Energy Conversion and Management: X 20 (2023) 100410

Contents lists available at ScienceDirect

Energy Conversion and Management: X

journal homepage: www.sciencedirect.com/journal/energy-conversion-and-management-x

United States offshore wind energy atlas: availability, potential, and economic insights based on wind speeds at different altitudes and thresholds and policy-informed exclusions

Anna-Katharina von Krauland [a,*], Qirui Long [a], Peter Enevoldsen [b], Mark Z. Jacobson [a]

[a] Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, United States

[b] Center for Energy Technologies, Department of Business Technology and Development, Aarhus University, Birk Centerpark 15, Herning 7400, Denmark

A R T I C L E I N F O

Keywords:
Energy mapping
Energy policy
Geographic Information System
Offshore wind energy
Renewable energy
Wind energy atlas

A B S T R A C T

This study presents the first comprehensive offshore United States wind energy atlas at multiple hub heights above 100 m that accounts for technical, climate, environmental, and social exclusions. The study uses Geographic Information System (GIS) mapping and open-source marine planning data. The atlas accounts for wind speed thresholds, bathymetry, ocean conditions, restrictions (including shipping lanes and military zones that can impede wind projects), regulations (including distance requirements from energy infrastructure, safety hazards, and marine protected areas), and modern wind turbine information (including size, spacing, and energy output). The results indicate that 64% of total (61.5% of contiguous) U.S. coastal area is available for offshore wind development, translating to a maximum possible nameplate capacity of 26,800 GW (7,150 GW for the contiguous U.S.). This far exceeds the U.S. 30 GW by 2030 target and projected capacity needs to power all energy sectors in 2050. The regions with the largest available areas at 150 m hub height and a 7 m/s wind speed threshold include Alaska (~1,784,300 km^2), Hawaii (~718,600 km^2), and the Northern California Coast (~127,000 km^2). The U.S. East and Gulf Coasts have ~363,200 km^2 and ~137,800 km^2 available, respectively. This atlas will enable site selection that maximizes energy generation while minimizing interference with other stakeholders, costs, required port infrastructure investments, and new transmission interconnection distances.

Introduction

The United States is undertaking a renewable energy transition in which offshore wind has a significant role to play [1–5]. Since 2014, advancements in wind technology have lowered the levelized cost of energy (LCOE) by more than 50%, moving floating offshore wind towards cost parity with fixed bottom turbine substructures and enabling global deployment of 260 GW by 2030 [6–8]. Given this trend, robust state-level procurement targets, strong federal support, ambitious new initiatives [9], and record-setting lease prices and pipeline expansions, the industry is poised for growth.

Several states, including New York [10,11], New Jersey, Massachusetts [12], and California [13,14], have set ambitious targets for offshore wind development and have taken steps to build the necessary infrastructure and supply chains [15–17]. In the coming years, national leasing plans call for offshore wind energy auctions in the Gulf of Mexico, South Atlantic, Pacific, and the Gulf of Maine. The federal government also plans to address the climate crisis, build new American infrastructure, and transition to a clean energy economy by setting a goal of deploying 30 GW of offshore wind capacity by 2030 [18]. This target is notable because it represents a substantial increase in the pace of offshore wind development in the U.S., establishing the pathway to deploy 110 GW or more by 2050 [18]. If achieved, this target would create tens of thousands of jobs, reduce greenhouse gas emissions, and provide an immense source of clean energy [18–20].

Reaching the 30 GW target will require considerable capital investments in new infrastructure, including wind turbines, transmission lines, and port facilities [21–25]. It will also necessitate coordination across multiple levels of government and the private sector to overcome technical, financial, environmental, and regulatory challenges. Among these, siting can be one of the most complex and time-consuming. However, if these obstacles are overcome with the help of a streamlined siting process that reduces development costs and uncertainty, the U.S. can emerge as a global leader in offshore wind.

* Corresponding author.
E-mail address: krauland@stanford.edu (A.-K. von Krauland).

https://doi.org/10.1016/j.ecmx.2023.100410
Received 16 April 2023; Received in revised form 5 June 2023; Accepted 18 June 2023
Available online 21 June 2023

The U.S. offshore wind industry is still in its nascency, with only 42 MW currently deployed between the Block Island Wind Farm and the Coastal Virginia Offshore Wind pilot project [26]. As of 2022, though, the wind energy development pipeline has over 40 GW of potential generating capacity, driven by the Bureau of Ocean Energy Management (BOEM)'s auctions of new lease areas in the Atlantic and California coasts [7,27]. The next step is to determine the optimal placement of wind farms, for which there are several important factors to consider. The first and most consequential is the wind resource, as the wind speeds and wind patterns will determine the energy production of a wind farm. Second, the water depth and ocean floor characteristics must be suitable [28]. Shallow water is often preferred to minimize installation and maintenance costs. The distance from shore also affects the cost of transmission to the electrical grid. Wind farms must be located near existing or planned electrical transmission infrastructure to reduce the cost and technical challenges of connecting to the grid. Furthermore, offshore wind farms should be sited away from shipping lanes, fishing grounds, and protected marine areas. Public acceptance is an important factor [29–32], as local communities can have concerns about the visual impact, noise, and potential impact on fishing, local tourism, recreation, and other activities.

There have been previous efforts to map the offshore wind energy potential and spatial availability across the U.S., taking into account one or more of the factors discussed above. One resulted in an estimated cumulative wind potential of 2,472 GW of fixed-bottom and 2,787 GW of floating capacity [33], and another in 1,500 GW of fixed-bottom and 2,800 GW of floating capacity for the continental U.S. [5]. Despite considering meteorology and bathymetry at very high resolutions, these studies examine exclusions more simplistically than here and neither consider results at multiple hub heights nor cover the entire U.S. Furthermore, in contrast with this study, other studies prescribe strict distance, depth, and wind speed limitations. For instance, some reports use a technically feasible distance of 30 km [34], or 7 m/s wind speed and 50 m (fixed-bottom) and 50–1,000 m (floating) depth cutoff [1,33,35]. Others include areas further from shore (e.g., 200 km [33]), but limit the study area in other artificial ways, or consider outdated turbine hub heights or capacities [1,36,37]. Other groups of studies omit infrastructural and ocean use restrictions altogether [38–43], do not focus on the United States [28,37,44], or focus on only one state or region [40,45–52]. Some reports and guides define best-practices, recommend strategies, list important siting parameters, or analyze trends, but do not necessarily implement this information to elucidate geographically-specific insights or recommendations [3,53–62], or again, focus outside the U.S. [63,64] (although many of these guides helped to inform the choice of relevant exclusions and setback distances, as described in the Methods). Some private software exists that can assist with site assessment, including EMD WindPRO, which generates high-quality mesoscale time series data to plan projects [65], UL Windographer, which is designed for analyzing and visualizing wind resource data [66], UL Openwind, which optimizes wind farm layouts and maximizes LCOE [67], and UL Windnavigator, which is for wind energy site prospecting [68]. However, these consider only wind resources (Windographer, Windnavigator) without other restrictions, rely on user expertise, are not widely accessible, and do not provide insights over larger geographies (i.e., for an entire state or region), as is done here. Certain openly-available software do not include the U.S. [69], or lack offshore wind analysis data [70].

In comparison, this study considers an extensive set of relevant infrastructural, environmental, ocean use, and metocean parameters that inform siting decisions, while presenting an array of different wind energy scenarios that represent rapidly evolving turbine technologies. Importantly, this study includes wind speeds for modern offshore wind turbines up to 250 m above surface level (ASL), in contrast with previous studies that focused on altitudes around or below 100–150 m [1,36–39,48–50]. Offshore wind turbine heights have increased markedly in recent years as technology has improved. Starting from 35 m hub heights in the early 1990s [71], the largest contemporary offshore wind turbines now have hub heights over 150 m and rotor diameters of over 230 m, accompanied by larger nameplate capacities [72–77]. Taller turbines and longer blades capture more energy, as wind velocity increases with altitude and more wind energy is captured with a larger swept area, which improves the overall capacity factor of the wind turbine [78]. The increase in height has also allowed for the development of offshore wind farms further from shore in deeper waters, where wind resources are typically stronger and more consistent [79]. Furthermore, as turbine tip heights reach beyond 200 m and blades become longer, it is increasingly important to account for the vertical profile of atmospheric conditions, instead of focusing on wind speeds at the hub height as a representative estimate [80]. This study uses a 15 MW turbine which will soon come to dominate the market, rather than lower turbine ratings in other studies, such as 6 MW or 10 MW [1,34].

Additionally, the appropriate turbine substructures are examined based on bathymetry and soil characteristics [35,81], similar to the methodology presented in Lopez et al. [82]. However, this study includes more nuanced and varied substructure types in favor of assigning regions with either a fixed-bottom or floating designation. The substructure outputs in this study include monopile, gravity-based, jacket, tripod, semi-submersible, tension-leg buoy, spar, and different combinations thereof in areas where more than one substructure would be suitable, for water depths up to 1,000 m.

Beyond spatially specific resource estimations, the available areas are examined with an economic lens to highlight low-cost locations based on variables that impact the LCOE of offshore wind. Some of the main drivers of LCOE include water depth, wind speed, proximity to onshore grid interconnection, the capacity of transmission infrastructure, the complexity of the wind farm array cabling, and shore-based construction port facilities [34,37,83]. Many of these parameters are weighted and considered in a set of economic heatmaps.

This study aggregates a diversity of policy-informed exclusions and industry-informed siting characteristics. Major output of this study includes maximum available offshore area, nameplate capacity (GW), energy output (TWh), output power density (MW/km^2), and output energy density (TWh/km^2) for fifteen coastal regions over all U.S. coastal waters, with thirteen wind speed thresholds at four hub heights, and with three wake loss scenarios. Some of these metrics are compared with 2050 clean energy targets and 2021 national energy consumption data. The objective of this atlas is to streamline and accelerate the process of wind farm development by creating the first high resolution, country-wide offshore U.S. wind atlas to inform siting decisions.

Methods

All U.S. coastal areas are included in this study, as seen in Fig. 1. These are divided into the following regions: East Coast (Northern East Coast, Mid-Atlantic Coast, North Carolina Coast, Southern East Coast), Gulf Coast (Eastern Gulf Coast, Central Gulf Coast, Western Gulf Coast), West Coast (Washington Coast, Oregon Coast, Northern California Coast, Southern California Coast), Great Lakes, Alaska, Hawaii, and Puerto Rico, for a total of 15 study areas. U.S. federal waters extend to 200 nautical miles (nm) from shore, an area called the Exclusive Economic Zone (EEZ). Wherever possible, the study area extends to the outer boundary of the EEZ, otherwise the outer edge is defined by the outer limit of available wind speed data [84]. An overview of the methodology is provided in Table 1.

