and electric cable length, and greater distances for service crews to travel because deeper waters tend to be farther from shore. It has been noted in Japan that electric cables may be limited to depths less than 1,300 m (A. Bossler, personal communication based on direct translation, 2016). In California, Trident Winds has proposed a project at the 1,000-m depth near Morro Bay, so it would seem the depth limit of 1,000 m is set low enough to avoid eliminating critical resource area while remaining consistent with past studies (Arent 2012; Weinstein 2016).

Referring to the bathymetry map in Figure 5, the area shaded in dark blue was excluded because the water depth is above 1,000 m. Note that in most cases, the depth limit is reached before the 200-nm EEZ limit, which makes the 1,000-m isobath the exterior boundary of the technical resource area for most locations, and effectively reduces the average distance to shore.

Also note that the previous exterior boundary used by Schwartz et al. (2010) was defined as the 50-nm distance to shore. Using depth criteria rather than the previous distance-to-shore criteria for the technical resource area boundary adds resource area to many locations on the East Coast while reducing resource area on the West Coast, where a narrow continental shelf results in very deep water near shore.

8.1.2 Wind Speed Less Than 7 m/s

Areas with wind speeds less than 7 m/s at a 100-m elevation were also eliminated from the technical potential assessment, which corresponds approximately to areas below 30% net capacity factor.[8] The 7-m/s cutoff is consistent with exclusions that were used by Schwartz et al. (2010). This exclusion sets a lower bound for average wind speed where studies do not show any economic potential for large, utility-scale offshore wind development in the United States (Beiter et al. 2016b). This low-wind technical resource exclusion does not preclude development in areas with low winds, where high energy prices may warrant consideration of less energetic sites (e.g., island communities).

8.1.3 Water Depth Greater Than 60 m in the Great Lakes

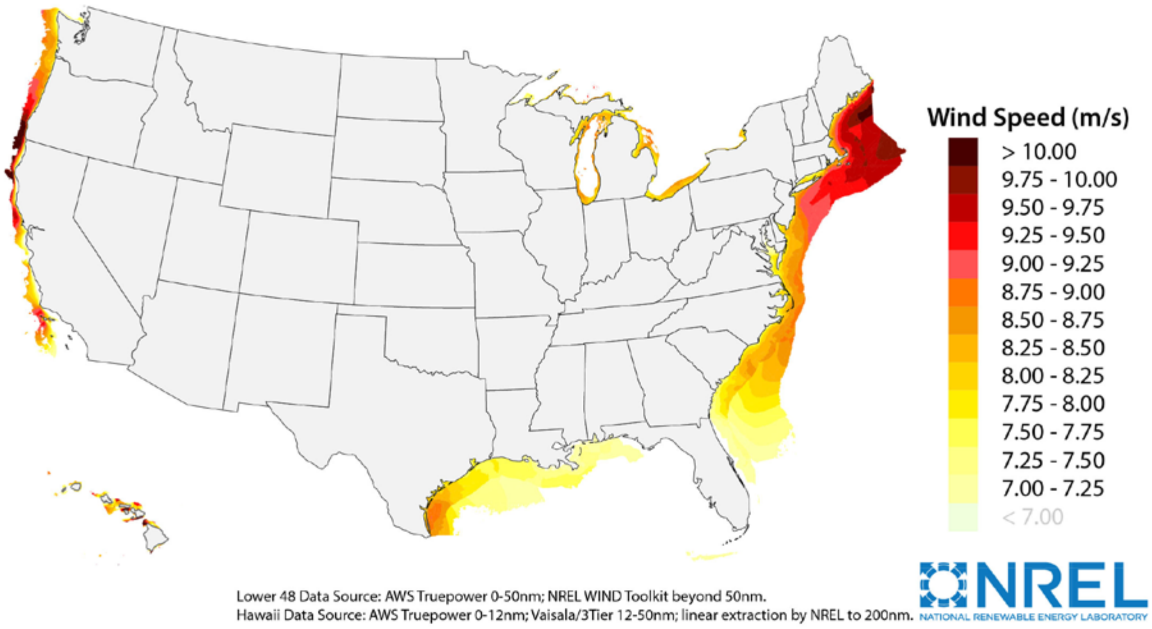
Technical resource potential also excludes the Great Lakes ice regions with depths greater than 60 m, which eliminates approximately 771 TWh/year of gross resource potential. The previous resource assessment performed by Schwartz et al. (2010) set no technology limits to account for ice in the Great Lakes. To date, there are no floating structures of any kind that are deployed year-round in the Great Lakes. Even navigation buoys are retrieved during the winter. Worldwide, deployment of wind turbines in freshwater ice conditions is rare and limited to fixed-bottom technology. Floating wind turbines could conceivably be designed to survive these conditions, however, there is no industry experience with this type of technology to date.

8.2 Technical Offshore Resource Area

Technical offshore resource area is determined by applying the technical exclusions described in Section 8.1 to the gross offshore resource area. When these exclusions are applied, the area is reduced from 3,599,975 km^2 to 886,026 km^2, a reduction of over 75% (Appendix E). Figure 17 shows the wind speed map for the continental United States and Hawaii for the total technical offshore resource area, which eliminates regions where depth is above 1,000 m and wind speed is below 7 /m/s, and in the Great Lakes region where depths are above 60 m.

---

[8] Note 30% net capacity factor was used as the cutoff for the *Wind Vision* study (DOE 2015). This analysis verified that 7 m/s and 30% net capacity factor yield nearly identical resource estimates.



Lower 48 Data Source: AWS Truepower 0-50nm; NREL WIND Toolkit beyond 50nm.
Hawaii Data Source: AWS Truepower 0-12nm; Vaisala/3Tier 12-50nm; linear extraction by NREL to 200nm.

Figure 17. Wind speed map for the U.S. offshore wind energy technical resource area

The technical offshore resource area was calculated by applying technical exclusions to the gross offshore resource area discussed in Section 7.1.

8.3 Technical Offshore Resource Capacity

The technical resource capacity was calculated in gigawatts by multiplying the technical resource area by the assumed nominal array power density of 3 MW/km^2, which results in a technical resource capacity of 2,658 GW for the entire United States excluding Alaska. This amount is the technically recoverable resource based on turbine nameplate capacity that is possible with today's technology if wind turbines were installed everywhere inside the boundaries of the technical offshore resource area and without regard for conflicting use or environmental restrictions (see Appendix E).

8.4 Technical Offshore Resource Energy Potential with Losses

Technical offshore resource energy potential with losses was calculated by applying the technology exclusion area reductions to the gross offshore resource energy potential with losses. This assessment was done without applying conflicting use exclusions, resulting in a technical resource energy potential of 9,284 TWh/year (see Appendix F). The technical energy potential was calculated using the same loss assumptions described in Section 7.4.1. The resulting energy values are the net energy resource that wind turbines would be able to produce within the technical offshore resource area if turbines were installed at 3 MW/km^2 everywhere inside the boundaries but without regard for conflicting use or environmental restrictions. These conflicting use and environmental reductions are discussed in Section 8.5.

8.5 Technical Offshore Resource Energy Potential with Land-Use and Environmental Exclusions

In this section, the technical offshore resource potential is further reduced both in the capacity of the total resource and in the net energy that can be produced.

8.5.1 Competing Use and Environmental Exclusions Data

In the 2015 *Wind Vision*, a Black & Veatch study was used to identify areas of competing-use and environmental exclusions (shown on the map in Figure 18 in red [Black & Veatch 2010]). These areas include national marine sanctuaries, marine protected areas, wildlife refuges, shipping and towing lanes, and offshore platforms and pipelines.

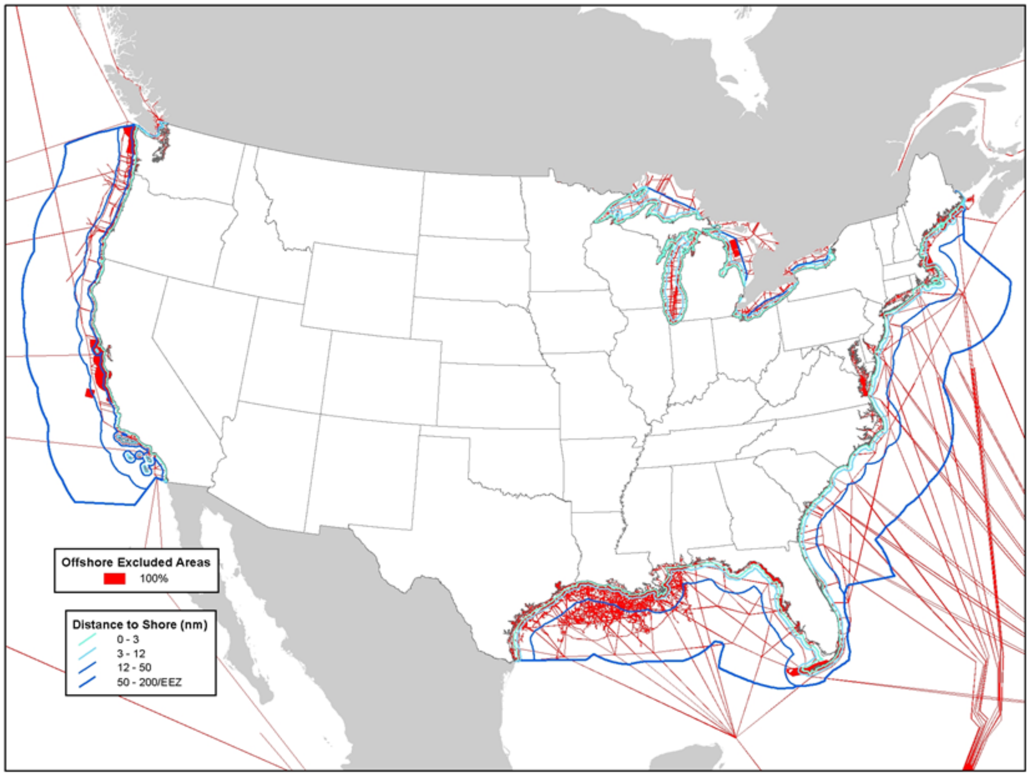


Figure 18. Estimated excluded areas due to competing use and environmental exclusions. *Figure from NREL; Black & Veatch (2010)*

For this study, additional analysis was performed to calculate the percentage of excluded areas that can be deducted from the technical potential resource totals as a function of distance to shore, and is shown in Figure 19.

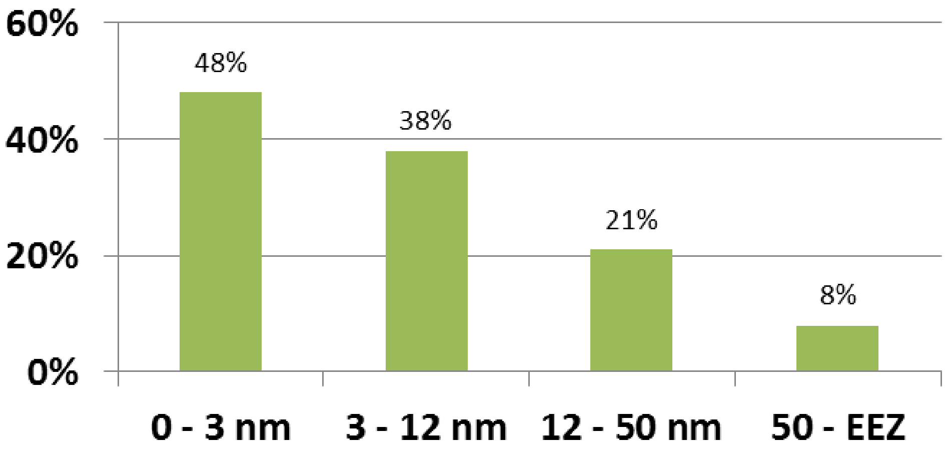


Figure 19. Excluded area percentages based on Black & Veatch study. *Figure provided by NREL, DOE (2015a), and Black & Veatch (2010)*

It is important to note that these percentages may not include all exclusions that may be required during a more rigorous marine spatial planning process and it is likely these percentages may increase under more detailed analysis with full stakeholder participation. However, for the purpose of this study, these percentage reductions serve to reduce the resource area by a significant amount and provide a more careful analysis that weighs these exclusions appropriately, in greater proportion closer to shore (Dhanju 2008, Krueger 2011).

8.5.2 Net Technical Resource Capacity with Land-Use and Environmental Exclusions

Using the Black & Veatch exclusions, net technical potential capacity for the contiguous United States and Hawaii is 2,058 GW (see Appendix H). This net technical capacity is calculated using the losses and conflicting use exclusions by applying Black & Veatch exclusion criteria.

8.5.3 Net Technical Resource Energy with Land-Use and Environmental Exclusions

Net technical resource potential energy, including Black & Veatch exclusions results in 7,203 TWh/year in U.S. offshore wind energy potential (see Appendix I). This net energy resource potential was calculated with losses and conflicting use exclusions by applying the Black & Veatch exclusion criteria.

Even after technical exclusions are applied, the resulting offshore wind technical potential is 2,058 GW, resulting in an energy potential of 7,203 TWh/year. This is almost twice the electric consumption of the United States (Energy Information Administration [EIA] 2015).

8.5.4 Relative Impact of Each Exclusion

The magnitudes of each of the reductions and exclusions used in this analysis, including losses, technical exclusions, and competing-use and environmental exclusions, were examined relative to the total gross resource potential and these values are shown in Table 2. The table shows the relative magnitude of the impact that each type of exclusion has on the amount of resource that is available in the final technical resource count that can be considered for actual development.

Table 2. Offshore Wind Resource Reductions by Exclusion Category

Gross Resource	**10,800 GW**		**44,378 TWh/yr**	
Exclusion Type	**Quantity of Capacity Reduction (GW)**	**Percent Change Capacity**	**Quantity of Annual Energy Reduction (TWh)**	**Percent Change Energy**
Losses (Relative to Gross Energy Potential)	NA	NA	7,559	17%
Depth Greater Than 1,000 m (Relative to Gross Resource)	6,904	64%	24,281	66%
Wind Speed Less Than 7 m/s (Relative to Gross Resource)	1,501	14%	3,517	10%
Depth Greater Than 60 m (Great Lakes Only) (Relative to Gross Resource)	204	2%	771	2%
Black & Veatch Exclusions (Relative to Technical Resource Area)	600	23%	2,081	23%
Total Exclusions Relative to Gross Resource*	8,742	81%	37,175	84%

*Note that total technical exclusions are smaller than the sum of all exclusions as a result of overlapping exclusion zones. Total exclusions are referenced from the total gross capacity/energy figures.

Note that some of the percentages are related to reductions from the gross potential and some are related to reductions from the technical potential as indicated. Also, some of the excluded areas overlap (e.g., water depth >1,000 m and wind speed < 7 m/s). Therefore, the sum of the percent reduction changes is greater than the total percent reductions shown in the last row of Table 2.

From Table 2, when the energy losses caused by wakes, electrical, availability, and other performance effects (Section 7.4.1) were applied, the gross resource energy resource potential was reduced by 7,559 TWh/year or 17% from the total 44,378 TWh/yr. Note that losses do not apply to resource capacity.

The exclusion that had the greatest impact on gross resource was the water depth exclusion. From a capacity standpoint, this resulted in a reduction of 6,904 GW from the original 10,800 GW in the gross offshore resource capacity. In terms of gross energy resource (taken after losses were assessed), the > 1,000 m water depth exclusion reduced the energy resource by 24,281 TWh/year, or approximately 66% of the gross resource area. Much of the excluded resource area as a result of depth is on the West Coast and Hawaii where water depths increase more rapidly with distance from shore. Generally, when the depth exclusion is applied in U.S. waters, the 1,000-m isobath becomes the outermost boundary of the technical resource area rather than the 200-nm EEZ; only one small region in the South Atlantic Bight has waters shallower than 1,000 m at the 200-nm EEZ boundary.

Wind speeds less than 7 m/s contributed to a reduction in gross resource capacity of 1,501 GW, or approximately 10%, indicating that most U.S. waters have some offshore wind energy resource. The resource capacity below 7 m/s that was excluded was mostly in the South Atlantic OCS and overlapped at some sites with sites that were also >1,000 m deep. These overlapping areas resulted in the sum of each technical exclusion category being larger than the total exclusions shown in the last row of Table 2.

For the Great Lakes only, approximately 204 GW of capacity was excluded where water depths exceeded 60 m. This technology limit was set to restrict floating wind systems from being deployed in freshwater ice environments in which the current floating technology may not be able to survive. This reduction accounted for only a 2% reduction in the gross resource capacity and energy potential, respectively.

The competing-use and environmental exclusions developed by Black & Veatch were applied after all other exclusions were assessed. Therefore, they were applied only to the technical offshore resource area, already reduced to 886,026 km^2 by including the technical exclusions. On average, these exclusions reduced the technical resource area to 686,541 km^2, or about 23% of the total remaining area. Note that these competing industry-use and possible environmental conflicts were applied as a function of distance from shore (as shown in Figure 19).