Using Geographic Information System (GIS) mapping, regions with other ocean uses or ecological significance, including airports, existing energy infrastructure, aquaculture, disposal areas, highly protected marine and bird areas, military areas, navigation and shipping lanes, reefs, kelp forests, submarine cables, and wrecks [57,64,85], were excluded (see Table S1). Rather than prescribing a minimum or maximum distance from shore to account for social (e.g., visibility) and economic (e.g., costs of installation and maintenance) concerns, this

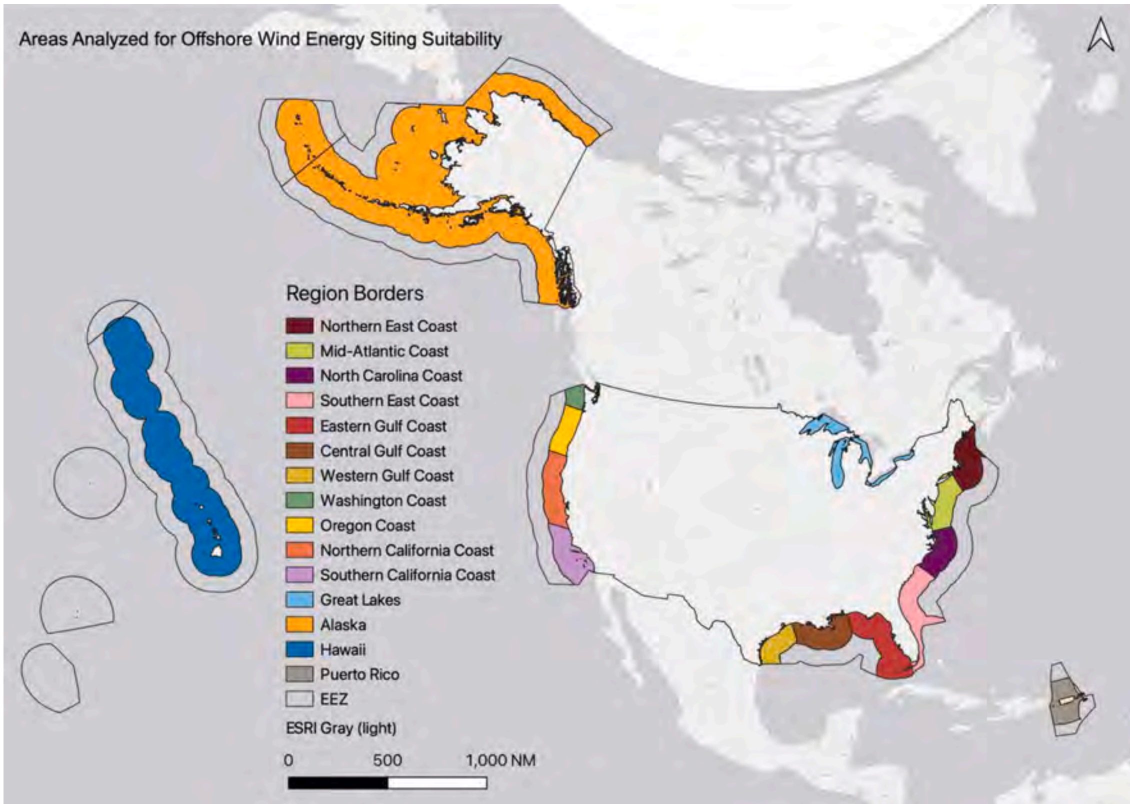

Fig. 1. Areas Analyzed for Offshore Wind Energy Siting Suitability. Map shows all areas included in the study; namely, all U.S. coastal waters, divided into regions.

atlas includes the full possible area and subsequently uses technical, social, environmental, and economic exclusions to restrict available areas to those most feasible for development. Further, no water depth maximum is imposed, as offshore floating technology in the U.S. is still rapidly evolving. However, the depth and seabed conditions are important components in the choice of the turbine foundation [2,26,86–89]. These restriction layers were buffered according to the policy-informed setback values in Table S1. Each layer was then rasterized to facilitate the calculation, following a similar methodology as Enevoldsen et al. [90], which was later refined in von Krauland et al [91].

To calculate the power generation in each study region, wind speed raster layers were obtained from the Global Wind Atlas at three different heights (100 m, 150 m, and 200 m) [84]. The Global Wind Atlas uses downscaled ERA5 multi-year average wind data from 2008 to 2017 to model local climates using WAsP on a 250 m grid [84]. The data was then aligned to the study resolution, 100 m. Since turbine hub height and blade length have increased rapidly in the past decades [75,76], wind speeds at 250 m were derived based on power-curve extrapolation, as seen in Equation S1. This data was validated with hourly-averaged annual data from the Vestas Climate Library, which consists of modeled data validated with in-situ measurements between 2000 and 2022. To analyze the wind power distribution and visualize the results, 13 binary wind speed threshold layers were generated in a range relevant for industry use (6 – 12 m/s with an interval of 0.5 m/s). These layers indicate whether the wind speed in each pixel exceeds the corresponding threshold.

The remaining area was calculated by subtracting each restriction layer and wind speed scenario from the border layer. The amount of available area (Fig. 2, Tables S3 and S4), maximum number of turbines (Table S5), and the average wind speed (Fig. 5, Figs. S5.1-S5.4, Table S8) were computed in all regions for each height and wind speed threshold. These statistics led to the computation of the maximum possible nameplate capacity (GW) (Figure S1.1, Equations S2-3, Tables S6 and S7), output power density (MW/km^2) (Fig. 5, Table S10), output energy and energy density under different wake loss scenarios (TWh/km^2) (Figs. S2.1-S2.2, Tables S11 – S14), and other useful metrics for site selection.

Furthermore, a reference layer was made to inform the appropriate turbine substructure choice throughout each region (Figs. 7-8, Figs. S7.1-S7.7). Following the foundation classification in Vazquez et. al. [81] the most suitable foundation type was evaluated based on bathymetry [92] and sediment data [93]. With this information, it was possible to determine which of the seven foundation types, or twelve total combinations of suitable foundations, would be the optimal choice at each location, which is relevant to port infrastructure requirements, capital expenditure (CapEx), and environmental impact.

To estimate the spatial cost variation for offshore wind projects, an economic parameter was designed that considers the relative costs of the turbine foundation, transmission interconnection, port proximity, and labor. Each of these parameters can have a significant impact on the CapEx of a wind project [94–96]. The proximity to a suitable port influences the transportation and installation costs. The cost of interconnecting the wind farm to the electrical grid depends on the distance to the nearest substation. Labor costs, including the cost of technicians and engineers, vary depending on the location of the wind farm and prevailing wages in the area. The cost of the turbine foundation depends on the water depth, sediment conditions, and foundation characteristics.

The economic parameter was computed from four independent equations for each of the CapEx variables (Equations S5-8), to create one unified equation (Equation S9) that can be used to draw conclusions about economic viability across all regions (Fig. 9, Figs. S8.1-S8.30). The turbine foundation cost was derived as a step function between water depth and foundation cost based on the turbine foundation type with the lowest cost in Bosch et. al. [87]. For substations and ports, the costs of the export cables and transportation, respectively, were similarly

Table 1

Summary of Methodology Component Descriptions and Impact. Each step of the methodology is described and the relevance to providing realistic wind power potential is elucidated. The supplemental information describes each component of the methodology in more detail.

Method Component	Description and Impact
Select Data and Setback Distances	Review of literature and best practices, including hundreds of academic papers and industry reports, review of over 150 databases, and interviews with dozens of experts; More comprehensive exclusion consideration than any U.S. offshore wind atlas
Organize Datasets by Study Region	First atlas to include all U.S. coastal areas (East Coast, Gulf Coast, West Coast, Great Lakes, Alaska, Hawaii, and Puerto Rico); Combine complementary datasets for unique level of detail and high resolution
Buffer Restrictions	Apply policy-informed setbacks to represent realistic siting parameters (more detail in Table S1)
Reproject Layers	North America Albers Equal Area Conic and Hawaii Albers Equal Area Conic reference systems minimize distortions over large study regions, equal area preserves area dimensions
Rasterize Restrictions and Resample	Create uniform 100 m resolution files for all layers with matching extent; Assign value of 1 to all restricted pixels to facilitate subsequent calculation with multiple restriction layers
Sort Wind Speed Data; Convert to Binary Format; Extrapolate to 250 m	Compute wind speed thresholds from 6 to 12 m/s with an interval of 0.5 m/s to determine technical and economic viability of potential sites; Convert to binary format; Extrapolate wind speed data to 250 m to account for climate dynamics affecting modern wind turbines with higher hub heights and longer blades (study encompasses 100 m, 150 m, 200 m, and 250 m altitudes)
Subtract from Border Layers	Merge restriction and wind speed raster layers for all combinations into one layer by subtracting from study boundary rasters
Convert to Binary; Calculate Available Areas	Convert to binary format to distinguish available from unavailable grid cells; Quantify available cells from single layer and mean wind speeds in each region
Calculate Key Metrics	Within available areas, compute maximum possible nameplate capacity (GW) with representative modern offshore wind turbine (V236-15) and realistic spacing density, potential energy output (TWh) with different wake loss scenarios (0%, 5%, 10%, 20%) and unique capacity factor for every region with each altitude and wind threshold, output power density (MW/km^2), and output energy density (TWh/km^2)
Create Turbine Foundation Map	Create map with appropriate turbine foundation type(s) for each available location based on bathymetry and sediment analysis
Create CapEx Heatmap	Economic analysis based on weighted summation of bathymetry, distance to ports and substations, and coastal state relative wage rates to produce heatmap with important CapEx parameters scaled relative to representative reference project

obtained as functions of various distance ranges. These distance layers were generated based on the presence of onshore substations that are less than 5 km from the coast and staging ports with a channel depth over 7.9 m and a shelter parameter of excellent, good, or fair categorization in the World Port Index [88,97]. The overhead limit was also considered as a port parameter, but due to inadequate labelling of the data, this parameter is used only for visualization (Fig. 9). As for the wage parameter, average hourly wages of the coastal states bordering the study region were considered for jobs directly pertinent to offshore wind development and installation (Table S2). The maximum state wage was compared to the average to determine a ratio that describes cost variation. All of these components were normalized based the reference project with a water depth of 34 m, a transmission and port distance of 50 km [98], and an average wage of all coastal states. They were then paired with a corresponding weighting factor [98,99] and summed to determine the relative cost.

Results

Fig. 2 shows an overview of the remaining area in all U.S. offshore regions, with restrictions and low wind speeds below 7 m/s at 150 m height excluded from the available areas. It is apparent that available area ranges from 7.9% off the Eastern Gulf Coast to 88.7% off the coast of Puerto Rico. Overall, 3,556,957.01 km^2, or 63.97% of areas, are available with this wind speed threshold, which translates to an enormous maximum possible nameplate capacity and energy output.

Although all regions have some restricted areas, certain areas are especially restricted due to conflicting ocean uses, protected areas, or low wind speeds. For instance, the coastal areas surrounding many of the smaller northwestern Hawaiian Islands are completely excluded due to their protected status as national wildlife sanctuaries, conservation areas, and other sensitive habitat designations. Similarly, large portions of the West Coast and some segments of the East Coast and Great Lakes are blocked for marine wildlife protection. The Aleutian Islands of Alaska are largely restricted due to shipping regulations that delineate areas to be avoided “to reduce the risk of a marine casualty and resulting pollution and damage to the environment” [100].

The U.S. military accounts for another portion of restricted areas, with presence in nearly all study regions. In the Western and Central Gulf Coast, oil and gas infrastructure, such as pipelines, wells, and platforms, account for most restricted areas. However, most of the restricted areas in the Eastern Gulf Coast and Southern East Coast are dominated by low wind speeds below the 7 m/s threshold. In contrast to the 17,918 km^2 available in this scenario, approximately 135,285 km^2 are available with no wind speed restriction in the Eastern Gulf Coast (see Table S4). Similarly, rather than 73,227 km^2 available for development above 7 m/s mean wind speeds, 113,774 km^2 would be available without considering wind in the Southern East Coast. Because areas with low wind speeds are unlikely to be economical, the more realistic 7 m/s wind speed threshold scenario is shown in Fig. 2 and in Figs. 4-8.

With a higher wind speed threshold, the amount of available area decreases, as shown in Fig. 3, particularly in the southeastern U.S. coastal regions, where wind speeds are not as strong. For instance, at 150 m and with a 9 m/s wind threshold, the average available area is only 29.9%. In this scenario, the Central and Eastern Gulf Coast, Puerto Rico, and the Southern East Coast have no available area for offshore wind, given the low mean wind speeds in these regions. At 150 m and 11 m/s, the average available area diminishes further to 1.71%. With a high wind speed threshold, most regions with the exception of Alaska, Hawaii, Northern California, and the Oregon Coast, which have particularly strong wind resources, will have no unrestricted area.

Fig. 4 reveals how available area is impacted by increasing hub height, ranging from 100 m to 250 m. At higher hub height (200 m) and with a 7 m/s wind speed threshold, the overall area (3,599,648.41 km^2) and percentage (65.32%) available are higher than those at 150 m, respectively, due to stronger average wind speeds at higher altitudes. At 250 m, with a 7 m/s wind threshold, these values are slightly higher still (3,631,052.6 km^2 and 66.3%). Correspondingly, at a lower hub height of 100 m and with a 7 m/s wind threshold, the available area (3,499,531.07 km^2 and 62.13%) is lower. The amount of available area is generally more sensitive to the wind speed threshold rather than the hub height, which is evidenced by the relatively constant (yet slightly increasing) bar heights in Fig. 4, particularly when compared to the sharper changes between threshold values in Fig. 3. However, in some regions, it is clear that there is a significant change in the available area with increasing hub height. Ultimately, the appropriate choice of

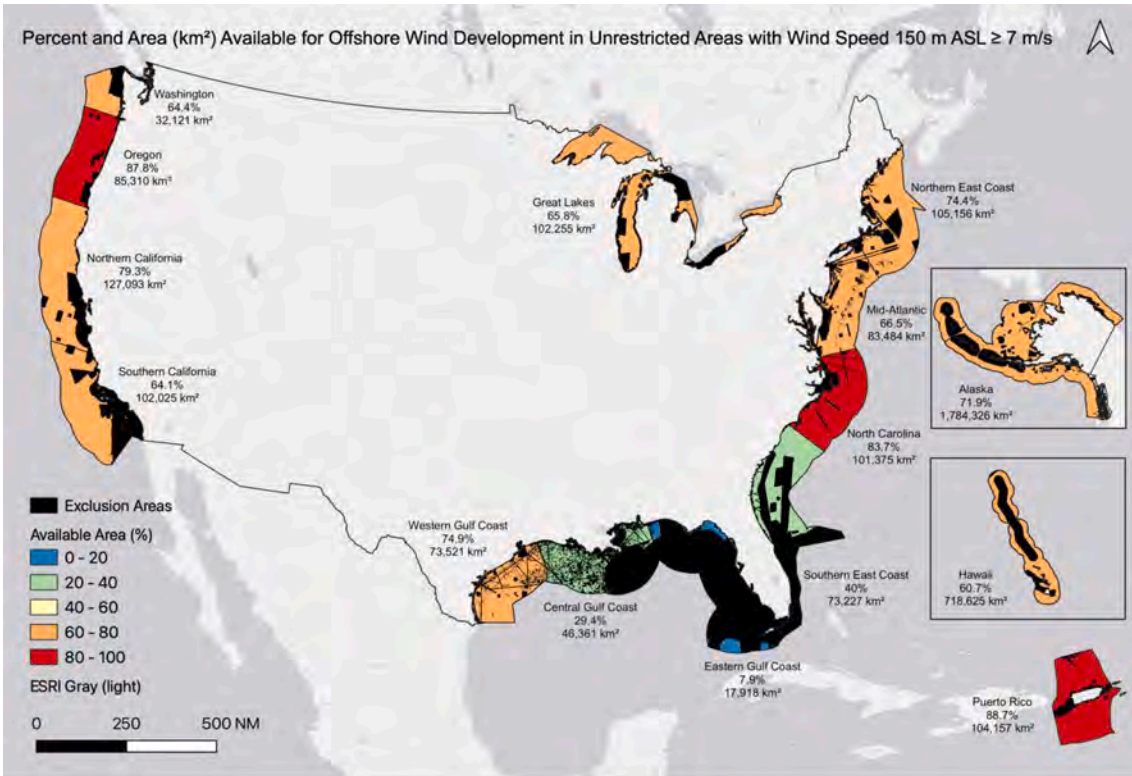

Fig. 2. Percent and Area (km^2) Available for Offshore Wind Development. Map shows the percentage and offshore area available for wind farms after excluding all restrictions in Table S1 and wind speeds below 7 m/s at 150 m ASL. Colors indicate the percentage of available area in each of the fifteen study regions. See Tables S3-4 for all hub height and wind speed threshold combinations.

turbine height and location will depend on highly site-specific energy production and subsequent economic tradeoffs, which depends on other criteria explored below.

The potential output power densities in Fig. 5 were calculated by multiplying maximum possible nameplate capacities by the capacity factor in each corresponding region, divided by the remaining area after

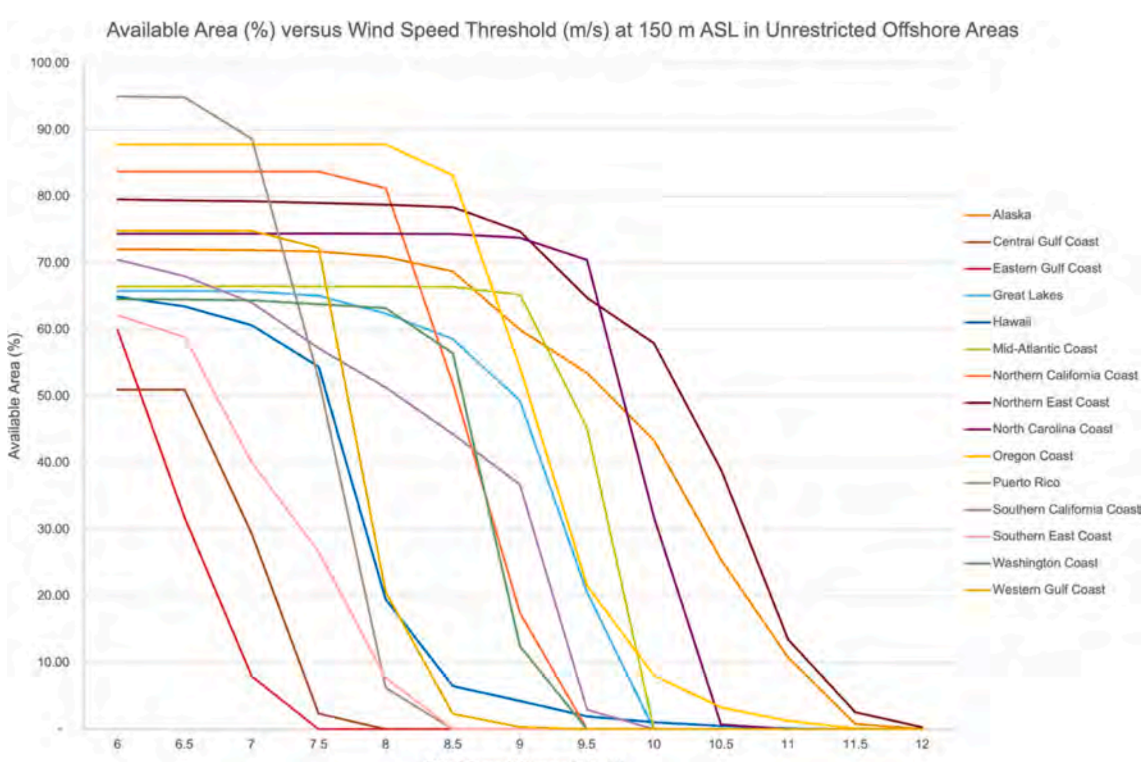

Fig. 3. Available Area (%) versus Wind Speed Threshold (m/s). Graph shows percentage of available area in each region after taking into account all restrictions in Table S1 for each wind speed threshold, from 6 m/s to 12 m/s at 150 m ASL. See Tables S3-4 for all hub height and wind speed threshold combinations.