Overall, the total technical resource capacity was reduced by 81% from the original gross capacity of 10,800 GW to 2,058 GW. The total offshore resource energy potential of 44,378 TWh/year was reduced by about 84%, to 7,203 TWh/year. In spite of these reductions, the remaining technical resource potential is still abundant enough in most regions to allow for a relatively high degree of flexibility in site selection and settlement of competing-use conflicts. When compared to the total annual U.S. electricity consumption reported by E IA for 2014, the technical resource energy potential is almost double the 3,863 TWh used (EIA 2015).

9 State and Regional Data Comparisons

In the United States, there are 30 states that have a boundary on an ocean or a Great Lake. In these coastal states, about 78% of the electricity of the United States is used (Musial and Ram 2010). As the nation advances its clean energy policies, offshore wind is poised to play a key role in many of these states, and individual state policies are driving the pace of offshore wind development as much as key federal initiatives (Smith, Stehly, and Musial 2015).

The U.S. resource totals were counted by region and individual state. Figure 20 shows the net capacity factor plotted inside the technical resource area (described earlier) with the five U.S. regions defined under the *Wind Vision* study scenario (DOE 2015a).

Figure 20. Net capacity factor for technical potential energy resource with technical exclusions for five U.S. offshore wind resource regions

Note: The states included in each region are shaded to show which states are in each region.

9.1 Comparison of Gross Resource to Net Technical Potential

Figure 21 shows the U.S. offshore wind technical resource potential relative to the gross resource potential and how it is distributed among the five U.S. regions shown in Figure 20.

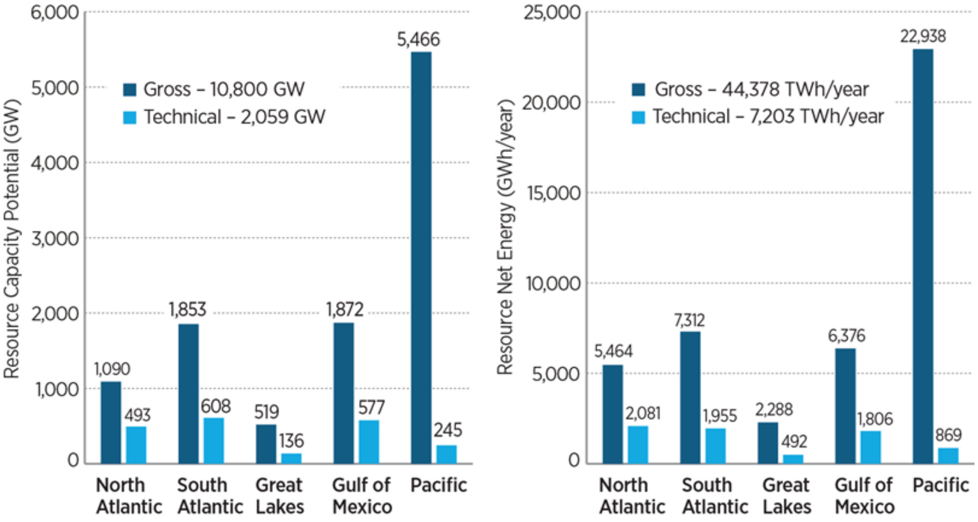


Figure 21. Offshore wind resource capacity (left) and net energy (right) gross resource (dark blue) and final net technical (light blue) potential estimates for five U.S. offshore wind resource regions

To reach the *Wind Vision* Study Scenario deployment of 86 GW, approximately 29,000 km^2 would be required for offshore wind development, which equates to approximately 4% of the nation's technical resource area (about 0.8% of the gross resource area). As estimated by the *Wind Vision* study, this amount would equate to approximately 7% of the U.S. electric consumption (DOE 2015a), with some coastal utilities potentially having much higher offshore wind electric generation penetrations on the grid. Each region shown in Figure 20 has the resource supply to contribute substantially to a viable offshore wind industry through deployment to serve its local and regional energy needs, as well the potential to participate in a robust manufacturing supply chain with supporting coastal infrastructure for marine construction and service operations.

9.2 State-by-State Comparisons

The net technical energy resource potential of 7,203 TWh/year for the United States was broken down for each state in this analysis. Figure 22 shows how the net energy potential is portioned for each state, divided into water depths of less than 60 m and greater than 60 m.

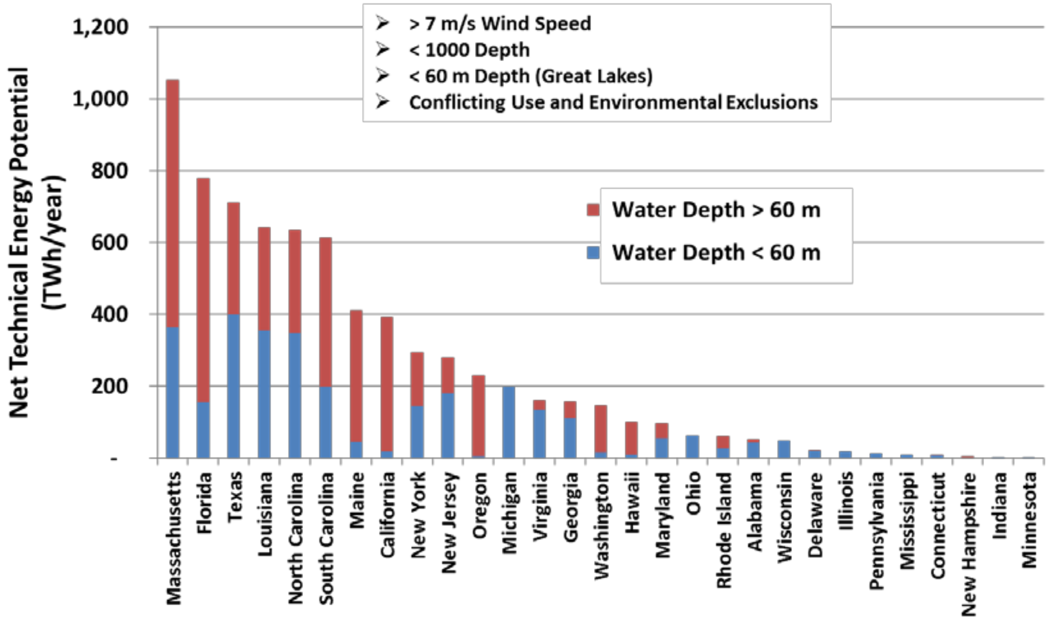


Figure 22. Offshore wind net technical energy potential (7,203 TWh/year) divided by state for water depths of less than 60 m (blue) and greater than 60 m (red)

The depth delineation at 60 m was used to distinguish the possible floating technology resource from the likely fixed-bottom resource. Figure 22 shows that after all the technology, conflicting-use, and environmental resource exclusions are deducted, Massachusetts has the largest fraction of total resource, followed by Florida, Texas, and Louisiana. The large energy resource in these southern states is attributed to a large quantity of ocean area that encompass relatively long coastlines and wide continential shelves. However, the quantity of the resource is not a good indication of resource quality. These southern states tend to have a high quantity of resource at low wind speeds between 7 m/s and 8 m/s, and net capacity factors are less than 35%.

To test the sensitivity of the net resource quantity to the wind speed technology exclusion criterion of 7 m/s, Figure 23 shows the distribution of net technical energy resource for the offshore states if the wind speed cutoff for the low wind speed technical exclusion were set to 8 m/s. In Figure 23, for winds above 8 m/s, Massachusetts' resource remains the highest with a net technical resource of over 1,000 TWh/year, whereas several states with lower wind speeds show virtually no net technical resource potential above 8 m/s. For this greater-than-8- m/s scenario, Massachusetts is now followed by North Carolina, Maine, South Carolina, and California.

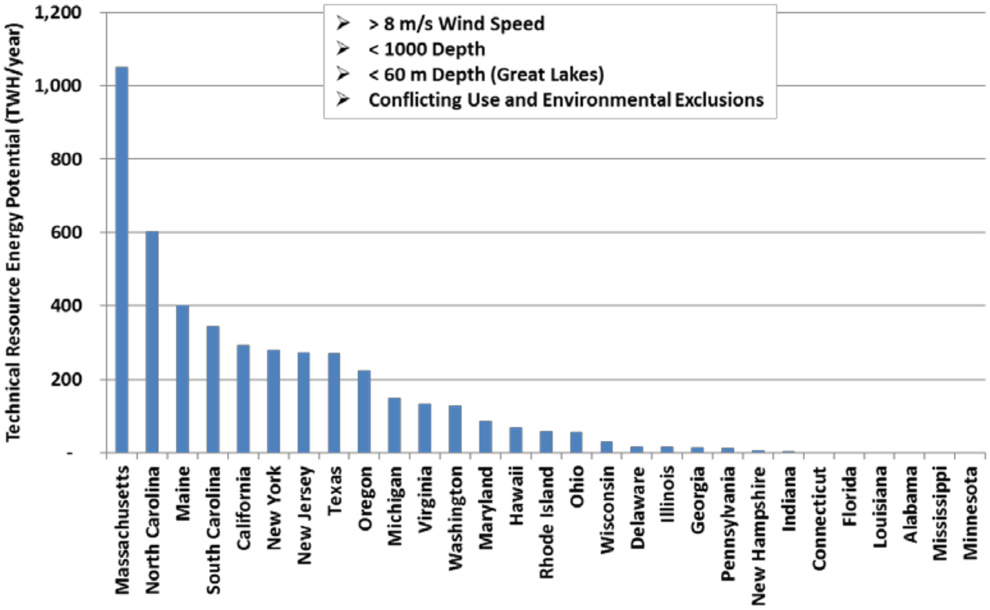


Figure 23. Offshore wind net technical energy potential with an 8-m/s wind speed exclusion by state

Figure 24 shows the ratio of each state's net technical resource potential compared to the state's total electric demand. The dashed red line indicates the level at which the state's electric load is equal to the state's resource. The figure shows that 19 states have resources that exceed their electric demand, and many states have resources many times greater.

In Figure 24, Maine, which has a relatively low electric demand (12.6 TWh/year according to the EIA [2014] figures), shows the greatest resource relative to its own electricity use, followed by Massachusetts, Hawaii, Rhode Island, South Carolina, and Louisiana.

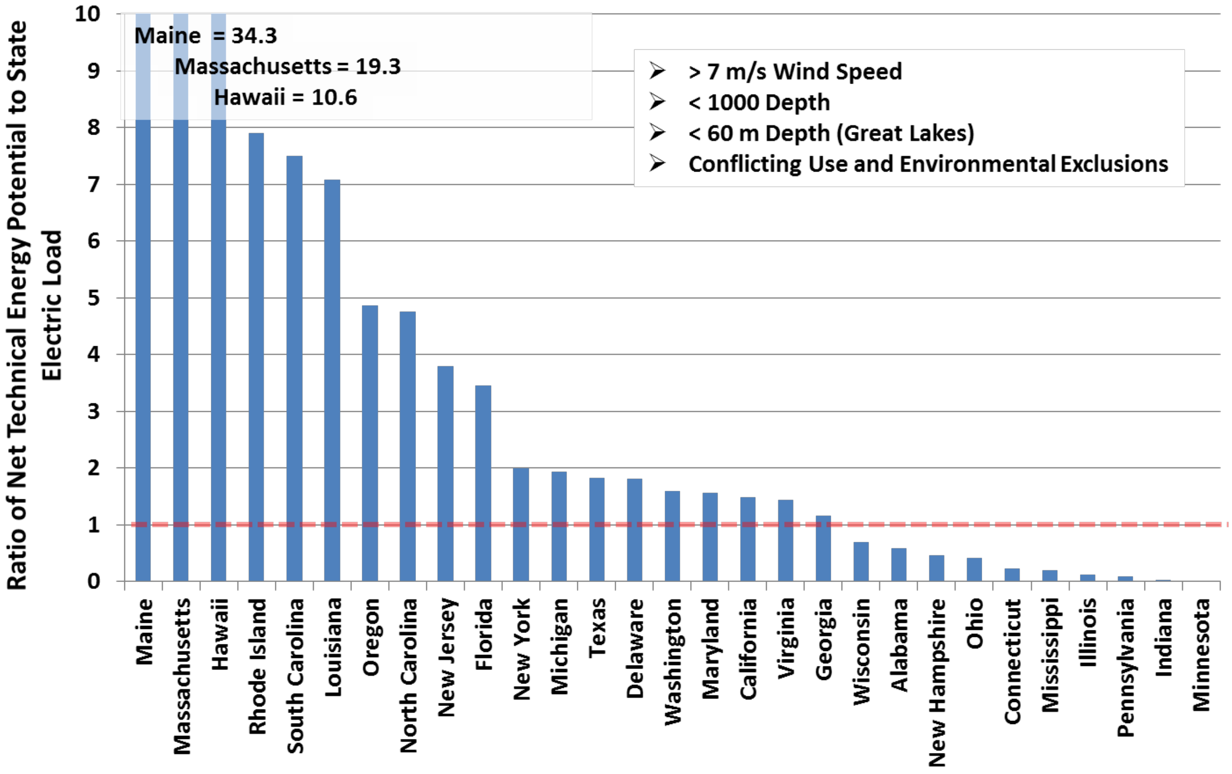


Figure 24. Ratio of net offshore wind technical energy resource potential to electric load by state. The dashed red line indicates the level at which the state's electric load is equal to its offshore wind technical resource potential. *Figure provided by NREL (2016) and EIA (2015c)*

Offshore wind has the advantage of providing significant economic benefits to states with copious resources through job growth, energy diversity, reduced pollution, electric system operational flexibility, and transmission congestion relief. However, in many offshore states, the current electric energy supply is imported from outside the state as shown in Figure 25.

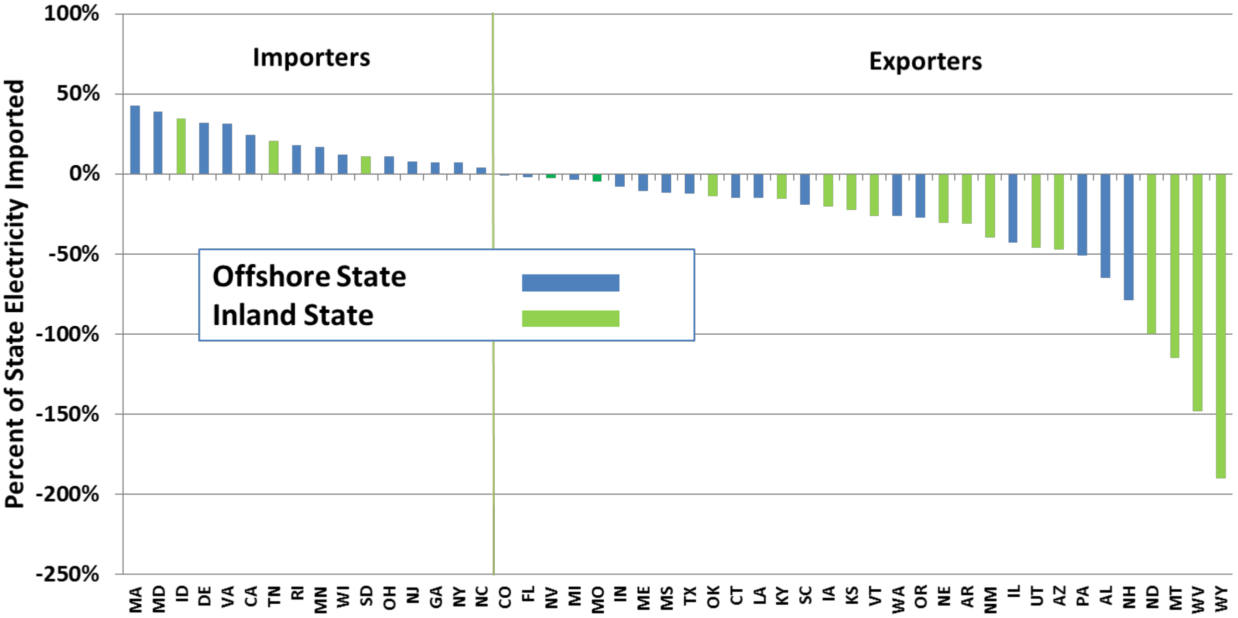


Figure 25. Percent of state electricity demand imported or exported *Figure provided by NREL (2016), EIA (2015b, 2015c)*

One of the reasons electricity is often imported is because of the lack of cost-effective indigenous resources. In planning future energy requirements in many states, offshore wind could provide a hedge to limit the required imports and help increase economic activity inside state borders (DOE 2015a; Beiter et al. 2016b).

9.3 Resource in State Versus Federal Waters

Out of more than 685,000 km^2 of technical potential resource area, 11.7%, or just over 80,000 km^2, lies in state waters. The remaining 606,000 km^2 is in federal waters. Table 3 details these results by distance from shore for the technical resource area with all exclusions applied.