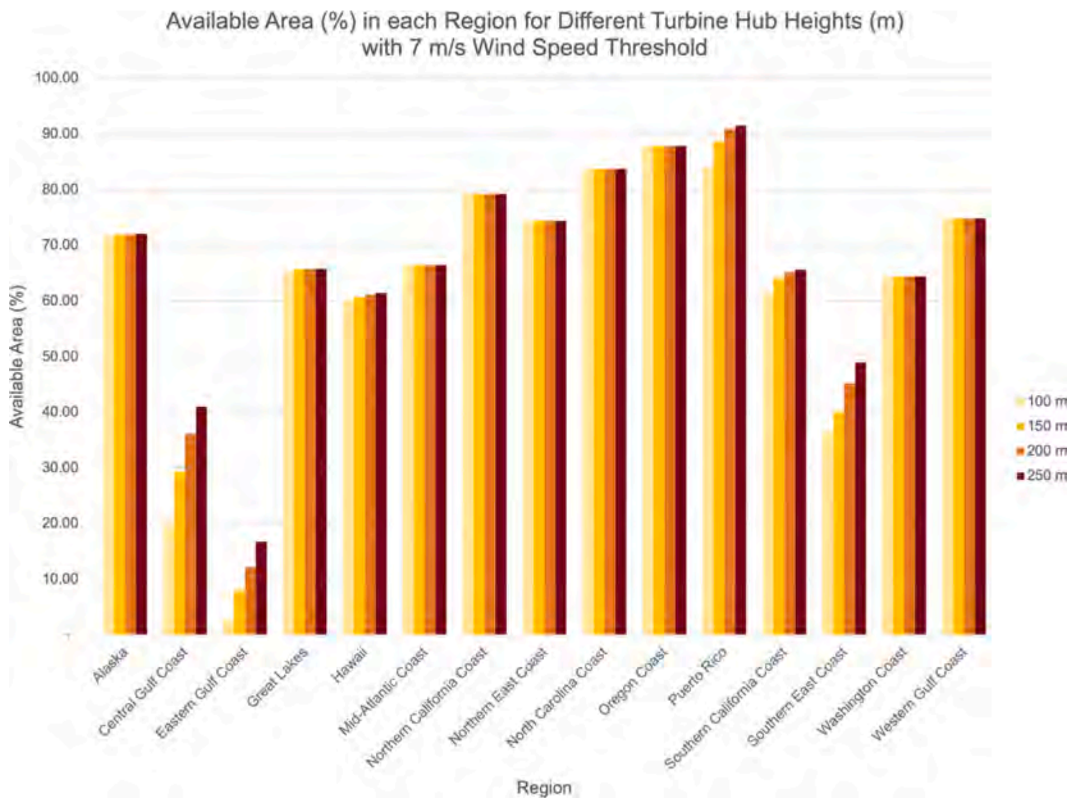

Fig. 4. Available Area (%) in each Region for Different Turbine Hub Heights (m). Height of each bar corresponds to available area (%) in each region at four different altitudes (100 m, 150 m, 200 m, and 250 m ASL), represented with different colors. Values are after accounting for all restrictions in Table S1 with 7 m/s wind speed threshold. See Tables S3-4 for all hub height and wind speed threshold combinations.

accounting for each wind speed threshold. Rather than relying on a uniform capacity factor, the capacity factor for each region (Table S9) was calculated as a function of mean Rayleigh-distributed wind speed, the rated power of the turbine, and the turbine blade diameter [101], as seen in Equation S4.

Regions with the largest mean wind speeds include Northern California and Alaska, followed by the Northern East Coast, the Mid-Atlantic Coast, Oregon Coast, and the Great Lakes. This can be seen in the areas shaded red and dark orange in the map, which have average wind speeds of 10–13 m/s. Portions of Northern California and Oregon relatively close to shore would be of particular interest for wind farm siting, and indeed these areas were among the first to be explored by BOEM for leasing. The lowest wind speeds can be found off the Eastern and Central Gulf Coast and Southern East Coast. Wind speed exclusions block large sections of these regions, as the wind speed falls below the threshold.

Following a similar pattern after normalizing by available area, the highest output power densities can be found off the coast of the Northeast, Northern California, and Alaska, which all have output power densities above 4.5 MW/km^2 in Fig. 5. Compared with the U.S.-wide average output power density of 3.6 MW/km^2 for wind speeds above 7 m/s at 150 m ASL, portions of the West Coast, Northeast, Great Lakes, and Alaska have higher than average power densities. The range of average output power densities across all regions from 100 m to 250 m hub height is 3.5–3.8 MW/km^2. When considering all wind speed thresholds and hub heights, the average output power density is 4.1 MW/km^2.

Also computed is the installed power density, which is found to be 7.5 MW/km^2 across all regions, wind speed thresholds, and hub height scenarios. Those in Europe were found from data to be 7.2 (3.3–20.2) MW/km^2 [102].

Fig. 6 shows the relationship between mean wind speed and increasing hub height across all regions. A similar pattern of mean wind speeds can be detected in each region to varying degrees as the turbine hub height increases due to reduced impact from surface frictional forces. The steepest increase in mean wind speed can be found off the coast of Northern California, followed by Alaska. This aligns with the regions in Fig. 5 that have areas of extremely high wind speeds, and correspondingly high output power densities (MW/km^2). A higher mean wind speed can generally be expected to translate to overall higher power output, which is indeed the case, as seen in Figs. S1.1. However, as wind speed thresholds increase, the amount of available area sharply declines, as discovered in Fig. 3, which actually results in a lower aggregated possible nameplate capacity (GW) for each incrementally increasing wind threshold, ranging from 28,700 GW across all regions in the 6 m/s threshold scenario, to below 1,000 GW in the highest wind speed threshold scenarios, which can be seen in Figure S1.2.

Fig. 7 shows how the choice of turbine foundation is highly dependent on bathymetry and substrate composition, resulting in bands of differently colored regions. The largest portion of available areas has a water depth of greater than 1,000 m, necessitating floating platforms. The next most common designation calls for either semi-submersible or spar technology, which are appropriate for water depths beyond 200 m. Closer to the coast, there is an array of acceptable foundation types, dominated by gravity-based platforms, but also including areas where jacket, tension-leg buoy, and spar platforms would be suitable. Within inland channels, there are almost exclusively monopile and some gravity-based platforms, due to the shallow water depth in these areas. As floating technology develops, technical potential will expand, enabling economic deployment in moderate-quality and deeper water sites [82].

It is apparent where the BOEM lease areas are in relation to available areas and turbine foundation types. The lease areas are close to shore, ranging from approximately 15–100 km off the coast, and in mostly shallow water, which explains why monopile and gravity-based

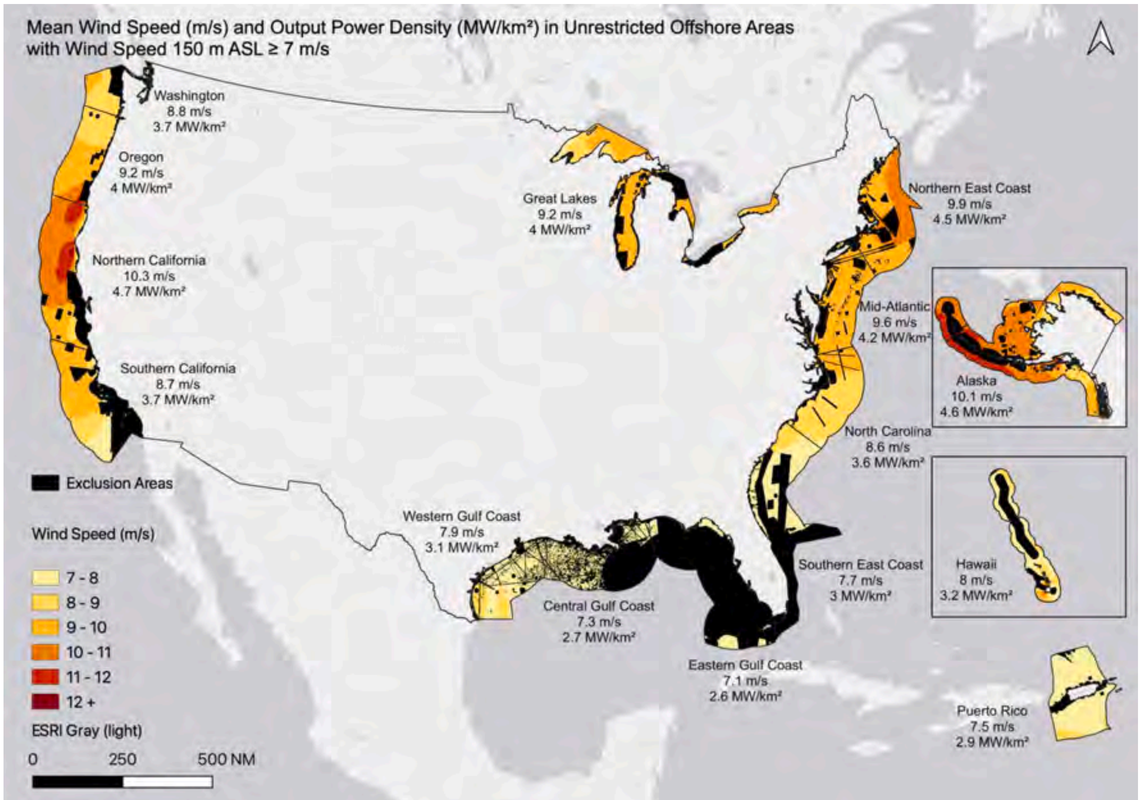

Fig. 5. Mean Wind Speed (m/s) and Output Power Density (MW/km^2). The mean wind speed in each region is shown alongside the output power density (MW/km^2) in all unrestricted offshore areas with wind speed at 150 m ASL ≥ 7 m/s. The color scale represents the full range of wind speed values (m/s) in each grid cell. See Figs. S5.1–5.4 and Table S8 for all hub height and wind speed threshold combinations.

substructures will likely be predominant in these areas. With a 7 m/s wind speed threshold, one can observe that BOEM lease boundaries occur outside of exclusion areas, especially for the northeastern projects. The conflict off the coast of New Jersey and Delaware is due to a military-designated area that overlaps partially with the BOEM lease areas, which may be due to a change in military use areas that is yet to be

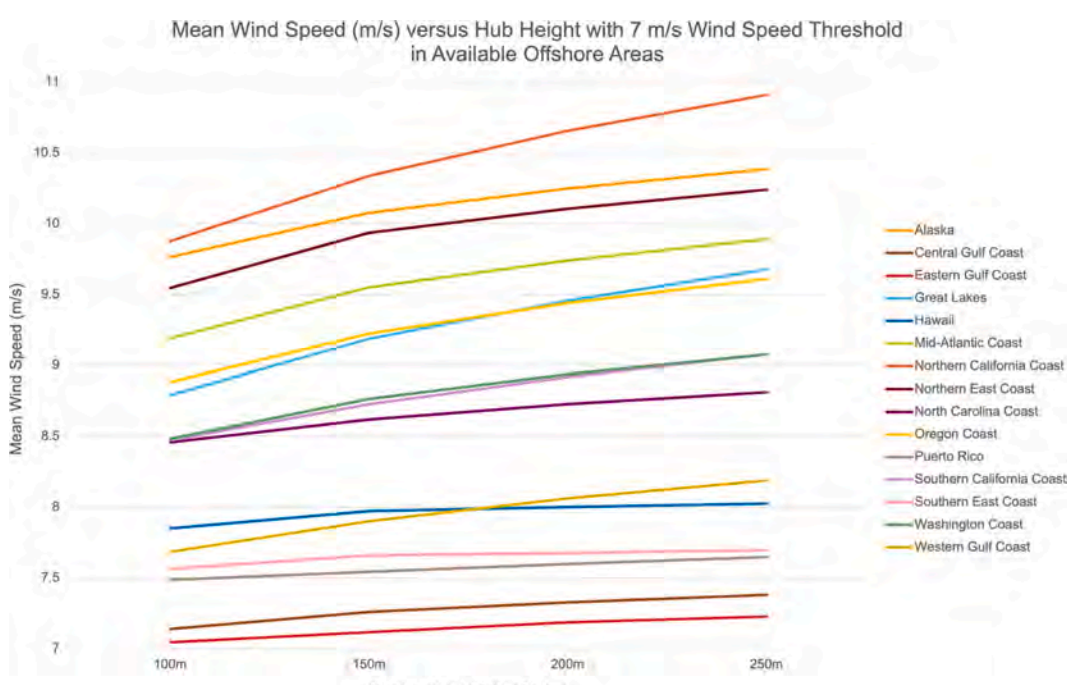

Fig. 6. Mean Wind Speed (m/s) versus Hub Height. Colored lines correspond to mean wind speed (m/s) in available areas with 7 m/s wind speed threshold for each region at four different altitudes (100 m, 150 m, 200 m, and 250 m ASL). See Table S8 for all hub height and wind speed threshold combinations.

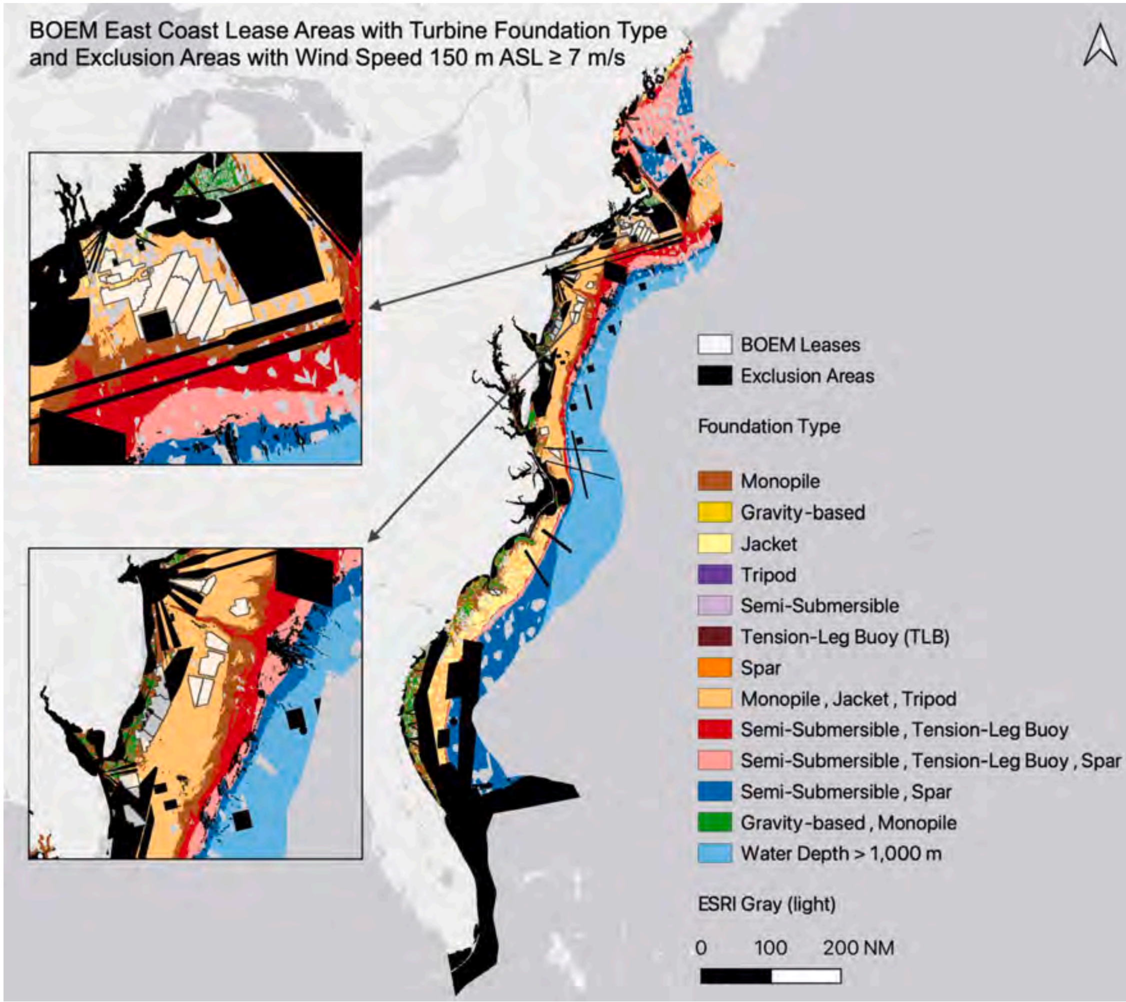

Fig. 7. BOEM East Coast Lease Areas with Turbine Foundation Type and Exclusion Areas. Boundaries of offshore wind energy lease areas [103] (white) in relation to exclusion areas (black) are shown. The remaining area is colored according to the appropriate turbine foundation, determined based on water depth and seabed composition, as detailed in the supplemental information. See Figs. S7.1–7.7 for other regions.

reflected in the latest iteration of publicly available data.

In contrast to the East Coast, Fig. 8 shows how the deeper bathymetry of the West Coast will result in strikingly different substructure technology requirements. Relatively close to shore, in some cases less than 10 km from the coast, it will be difficult to find water depths shallower than 1,000 m.

The BOEM lease areas off the west coast are located the same distance from shore, approximately 30–60 km away. However, the entire lease boundary falls within areas requiring semi-submersible, spar, or other floating platform types, where much of the region is deeper than 1,000 m. One can again see relatively good alignment between areas identified by BOEM and exclusion areas, with an exception in California's central coast where the southeastern portion of the lease area overlaps with part of the Piedras Blancas State Marine protected area offshore of San Luis Obispo County.

Over time, the choice of substructure may change as other factors, such as component costs, installations and maintenance logistics, seafloor geologic conditions, stakeholder ocean use, and permitting evolve with technology and policy [5]. However, these maps provide a reasonable estimation of foundation choice given contemporary conditions and can assist in the selection of the wind farm configuration, which has major implications for wind farm cost, as discussed below.

Fig. 9 provides an overview of the relative cost values in unrestricted areas across the entire United States, along with the locations of ports that could potentially support offshore wind projects. The cost values are based on four important parameters that influence capital expenditure (CapEx): turbine substructure (20%), transmission interconnection (10%), relative wages of coastal states (2.45%), and port to project roundtrip transit distance (0.63%).

The maximum cost value in any region is 9.82 in Alaska, which has a high portion of cost-prohibitive areas. However, given Alaska's small energy demand, this is unlikely to be a barrier in developing sufficient offshore wind capacity to fulfill a substation portion of power demand. Other high-cost regions include Hawaii, Puerto Rico, much of the West Coast, and some parts of the East Coast, due primarily to water depth.

In contrast, the lowest cost values can be found in the Great Lakes, which has a maximum cost value of only 1.41. In fact, the bulk of pixels are below 0.5 in this region, making it the region with the highest frequency of low-cost locations. The East Coast also has large low-cost areas, and indeed, this is where the most new projects are being

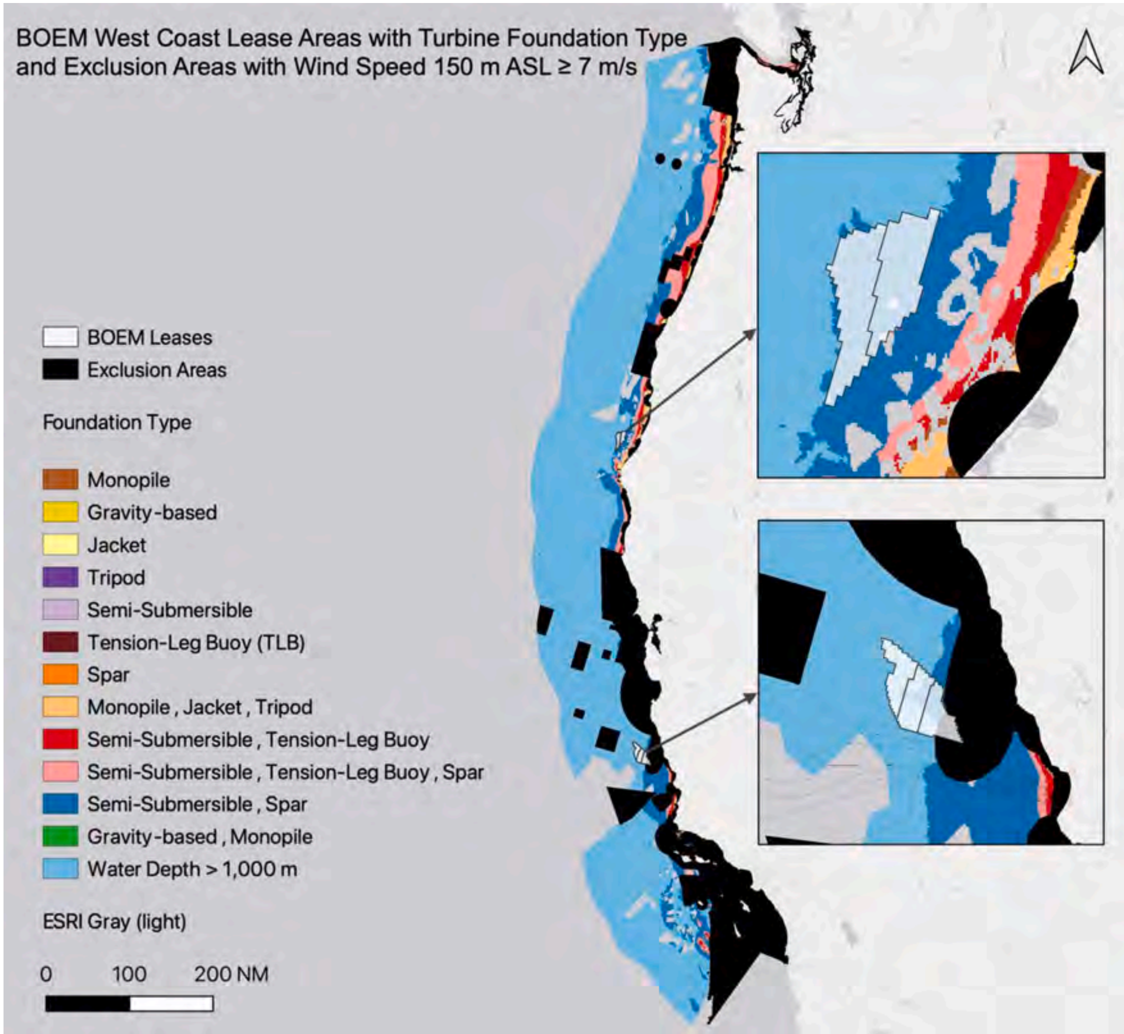

Fig. 8. BOEM West Coast Lease Areas with Turbine Foundation Type and Exclusion Areas. Boundaries of offshore wind energy lease areas [103] (white), in relation to exclusion areas (black) are shown. The remaining area is colored according to the appropriate turbine foundation, determined based on water depth and seabed composition, as detailed in the supplemental information. See Figs. S7.1–7.7 for other regions.

proposed.

Throughout the country, the mean cost value is 2.16. A histogram with all values shows a bimodal distribution where values peak at 1.3 and 3.8. When removing the Great Lakes from the analysis to exclude a high concentration of low-cost values, the mean increases to 2.36.