Table 3. Technical Resource in State and Federal Waters

Distance to Shore (nm)	< 3	3 - 12	12 - 50	50 - 200	Totals	Percent of Technical Area
State Waters, only 0-3 nm (no exclusions) (km2)	102,141	0	0	0	102,141	
Additional State Waters in Great Lakes (no exclusions) (km2)	0	27,550	6,644	0	34,194	
Additional State Waters in TX and FL (no exclusions) (km2)	0	7,566	0	0	7,566	
Total State Waters (no exclusions) (km2)	102,141	35,116	6,644	0	143,901	
Total State Waters (with Exclusions) (km^2) TECHNICAL POTENTIAL	53,113	21,772	5,249	0	80,134	11.68%
Federal Waters Area (with Exclusions)(km^2)	0	66,789	270,908	268,161	605,858	88.32%
Total Area Technical Potential (with exclusions)(km^2)	53,113	88,561	276,156	268,161	685,992	100.00%

From the technical resource capacity in Appendix E, the area in state waters is 102,141 km^2 but was reduced by 48% to 53,113 km^2 to account for competing industry use and environmental exclusions (see Figure 19). In addition, the area in the Great Lakes, from 3 nm to the midlake Canadian border (or midlake between states), is also considered state waters. This area adds an additional 34,194 km^2 to the state water area, and can be broken down with 27,550 km^2 between 3 and 12 nm, and 6,644 km^2 between 12 and 50 nm. Also, in Texas, and on the gulf side of Florida, state waters extend to 9 nm. This area from 3 nm to 9 nm adds an additional 7,566 km^2 to the U.S. state waters. When the exclusions to account for competing industry use and environmental exclusions are applied (38% between 3 and 12 nm and 21% between 12 and 50 nm [from Figure 19]), the total state water technical potential area is 80,134 km^2.

Although there has been activity in state and federal waters, this study calculated that about 88.3% of the technical offshore wind resource potential area (605,858 km^2) in the United States is in federal waters and approximately 11.7% of the total technical resource area is in state waters. Because the majority of the resource is in federal waters, to build 86 GW of offshore wind by 2050 as prescribed by the *Wind Vision* Study Scenario, it is likely that most of the development would take place on the OCS under federal jurisdiction. Therefore, an efficient, clearly defined federal regulatory process that works closely with stakeholders to identify wind energy areas and facilitate the safe development of offshore wind projects is essential for the growth of offshore wind in the United States.

10 Summary and Key Findings

This report was sponsored by DOE to inform a new DOE/U.S. Department of the Interior offshore wind strategy scheduled to be released in 2016. This new resource assessment is the most comprehensive and up-to-date analysis of the offshore wind resource in the United States.

The report replaces the previous analysis done by NREL (Schwartz et al. 2010), which only considered gross resource capacity. By comparison, the gross resource capacity in this report increased from the 4,150 GW reported by Schwartz to 10,800 GW. This increase was because of the expansion of the resource domain that was extended from an arbitrary 50-nm outer boundary to the edge of the 200-nm EEZ defined by international law.

Gross resource capacity estimates are insufficient, however, for defining or estimating the developable resource area or actual deployment potential. Many offshore areas are unsuitable for offshore wind deployment on the basis of competing uses, or technical and environmental incompatibilities. As a result, exclusion criteria were developed and applied to the offshore resource area to filter out sites that are unlikely to be developable. Technical exclusions included all areas with water depth greater than 1,000 m, with wind speeds less than 7 m/s, and with water depths greater than 60 m (in the Great Lakes). The competing-use and environmental exclusions were applied by eliminating a percentage of the remaining area based on analysis performed by Black & Veatch and NREL as a function of distance to shore. The resource remaining after subtracting for these exclusions was the final technical resource potential. This technical resource potential with all exclusions applied is the best estimate of developable offshore resource area and is the primary metric for quantifying U.S. offshore wind potential in both installed capacity and energy production units.

Energy production estimates included with this analysis are based on 2015 turbine technology assumptions and include basic criteria for losses including wakes, electrical, and availability. Energy estimates enable better site-to-site comparisons especially on a regional level, but should not be used for site-specific engineering design.

Technical resource potential was found to be 2,058 GW of capacity at 3 MW/km^2 and 7,203 TWh/year of net energy production for the United States. This technical energy potential of 7,203 TWh/year is approximately twice the electricity used in the United States in 2014. On a capacity basis, the revised technical capacity potential is approximately half of the capacity estimated by Schwartz et al. (2010) but is a much better metric for estimating the developable resource.

The U.S. offshore wind resource compares favorably with the DOE *Wind Vision* scenario, which prescribes that 86 GW of offshore wind will be deployed by 2050. This scenario would require the United States to use only 0.8% of the gross resource area, or about 4.2% of the total technical resource potential area.

State-by-state comparisons indicate an abundance of resource potential in all U.S. regions relative to their electricity consumption. The best resource, based on quality and quantity, was found to be in northeast states such as Maine, Massachusetts, Rhode Island, New York, and New Jersey. Massachusetts has the highest technical offshore resource potential. Southern states such as Florida, Texas, and Louisiana all had large resource areas because of large coast lines and wider continental shelves, but the quality of their resource was lower due to lower wind speeds.

11 Recommendations for Future Analyses

The analyses presented in this report are based on modeled data by state and region. However, these data are not fully validated with measurements, especially hub-height wind speeds. More effort should be placed into reducing uncertainty of the data sets (Bailey et al. 2015).

Alaska's offshore resource has not yet been quantified. The state's resource should be quantitatively assessed and added to the WIND Toolkit database.

To integrate offshore wind into the grid at various regional locations, the time-varying component must be characterized better on a daily, seasonal, and yearly basis to allow for more robust modeling of electric systems and more precise estimates of the operational costs and capacity value benefits.

Future resource assessments should be conducted periodically on approximately a 5-year basis for the entire United States. The modeling capabilities are continuously improving and state-of-the-art mesoscale analysis tools are needed to aid regulators, policymakers, energy planners, and developers in determining capacity factors and seasonal capacity value, and to conduct comparative site selection and trade-offs.

References

Arent, D., P. Sullivan, D. Heimiller, A. Lopez, K. Eurek, J. Badger, H. E. Jørgensen, M. Kelly, L. Clarke, and P. Luckow. 2012. *Improved Offshore Wind Resource Assessment in Global Climate Stabilization Scenarios* (Technical Report). NREL/TP-6A20-55049. National Renewable Energy Laboratory (NREL), Golden, CO (US). http://www.nrel.gov/docs/fy13osti/55049.pdf.

AWS Truepower, LLC. 2010. OpenWind Theoretical Basis and Validation. http://www.awsopenwind.org/downloads/documentation/OpenWindTheoryAndValidation.pdf Accessed April 6, 2013.

AWS Truepower, LLC. 2012. Wind Resource Maps and Data: Methods and Validation. https://www.awstruepower.com/products/maps-and-resource-data Accessed July 2016.

AWS Truepower, LLC. 2014. "AWS Truepower Loss and Uncertainty Methods," Memorandum. June 5, 2014, https://www.awstruepower.com/assets/AWS-Truepower-Loss-and-Uncertainty-Memorandum-5-Jun-2014.pdf.

Bailey, B., Filippelli, M., and Baker, M. 2015. "Metocean Data Needs Assessment for US Offshore Wind Energy," Prepared for the U.S. Department of Energy under Contract DE-EE0005372: National Offshore Wind Energy Resource and Design Data Campaign—Analysis and Collaboration. usmodcore.com/.../AWST_MetoceanDataNeedsAssessment_DOE_FinalReport_14Jan2015.pdf

Beaver, J. 2006. *U.S. International Borders: Brief Facts*, Knowledge Services Group, Updated November 9, 2006, Order Code RS21729, https://fas.org/sgp/crs/misc/RS21729.pdf.

Beiter, P., W. Musial, and A. Smith. 2016a. *Terminology Guideline for Classifying Offshore Wind Energy Resources* (Technical Report), NREL/TP-6A20-65431. National Renewable Energy Laboratory (NREL), Golden, CO (US). www.nrel.gov/docs/fy16/65431.pdf.

Beiter, P., W. Musial, A. Smith, L. Kilcher, R. Damiani, M. Maness, S. Sirnivas, T. Stehly, V. Gevorgian, M. Mooney, and G. Scott. 2016b. *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.

Black & Veatch. 2010. Technology Characterization for Renewable Energy Electricity Futures Study: GIS Database of Offshore Wind Resource Competing Uses and Environmentally Sensitive Areas. Overland Park, KS: Black & Veatch. Unpublished report contracted by NREL.

Brown, A., P. Beiter, D. Heimiller, C. Davidson, P. Denholm, J. Melius, A. Lopez, D. Hettinger, D. Mulcahy, and G. Porro. 2015. *Estimating Renewable Energy Economic Potential in the United States: Methodology and Initial Results* (Technical Report.) NREL/TP-6A20-64503. National Renewable Energy Laboratory (NREL), Golden, CO (US). http://www.nrel.gov/docs/fy15osti/64503.pdf.

Campbell, S. 2016. “Growing interest in Hawaiian offshore potential” May 17, 2016 *Windpower Monthly*. Accessed July 2016. http://www.windpoweroffshore.com/article/1395274/growing-interest-hawaiian-offshore-potential.

Dhanju A., P. Whitaker, and W. Kempton. 2008. “Assessing offshore wind resources: An accessible methodology.” *Renewable Energy* 35: 1244–1254. http://www.sciencedirect.com/science/article/pii/S096014810700078X.

DOE (U.S. Department of Energy). 2013. “Report to Congress on Renewable Energy Resource Assessment Information for the United States.” DOE Office of Energy Efficiency and Renewable Energy (EERE). (EPACT) Prepared by the National Renewable Energy Laboratory.

DOE. 2015a. *Wind Vision: A New Era for Wind Power in the United States*. U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. DOE/GO-102015-4557. Washington, D.C. Accessed May 2015. http://www.energy.gov/sites/prod/files/WindVision_Report_final.pdf.

DOE. 2015b. *Revolution…Now. The Future Arrives for Five Clean Energy Technologies – 2015 Update*. U.S. Department of Energy (DOE), Washington, D.C. (US). http://www.energy.gov/sites/prod/files/2015/11/f27/Revolution-Now-11132015.pdf.

Draxl. 2015. Draxl, C, Clifton, A. Hodge, B., McCaa, J. *The Wind Integration National Dataset (WIND) Toolkit, Applied Energ*y, Volume 151, 1 August 2015, Pages 355-366, ISSN 0306-2619, http://dx.doi.org/10.1016/j.apenergy.2015.03.121.

DNV KEMA. *Framework for the Categorisation of Losses and Uncertainty for Wind Energy Assessments,* Sustainable Energy. energize - March 2013. Accessed July 2016. http://www.ee.co.za/wp-content/uploads/legacy/Energize_2013/08_ST_01_DNV_Categorisation-.pdf.

EIA. 2015a. “Summary Statistics for the United States, 2004 - 2014” Accessed July 2016. http://www.eia.gov/electricity/annual/

EIA. 2015b. “Net Generation by State by Type of Producer by Energy Source (EIA forms 906, 920, and 923).” Accessed June 2016. https://www.eia.gov/electricity/data/state/.

EIA. 2015c. “Retail Sales of Electricity by State by Sector by Provider (EIA form 861).” Accessed June 2016. https://www.eia.gov/electricity/data/state/.

Johnson, E. J. Meyer, M. Mager, A. Horel, and G. Holdmann. 2012. *Stranded Renewable Energy Resources of Alaska: A Preliminary Overview of Opportunities and Challenges to Development*. Prepared for: The National Renewable Energy Laboratory, The Alaska Center for Energy and Power, University of Alaska Fairbanks. http://www.uaf.edu/files/acep/Standed-Renewables-Report-Final.pdf.

Krueger, A. D., G. R. Parsons, and J. Firestone. 2011. *Valuing the Visual Disamenity of Offshore Wind Power 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/.

Lopez A., B. Roberts, D. Heimiller, N. Blair, and G. Porro. 2012. *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis* (Technical Report). NREL/TP-6A20-51946. National Renewable Energy Laboratory (NREL), Golden, CO (US). http://www.nrel.gov/docs/fy12osti/51946.pdf.

Lilley M., Firestone J., and Kempton . 2010. "The Effect of Wind Power Installations on Coastal Tourism," *Energies 2010*, 3: 1–22; doi:10.3390/en3010001 energies ISSN 1996-1073. http://www.mdpi.com/1996-1073/3/1/1.

Moné, C., T. Stehly, B. Maples, E. Settle. 2015. *2014 Cost of Wind Energy Review* (Technical Report). NREL/TP-6A20-64281. National Renewable Energy Laboratory (NREL), Golden, CO (US). http://www.nrel.gov/docs/fy16osti/64281.pdf.

Musial, W. and B. Ram. 2010. *Large-Scale Offshore Wind Power in the United States: Assessment of Opportunities and Barriers* (Technical Report). NREL/TP-500-40745. National Renewable Energy Laboratory, Golden, CO (US). http://www.nrel.gov/docs/fy10osti/40745.pdf.

Musial, W. D. 2013. "Proposed Methodology for Massachusetts Wind Energy Area Delineation," Webinar presentation at BOEM Massachusetts Task Force meeting, May 15, 2013. Accessed July 2016. http://www.nrel.gov/docs/fy14osti/60942.pdf.

Musial, W., D. Elliott, J. Fields, Z. Parker, G. Scott, C. Draxl. 2013. *Assessment of Offshore Wind Energy Leasing Areas for the BOEM New Jersey Wind Energy Area* (Technical Report). NREL/TP-5000-60403. National Renewable Energy Laboratory (NREL), Golden, CO (US). http://www.nrel.gov/docs/fy13osti/60403.pdf.

Namovicz, C. 2013. "Assessing the Economic Value of New Utility-Scale Renewable Generation Projects." Presented at the EIA Energy Conference, June 17, 2013. Washington, DC: U.S. Energy Information Administration. Accessed May 2015. http://www.eia.gov/conference/2013/pdf/presentations/namovicz.pdf.

NOAA. 2013 National Oceanic and Atmospheric Administration (NOAA). 2013. "U.S. Coastal Relief Model Volume," (New England). Accessed November 25, 2013. http://www.ngdc.noaa.gov/mgg/coastal/crm.html.

NOAA. 2015. "Great Lakes Bathymetry." Accessed July 2016. https://www.ngdc.noaa.gov/mgg/greatlakes/greatlakes.html

NOAA. 2016. "ETOPO1." Accessed July 2016. https://www.ngdc.noaa.gov/mgg/global/global.html

Phillips 1979. Phillips, G.T. "A Preliminary Users Guide for the NOABL Objectives Analysis Code", DOE/ET/20280-T1, July 1979. http://www.osti.gov/scitech/servlets/purl/7080538 Accessed 7-12-16.

Previsic, M., J. Epler, M. Hand, D. Heimiller, W. Short, K. Eurek. 2012. *The Future Potential of Wave Power in the United States*. RE-Vision, Sacramento, CA. http://www.re-vision.net/documents/The%20Future%20of%20Wave%20Power%20MP%209-20-12%20V2.pdf.

Schwartz, M., D. Heimiller, S. Haymes, W. Musial, W. 2010. *Assessment of Offshore Wind Energy Resources for the United States* (Technical Report). NREL/TP-500-45889. National Renewable Energy Laboratory (NREL), Golden, CO (US).http://www.nrel.gov/docs/fy10osti/45889.pdf.

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

Thormahlen, L. 1999. *Boundary Development on the Outer Continental Shelf*. OCS Report MMS 99-006.: Department of the Interior Minerals Management Service. Lakewood, CO. http://www.worldcat.org/title/boundary-development-on-the-outer-continental-shelf/oclc/263996802.

Weinstein, A. 2016. "Morro Bay Offshore: a 1,000 MW floating offshore wind farm." Presentation given at the Integrated Energy Policy Report Workshop on Offshore Renewable Energy, Sacramento, CA, May 25, 2016.

Appendices

Appendices A through I provide the raw data from the current resource assessment. Each appendix provides a breakdown of the resource by water depth, distance from shore, and wind speed. These data are broken down by state in alphabetical order. The appendices are presented in the same order described in Section 5 and outlined in Figure 2. Most of the analysis in Section 9 comes directly from the data provided in Appendix I.

Appendix A. Gross Offshore Resource Area Tables

The Tables in Appendix A display the data for Gross Offshore Resource Area by water depth, distance from shore and wind speed as discussed in Section 7.