The availability of port infrastructure with the necessary conditions is a crucial component for offshore wind development, and currently millions of dollars are being invested to make necessary upgrades across all coasts [104–109]. Overlaid on the heatmap are locations of staging ports, which are used for the construction phase of wind projects (as opposed to operational ports post-installation). The channel depth and degree of shelter are two principal factors in targeting viable ports, although many other factors are also important [110,111]. The ports labelled with blue points in Fig. 9 have a channel depth of at least 7.9 m and shelter rating of either “fair,” “good,” or “excellent” [88]. Additionally, the ports shown in yellow have no overhead limit, which is a necessary characteristic to support semisubmersible technologies and other fully integrated substructures. Across the U.S., there are 227 ports that meet the first two conditions, and, of these, 30 ports that also meet the third. There are several ports scattered across all regions that could potentially meet the needs of offshore wind installation, which will enable the rapid construction of installed capacity.

This heatmap helps to determine where to prioritize siting efforts. Meeting the Biden Administration’s target of 30 GW by 2030 would require 11,727 km^2 of coastal area. The lowest-cost available areas are concentrated in the Great Lakes, which alone could meet this target at a cost of less than half the reference project. Alternatively, for a more geographically dispersed approach, a thin stretch of areas along the East and Gulf Coasts could achieve this target at low cost, particularly the southern half of the East Coast and areas off the coast of Texas and the Gulf Coast of Florida. Either of these scenarios in Fig. S9.1-S9.2 would be sufficient to meet the 30 GW target. In addition to considering capital costs, it will also be necessary to account for grid integration challenges, state goals, energy demand, electricity markets, transmission systems, and other interrelated variables that impact the overall project cost.

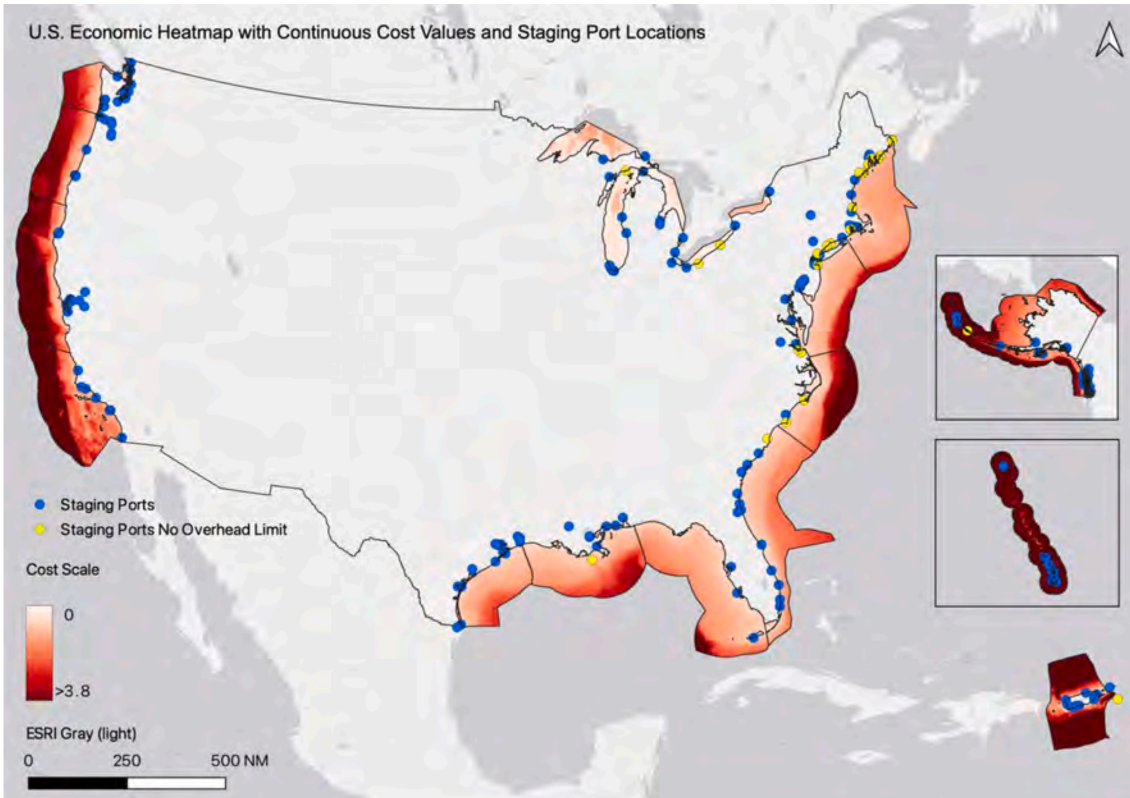

Fig. 9. U.S. Economic Heatmap with Continuous Cost Values and Staging Port Locations. U.S. economic heatmap with uniform continuous color ramp is shown. The unitless cost scale is the cost of a project relative to that of a reference project with a value of 1 (fixed-bottom 2018 baseline LCOE: $83/MWh, 2030 target LCOE: $51/MWh [98]). Staging port locations that have a channel depth of greater than 7.9 m and shelter rating of either "fair," "good," or "excellent" [88] (blue), and staging ports with an additional "no overhead limit" criteria (yellow) are shown. See Figs. S3.1–3.2, S8.1–8.30 for continuous and discrete economic heatmaps of all regions.

Discussion

The emerging offshore wind industry will require substantial planning efforts to meet state and federal deployment targets in a timely, cost-effective, environmentally sustainable, and socially responsible way. Commercial developers and government agencies, particularly BOEM, would benefit from a streamlined wind farm site selection process. Existing BOEM lease areas have already been examined in the context of study results, but this atlas can also be used to expedite the identification of the next set of lease areas.

Beyond site identification, this atlas can answer important questions about the offshore wind capacity necessary to fulfill energy demand in a particular region or grid. For instance, 1,203 15-MW turbines off the coast of Hawaii could provide 9 GW of nameplate capacity, translating to 71.4 TWh, assuming a 7 m/s wind speed threshold at 150 m ASL and 10% wake loss. This is enough to meet 100% of Hawaii's 2021 total energy demand from offshore wind energy alone [112]. In fact, offshore wind can generate up to 252 times as much energy as needed in the state. Hawaii currently relies on imported petroleum for 60% of its electricity generation and has the highest electricity retail price of any state, nearly triple the U.S. average [113]. Strategic placement of offshore wind turbines could present an opportunity to capture high quality wind energy resources without compromising other ocean uses or protected areas, contributing to Hawaii's energy independence while reducing emissions and potentially energy costs. This is also true in other regions, where the enormous offshore wind energy potential can become a significant portion of grid capacity.

It is also possible to make initial estimations of cost feasibility using this atlas, and for the first time these can be made at higher altitudes, up to 250 m. One important question to consider when determining the appropriate turbine hub height is the tradeoff between increased component costs and power output with height. With every 50 m increment in altitude, the turbine tower cost increases 32.8%, on average, with larger cost increments between lower altitudes. However, considering that the tower is only about 1.9% of the total cost of an offshore wind project (including installation, maintenance, operations, and decommissioning) [99], the incremental impact on the project cost is only 0.62% between 50 m hub heights. On the other hand, the maximum possible nameplate capacity increases approximately 4.3% on average between incremental heights. As the annual energy production correlates with revenue, it is worth building taller turbines that capture more energy, which is indeed the trend seen in industry. This atlas can help predict energy output for future turbine scenarios, and enable studies that explore this tradeoff in more depth.

Although most studies conclude that the U.S. has vast offshore wind resources, this study tends to report higher technical potential estimates. This is in part due to the higher hub heights used in this study, as well more inclusive study areas. For instance, Musial et. al. [1] only includes areas less than 1,000 m in depth, arbitrarily limiting the study area. Compared to Lopez et. al. [82], this study uses more conservative setback distances in some instances (e.g., for shipping lanes and existing energy infrastructure), and less conservative distances in other cases, (e.g., submarine cables, excluding state waters, limiting depth to 1,300 m). The proper choice of setback distance is often ambiguous and in flux, particularly as policies may change to accommodate future offshore wind development [114]. Another distinction is the output power density, which is 3 MW/km^2 in most studies [1,82], or 3 MW/km^2 for wind speeds between 7 and 8 m/s and 4 MW/km^2 for wind speeds greater than 8 m/s [33]. Output power densities from European offshore wind farms average 2.9 (1.2–6.3) MW/km^2 [102]. This study uses an average output power density of 3.5–3.8 MW/km^2 with a 7 m/s wind speed threshold at 150 m ASL based on [115], which uses an average factor of 5.98 rotor diameters between turbines. However, with higher hub heights, the power density reaches a maximum of 6 MW/km^2. Installed and output power densities have been historically underestimated due to the inclusion of space outside of wind farm boundaries, space between clusters of turbines, and double counting [102], resulting in lower estimated power output. As a consequence, the results here point toward higher energy projections than previous studies.

In creating an atlas over a large geographical extent, necessary simplifications are made that homogenize the wind farm siting process. In reality, each project is unique and must be considered in the context of its local regulatory, environmental, and social climates. Where feasible, this study includes a range of possible values to represent realistic conditions that developers might face. For instance, wake loss depends on many factors, including wind conditions, turbine size and configuration, and site layout. Similarly, costs will vary based on specific site conditions, prevailing market conditions, and technology used, which may change over time as new practices are adopted and turbines evolve. This study encapsulates several important variables that affect CapEx, but does not capture others, such as the lease price or the turbine cost [98]. Further, the economic heatmap does not yet describe the full nuance and variability in projects costs, such as being able to model the entire range of turbine foundation technology cost functions. The data itself is in part the cause of incomplete modelling, as there is a high degree of uncertainty in some data layers. For example, a large portion of the ports layer has no indication of whether overhead limits are present. Other data, such as military zones, which might include sensitive or secure information, can be imprecise. Finally, policy guidelines are unclear or nonexistent in many cases. For example, it is difficult to ascertain precisely which marine protections apply to offshore wind development, as this was likely not a consideration when many policies were made. This study provides insights to expedite decision making for the first steps in the siting process, but is not meant to replace micro-siting. Using this atlas as a foundation, it would be beneficial to conduct a micro-siting analysis to narrow the selection of suitable areas to prioritize.

The U.S. has the rare opportunity to rethink its aging energy infrastructure and significantly curtail emissions with a new industry that promises to benefit both the economy and the environment. Major federal legislation has already been passed that paves the way for offshore wind development. The Inflation Reduction Act has multiple provisions for offshore wind leasing, transmission interconnections, and tax credits that facilitate planning and investment [116]. The Biden-Harris Action Plan for America's Ports and Waterways will launch programs to modernize ports and enhance supply chains, supporting the deployment of offshore wind turbines [117]. In the future, an expanded analysis with data that enables more detailed criteria for port infrastructure and transmission interconnection requirements can help guide strategic investment decisions.