Table A-1. Gross Offshore Wind Potential by Water Depth: Area (km^2)

State	< 30 m	30–60 m	60–700 m	700–1000 m	< 1000 m	Grand Total
Alabama	4,854	2,900	2,340	1,204	1,585	12,883
California	3,468	3,222	48,518	30,862	479,988	566,058
Connecticut	1,224	263	40	0	0	1,527
Delaware	2,351	655	38	0	0	3,044
Florida	102,000	55,117	118,478	72,269	86,386	434,248
Georgia	10,817	4,948	3,383	1,914	0	21,063
Hawaii	1,105	1,354	14,666	5,105	979,257	1,001,486
Illinois	1,396	994	1,800	0	0	4,190
Indiana	591	0	0	0	0	591
Louisiana	43,113	16,716	34,147	14,418	151,369	259,763
Maine	4,797	2,773	34,939	0	0	42,509
Maryland	7,931	3,441	3,520	536	28,175	43,603
Massachusetts	10,828	25,182	57,507	2,014	86,411	181,943
Michigan	18,956	14,284	65,525	0	0	98,766
Minnesota	277	274	6,079	0	0	6,631
Mississippi	2,980	279	0	0	0	3,258
New Hampshire	146	143	416	0	0	706
New Jersey	8,841	12,402	8,150	711	25,060	55,164
New York	8,009	11,304	19,068	909	15,899	55,188
North Carolina	30,371	16,242	21,718	7,443	193,375	269,149
Ohio	9,145	0	0	0	0	9,145
Oregon	693	786	23,440	4,468	139,882	169,270
Pennsylvania	1,480	432	0	0	0	1,912
Rhode Island	1,078	2,480	2,916	139	470	7,083
South Carolina	17,860	8,320	26,176	19,338	7,563	79,258
Texas	35,525	20,430	26,878	10,308	37,872	131,013
Virginia	14,411	5,065	2,494	349	8,790	31,110
Washington	5,031	3,034	14,197	4,139	58,850	85,250
Wisconsin	5,209	3,671	15,283	0	0	24,163
Total	354,488	216,712	551,717	176,126	2,300,932	3,599,975

Table A-2. Gross Offshore Wind Potential by Distance from Shore: Area (km^2)

State	< 3 nm	3–12 nm	12–50 nm	50–200 nm	Grand Total
Alabama	1,794	1,534	6,073	3,483	12,883
California	10,401	38,770	110,793	406,094	566,058
Connecticut	1,527	0	0	0	1,527
Delaware	1,184	671	1,179	10	3,044
Florida	33,140	35,362	124,846	240,901	434,248
Georgia	1,192	2,691	8,793	8,387	21,063
Hawaii	8,560	29,274	141,483	822,169	1,001,486
Illinois	497	1,574	2,119	0	4,190
Indiana	347	245	0	0	591
Louisiana	13,251	12,009	46,611	187,892	259,763
Maine	6,404	7,946	18,843	9,316	42,509
Maryland	6,087	935	5,543	31,038	43,603
Massachusetts	5,531	7,087	27,568	141,757	181,943
Michigan	17,946	36,885	43,934	0	98,766
Minnesota	1,402	3,270	1,959	0	6,631
Mississippi	1,938	749	571	0	3,258
New Hampshire	187	365	153	0	706
New Jersey	2,547	3,664	14,020	34,932	55,164
New York	6,883	8,911	14,296	25,098	55,188
North Carolina	10,534	8,985	41,710	207,920	269,149
Ohio	1,936	4,150	3,060	0	9,145
Oregon	2,746	8,583	33,022	124,919	169,270
Pennsylvania	418	1,206	288	0	1,912
Rhode Island	929	1,527	2,788	1,839	7,083
South Carolina	2,159	5,269	19,347	52,482	79,258
Texas	15,230	9,545	36,223	70,015	131,013
Virginia	6,760	3,046	10,207	11,097	31,110
Washington	8,719	5,132	18,565	52,835	85,250
Wisconsin	5,130	9,552	9,481	0	24,163
Total	175,381	248,939	743,473	2,432,183	3,599,975

Table A-3. Gross Offshore Wind Potential by Wind Speed: Area (km^2)

State	< 7 m/s	7–7.25 m/s	7.25–7.5 m/s	7.5–7.75 m/s	7.75–8 m/s	8–8.25 m/s	8.25–8.5 m/s	8.5–8.75 m/s	8.75–9 m/s	9–9.25 m/s	9.25–9.5 m/s	9.5–9.75 m/s	9.75–10 m/s	10–10.25 m/s	10.25–10.5 m/s	10.5–10.75 m/s	10.75–11 m/s	11–11.25 m/s	11.25–11.5 m/s	Grand Total
Alabama	4,347	5,426	3,111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,883
California	58,758	11,380	17,188	20,821	26,638	46,300	87,822	36,051	36,808	71,147	51,419	39,537	30,216	17,367	8,741	4,865	1,001	0	0	566,058
Connecticut	154	156	217	458	373	170	0	0	0	0	0	0	0	0	0	0	0	0	0	1,527
Delaware	26	112	131	221	344	680	1,014	511	5	0	0	0	0	0	0	0	0	0	0	3,044
Florida	289,178	87,808	45,988	11,138	137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	434,248
Georgia	475	391	3,955	9,675	4,827	1,740	0	0	0	0	0	0	0	0	0	0	0	0	0	21,063
Hawaii	23,704	4,826	7,743	20,647	16,282	139,192	185,565	124,674	212,008	86,764	19,351	18,924	42,427	53,659	38,690	3,596	897	667	1,871	1,001,486
Illinois	0	3	25	61	83	149	1,771	2,085	13	0	0	0	0	0	0	0	0	0	0	4,190
Indiana	0	5	29	56	75	171	255	1	0	0	0	0	0	0	0	0	0	0	0	591
Louisiana	104,709	89,186	28,111	35,986	1,770	0	0	0	0	0	0	0	0	0	0	0	0	0	0	259,763
Maine	411	417	502	589	585	758	1,080	1,237	1,647	2,385	5,731	13,918	8,749	4,499	0	0	0	0	0	42,509
Maryland	3,683	1,184	665	400	129	424	3,766	2,491	4,842	13,434	6,645	5,939	0	0	0	0	0	0	0	43,603
Massachusetts	29	76	116	211	331	517	1,082	1,777	2,316	3,112	28,179	92,826	51,370	0	0	0	0	0	0	181,943
Michigan	812	1,137	1,866	3,440	7,033	13,470	13,827	17,348	24,405	7,797	4,963	2,668	0	0	0	0	0	0	0	98,766
Minnesota	1,815	1,545	1,550	1,163	556	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6,631
Mississippi	1,461	1,316	482	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,258
New Hampshire	25	8	8	22	25	31	88	142	202	129	25	0	0	0	0	0	0	0	0	706
New Jersey	55	114	282	427	638	793	2,437	5,850	5,515	26,109	9,778	3,166	0	0	0	0	0	0	0	55,164
New York	221	231	437	713	1,840	4,789	5,888	851	1,445	11,992	25,133	1,649	0	0	0	0	0	0	0	55,188
North Carolina	978	681	1,147	3,761	14,180	23,780	49,636	56,573	52,500	36,779	24,099	5,038	0	0	0	0	0	0	0	269,149
Ohio	0	5	45	225	877	2,610	4,067	1,318	0	0	0	0	0	0	0	0	0	0	0	9,145
Oregon	737	265	323	379	457	2,978	21,409	52,491	50,937	14,977	8,515	4,554	4,037	1,976	1,881	2,241	1,114	0	0	169,270
Pennsylvania	0	0	2	16	42	376	1,092	384	0	0	0	0	0	0	0	0	0	0	0	1,912
Rhode Island	63	96	171	59	74	147	170	259	563	533	4,917	32	0	0	0	0	0	0	0	7,083
South Carolina	234	296	399	12,558	26,159	25,417	11,036	3,160	0	0	0	0	0	0	0	0	0	0	0	79,258
Texas	63	197	41,006	29,943	24,605	9,329	9,126	9,845	6,834	66	0	0	0	0	0	0	0	0	0	131,013
Virginia	1,029	440	782	1,635	2,900	2,117	3,880	7,093	7,996	2,540	698	0	0	0	0	0	0	0	0	31,110
Washington	6,973	744	642	978	1,223	9,360	18,924	27,346	18,320	741	0	0	0	0	0	0	0	0	0	85,250
Wisconsin	557	779	2,051	1,532	1,907	1,390	2,548	6,039	7,353	7	0	0	0	0	0	0	0	0	0	24,163
Total	500,497	208,823	158,969	157,112	134,090	286,688	426,484	357,526	433,709	278,512	189,451	188,252	136,799	77,500	49,312	10,702	3,011	667	1,871	3,599,975

Appendix B. Gross Offshore Resource Capacity Tables

The Tables in Appendix B display the data for Gross Offshore Wind Potential by water depth, distance from shore and wind speed as discussed in Section 7.2.

Table B-1. Gross Offshore Wind Potential by Water Depth: Capacity (MW)

State	< 30 m	30–60 m	60–700 m	700–1000 m	< 1000 m	Grand Total
Alabama	14,562	8,699	7,020	3,612	4,756	38,650
California	10,403	9,665	145,555	92,586	1,439,965	1,698,173
Connecticut	3,673	790	120	0	0	4,582
Delaware	7,053	1,964	115	0	0	9,132
Florida	305,999	165,350	355,433	216,806	259,157	1,302,745
Georgia	32,451	14,845	10,150	5,741	0	63,188
Hawaii	3,314	4,062	43,998	15,314	2,937,771	3,004,459
Illinois	4,188	2,983	5,399	0	0	12,570
Indiana	1,774	0	0	0	0	1,774
Louisiana	129,339	50,148	102,440	43,254	454,107	779,288
Maine	14,391	8,320	104,817	0	0	127,528
Maryland	23,792	10,323	10,561	1,609	84,524	130,809
Massachusetts	32,483	75,547	172,522	6,042	259,234	545,828
Michigan	56,868	42,853	196,576	0	0	296,297
Minnesota	832	823	18,238	0	0	19,892
Mississippi	8,939	836	0	0	0	9,775
New Hampshire	438	430	1,249	0	0	2,117
New Jersey	26,524	37,206	24,449	2,132	75,181	165,491
New York	24,026	33,912	57,203	2,728	47,696	165,565
North Carolina	91,113	48,726	65,154	22,330	580,124	807,447
Ohio	27,436	0	0	0	0	27,436
Oregon	2,079	2,359	70,321	13,404	419,647	507,810
Pennsylvania	4,441	1,295	0	0	0	5,737
Rhode Island	3,235	7,440	8,749	418	1,409	21,250
South Carolina	53,581	24,960	78,528	58,014	22,690	237,773
Texas	106,576	61,291	80,634	30,923	113,615	393,040
Virginia	43,234	15,194	7,483	1,048	26,371	93,330
Washington	15,092	9,103	42,590	12,417	176,549	255,751
Wisconsin	15,626	11,012	45,849	0	0	72,488
Total	1,063,464	650,137	1,655,152	528,378	6,902,796	10,799,926

Table B-2. Gross Offshore Wind Potential by Distance from Shore: Capacity (MW)

State	< 3 nm	3–12 nm	12–50 nm	50–200 nm	Grand Total
Alabama	5,382	4,601	18,218	10,449	38,650
California	31,203	116,310	332,379	1,218,281	1,698,173
Connecticut	4,582	0	0	0	4,582
Delaware	3,552	2,014	3,537	29	9,132
Florida	99,419	106,086	374,537	722,703	1,302,745
Georgia	3,577	8,072	26,379	25,160	63,188
Hawaii	25,680	87,823	424,448	2,466,508	3,004,459
Illinois	1,491	4,723	6,357	0	12,570
Indiana	1,041	734	0	0	1,774
Louisiana	39,754	36,027	139,832	563,675	779,288
Maine	19,211	23,838	56,530	27,948	127,528
Maryland	18,262	2,804	16,628	93,115	130,809
Massachusetts	16,592	21,262	82,704	425,270	545,828
Michigan	53,839	110,656	131,801	0	296,297
Minnesota	4,205	9,810	5,877	0	19,892
Mississippi	5,814	2,248	1,713	0	9,775
New Hampshire	562	1,095	460	0	2,117
New Jersey	7,642	10,992	42,061	104,796	165,491
New York	20,650	26,732	42,888	75,295	165,565
North Carolina	31,603	26,956	125,129	623,759	807,447
Ohio	5,807	12,449	9,180	0	27,436
Oregon	8,237	25,750	99,066	374,757	507,810
Pennsylvania	1,253	3,619	864	0	5,737
Rhode Island	2,787	4,581	8,364	5,518	21,250
South Carolina	6,478	15,807	58,042	157,446	237,773
Texas	45,691	28,636	108,669	210,044	393,040
Virginia	20,281	9,137	30,620	33,291	93,330
Washington	26,156	15,395	55,694	158,506	255,751
Wisconsin	15,389	28,656	28,443	0	72,488
Total	526,143	746,816	2,230,418	7,296,549	10,799,926

Table B-3. Gross Offshore Wind Potential by Wind Speed: Capacity (MW)

State	< 7 m/s	7–7.25 m/s	7.25–7.5 m/s	7.5–7.75 m/s	7.75–8 m/s	8–8.25 m/s	8.25–8.5 m/s	8.5–8.75 m/s	8.75–9 m/s	9–9.25 m/s	9.25–9.5 m/s	9.5–9.75 m/s	9.75–10 m/s	10–10.25 m/s	10.25–10.5 m/s	10.5–10.75 m/s	10.75–11 m/s	11–11.25 m/s	11.25–11.5 m/s	Grand Total
Alabama	13,041	16,277	9,332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38,650
California	176,275	34,141	51,565	62,463	79,914	138,899	263,466	108,153	110,424	213,440	154,256	118,611	90,647	52,100	26,223	14,595	3,002	0	0	1,698,173
Connecticut	461	467	650	1,374	1,120	511	0	0	0	0	0	0	0	0	0	0	0	0	0	4,582
Delaware	78	337	392	662	1,033	2,039	3,041	1,534	16	0	0	0	0	0	0	0	0	0	0	9,132
Florida	867,533	263,424	137,964	33,414	411	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,302,745
Georgia	1,425	1,173	11,865	29,026	14,480	5,219	0	0	0	0	0	0	0	0	0	0	0	0	0	63,188
Hawaii	71,112	14,477	23,230	61,940	48,846	417,575	556,696	374,023	636,024	260,292	58,052	56,773	127,281	160,976	116,070	10,788	2,691	2,002	5,612	3,004,459
Illinois	0	9	75	182	249	448	5,313	6,254	40	0	0	0	0	0	0	0	0	0	0	12,570
Indiana	1	15	86	168	226	512	764	3	0	0	0	0	0	0	0	0	0	0	0	1,774
Louisiana	314,127	267,559	84,334	107,957	5,310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	779,288
Maine	1,234	1,252	1,505	1,767	1,756	2,273	3,241	3,711	4,940	7,154	17,194	41,755	26,248	13,498	0	0	0	0	0	127,528
Maryland	11,049	3,551	1,996	1,201	387	1,271	11,299	7,474	14,527	40,302	19,935	17,817	0	0	0	0	0	0	0	130,809
Massachusetts	87	228	347	632	994	1,552	3,245	5,331	6,949	9,337	84,536	278,479	154,111	0	0	0	0	0	0	545,828
Michigan	2,435	3,410	5,599	10,321	21,098	40,410	41,480	52,043	73,216	23,391	14,890	8,003	0	0	0	0	0	0	0	296,297
Minnesota	5,446	4,636	4,650	3,490	1,667	5	0	0	0	0	0	0	0	0	0	0	0	0	0	19,892
Mississippi	4,383	3,947	1,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9,775
New Hampshire	76	24	23	66	75	93	265	425	607	388	75	0	0	0	0	0	0	0	0	2,117
New Jersey	165	342	845	1,282	1,913	2,379	7,312	17,550	16,544	78,328	29,333	9,499	0	0	0	0	0	0	0	165,491
New York	664	694	1,310	2,138	5,519	14,367	17,665	2,553	4,334	35,975	75,398	4,948	0	0	0	0	0	0	0	165,565
North Carolina	2,934	2,042	3,440	11,282	42,540	71,339	148,907	169,718	157,500	110,338	72,296	15,113	0	0	0	0	0	0	0	807,447
Ohio	0	14	134	674	2,631	7,829	12,200	3,955	0	0	0	0	0	0	0	0	0	0	0	27,436
Oregon	2,210	795	970	1,138	1,371	8,933	64,228	157,472	152,811	44,932	25,544	13,661	12,112	5,928	5,643	6,723	3,341	0	0	507,810
Pennsylvania	0	0	5	49	126	1,129	3,276	1,151	0	0	0	0	0	0	0	0	0	0	0	5,737
Rhode Island	190	287	512	177	221	442	510	778	1,688	1,598	14,751	95	0	0	0	0	0	0	0	21,250
South Carolina	701	889	1,196	37,673	78,478	76,251	33,107	9,479	0	0	0	0	0	0	0	0	0	0	0	237,773
Texas	188	591	123,017	89,829	73,815	27,988	27,379	29,536	20,501	197	0	0	0	0	0	0	0	0	0	393,040
Virginia	3,087	1,320	2,345	4,904	8,701	6,350	11,641	21,280	23,989	7,621	2,093	0	0	0	0	0	0	0	0	93,330
Washington	20,920	2,232	1,925	2,934	3,668	28,080	56,772	82,038	54,959	2,223	0	0	0	0	0	0	0	0	0	255,751
Wisconsin	1,671	2,337	6,152	4,595	5,722	4,171	7,645	18,116	22,058	22	0	0	0	0	0	0	0	0	0	72,488
Total	1,501,491	626,469	476,906	471,336	402,270	860,063	1,279,453	1,072,578	1,301,126	835,536	568,354	564,755	410,398	232,501	147,935	32,106	9,034	2,002	5,612	10,799,926

Appendix C. Gross Offshore Resource Energy Tables

The Tables in Appendix C display the data for Gross Offshore Resource Energy by water depth, distance from shore and wind speed as discussed in Section 7.3.

Table C-1. Gross Offshore Wind Potential by Water Depth: Generation (GWh/yr)

State	< 30 m	30–60 m	60–700 m	700–1000 m	> 1000 m	Grand Total
Alabama	47,348	30,218	23,471	11,558	15,218	127,813
California	30,256	28,279	483,563	318,753	6,098,776	6,959,627
Connecticut	13,534	3,059	399	0	0	16,992
Delaware	28,799	8,572	521	0	0	37,892
Florida	904,174	495,564	1,098,463	747,661	845,603	4,091,465
Georgia	121,897	56,741	37,998	21,927	0	238,563
Hawaii	9,184	14,143	148,733	57,327	12,545,349	12,774,736
Illinois	18,158	13,423	24,082	0	0	55,663
Indiana	7,267	0	0	0	0	7,267
Louisiana	453,072	176,728	354,669	147,864	1,495,400	2,627,733
Maine	57,840	39,311	548,703	0	0	645,854
Maryland	80,180	45,108	48,267	7,640	421,972	603,167
Massachusetts	155,182	394,550	897,932	31,237	1,379,154	2,858,055
Michigan	225,492	183,971	905,017	0	0	1,314,481
Minnesota	2,290	2,554	63,491	0	0	68,335
Mississippi	28,338	2,863	0	0	0	31,201
New Hampshire	1,717	1,916	5,856	0	0	9,489
New Jersey	114,844	175,425	119,096	10,419	376,382	796,166
New York	98,626	161,517	269,815	13,687	242,447	786,093
North Carolina	376,933	217,974	290,757	99,292	2,676,343	3,661,299
Ohio	113,182	0	0	0	0	113,182
Oregon	6,362	8,845	303,322	61,410	1,794,823	2,174,763
Pennsylvania	18,788	5,519	0	0	0	24,307
Rhode Island	13,527	36,089	44,236	2,119	7,149	103,120
South Carolina	217,819	105,442	322,034	228,637	87,778	961,710
Texas	432,825	253,505	319,371	116,114	421,760	1,543,576
Virginia	171,392	67,691	34,360	4,925	126,153	404,522
Washington	33,781	30,538	167,031	54,401	743,555	1,029,306
Wisconsin	60,843	45,775	205,205	0	0	311,822
Total	3,843,651	2,605,322	6,716,392	1,934,971	29,277,864	44,378,200

Table C-2. Gross Offshore Wind Potential by Distance from Shore: Generation (GWh/yr)

State	< 3 nm	3–12 nm	12–50 nm	50–200 nm	Grand Total
Alabama	15,630	15,695	63,005	33,483	127,813
California	79,681	371,992	1,365,870	5,142,084	6,959,627
Connecticut	16,992	0	0	0	16,992
Delaware	13,805	8,486	15,468	134	37,892
Florida	272,610	320,194	1,178,204	2,320,456	4,091,465
Georgia	11,831	29,397	103,142	94,194	238,563
Hawaii	76,688	297,850	1,792,327	10,607,871	12,774,736
Illinois	6,188	21,230	28,245	0	55,663
Indiana	4,209	3,058	0	0	7,267
Louisiana	122,855	128,980	514,575	1,861,322	2,627,733
Maine	80,600	118,310	300,336	146,609	645,854
Maryland	55,920	11,912	72,846	462,489	603,167
Massachusetts	73,438	104,049	426,552	2,254,016	2,858,055
Michigan	212,294	482,689	619,498	0	1,314,481
Minnesota	13,170	33,078	22,087	0	68,335
Mississippi	17,596	7,654	5,951	0	31,201
New Hampshire	2,231	5,010	2,249	0	9,489
New Jersey	29,879	48,656	197,044	520,587	796,166
New York	82,240	116,521	207,963	379,369	786,093
North Carolina	120,596	113,567	563,558	2,863,579	3,661,299
Ohio	22,603	51,575	39,003	0	113,182
Oregon	29,246	110,931	451,984	1,582,603	2,174,763
Pennsylvania	5,299	15,288	3,719	0	24,307
Rhode Island	11,201	21,816	42,110	27,993	103,120
South Carolina	23,639	63,186	245,497	629,388	961,710
Texas	184,391	122,503	458,676	778,005	1,543,576
Virginia	73,051	37,712	135,207	158,553	404,522
Washington	64,830	59,166	241,643	663,666	1,029,306
Wisconsin	59,208	121,439	131,176	0	311,822
Total	1,781,920	2,841,944	9,227,935	30,526,401	44,378,200

Table C-3. Gross Offshore Wind Potential by Wind Speed: Generation (GWh/yr)

State	< 7 m/s	7–7.25 m/s	7.25–7.5 m/s	7.5–7.75 m/s	7.75–8 m/s	8–8.25 m/s	8.25–8.5 m/s	8.5–8.75 m/s	8.75–9 m/s	9–9.25 m/s	9.25–9.5 m/s	9.5–9.75 m/s	9.75–10 m/s	10–10.25 m/s	10.25–10.5 m/s	10.5–10.75 m/s	10.75–11 m/s	11–11.25 m/s	11.25–11.5 m/s	Grand Total
Alabama	40,525	54,396	32,892	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	127,813
California	425,464	113,960	180,705	228,600	304,425	549,742	1,081,388	459,212	482,387	948,941	720,407	556,639	434,501	255,785	129,931	72,496	15,046	0	0	6,959,627
Connecticut	1,436	1,586	2,326	5,114	4,405	2,125	0	0	0	0	0	0	0	0	0	0	0	0	0	16,992
Delaware	250	1,143	1,402	2,495	4,140	8,473	13,104	6,809	76	0	0	0	0	0	0	0	0	0	0	37,892
Florida	2,579,349	893,313	491,370	125,823	1,609	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,091,465
Georgia	4,350	3,861	42,551	109,296	57,334	21,172	0	0	0	0	0	0	0	0	0	0	0	0	0	238,563
Hawaii	151,720	48,662	81,775	227,542	186,656	1,655,063	2,282,517	1,582,545	2,770,896	1,165,192	266,503	266,807	611,289	788,822	579,451	54,791	13,884	10,479	30,142	12,774,736
Illinois	0	32	268	687	987	1,872	23,294	28,332	191	0	0	0	0	0	0	0	0	0	0	55,663
Indiana	3	50	308	633	898	2,129	3,231	14	0	0	0	0	0	0	0	0	0	0	0	7,267
Louisiana	997,041	907,223	301,859	400,901	20,709	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,627,733
Maine	3,852	4,248	5,381	6,634	6,818	9,397	13,893	16,686	23,113	34,784	86,729	218,799	141,395	74,127	0	0	0	0	0	645,854
Maryland	30,924	11,763	6,927	4,447	1,531	5,344	48,977	33,172	68,281	196,945	101,139	93,718	0	0	0	0	0	0	0	603,167
Massachusetts	275	774	1,244	2,380	3,929	6,346	14,122	24,076	32,447	45,371	428,107	1,460,874	838,111	0	0	0	0	0	0	2,858,055
Michigan	7,604	11,602	19,924	38,628	82,862	166,799	178,594	234,381	342,867	114,429	75,303	41,487	0	0	0	0	0	0	0	1,314,481
Minnesota	16,476	15,578	16,592	13,109	6,562	19	0	0	0	0	0	0	0	0	0	0	0	0	0	68,335
Mississippi	13,013	13,108	5,080	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31,201
New Hampshire	229	83	84	251	297	384	1,145	1,902	2,849	1,888	378	0	0	0	0	0	0	0	0	9,489
New Jersey	481	1,160	3,026	4,831	7,565	9,706	31,567	79,026	77,763	382,259	148,817	49,964	0	0	0	0	0	0	0	796,166
New York	2,036	2,355	4,694	8,067	21,773	58,520	74,809	11,191	20,233	175,706	380,868	25,840	0	0	0	0	0	0	0	786,093
North Carolina	8,892	6,929	11,930	41,926	167,624	294,234	643,965	763,832	736,906	538,783	366,785	79,494	0	0	0	0	0	0	0	3,661,299
Ohio	0	48	482	2,547	10,413	31,397	51,426	16,869	0	0	0	0	0	0	0	0	0	0	0	113,182
Oregon	6,016	2,673	3,413	4,100	5,239	35,177	262,889	666,176	643,081	200,753	115,646	63,235	58,065	29,201	28,219	33,886	16,995	0	0	2,174,763
Pennsylvania	0	0	18	185	502	4,661	13,826	5,115	0	0	0	0	0	0	0	0	0	0	0	24,307
Rhode Island	585	975	1,832	667	875	1,831	2,231	3,516	7,970	7,709	74,429	501	0	0	0	0	0	0	0	103,120
South Carolina	2,164	3,016	4,282	141,865	310,462	315,330	142,652	41,940	0	0	0	0	0	0	0	0	0	0	0	961,710
Texas	599	2,007	441,872	341,114	293,542	114,722	118,842	133,345	96,581	952	0	0	0	0	0	0	0	0	0	1,543,576
Virginia	9,140	4,481	8,398	17,915	33,395	25,864	50,051	94,831	112,585	37,243	10,620	0	0	0	0	0	0	0	0	404,522
Washington	45,648	7,496	6,748	10,652	13,655	110,963	232,994	349,876	241,372	9,902	0	0	0	0	0	0	0	0	0	1,029,306
Wisconsin	5,086	7,989	21,832	17,263	22,426	17,301	33,570	82,623	103,622	110	0	0	0	0	0	0	0	0	0	311,822
Total	4,353,158	2,120,511	1,699,215	1,757,670	1,570,631	3,448,568	5,319,089	4,635,469	5,763,219	3,860,966	2,775,732	2,857,357	2,083,361	1,147,935	737,601	161,172	45,925	10,479	30,142	44,378,200

Appendix D. Gross Resource Energy Tables (With Losses)

The Tables in Appendix D display the data for Gross Resource Energy (with losses) by water depth, distance from shore and wind speed as discussed in Section 7.4.2.

Table D-1. Net Offshore Wind Potential by Water Depth: Generation (GWh/yr)

State	< 30 m	30–60 m	60–700 m	700–1000 m	> 1000 m	Grand Total
Alabama	38,976	24,843	19,156	9,333	12,295	104,604
California	25,334	23,642	407,147	267,535	5,110,089	5,833,748
Connecticut	11,238	2,550	328	0	0	14,117
Delaware	24,058	7,166	435	0	0	31,659
Florida	735,527	401,391	887,337	603,550	677,096	3,304,901
Georgia	100,654	46,690	31,080	17,847	0	196,271
Hawaii	7,692	11,905	125,057	48,185	10,372,700	10,565,540
Illinois	15,249	11,248	20,060	0	0	46,558
Indiana	6,092	0	0	0	0	6,092
Louisiana	374,011	145,203	289,983	120,006	1,206,238	2,135,442
Maine	48,459	33,322	465,138	0	0	546,920
Maryland	66,293	37,734	40,368	6,373	352,875	503,643
Massachusetts	131,543	334,629	759,244	26,241	1,160,709	2,412,366
Michigan	188,561	154,186	759,036	0	0	1,101,783
Minnesota	1,873	2,102	52,322	0	0	56,298
Mississippi	23,287	2,355	0	0	0	25,642
New Hampshire	1,435	1,613	4,938	0	0	7,986
New Jersey	96,303	147,290	100,024	8,706	314,719	667,042
New York	82,773	136,334	226,909	11,471	202,956	660,443
North Carolina	315,669	182,802	242,359	82,133	2,220,945	3,043,907
Ohio	95,121	0	0	0	0	95,121
Oregon	5,318	7,478	258,742	52,042	1,503,538	1,827,117
Pennsylvania	15,842	4,651	0	0	0	20,492
Rhode Island	11,363	30,550	37,323	1,778	5,995	87,009
South Carolina	181,718	87,823	265,623	186,432	71,518	793,114
Texas	360,115	210,373	263,109	94,655	342,997	1,271,248
Virginia	143,220	56,757	28,748	4,105	105,147	337,976
Washington	27,908	25,655	140,568	45,561	621,620	861,312
Wisconsin	50,785	38,299	171,531	0	0	260,615
Total	3,186,418	2,168,590	5,596,565	1,585,952	24,281,439	36,818,964

Table D-2. Net Offshore Wind Potential by Distance from Shore: Generation (GWh/yr)

State	< 3 nm	3–12 nm	12–50 nm	50–200 nm	Grand Total
Alabama	12,842	12,958	51,729	27,075	104,604
California	66,283	313,097	1,152,211	4,302,157	5,833,748
Connecticut	14,117	0	0	0	14,117
Delaware	11,505	7,103	12,939	112	31,659
Florida	221,998	260,883	956,520	1,865,501	3,304,901
Georgia	9,746	24,260	85,266	76,999	196,271
Hawaii	64,572	250,158	1,509,574	8,741,236	10,565,540
Illinois	5,196	17,824	23,538	0	46,558
Indiana	3,527	2,565	0	0	6,092
Louisiana	101,147	106,769	424,595	1,502,931	2,135,442
Maine	67,797	100,374	254,667	124,082	546,920
Maryland	45,928	9,990	60,953	386,772	503,643
Massachusetts	61,995	88,300	361,179	1,900,892	2,412,366
Michigan	177,596	404,781	519,406	0	1,101,783
Minnesota	10,845	27,210	18,243	0	56,298
Mississippi	14,433	6,313	4,896	0	25,642
New Hampshire	1,866	4,219	1,901	0	7,986
New Jersey	24,933	40,861	165,449	435,799	667,042
New York	68,841	98,222	175,262	318,118	660,443
North Carolina	100,670	95,354	472,257	2,375,625	3,043,907
Ohio	18,947	43,366	32,807	0	95,121
Oregon	24,684	95,183	384,171	1,323,079	1,827,117
Pennsylvania	4,455	12,904	3,133	0	20,492
Rhode Island	9,383	18,475	35,580	23,572	87,009
South Carolina	19,626	52,766	204,824	515,897	793,114
Texas	153,886	102,326	380,879	634,157	1,271,248
Virginia	60,692	31,631	113,408	132,244	337,976
Washington	53,791	49,933	202,845	554,743	861,312
Wisconsin	49,424	101,422	109,769	0	260,615
Total	1,480,724	2,379,246	7,718,003	25,240,991	36,818,964

Table D-3. Net Offshore Wind Potential by Wind Speed: Generation (GWh/yr)

State	< 7 m/s	7–7.25 m/s	7.25–7.5 m/s	7.5–7.75 m/s	7.75–8 m/s	8–8.25 m/s	8.25–8.5 m/s	8.5–8.75 m/s	8.75–9 m/s	9–9.25 m/s	9.25–9.5 m/s	9.5–9.75 m/s	9.75–10 m/s	10–10.25 m/s	10.25–10.5 m/s	10.5–10.75 m/s	10.75–11 m/s	11–11.25 m/s	11.25–11.5 m/s	Grand Total
Alabama	32,857	44,681	27,066	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	104,604
California	346,785	93,852	149,054	189,113	252,597	457,346	902,057	384,175	405,123	797,597	606,109	472,559	370,620	219,104	111,865	62,721	13,070	0	0	5,833,748
Connecticut	1,176	1,308	1,927	4,249	3,674	1,782	0	0	0	0	0	0	0	0	0	0	0	0	0	14,117
Delaware	205	942	1,161	2,076	3,459	7,088	10,969	5,694	64	0	0	0	0	0	0	0	0	0	0	31,659
Florida	2,080,106	722,676	398,551	102,241	1,327	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,304,901
Georgia	3,561	3,179	34,925	89,692	47,362	17,552	0	0	0	0	0	0	0	0	0	0	0	0	0	196,271
Hawaii	123,172	40,007	67,105	185,848	153,689	1,355,396	1,872,831	1,303,546	2,290,707	968,948	223,901	223,436	511,652	662,074	488,460	47,285	12,045	9,107	26,330	10,565,540
Illinois	0	27	223	573	826	1,568	19,451	23,730	161	0	0	0	0	0	0	0	0	0	0	46,558
Indiana	3	41	256	528	752	1,786	2,715	12	0	0	0	0	0	0	0	0	0	0	0	6,092
Louisiana	803,606	735,417	248,196	331,090	17,133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,135,442
Maine	3,157	3,503	4,456	5,518	5,686	7,880	11,676	14,071	19,541	29,481	73,482	185,387	120,042	63,039	0	0	0	0	0	546,920
Maryland	25,238	9,703	5,733	3,699	1,279	4,480	40,998	27,747	56,992	164,344	84,609	78,820	0	0	0	0	0	0	0	503,643
Massachusetts	226	638	1,031	1,979	3,282	5,316	11,873	20,316	27,454	38,498	360,987	1,232,230	708,535	0	0	0	0	0	0	2,412,366
Michigan	6,269	9,610	16,554	32,118	69,030	139,212	149,554	196,794	288,023	96,158	63,449	35,013	0	0	0	0	0	0	0	1,101,783
Minnesota	13,503	12,817	13,697	10,833	5,433	16	0	0	0	0	0	0	0	0	0	0	0	0	0	56,298
Mississippi	10,662	10,792	4,188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,642
New Hampshire	187	68	70	208	248	322	964	1,602	2,401	1,595	321	0	0	0	0	0	0	0	0	7,986
New Jersey	392	957	2,507	4,019	6,318	8,123	26,483	66,181	65,329	320,218	124,494	42,020	0	0	0	0	0	0	0	667,042
New York	1,667	1,944	3,892	6,718	18,184	49,166	62,753	9,423	17,110	147,984	319,839	21,763	0	0	0	0	0	0	0	660,443
North Carolina	7,274	5,715	9,863	34,406	137,458	242,296	533,468	635,335	614,143	450,070	307,067	66,812	0	0	0	0	0	0	0	3,043,907
Ohio	0	40	400	2,124	8,708	26,342	43,296	14,211	0	0	0	0	0	0	0	0	0	0	0	95,121
Oregon	4,984	2,238	2,867	3,454	4,428	29,472	219,936	556,823	537,336	169,429	98,429	54,046	49,844	25,162	24,398	29,494	14,775	0	0	1,827,117
Pennsylvania	0	0	15	154	420	3,926	11,670	4,307	0	0	0	0	0	0	0	0	0	0	0	20,492
Rhode Island	479	804	1,518	555	731	1,534	1,876	2,971	6,753	6,536	62,827	426	0	0	0	0	0	0	0	87,009
South Carolina	1,772	2,487	3,547	115,747	254,759	260,703	118,952	35,147	0	0	0	0	0	0	0	0	0	0	0	793,114
Texas	493	1,654	359,410	279,294	242,403	95,260	99,065	111,579	81,284	807	0	0	0	0	0	0	0	0	0	1,271,248
Virginia	7,465	3,695	6,956	14,886	27,904	21,686	42,013	79,518	93,909	31,059	8,883	0	0	0	0	0	0	0	0	337,976
Washington	37,630	6,277	5,669	8,983	11,561	92,729	194,984	292,693	202,458	8,326	0	0	0	0	0	0	0	0	0	861,312
Wisconsin	4,187	6,612	18,081	14,339	18,644	14,487	28,125	69,160	86,886	92	0	0	0	0	0	0	0	0	0	260,615
Total	3,517,056	1,721,684	1,388,918	1,444,448	1,297,295	2,845,470	4,405,707	3,855,036	4,795,676	3,231,141	2,334,399	2,412,511	1,760,694	969,379	624,723	139,500	39,889	9,107	26,330	36,818,964