The critical next step is to transform ambition into action. This study aims to integrate many of the complex components of the wind farm siting process to facilitate decision making for policymakers and developers. Through detailed analyses of exclusion areas, wind speed threshold and wake loss scenarios, and economic cost modelling, it is possible to reduce time in the initial site selection phase of a wind project. Having the capability to plan more strategically will ultimately lower the LCOE of projects, enhance the certainty around long-term target-setting, and accelerate the deployment of offshore wind energy.

Conclusions

In 2023, the United States is far short of meeting climate targets despite a rising penetration of renewable electricity on the grid and a rapidly mobilizing offshore wind industry. By transitioning to 100% clean, renewable energy, the United States has the opportunity to drastically reduce annual energy and social costs, prevent tens of thousands of premature air pollution deaths per year, and create long-term, full-time jobs, while keeping the grid stable [19]. Offshore wind energy is a key component of the transition, given the extensive wind resources along U.S. coastlines and the potential to provide large-scale, reliable, and emissions-free energy. With faster and more consistent winds available offshore, modern offshore wind turbines will be able to power millions of homes throughout the country. Technical feasibility combined with the U.S. target of building 30 GW of offshore wind capacity by 2030 mean that this goal should quickly become a reality. Because state and federal waters are being used for many purposes, such as for fishing and shipping, marine protection, and military activities, maps of available offshore area are needed to facilitate the siting and building of offshore wind farms.

This study aims to provide such maps in an atlas. The U.S. has ~3,557,000 km^2 of available space for offshore wind, equating to 64% of all coastal regions (~949,900 km^2, equivalent to 61.5% of contiguous U.S. regions) when using a 7 m/s wind speed threshold 150 m ASL. The regions with the largest available areas include Alaska (~1,784,300 km^2), Hawaii (~718,600 km^2), and the Northern California Coast (~127,000 km^2). The U.S. East, West, and Gulf Coasts have ~363,200 km^2, ~346,500 km^2, and ~137,800 km^2 available, respectively. In relation to region size, Puerto Rico (88.6%), the Oregon Coast (87.8%), and the North Carolina Coast (83.7%) have the most available area. The cumulative maximum possible nameplate capacity across the U.S. is 26,800 GW (7,150 GW for the contiguous U.S.) with 10% array losses, far exceeding the U.S. 30 GW by 2030 target and projected capacity requirements for all energy uses in 2050. This atlas is the first to present results for 13 wind speed thresholds at four different turbine hub heights. From this analysis, it is clear that technical potential is generally more sensitive to increasing wind speed than hub height, and that regions with low annual wind speeds, such as the Central and Eastern Gulf Coast, Puerto Rico, and the Southern East Coast, experience particularly acute diminishing area with higher wind speed thresholds. Evaluating available areas from an economic lens, this study finds which regions can deploy offshore wind turbines for the lowest capital cost. Prioritizing siting efforts in the Great Lakes, and the East and Gulf Coasts would be the most cost-effective way to deploy 30 GW by 2030 from a capital cost perspective. However, each region has substantial resources and most have opportunities to develop at relatively low costs. Results from this study will help catalyze the U.S. offshore wind industry, ultimately moving the U.S. toward a sustainable energy grid.

CRediT authorship contribution statement

Anna-Katharina von Krauland: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration, Funding acquisition. **Qirui Long:** Methodology, Validation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Peter Enevoldsen:** Conceptualization, Writing – review & editing. **Mark Z. Jacobson:** Conceptualization, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

This work was supported by the Stanford TomKat Center for Sustainable Energy, Stanford King Center on Global Development, and Stanford Leavell Fellowship on Sustainable Built Environment.

The authors would also like to thank The Solutions Project team that assisted with the literature review and data sourcing, Vestas for lending their expertise and access to their Climate Library, and the many experts who generously gave their time to answer questions and provide insight into offshore wind siting.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecmx.2023.100410.

References

[1] W. Musial, D. Heimiller, P. Beiter, G. Scott, and C. Draxl, "2016 Offshore Wind Energy Resource Assessment for the United States," 2016.
[2] "GOING GLOBAL Expanding Offshore Wind to Emerging Markets," 2019.
[3] U.S. Department of the Interior, "National Offshore Wind Strategy: Facilitating the Development of the Offshore Wind Industry in the United States," 2016.
[4] Office of Energy Efficiency & Renewable Energy, "National Offshore Wind Energy Grid Interconnection Study (NOWEGIS)," 2014.
[5] "Offshore Wind Resource Assessment | Wind Research | NREL." [Online]. Available: https://www.nrel.gov/wind/offshore-resource.html. [Accessed: 23-Feb-2023].
[6] R. Wiser *et al.*, "Expert elicitation survey predicts 37% to 49% declines in wind energy costs by 2050," *Nat. Energy 2021 65*, 6, 5, 555–565, Apr. 2021, doi: 10.1038/s41560-021-00810-z.
[7] W. Musial *et al.*, "Offshore Wind Market Report: 2022 Edition," 2022.
[8] Enevoldsen P, Victor Valentine S. "Do onshore and offshore wind farm development patterns differ?". Energy Sustain Dev 2016;35:41–51. https://doi.org/10.1016/j.esd.2016.10.002.
[9] "National Offshore Wind R&D Consortium | Department of Energy." [Online]. Available: https://www.energy.gov/eere/wind/national-offshore-wind-rd-consortium. [Accessed: 18-Feb-2023].
[10] "Commercial and Research Wind Lease and Grant Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf of the New York Bight," 2021.
[11] "Master Plan - NYSERDA." [Online]. Available: https://www.nyserda.ny.gov/All-Programs/Offshore Wind/About Offshore Wind/Master Plan. [Accessed: 16-Feb-2023].
[12] W. Musial and J. Nunemaker, "2018 Offshore Wind Technologies Market Report," 2018.
[13] "SB-100 California Renewables Portfolio Standard Program: emissions of greenhouse gases." [Online]. Available: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100. [Accessed: 16-Feb-2023].
[14] California Energy Commission, "Offshore Wind Energy Development off the California Coast: Maximum Feasible Capacity and Megawatt Planning Goals for 2030 and 2045 | California Energy Commission," 2022.
[15] M. Shields *et al.*, "A Supply Chain Road Map for Offshore Wind Energy in the United States," 2030.
[16] L. Burdock, R. Gould, and S. Salustro, "Advancing Policy Measures to Drive Development of the Domestic Offshore Wind Supply Chain," 2022.
[17] M. Hahn *et al.*, "U.S. Offshore Wind Manufacturing and Supply Chain Development.".
[18] "FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs - The White House." [Online]. Available: https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/. [Accessed: 17-Feb-2023].
[19] Jacobson MZ, von Krauland A-K, Coughlin SJ, Palmer FC, Smith MM. Zero air pollution and zero carbon from all energy at low cost and without blackouts in variable weather throughout the U.S. with 100% wind-water-solar and storage. Renew Energy 2022;184:430–44. https://doi.org/10.1016/j.renene.2021.11.067.
[20] E. Lantz *et al.*, "Power Sector, Supply Chain, Jobs, and Emissions Implications of 30 Gigawatts of Offshore Wind Power by 2030," 2030.
[21] B. W. Burke, M. Goggin, and R. Gramlich, "Offshore Wind Transmission White Paper," 2020.
[22] D. Holody, "U.S. Wind Energy Manufacturing and Supply Chain: A Competitiveness Analysis," 2014.
[23] B. Maples, G. Saur, M. Hand, R. Van De Pietermen, and T. Obdam, "Installation, Operation, and Maintenance Strategies to Reduce the Cost of Offshore Wind Energy," 2013.
[24] Sarker BR, Faiz TI. Minimizing transportation and installation costs for turbines in offshore wind farms. Renew Energy 2017;101:667–79. https://doi.org/10.1016/J.RENENE.2016.09.014.
[25] "California Offshore Wind Industry Report," 2022.
[26] W. Musial *et al.*, "Offshore Wind Market Report: 2021 Edition," 2015.
[27] P. Denholm *et al.*, "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035," 2035.
[28] D. O. Lambkin, J. M. Harris, W. S. Cooper, and T. Coates, "Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment: Best Practice Guide," 2009.
[29] Enevoldsen P, Sovacool BK. Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France. Renew Sustain Energy Rev 2016;53:178–84.
[30] Chapman A, Shigetomi Y, Karmaker SC, Saha B, Brooks C. Cultural and demographic energy system awareness and preference: Implications for future energy system design in the United States. Energy Econ 2022;112:106141. https://doi.org/10.1016/J.ENECO.2022.106141.
[31] Chapman A, Shigetomi Y, Chandra Karmaker S, Baran Saha B, Huff K, Brooks C, et al. The cultural dynamics of energy: The impact of lived experience, preference and demographics on future energy policy in the United States. Energy Res Soc Sci 2021;80:102231.
[32] Hosan S, Karmaker SC, Rahman MM, Chapman AJ, Saha BB. Dynamic links among the demographic dividend, digitalization, energy intensity and sustainable economic growth: Empirical evidence from emerging economies. J Clean Prod 2022;330:129858. https://doi.org/10.1016/J.JCLEPRO.2021.129858.
[33] "Offshore Wind Technical Potential | Analysis and Maps | ESMAP." [Online]. Available: https://esmap.org/esmap_offshorewind_techpotential_analysis_maps. [Accessed: 25-Oct-2022].
[34] P. Beiter, W. Musial, L. Kilcher, M. Maness, and A. Smith, "An Assessment of the Economic Potential of Offshore Wind in the United States from 2015 to 2030," 2017.
[35] W. Musial, P. Beiter, S. Tegen, and A. Smith, "Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs," 2016.
[36] "Offshore Wind Technical Potential | Analysis and Maps | ESMAP." [Online]. Available: https://esmap.org/esmap_offshorewind_techpotential_analysis_maps. [Accessed: 18-Feb-2023].
[37] "Offshore Wind Development Program: Roadmap for Vietnam | ESMAP." [Online]. Available: https://esmap.org/offshore-wind-devprogram_wind-roadmap-for-vietnam. [Accessed: 18-Feb-2023].
[38] Archer CL, Jacobson MZ. Spatial and temporal distributions of U.S. winds and wind power at 80 m derived from measurements. J Geophys Res 2003;108(D9):n/a–.
[39] Archer CL, Jacobson MZ. Evaluation of global wind power. J Geophys Res 2005;110:D12110. https://doi.org/10.1029/2004JD005462.
[40] A. Rybchuk, M. Optis, J. K. Lundquist, M. Rossol, and W. Musial, "A Twenty-Year Analysis of Winds in California for Offshore Wind Energy Production Using WRF v4.1.2," doi: 10.5194/gmd-2021-50.
[41] "Wind Supply Curves | Geospatial Data Science | NREL." [Online]. Available: https://www.nrel.gov/gis/wind-supply-curves.html. [Accessed: 18-Feb-2023].
[42] Draxl C, Clifton A, Hodge BM, McCaa J. The Wind Integration National Dataset (WIND) Toolkit. Appl Energy 2015;151:355–66. https://doi.org/10.1016/J.APENERGY.2015.03.121.
[43] "Marine Energy Atlas." [Online]. Available: https://maps.nrel.gov/marine-energy-atlas/download/intro. [Accessed: 27-Jan-2023].
[44] "Unleashing Europe's offshore wind potential A new resource assessment," 2017.
[45] M. Shields *et al.*, "The Cost and Feasibility of Floating Offshore Wind Energy in the O'ahu Region," 2045.
[46] "Lake Michigan Offshore Wind Energy Report Preface From the Director of the Department of Natural Resources.".
[47] Kempton W, Archer CL, Dhanju A, Garvine RW, Jacobson MZ. Large CO 2 reductions via offshore wind power matched to inherent storage in energy end-uses. Geophys Res Lett 2007;34:L02817. https://doi.org/10.1029/2006GL028016.
[48] Dvorak MJ, Archer CL, Jacobson MZ. California offshore wind energy potential. Renew Energy 2009;35:1244–54. https://doi.org/10.1016/j.renene.2009.11.022.
[49] Dvorak MJ, Stoutenburg ED, Archer CL, Kempton W, Jacobson MZ. Where is the ideal location for a US East Coast offshore grid? Geophys Res Lett 2012;39(6):n/a–.
[50] Dvorak MJ, Corcoran BA, Ten Hoeve JE, Mcintyre NG, Jacobson MZ. US East Coast offshore wind energy resources and their relationship to peak-time electricity demand. Wind Energy 2012;16:977–97. https://doi.org/10.1002/we.1524.
[51] "Oregon Renewable Energy Siting Assessment (ORESA).".
[52] K. E. Wehrly, E. S. Rutherford, L. Wang, J. Breck, L. Mason, and S. Nelson, "Development of a Geographic Information System-Based Decision Support Tool for Evaluating Windfarm Sitings in Great Lakes Aquatic Habitats," Jul. 2011, doi: 10.2172/1303492.
[53] Ocean Stewardship Coalition, "ROADMAP TO INTEGRATE CLEAN OFFSHORE RENEWABLE ENERGY INTO CLIMATE-SMART MARINE SPATIAL PLANNING," 2021.
[54] Bailey BH, Filippelli M, Baker M. "Metocean Data Needs Assessment for U.S. Offshore Wind Energy" 2015. https://doi.org/10.2172/1338823.
[55] U.S. Department of Energy, "Wind Vision: A New Era for Wind Power in the United States," 2015.
[56] WWF-European Policy Office, "Guidance Paper: Ecosystem-based Maritime Spatial Planning in Europe and how to assess it," 2021.
[57] Ehler, Charles, Douvere, Fanny, and Ioc, "Marine spatial planning: a step-by-step approach toward ecosystem-based management; IOC. Manuals and guides; 53; 2013," 2009.