Appendix E. Technical Offshore Resource Area Tables

The Tables in Appendix E display the data for Technical Offshore Resource Area by water depth, distance from shore and wind speed as discussed in Section 8.2.

Table E-1. Technical Offshore Wind Potential by Water Depth: Area (km^2)

State	< 30 m	30–60 m	60–700 m	700–1000 m	Grand Total
Alabama	4,029	2,854	1,653	0	8,536
California	1,556	1,380	30,987	18,946	52,869
Connecticut	1,088	262	24	0	1,374
Delaware	2,325	655	38	0	3,018
Florida	13,522	10,755	26,621	55,974	106,871
Georgia	10,342	4,948	3,383	1,914	20,588
Hawaii	395	916	9,978	3,935	15,225
Illinois	1,396	994	0	0	2,390
Indiana	591	0	0	0	591
Louisiana	37,626	16,440	28,381	10,290	92,737
Maine	4,390	2,769	34,939	0	42,098
Maryland	4,347	3,417	3,446	536	11,745
Massachusetts	10,799	25,182	57,507	2,014	95,503
Michigan	18,244	14,222	0	0	32,466
Minnesota	5	80	0	0	85
Mississippi	1,552	246	0	0	1,797
New Hampshire	121	143	416	0	680
New Jersey	8,786	12,402	8,150	711	30,048
New York	7,790	11,304	12,755	909	32,758
North Carolina	29,405	16,239	21,709	7,443	74,796
Ohio	9,145	0	0	0	9,145
Oregon	288	705	23,190	4,468	28,651
Pennsylvania	1,480	432	0	0	1,912
Rhode Island	1,015	2,480	2,916	139	6,550
South Carolina	17,627	8,320	26,175	19,338	71,461
Texas	35,463	20,430	26,878	10,308	93,079
Virginia	13,415	5,054	2,473	349	21,291
Washington	644	2,032	12,612	4,139	19,427
Wisconsin	4,757	3,575	0	0	8,332
Total	242,144	168,237	334,231	141,414	886,026

Table E-2. Technical Offshore Wind Potential by Distance from Shore: Area (km^2)

State	< 3 nm	3–12 nm	12–50 nm	50–200 nm	Grand Total
Alabama	877	1,534	6,073	53	8,536
California	2,611	21,223	28,796	240	52,869
Connecticut	1,374	0	0	0	1,374
Delaware	1,158	671	1,179	10	3,018
Florida	1,184	2,877	40,482	62,328	106,871
Georgia	717	2,691	8,793	8,387	20,588
Hawaii	3,679	8,365	2,941	240	15,225
Illinois	497	1,439	454	0	2,390
Indiana	347	245	0	0	591
Louisiana	7,441	12,009	42,255	31,032	92,737
Maine	5,997	7,942	18,843	9,316	42,098
Maryland	2,405	935	5,543	2,863	11,745
Massachusetts	5,502	7,087	27,568	55,346	95,503
Michigan	14,766	15,005	2,695	0	32,466
Minnesota	23	62	0	0	85
Mississippi	477	749	571	0	1,797
New Hampshire	162	365	153	0	680
New Jersey	2,492	3,664	14,020	9,872	30,048
New York	6,489	4,927	12,142	9,200	32,758
North Carolina	9,557	8,985	34,430	21,824	74,796
Ohio	1,936	4,150	3,060	0	9,145
Oregon	2,012	8,581	18,027	31	28,651
Pennsylvania	418	1,206	288	0	1,912
Rhode Island	866	1,527	2,788	1,370	6,550
South Carolina	1,926	5,269	19,347	44,919	71,461
Texas	15,168	9,545	36,223	32,143	93,079
Virginia	5,732	3,046	10,207	2,307	21,291
Washington	1,971	4,906	12,550	0	19,427
Wisconsin	4,361	3,834	138	0	8,332
Total	102,141	142,841	349,565	291,479	886,026

Table E-3. Technical Offshore Wind Potential by Wind Speed: Area (km^2)

State	7–7.25 m/s	7.25–7.5 m/s	7.5–7.75 m/s	7.75–8 m/s	8–8.25 m/s	8.25–8.5 m/s	8.5–8.75 m/s	8.75–9 m/s	9–9.25 m/s	9.25–9.5 m/s	9.5–9.75 m/s	9.75–10 m/s	10–10.25 m/s	10.25–10.5 m/s	10.5–10.75 m/s	10.75–11 m/s	11–11.25 m/s	11.25–11.5 m/s	Grand Total
Alabama	5,426	3,111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,536
California	3,503	3,727	4,361	4,604	5,622	6,536	4,931	3,900	4,421	3,744	2,077	1,044	1,438	952	1,173	835	0	0	52,869
Connecticut	156	217	458	373	170	0	0	0	0	0	0	0	0	0	0	0	0	0	1,374
Delaware	112	131	221	344	680	1,014	511	5	0	0	0	0	0	0	0	0	0	0	3,018
Florida	55,647	39,949	11,138	137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	106,871
Georgia	391	3,955	9,675	4,827	1,740	0	0	0	0	0	0	0	0	0	0	0	0	0	20,588
Hawaii	1,060	1,219	1,472	1,953	2,088	1,947	1,446	882	569	785	453	307	283	215	288	156	88	13	15,225
Illinois	3	25	61	83	149	859	1,197	13	0	0	0	0	0	0	0	0	0	0	2,390
Indiana	5	29	56	75	171	255	1	0	0	0	0	0	0	0	0	0	0	0	591
Louisiana	34,321	24,028	32,619	1,770	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92,737
Maine	417	502	589	585	758	1,080	1,237	1,647	2,385	5,731	13,918	8,749	4,499	0	0	0	0	0	42,098
Maryland	1,184	665	400	129	424	3,766	2,491	2,262	424	0	0	0	0	0	0	0	0	0	11,745
Massachusetts	76	116	211	331	517	1,082	1,777	2,316	3,112	20,543	49,558	15,863	0	0	0	0	0	0	95,503
Michigan	1,077	1,711	2,537	4,723	8,310	7,318	4,830	1,786	40	120	14	0	0	0	0	0	0	0	32,466
Minnesota	83	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85
Mississippi	1,316	482	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,797
New Hampshire	8	8	22	25	31	88	142	202	129	25	0	0	0	0	0	0	0	0	680
New Jersey	114	282	427	638	793	2,437	5,850	5,515	13,946	48	0	0	0	0	0	0	0	0	30,048
New York	231	437	713	1,835	3,023	1,525	674	1,445	11,603	10,850	422	0	0	0	0	0	0	0	32,758
North Carolina	681	1,147	1,665	2,818	5,672	25,282	27,667	9,866	0	0	0	0	0	0	0	0	0	0	74,796
Ohio	5	45	225	877	2,610	4,067	1,318	0	0	0	0	0	0	0	0	0	0	0	9,145
Oregon	265	323	379	457	1,048	2,872	4,684	4,870	4,817	3,320	1,389	1,212	553	631	1,205	626	0	0	28,651
Pennsylvania	0	2	16	42	376	1,092	384	0	0	0	0	0	0	0	0	0	0	0	1,912
Rhode Island	96	171	59	74	147	170	259	563	533	4,447	32	0	0	0	0	0	0	0	6,550
South Carolina	296	399	8,496	23,267	24,808	11,036	3,160	0	0	0	0	0	0	0	0	0	0	0	71,461
Texas	197	22,174	13,746	21,762	9,329	9,126	9,845	6,834	66	0	0	0	0	0	0	0	0	0	93,079
Virginia	440	782	1,635	2,900	2,117	3,880	7,093	2,444	0	0	0	0	0	0	0	0	0	0	21,291
Washington	744	642	978	1,223	1,667	4,247	7,500	2,151	276	0	0	0	0	0	0	0	0	0	19,427
Wisconsin	620	1,023	1,015	1,041	1,252	1,679	1,352	350	0	0	0	0	0	0	0	0	0	0	8,332
Total	108,473	107,299	93,172	76,893	73,501	91,358	88,350	47,051	42,320	49,615	67,864	27,175	6,773	1,799	2,666	1,617	88	13	886,026

Appendix F. Technical Offshore Resource Capacity Tables

The Tables in Appendix F display the data for Technical Offshore Resource Capacity by water depth, distance from shore and wind speed as discussed in Section 8.3.

Table F-1. Technical Offshore Wind Potential by Water Depth: Area (km^2)

State	< 30 m	30–60 m	60–700 m	700–1000 m	Grand Total
Alabama	12,088	8,562	4,960	0	25,609
California	4,667	4,140	92,962	56,838	158,607
Connecticut	3,265	785	71	0	4,121
Delaware	6,975	1,964	115	0	9,054
Florida	40,565	32,266	79,862	167,921	320,613
Georgia	31,027	14,845	10,150	5,741	61,763
Hawaii	1,186	2,748	29,935	11,805	45,674
Illinois	4,188	2,983	0	0	7,171
Indiana	1,773	0	0	0	1,773
Louisiana	112,877	49,321	85,143	30,871	278,212
Maine	13,171	8,306	104,816	0	126,294
Maryland	13,040	10,251	10,337	1,609	35,236
Massachusetts	32,397	75,547	172,522	6,042	286,508
Michigan	54,732	42,666	0	0	97,398
Minnesota	15	240	0	0	255
Mississippi	4,655	737	0	0	5,392
New Hampshire	362	430	1,249	0	2,041
New Jersey	26,359	37,206	24,449	2,132	90,145
New York	23,369	33,911	38,265	2,728	98,273
North Carolina	88,214	48,718	65,126	22,330	224,389
Ohio	27,436	0	0	0	27,436
Oregon	865	2,115	69,569	13,404	85,954
Pennsylvania	4,441	1,295	0	0	5,737
Rhode Island	3,044	7,440	8,749	418	19,650
South Carolina	52,882	24,960	78,526	58,014	214,382
Texas	106,390	61,290	80,634	30,923	279,237
Virginia	40,246	15,161	7,418	1,048	63,872
Washington	1,933	6,096	37,835	12,417	58,281
Wisconsin	14,271	10,726	0	0	24,997
Total	726,433	504,711	1,002,692	424,242	2,658,078

Table F-2. Technical Offshore Wind Potential by Distance from Shore: Area (km^2)

State	< 3 nm	3–12 nm	12–50 nm	50–200 nm	Grand Total
Alabama	2,630	4,601	18,218	160	25,609
California	7,833	63,668	86,387	720	158,607
Connecticut	4,121	0	0	0	4,121
Delaware	3,474	2,014	3,537	29	9,054
Florida	3,553	8,632	121,445	186,984	320,613
Georgia	2,152	8,072	26,379	25,160	61,763
Hawaii	11,036	25,095	8,823	720	45,674
Illinois	1,491	4,318	1,362	0	7,171
Indiana	1,040	734	0	0	1,773
Louisiana	22,322	36,027	126,765	93,097	278,212
Maine	17,990	23,825	56,530	27,948	126,294
Maryland	7,214	2,804	16,628	8,590	35,236
Massachusetts	16,506	21,262	82,704	166,037	286,508
Michigan	44,297	45,016	8,085	0	97,398
Minnesota	68	187	0	0	255
Mississippi	1,432	2,248	1,713	0	5,392
New Hampshire	486	1,095	460	0	2,041
New Jersey	7,477	10,992	42,061	29,615	90,145
New York	19,468	14,781	36,425	27,599	98,273
North Carolina	28,670	26,956	103,291	65,472	224,389
Ohio	5,807	12,449	9,180	0	27,436
Oregon	6,036	25,742	54,082	94	85,954
Pennsylvania	1,253	3,619	864	0	5,737
Rhode Island	2,597	4,581	8,364	4,109	19,650
South Carolina	5,777	15,807	58,042	134,756	214,382
Texas	45,504	28,636	108,669	96,429	279,237
Virginia	17,195	9,137	30,620	6,920	63,872
Washington	5,913	14,719	37,649	0	58,281
Wisconsin	13,082	11,502	413	0	24,997
Total	306,422	428,523	1,048,695	874,438	2,658,078

Table F-3. Technical Offshore Wind Potential by Wind Speed: Area (km^2)

State	7–7.25 m/s	7.25–7.5 m/s	7.5–7.75 m/s	7.75–8 m/s	8–8.25 m/s	8.25–8.5 m/s	8.5–8.75 m/s	8.75–9 m/s	9–9.25 m/s	9.25–9.5 m/s	9.5–9.75 m/s	9.75–10 m/s	10–10.25 m/s	10.25–10.5 m/s	10.5–10.75 m/s	10.75–11 m/s	11–11.25 m/s	11.25–11.5 m/s	Grand Total
Alabama	16,277	9,332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,609
California	10,508	11,182	13,083	13,811	16,867	19,608	14,794	11,699	13,264	11,233	6,232	3,132	4,314	2,856	3,518	2,506	0	0	158,607
Connecticut	467	650	1,374	1,120	511	0	0	0	0	0	0	0	0	0	0	0	0	0	4,121
Delaware	337	392	662	1,033	2,039	3,041	1,534	16	0	0	0	0	0	0	0	0	0	0	9,054
Florida	166,942	119,847	33,414	411	0	0	0	0	0	0	0	0	0	0	0	0	0	0	320,613
Georgia	1,173	11,865	29,026	14,480	5,219	0	0	0	0	0	0	0	0	0	0	0	0	0	61,763
Hawaii	3,179	3,658	4,415	5,859	6,265	5,842	4,339	2,646	1,706	2,356	1,360	921	850	646	864	467	264	38	45,674
Illinois	9	75	182	249	448	2,576	3,592	40	0	0	0	0	0	0	0	0	0	0	7,171
Indiana	15	86	168	226	512	764	3	0	0	0	0	0	0	0	0	0	0	0	1,773
Louisiana	102,963	72,083	97,856	5,310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	278,212
Maine	1,252	1,505	1,767	1,756	2,273	3,241	3,711	4,940	7,154	17,194	41,755	26,248	13,498	0	0	0	0	0	126,294
Maryland	3,551	1,996	1,201	387	1,271	11,299	7,474	6,785	1,272	0	0	0	0	0	0	0	0	0	35,236
Massachusetts	228	347	632	994	1,552	3,245	5,331	6,949	9,337	61,628	148,674	47,590	0	0	0	0	0	0	286,508
Michigan	3,231	5,132	7,610	14,169	24,929	21,953	14,490	5,359	119	361	43	0	0	0	0	0	0	0	97,398
Minnesota	250	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	255
Mississippi	3,947	1,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,392
New Hampshire	24	23	66	75	93	265	425	607	388	75	0	0	0	0	0	0	0	0	2,041
New Jersey	342	845	1,282	1,913	2,379	7,312	17,550	16,544	41,837	143	0	0	0	0	0	0	0	0	90,145
New York	694	1,310	2,138	5,506	9,068	4,576	2,023	4,334	34,809	32,551	1,265	0	0	0	0	0	0	0	98,273
North Carolina	2,042	3,440	4,995	8,453	17,017	75,845	83,000	29,598	0	0	0	0	0	0	0	0	0	0	224,389
Ohio	14	134	674	2,631	7,829	12,200	3,955	0	0	0	0	0	0	0	0	0	0	0	27,436
Oregon	795	970	1,138	1,371	3,144	8,615	14,051	14,611	14,450	9,961	4,167	3,635	1,659	1,893	3,616	1,877	0	0	85,954
Pennsylvania	0	5	49	126	1,129	3,276	1,151	0	0	0	0	0	0	0	0	0	0	0	5,737
Rhode Island	287	512	177	221	442	510	778	1,688	1,598	13,342	95	0	0	0	0	0	0	0	19,650
South Carolina	889	1,196	25,487	69,802	74,424	33,107	9,479	0	0	0	0	0	0	0	0	0	0	0	214,382
Texas	591	66,521	41,239	65,286	27,988	27,379	29,536	20,501	197	0	0	0	0	0	0	0	0	0	279,237
Virginia	1,320	2,345	4,904	8,701	6,350	11,641	21,280	7,332	0	0	0	0	0	0	0	0	0	0	63,872
Washington	2,232	1,925	2,934	3,668	5,000	12,740	22,499	6,454	829	0	0	0	0	0	0	0	0	0	58,281
Wisconsin	1,861	3,070	3,046	3,122	3,755	5,038	4,055	1,049	0	0	0	0	0	0	0	0	0	0	24,997
Total	325,420	321,896	279,517	230,679	220,502	274,074	265,049	141,154	126,960	148,845	203,591	81,526	20,320	5,396	7,999	4,850	264	38	2,658,078

Appendix G. Technical Offshore Resource Energy Potential (With Losses; No Conflicting Exclusions)

The Tables in Appendix G display the data for Technical Offshore Resource Energy Potential by water depth, distance from shore and wind speed as discussed in Section 8.4.

Table G-1. Technical Offshore Wind Potential by Water Depth: Generation (GWh/yr)

State	< 30 m	30–60 m	60–700 m	700–1000 m	Grand Total
Alabama	33,366	24,530	13,851	0	71,747
California	15,027	13,357	315,112	207,697	551,193
Connecticut	10,200	2,538	203	0	12,941
Delaware	23,853	7,166	435	0	31,453
Florida	112,658	89,871	223,841	481,404	907,774
Georgia	97,094	46,689	31,080	17,847	192,710
Hawaii	3,941	9,338	102,300	41,592	157,171
Illinois	15,249	11,248	0	0	26,497
Indiana	6,089	0	0	0	6,089
Louisiana	337,152	143,336	245,109	88,024	813,620
Maine	45,338	33,288	465,137	0	543,763
Maryland	41,697	37,575	39,885	6,373	125,529
Massachusetts	131,317	334,629	759,244	26,241	1,251,431
Michigan	183,071	153,698	0	0	336,770
Minnesota	42	677	0	0	719
Mississippi	12,860	2,120	0	0	14,980
New Hampshire	1,248	1,613	4,938	0	7,799
New Jersey	95,911	147,290	100,024	8,706	351,931
New York	81,124	136,331	160,293	11,471	389,220
North Carolina	308,486	182,783	242,286	82,133	815,688
Ohio	95,121	0	0	0	95,121
Oregon	2,707	6,876	256,970	52,042	318,595
Pennsylvania	15,842	4,651	0	0	20,492
Rhode Island	10,885	30,550	37,323	1,778	80,536
South Carolina	179,952	87,823	265,617	186,432	719,824
Texas	359,625	210,370	263,109	94,655	927,757
Virginia	136,004	56,672	28,584	4,105	225,364
Washington	5,763	19,595	131,143	45,561	202,061
Wisconsin	47,409	37,565	0	0	84,973
Total	2,409,030	1,832,176	3,686,484	1,356,059	9,283,750

Table G-2. Techical Offshore Wind Potential by Distance from Shore: Generation (GWh/yr)

State	< 3 nm	3–12 nm	12–50 nm	50–200 nm	Grand Total
Alabama	6,601	12,958	51,729	459	71,747
California	25,840	216,662	306,525	2,166	551,193
Connecticut	12,941	0	0	0	12,941
Delaware	11,300	7,103	12,939	112	31,453
Florida	9,798	24,007	336,699	537,271	907,774
Georgia	6,186	24,260	85,266	76,998	192,710
Hawaii	37,713	84,867	32,052	2,539	157,171
Illinois	5,196	16,284	5,018	0	26,497
Indiana	3,525	2,565	0	0	6,089
Louisiana	62,076	106,769	385,364	259,412	813,620
Maine	64,673	100,341	254,667	124,082	543,763
Maryland	20,692	9,990	60,953	33,895	125,529
Massachusetts	61,769	88,300	361,179	740,183	1,251,431
Michigan	146,207	159,601	30,962	0	336,770
Minnesota	193	526	0	0	719
Mississippi	3,771	6,313	4,896	0	14,980
New Hampshire	1,679	4,219	1,901	0	7,799
New Jersey	24,541	40,861	165,449	121,080	351,931
New York	65,311	56,437	152,309	115,162	389,220
North Carolina	93,397	95,354	387,038	239,898	815,688
Ohio	18,947	43,366	32,807	0	95,121
Oregon	19,722	95,162	203,389	322	318,595
Pennsylvania	4,455	12,904	3,133	0	20,492
Rhode Island	8,904	18,475	35,580	17,577	80,536
South Carolina	17,854	52,766	204,824	444,378	719,824
Texas	153,392	102,326	380,879	291,160	927,757
Virginia	53,228	31,631	113,408	27,097	225,364
Washington	17,567	48,528	135,966	0	202,061
Wisconsin	43,310	40,156	1,507	0	84,973
Total	1,000,787	1,502,731	3,746,441	3,033,790	9,283,750

Table G-3. Technical Offshore Wind Potential by Wind Speed: Generation (GWh/yr)

State	7–7.25 m/s	7.25–7.5 m/s	7.5–7.75 m/s	7.75–8 m/s	8–8.25 m/s	8.25–8.5 m/s	8.5–8.75 m/s	8.75–9 m/s	9–9.25 m/s	9.25–9.5 m/s	9.5–9.75 m/s	9.75–10 m/s	10–10.25 m/s	10.25–10.5 m/s	10.5–10.75 m/s	10.75–11 m/s	11–11.25 m/s	11.25–11.5 m/s	Grand Total
Alabama	44,681	27,066	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71,747
California	28,897	32,360	39,569	43,773	55,750	67,368	52,887	43,184	50,570	43,747	24,430	12,633	18,092	12,101	14,983	10,849	0	0	551,193
Connecticut	1,308	1,927	4,249	3,674	1,782	0	0	0	0	0	0	0	0	0	0	0	0	0	12,941
Delaware	942	1,161	2,076	3,459	7,088	10,969	5,694	64	0	0	0	0	0	0	0	0	0	0	31,453
Florida	457,320	346,887	102,241	1,327	0	0	0	0	0	0	0	0	0	0	0	0	0	0	907,774
Georgia	3,179	34,925	89,692	47,362	17,552	0	0	0	0	0	0	0	0	0	0	0	0	0	192,710
Hawaii	8,902	10,759	13,581	18,807	20,919	20,196	15,544	9,735	6,496	9,223	5,480	3,815	3,601	2,802	3,822	2,105	1,211	174	157,171
Illinois	27	223	573	826	1,568	9,413	13,707	161	0	0	0	0	0	0	0	0	0	0	26,497
Indiana	41	256	528	752	1,786	2,715	12	0	0	0	0	0	0	0	0	0	0	0	6,089
Louisiana	283,635	212,329	300,523	17,133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	813,620
Maine	3,503	4,456	5,518	5,686	7,880	11,676	14,071	19,541	29,481	73,482	185,387	120,042	63,039	0	0	0	0	0	543,763
Maryland	9,703	5,733	3,699	1,279	4,480	40,998	27,747	26,675	5,215	0	0	0	0	0	0	0	0	0	125,529
Massachusetts	638	1,031	1,979	3,282	5,316	11,873	20,316	27,454	38,498	263,639	658,676	218,728	0	0	0	0	0	0	1,251,431
Michigan	9,108	15,164	23,620	46,194	85,868	78,806	54,741	21,021	498	1,559	191	0	0	0	0	0	0	0	336,770
Minnesota	703	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	719
Mississippi	10,792	4,188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14,980
New Hampshire	68	70	208	248	322	964	1,602	2,401	1,595	321	0	0	0	0	0	0	0	0	7,799
New Jersey	957	2,507	4,019	6,318	8,123	26,483	66,181	65,329	171,402	612	0	0	0	0	0	0	0	0	351,931
New York	1,944	3,892	6,718	18,140	30,937	16,437	7,412	17,110	143,227	137,932	5,472	0	0	0	0	0	0	0	389,220
North Carolina	5,715	9,863	15,156	27,418	57,943	273,281	311,750	114,559	0	2	0	0	0	0	0	0	0	0	815,688
Ohio	40	400	2,124	8,708	26,342	43,296	14,211	0	0	0	0	0	0	0	0	0	0	0	95,121
Oregon	2,238	2,867	3,454	4,428	10,339	29,461	49,908	53,652	54,413	37,986	16,136	14,649	6,913	8,069	15,794	8,285	0	0	318,595
Pennsylvania	0	15	154	420	3,926	11,670	4,307	0	0	0	0	0	0	0	0	0	0	0	20,492
Rhode Island	804	1,518	555	731	1,534	1,876	2,971	6,753	6,536	56,832	426	0	0	0	0	0	0	0	80,536
South Carolina	2,487	3,547	78,416	226,768	254,507	118,952	35,147	0	0	0	0	0	0	0	0	0	0	0	719,824
Texas	1,654	194,714	128,939	214,456	95,260	99,065	111,579	81,284	807	0	0	0	0	0	0	0	0	0	927,757
Virginia	3,695	6,956	14,886	27,904	21,686	42,013	79,518	28,705	0	0	0	0	0	0	0	0	0	0	225,364
Washington	6,277	5,669	8,983	11,561	16,462	44,222	81,485	24,193	3,208	0	0	0	0	0	0	0	0	0	202,061
Wisconsin	5,256	9,037	9,492	10,121	13,029	18,502	15,424	4,113	0	0	0	0	0	0	0	0	0	0	84,973
Total	894,513	939,536	860,955	750,778	750,401	980,234	986,214	545,935	511,945	625,335	896,197	369,867	91,644	22,972	34,599	21,239	1,211	174	9,283,750

Appendix H. Net Technical Resource Capacity

The Tables in Appendix H display the data for Net Technical Resource Capacity by water depth, distance from shore and wind speed as discussed in Section 8.5.2.

Table H-1. Technical Offshore Wind Potential by Water Depth: Capacity (MW)

State	< 30 m	30–60 m	60–700 m	700–1000 m	Grand Total
Alabama	8,166	6,656	3,939	0	18,760
California	2,769	2,498	63,881	43,307	112,455
Connecticut	1,698	408	37	0	2,143
Delaware	4,272	1,510	94	0	5,876
Florida	30,284	25,628	66,052	153,203	275,166
Georgia	22,630	12,909	9,290	5,282	50,110
Hawaii	617	1,801	18,711	7,802	28,930
Illinois	2,458	2,070	0	0	4,528
Indiana	995	0	0	0	995
Louisiana	79,667	40,249	72,713	27,109	219,739
Maine	6,935	4,972	82,591	0	94,498
Maryland	7,905	8,087	9,057	1,480	26,529
Massachusetts	20,521	62,874	150,900	5,559	239,855
Michigan	30,505	26,827	0	0	57,331
Minnesota	8	144	0	0	151
Mississippi	2,974	517	0	0	3,491
New Hampshire	201	259	836	0	1,295
New Jersey	17,039	29,800	22,377	1,961	71,177
New York	13,029	24,543	33,373	2,510	73,454
North Carolina	57,837	38,366	57,037	20,215	173,455
Ohio	17,990	0	0	0	17,990
Oregon	478	1,187	49,706	10,538	61,910
Pennsylvania	2,744	834	0	0	3,578
Rhode Island	1,695	5,108	7,391	384	14,578
South Carolina	37,578	20,039	71,643	53,373	182,633
Texas	68,136	49,324	70,070	28,449	215,979
Virginia	25,670	12,062	6,466	964	45,163
Washington	1,030	3,624	27,483	9,806	41,944
Wisconsin	7,781	6,479	0	0	14,260
Total	473,612	388,774	823,646	371,944	2,057,976

Table H-2. Technical Offshore Wind Potential by Distance from Shore: Capacity (MW)

State	< 3 nm	3–12 nm	12–50 nm	50–200 nm	Grand Total
Alabama	1,368	2,852	14,392	148	18,760
California	4,073	39,474	68,246	662	112,455
Connecticut	2,143	0	0	0	2,143
Delaware	1,806	1,249	2,794	27	5,876
Florida	1,847	5,352	95,941	172,025	275,166
Georgia	1,119	5,005	20,839	23,147	50,110
Hawaii	5,738	15,559	6,970	662	28,930
Illinois	775	2,677	1,076	0	4,528
Indiana	541	455	0	0	995
Louisiana	11,608	22,337	100,145	85,649	219,739
Maine	9,355	14,772	44,659	25,712	94,498
Maryland	3,751	1,738	13,136	7,903	26,529
Massachusetts	8,583	13,182	65,336	152,754	239,855
Michigan	23,034	27,910	6,387	0	57,331
Minnesota	35	116	0	0	151
Mississippi	744	1,394	1,353	0	3,491
New Hampshire	253	679	363	0	1,295
New Jersey	3,888	6,815	33,228	27,246	71,177
New York	10,123	9,164	28,776	25,391	73,454
North Carolina	14,908	16,713	81,600	60,234	173,455
Ohio	3,020	7,718	7,252	0	17,990
Oregon	3,139	15,960	42,725	86	61,910
Pennsylvania	652	2,244	682	0	3,578
Rhode Island	1,350	2,840	6,608	3,780	14,578
South Carolina	3,004	9,800	45,853	123,975	182,633
Texas	23,662	17,755	85,848	88,715	215,979
Virginia	8,941	5,665	24,190	6,366	45,163
Washington	3,075	9,126	29,743	0	41,944
Wisconsin	6,803	7,131	326	0	14,260
Total	159,340	265,684	828,469	804,483	2,057,976

Table H-3. Technical Offshore Wind Potential by Wind Speed: Capacity (MW)

State	7–7.25 m/s	7.25–7.5 m/s	7.5–7.75 m/s	7.75–8 m/s	8–8.25 m/s	8.25–8.5 m/s	8.5–8.75 m/s	8.75–9 m/s	9–9.25 m/s	9.25–9.5 m/s	9.5–9.75 m/s	9.75–10 m/s	10–10.25 m/s	10.25–10.5 m/s	10.5–10.75 m/s	10.75–11 m/s	11–11.25 m/s	11.25–11.5 m/s	Grand Total
Alabama	11,507	7,253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18,760
California	7,069	7,516	9,003	9,763	12,138	14,265	10,442	8,159	9,157	8,001	4,708	2,285	3,222	2,059	2,692	1,980	0	0	112,455
Connecticut	243	338	714	582	265	0	0	0	0	0	0	0	0	0	0	0	0	0	2,143
Delaware	175	204	344	541	1,168	2,215	1,214	15	0	0	0	0	0	0	0	0	0	0	5,876
Florida	137,997	106,293	30,551	325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	275,166
Georgia	635	9,006	24,712	11,610	4,147	0	0	0	0	0	0	0	0	0	0	0	0	0	50,110
Hawaii	1,838	2,143	2,618	3,554	3,903	3,914	2,870	1,925	1,169	1,679	888	555	517	380	518	277	155	27	28,930
Illinois	5	39	95	129	260	1,686	2,290	25	0	0	0	0	0	0	0	0	0	0	4,528
Indiana	8	45	87	118	289	448	2	0	0	0	0	0	0	0	0	0	0	0	995
Louisiana	86,720	54,040	75,048	3,931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	219,739
Maine	657	785	920	917	1,220	1,803	2,103	2,925	4,680	12,696	34,429	20,782	10,580	0	0	0	0	0	94,498
Maryland	1,846	1,038	624	203	778	8,652	5,973	6,243	1,171	0	0	0	0	0	0	0	0	0	26,529
Massachusetts	119	181	328	517	808	1,737	2,986	3,967	5,861	51,242	129,180	42,930	0	0	0	0	0	0	239,855
Michigan	1,680	2,677	4,013	7,863	14,693	13,205	8,910	3,896	76	286	34	0	0	0	0	0	0	0	57,331
Minnesota	149	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151
Mississippi	2,448	1,044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,491
New Hampshire	13	12	35	39	48	155	252	380	303	59	0	0	0	0	0	0	0	0	1,295
New Jersey	178	440	667	995	1,272	4,618	13,209	13,142	36,534	124	0	0	0	0	0	0	0	0	71,177
New York	361	681	1,112	2,884	5,056	2,566	1,161	2,805	28,816	27,014	999	0	0	0	0	0	0	0	73,454
North Carolina	1,062	1,789	2,684	4,723	10,891	61,198	67,312	23,795	0	0	0	0	0	0	0	0	0	0	173,455
Ohio	7	70	350	1,488	4,653	8,385	3,037	0	0	0	0	0	0	0	0	0	0	0	17,990
Oregon	415	505	598	747	1,972	6,039	10,065	10,973	11,089	7,631	3,021	2,544	1,058	1,251	2,521	1,481	0	0	61,910
Pennsylvania	0	3	25	66	663	2,013	808	0	0	0	0	0	0	0	0	0	0	0	3,578
Rhode Island	149	266	92	115	247	293	439	1,005	1,026	10,870	75	0	0	0	0	0	0	0	14,578
South Carolina	462	624	21,836	60,871	64,322	27,014	7,504	0	0	0	0	0	0	0	0	0	0	0	182,633
Texas	371	60,428	31,561	49,743	19,129	19,375	21,144	14,107	122	0	0	0	0	0	0	0	0	0	215,979
Virginia	687	1,220	2,554	4,635	3,894	8,670	16,898	6,605	0	0	0	0	0	0	0	0	0	0	45,163
Washington	1,191	1,039	1,639	2,219	3,217	9,224	17,661	5,099	655	0	0	0	0	0	0	0	0	0	41,944
Wisconsin	1,033	1,745	1,736	1,684	2,050	2,903	2,426	683	0	0	0	0	0	0	0	0	0	0	14,260
Total	259,024	261,423	213,949	170,260	157,082	200,378	198,707	105,747	100,658	119,602	173,333	69,096	15,377	3,689	5,731	3,738	155	27	2,057,976

Appendix I. Net Technical Energy Potential

The Tables in Appendix I display the data for Technical Offshore Wind Potential by water depth, distance from shore and wind speed as discussed in Section 8.5.3.

Table I-1. Technical Offshore Wind Potential by Water Depth: Generation (GWh/yr)

State	< 30 m	30–60 m	60–700 m	700–1000 m	Grand Total
Alabama	22,684	19,070	11,002	0	52,755
California	8,920	8,068	216,579	158,348	391,915
Connecticut	5,304	1,320	106	0	6,729
Delaware	14,719	5,528	358	0	20,604
Florida	84,141	71,412	185,315	439,393	780,260
Georgia	71,120	40,466	28,452	16,419	156,456
Hawaii	2,049	6,127	64,100	27,608	99,885
Illinois	8,974	7,788	0	0	16,762
Indiana	3,423	0	0	0	3,423
Louisiana	239,034	116,697	208,772	77,069	641,572
Maine	23,902	20,120	367,162	0	411,184
Maryland	25,735	29,656	35,036	5,863	96,289
Massachusetts	84,384	279,883	664,758	24,142	1,053,166
Michigan	102,386	97,054	0	0	199,440
Minnesota	22	405	0	0	426
Mississippi	8,259	1,484	0	0	9,743
New Hampshire	693	976	3,322	0	4,991
New Jersey	62,564	118,033	91,587	8,010	280,193
New York	45,542	99,377	139,754	10,553	295,226
North Carolina	203,990	143,936	211,934	74,292	634,153
Ohio	62,657	0	0	0	62,657
Oregon	1,504	3,877	183,961	40,888	230,230
Pennsylvania	9,793	2,999	0	0	12,792
Rhode Island	6,107	21,081	31,539	1,636	60,363
South Carolina	128,518	70,389	242,215	171,517	612,639
Texas	229,811	168,020	227,055	87,082	711,968
Virginia	87,924	45,128	24,983	3,776	161,812
Washington	3,079	11,684	95,889	35,984	146,636
Wisconsin	25,874	22,735	0	0	48,609
Total	1,573,108	1,413,312	3,033,877	1,182,581	7,202,878

Table I-2. Technical Offshore Wind Potential by Distance from Shore: Generation (GWh/yr)

State	< 3 nm	3–12 nm	12–50 nm	50–200 nm	Grand Total
Alabama	3,432	8,034	40,866	423	52,755
California	13,437	134,331	242,155	1,992	391,915
Connecticut	6,729	0	0	0	6,729
Delaware	5,876	4,404	10,222	103	20,604
Florida	5,095	14,884	265,992	494,289	780,260
Georgia	3,217	15,041	67,360	70,838	156,456
Hawaii	19,611	52,618	25,321	2,336	99,885
Illinois	2,702	10,096	3,964	0	16,762
Indiana	1,833	1,590	0	0	3,423
Louisiana	32,279	66,197	304,438	238,659	641,572
Maine	33,630	62,211	201,187	114,155	411,184
Maryland	10,760	6,194	48,153	31,183	96,289
Massachusetts	32,120	54,746	285,332	680,968	1,053,166
Michigan	76,027	98,953	24,460	0	199,440
Minnesota	100	326	0	0	426
Mississippi	1,961	3,914	3,868	0	9,743
New Hampshire	873	2,616	1,502	0	4,991
New Jersey	12,761	25,334	130,704	111,394	280,193
New York	33,962	34,991	120,324	105,949	295,226
North Carolina	48,567	59,120	305,760	220,706	634,153
Ohio	9,852	26,887	25,918	0	62,657
Oregon	10,255	59,000	160,677	297	230,230
Pennsylvania	2,316	8,001	2,475	0	12,792
Rhode Island	4,630	11,454	28,108	16,170	60,363
South Carolina	9,284	32,715	161,811	408,828	612,639
Texas	79,764	63,442	300,894	267,867	711,968
Virginia	27,679	19,611	89,593	24,929	161,812
Washington	9,135	30,087	107,413	0	146,636
Wisconsin	22,521	24,897	1,190	0	48,609
Total	520,409	931,694	2,959,688	2,791,087	7,202,878

Table I-3. Technical Offshore Wind Potential by Wind Speed: Generation (GWh/yr)

State	7–7.25 m/s	7.25–7.5 m/s	7.5–7.75 m/s	7.75–8 m/s	8–8.25 m/s	8.25–8.5 m/s	8.5–8.75 m/s	8.75–9 m/s	9–9.25 m/s	9.25–9.5 m/s	9.5–9.75 m/s	9.75–10 m/s	10–10.25 m/s	10.25–10.5 m/s	10.5–10.75 m/s	10.75–11 m/s	11–11.25 m/s	11.25–11.5 m/s	Grand Total
Alabama	31,718	21,037	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52,755
California	19,421	21,760	27,223	30,929	40,106	49,012	37,346	30,144	34,927	31,118	18,457	9,215	13,517	8,717	11,452	8,570	0	0	391,915
Connecticut	680	1,002	2,210	1,911	927	0	0	0	0	0	0	0	0	0	0	0	0	0	6,729
Delaware	490	604	1,079	1,812	4,062	7,994	4,504	59	0	0	0	0	0	0	0	0	0	0	20,604
Florida	378,019	307,711	93,482	1,048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	780,260
Georgia	1,724	26,489	76,332	37,963	13,948	0	0	0	0	0	0	0	0	0	0	0	0	0	156,456
Hawaii	5,146	6,300	8,051	11,405	13,027	13,518	10,274	7,069	4,447	6,567	3,572	2,299	2,188	1,646	2,291	1,250	711	123	99,885
Illinois	14	116	298	429	910	6,155	8,739	100	0	0	0	0	0	0	0	0	0	0	16,762
Indiana	22	133	275	391	1,007	1,589	7	0	0	0	0	0	0	0	0	0	0	0	3,423
Louisiana	239,170	159,284	230,434	12,684	0	0	0	0	0	0	0	0	0	0	0	0	0	0	641,572
Maine	1,838	2,323	2,874	2,970	4,228	6,496	7,981	11,579	19,267	54,251	152,901	95,062	49,412	0	0	0	0	0	411,184
Maryland	5,046	2,981	1,924	672	2,743	31,405	22,181	24,541	4,798	0	0	0	0	0	0	0	0	0	96,289
Massachusetts	332	536	1,029	1,707	2,766	6,354	11,383	15,682	24,188	219,198	572,555	197,435	0	0	0	0	0	0	1,053,166
Michigan	4,736	7,909	12,454	25,650	50,607	47,443	33,669	15,274	315	1,232	151	0	0	0	0	0	0	0	199,440
Minnesota	418	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	426
Mississippi	6,720	3,023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9,743
New Hampshire	36	36	108	129	167	564	950	1,501	1,245	253	0	0	0	0	0	0	0	0	4,991
New Jersey	498	1,304	2,090	3,285	4,345	16,736	49,812	51,889	149,703	531	0	0	0	0	0	0	0	0	280,193
New York	1,011	2,024	3,494	9,503	17,247	9,204	4,270	11,077	118,546	114,529	4,323	0	0	0	0	0	0	0	295,226
North Carolina	2,972	5,130	8,153	15,313	37,167	220,396	252,900	92,120	0	1	0	0	0	0	0	0	0	0	634,153
Ohio	21	208	1,104	4,923	15,702	29,785	10,914	0	0	0	0	0	0	0	0	0	0	0	62,657
Oregon	1,167	1,495	1,816	2,413	6,485	20,664	35,783	40,290	41,765	29,104	11,707	10,253	4,412	5,335	11,005	6,536	0	0	230,230
Pennsylvania	0	8	80	218	2,304	7,165	3,016	0	0	0	0	0	0	0	0	0	0	0	12,792
Rhode Island	418	789	289	381	856	1,079	1,678	4,021	4,201	46,315	336	0	0	0	0	0	0	0	60,363
South Carolina	1,294	1,850	67,113	197,594	219,915	97,047	27,827	0	0	0	0	0	0	0	0	0	0	0	612,639
Texas	1,037	177,067	98,618	163,453	65,284	70,191	79,931	55,885	500	0	0	0	0	0	0	0	0	0	711,968
Virginia	1,922	3,617	7,754	14,874	13,314	31,313	63,146	25,872	0	0	0	0	0	0	0	0	0	0	161,812
Washington	3,349	3,061	5,012	6,995	10,598	32,011	63,963	19,113	2,535	0	0	0	0	0	0	0	0	0	146,636
Wisconsin	2,919	5,141	5,407	5,460	7,107	10,674	9,223	2,677	0	0	0	0	0	0	0	0	0	0	48,609
Total	712,135	762,946	658,704	554,112	534,824	716,796	739,499	408,895	406,436	503,099	764,002	314,264	69,530	15,698	24,749	16,357	711	123	7,202,878

Appendix J. Comparison to Wind Vision

This study was intended to build on the discussions and analysis performed in the U.S. Department of Energy *Wind Vision* study published in March 2015. However, the tools and procedures used are continuously evolving. Therefore, many assumptions used in this report changed since the *Wind Vision* analysis was conducted.

Wind Vision 2015 Assumptions

The key assumptions are provided here to allow the reader to compare the Wind Vision to this report.   The bullets below pertain to the Wind Vision scenario (DOE 20150.

- Gross area not calculated
- Hub height is 90 m
- Domain boundary calculated by depth and wind speed bands of:
  - 0–30 m
  - 30–60 m
  - 60–700 m (shallower cutoff than this report)
- Distance-from-shore bands of:
  - None
- Array power density is 3 MW/km^2
- Turbine specific power is 318 W/m^2
- Gross energy is based on supply curves only
- Losses fixed at 15% (same as land-based)
- Technology exclusions:
  - Below 30% net capacity factor excluded
  - Greater than 700-m depth excluded
  - Great Lakes ice exclusion: none
- Conflicting-use Exclusions: Black & Veatch 36% offshore (no distance-to- shore gradient).

2016 Offshore Wind Resource Assessment Assumptions

The key assumptions for this report are provided again to allow the reader to compare the Wind Vision to this report.   The bullets below pertain to this report.

- Gross area defined by 200-nm EEZ
- Hub height raised to 100 m
- Resource classification depth bands of:
  - 0–30 m
  - 30–60 m
  - 60–1,000 m
- Distance-from-shore bands:
  - 0–3 nm
  - 3–12 nm
  - 12 nm–50 nm
  - 50 nm–200 nm
- Gross capacity power density is 3 MW/km^2
- Turbine specific power is 318 W/m^2

- Variable losses 12% to 23% based on actual wind plant performance (17% on average)
    - 6% fixed (4% availability, 2% other based on Beiter 2016)
    - Electrical losses (1%–5%)
    - Wake losses (4% to 12%) from Openwind
- Technology exclusions:
    - Less than 7 m/s excluded (same as 2010 assessment)
    - Greater than 1,000 m excluded (updated based on developer feedback)
    - Greater than 60 m in Great Lakes excluded
- Conflicting-use exclusions: Black & Veatch 36% offshore.

Appendix K. State-to-State Boundary Data

Table K-1. State-to-State Boundary Data

State	Source
California [1]	NREL digitized line from the Minerals Management Service Submerged Lands Act (SLA) line to the California/Oregon state line
Connecticut	http://www.ct.gov/dep/site/default.asp;http://www.nyswaterfronts.com/index.asp
Georgia	http://gis.state.ga.us/
Illinois	http://www.isgs.uiuc.edu/nsdihome/; http://www.mcgi.state.mi.us/mgdl/
Louisiana[1]	http://atlas.lsu.edu/; http://www.glo.state.tx.us/; NREL digitized line from the MMS SLA line to the Texas/Louisiana state line
Maine	http://megis.maine.gov/
Maryland	http://www.marylandgis.net/SHAdata/
Massachusetts	http://www.whoi.edu/
Michigan	http://www.mcgi.state.mi.us/mgdl/
Minnesota	http://deli.dnr.state.mn.us/data_catalog.html
Mississippi[1]	http://www.maris.state.ms.us/; http://atlas.lsu.edu/; NREL digitized line from the MMS SLA line to the Mississippi/Alabama state line
New Jersey	http://www.state.nj.us/dep/njgs/; http://www.nyswaterfronts.com/index.asp
New York	http://www.nyswaterfronts.com/index.asp
North Carolina	http://www.cgia.state.nc.us/; http://www.ors.state.sc.us/digital/gisdata.asp
Ohio	http://www.dnr.state.oh.us/gims/; http://www.mcgi.state.mi.us/mgdl/
Oregon[1]	NREL digitized line from the MMS SLA line to the Oregon/California and Oregon/Washington state lines
Pennsylvania	http://nationalatlas.gov/atlasftp.html; http://www.dnr.state.oh.us/gims/; http://www.nyswaterfronts.com/index.asp
South Carolina	http://www.ors.state.sc.us/digital/gisdata.asp; http://gis.state.ga.us/
Texas[1]	http://www.glo.state.tx.us/; NREL digitized line from the MMS SLA line to the Texas/Louisiana state line
Washington	http://www.ecy.wa.gov/services/gis/data/data.htm

[1] Environmental Systems Research Institute, Inc. Data & Maps 9.1 Detailed States

Appendix L. Annual Energy Production Loss Assumption Table

Table L-1. Gross Theoretical Recoverable Resource Energy with Losses (Wakes, Electrical, Availability, and Other) in TWh/year

Variable	Assumption	Source
AEP net	AEP_{net} = GCF * 8760 * 600 * (1-AEPSysLosses)	Smith, Stehly, and Musial 2015, pg. 74
AEP System Losses	AEP System Losses = 1 - (1 * (1 – Electrical Losses) * (1 – Wake Losses) * (1 – Other Losses) * Availability)	Smith, Stehly, and Musial 2015, pg. 74
Gross Capacity Factor	Atlantic: GCF = -0.2196 + 0.0852 x windspeed (R2=0.998) Gulf of Mexico: GCF = -0.2590 + 0.0908 x windspeed (R2= 0.999) Great Lakes: GCF = -0.2265 + 0.0863 x R2 (R2= 0.988) Pacific: GCF = -0.4007 + 0.14636 x windspeed -0.00508793 x ($windspeed^2$) (R2 = 0.985)	Linear relationship developed by George Scott, NREL for Openwind analysis
Electrical Losses Equation Based on Depth and Distance to Shore	Electrical losses = (2.07+(0.073 x Dist) + (-0.0016 x $Dist^2$)+(0.000017 x $Dist^3$) + (-0.000000086 x $Dist^4$) + (0.000000000157 x $Dist^5$) + 0.0015 x Depth + (-0.0000047 x $Depth^2$) + (0.0000000082 x $Depth^3$) + (-0.0000000000041 x $Depth^4$))/100 Dist: Distance from site to cable landfall (km) Depth: Water depth (m)	Smith, Stehly, and Musial 2015, pg. 100–101
Wake Losses from Openwind	Linear relationship (Openwind 600-MW wind farm with 10-by-10 wind turbine grid (6 MW each); whole ocean tiled with these cells; and then … within 0–50 nm; for each location, for more ~7,000 spots (not Hawaii) calculated wake losses). Plotted against wind speed.	Linear relationship developed by George Scott, NREL from Openwind analysis
Other Losses	2% (performance, environmental, curtailment)	Smith, Stehly, and Musial 2015, pg. 22
Availability	96%	Mone et al. 2015, p. 42