[58] Musial WD, Sheppard RE, Dolan D. "Development of Offshore Wind Recommended Practice for U.S. Waters 2013.
[59] S. Rynne, L. Flowers, E. Lantz, and E. Heller, "Planning for Wind Energy," 2011.
[60] G. Newsom, "Research and Development Opportunities for Offshore Wind Energy in California," 2020.
[61] "Guiding Principles for Offshore Wind Stakeholder Engagement.".
[62] "RODEO | Bureau of Ocean Energy Management." [Online]. Available: https://www.boem.gov/rodeo. [Accessed: 18-Feb-2023].
[63] "Key Factors for Successful Development of Offshore Wind in Emerging Markets | ESMAP," 2021.
[64] "Our energy, our future: How offshore wind will help Europe go carbon-neutral," 2019.
[65] "windPRO – The premier software package for design of wind farms and PV projectsEMD International." [Online]. Available: https://www.emd-international.com/windpro/. [Accessed: 16-Mar-2023].
[66] "Windographer | Wind Data Analytics and Visualization Solution | UL Solutions." [Online]. Available: https://www.ul.com/software/windographer-wind-data-analytics-and-visualization-solution. [Accessed: 18-Feb-2023].
[67] "Openwind | Wind Farm Modeling and Layout Design Software | UL Solutions." [Online]. Available: https://www.ul.com/software/openwind-wind-farm-modeling-and-layout-design-software. [Accessed: 18-Feb-2023].
[68] "Windnavigator | For Wind Energy Site Prospecting and Feasibility | UL Solutions." [Online]. Available: https://www.ul.com/services/windnavigator-wind-energy-site-prospecting-and-feasibility. [Accessed: 18-Feb-2023].
[69] "Explore — REZoning Web." [Online]. Available: https://rezoning.energydata.info/explore?maxLCOE=false. [Accessed: 16-Feb-2023].
[70] "RE Data Explorer." [Online]. Available: https://www.re-explorer.org/re-data-explorer/query/intro. [Accessed: 18-Feb-2023].
[71] F. Olsen and K. Dyre, "Vindeby Off-Shore Wind Farm - Construction and Operation on JSTOR," 1993.
[72] "World's Most Powerful Offshore Wind Platform: Haliade-X | GE Renewable Energy." [Online]. Available: https://www.ge.com/renewableenergy/wind-energy/offshore-wind/haliade-x-offshore-turbine. [Accessed: 28-Feb-2023].
[73] "V236-15.0 MW™." [Online]. Available: https://us.vestas.com/en-us/products/offshore/V236-15MW. [Accessed: 28-Feb-2023].
[74] "Offshore Wind Turbine SG 14-236 DD I Siemens Gamesa." [Online]. Available: https://www.siemensgamesa.com/en-int/products-and-services/offshore/wind-turbine-sg-14-236-dd. [Accessed: 28-Feb-2023].
[75] Díaz H, Guedes Soares C. Review of the current status, technology and future trends of offshore wind farms. Ocean Eng 2020;209:107381. https://doi.org/10.1016/J.OCEANENG.2020.107381.
[76] Enevoldsen P, Xydis G. Examining the trends of 35 years growth of key wind turbine components. Energy Sustain Dev 2019;50:18–26.
[77] "Wind Turbines: the Bigger, the Better | Department of Energy." [Online]. Available: https://www.energy.gov/eere/articles/wind-turbines-bigger-better. [Accessed: 28-Feb-2023].
[78] R. Wiser *et al.*, "2016 Wind Technologies Market Report." 2016.
[79] Sovacool BK, Enevoldsen P. One style to build them all: Corporate culture and innovation in the offshore wind industry. Energy Policy 2015;86:402–15. https://doi.org/10.1016/J.ENPOL.2015.07.015.
[80] Pichugina YL, Banta RM, Brewer WA, Sandberg SP, Hardesty RM. Doppler Lidar-Based Wind-Profile Measurement System for Offshore Wind-Energy and Other Marine Boundary Layer Applications. J Appl Meteorol Climatol 2012;51(2):327–49. https://doi.org/10.1175/JAMC-D-11-040.1.
[81] Vazquez A, Izquierdo U, Enevoldsen P, Andersen F-H, Blanco JM. A Macroscale Optimal Substructure Selection for Europe's Offshore Wind Farms. SSRN Electron J 2022. https://doi.org/10.2139/SSRN.4111111.
[82] A. Lopez, R. Green, T. Williams, E. Lantz, G. Buster, and B. Roberts, "Offshore Wind Energy Technical Potential for the Contiguous United States," Aug. 2022, doi: 10.2172/1882929.
[83] Green R, Vasilakos N. The economics of offshore wind. Energy Policy 2011;39(2):496–502. https://doi.org/10.1016/J.ENPOL.2010.10.011.
[84] "Global Wind Atlas." [Online]. Available: https://globalwindatlas.info/en. [Accessed: 01-Apr-2023].
[85] "MSP Sectors and Conflicts | The European Maritime Spatial Planning Platform." [Online]. Available: https://maritime-spatial-planning.ec.europa.eu/sectors. [Accessed: 16-Feb-2023].
[86] "Discover the potential for offshore wind around the world - Global Wind Energy Council." [Online]. Available: https://gwec.net/discover-the-potential-for-offshore-wind-around-the-world/. [Accessed: 25-Oct-2022].
[87] Bosch J, Staffell I, Hawkes AD. Global levelised cost of electricity from offshore wind. Energy 2019;189:116357. https://doi.org/10.1016/J.ENERGY.2019.116357.
[88] P. Beiter *et al.*, "A Spatial-Economic Cost-Reduction Pathway Analysis for U.S. Offshore Wind Energy Development from 2015–2030," Sep. 2016, doi: 10.2172/1324526.
[89] M. Schwartz, D. Heimiller, S. Haymes, and W. Musial, "Assessment of Offshore Wind Energy Resources for the United States," 2009.
[90] Enevoldsen P, Permien F-H, Bakhtaoui I, Krauland A-K, Jacobson MZ, Xydis G, et al. How much wind power potential does europe have? Examining european wind power potential with an enhanced socio-technical atlas. Energy Policy 2019;132:1092–100.
[91] von Krauland AK, Permien FH, Enevoldsen P, Jacobson MZ. Onshore wind energy atlas for the United States accounting for land use restrictions and wind speed thresholds. Smart Energy 2021;3:100046. https://doi.org/10.1016/J.SEGY.2021.100046.
[92] "GEBCO Gridded Bathymetry Data." [Online]. Available: https://www.gebco.net/data_and_products/gridded_bathymetry_data/. [Accessed: 23-Feb-2023].
[93] "USGS usSEABED: interactive map." [Online]. Available: https://cmgds.marine.usgs.gov/usseabed/#search-results. [Accessed: 28-Oct-2022].
[94] J. Nunemaker, M. Shields, R. Hammond, and P. Duffy, "ORBIT: Offshore Renewables Balance-of-System and Installation Tool." 2020.
[95] P. Beiter *et al.*, "The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032 Cost and Performance Results Data.".
[96] "Wind farm costs – Guide to an offshore wind farm." [Online]. Available: https://guidetoanoffshorewindfarm.com/wind-farm-costs. [Accessed: 28-Feb-2023].
[97] "Maritime Safety Information." [Online]. Available: https://msi.nga.mil/Publications/WPI. [Accessed: 23-Feb-2023].
[98] T. Stehly, P. Beiter, and P. Duffy, "2019 Cost of Wind Energy Review," 2019.
[99] The Crown Estate Offshore Renewable Energy Catapult, "Guide to an offshore wind farm Updated and extended," 2019.
[100] International Maritime Organization, "ROUTEING MEASURES OTHER THAN TRAFFIC SEPARATION SCHEMES.".
[101] M. Z. Jacobson, *100 Percent Clean, Renewable Energy and Storage for Everything.* New York: Cambridge University Press, New York, 427 pp., 2020.
[102] Enevoldsen P, Jacobson MZ. Data investigation of installed and output power densities of onshore and offshore wind turbines worldwide. Energy Sustain Dev 2021;60:40–51. https://doi.org/10.1016/j.esd.2020.11.004.
[103] "Renewable Energy GIS Data | Bureau of Ocean Energy Management." [Online]. Available: https://www.boem.gov/renewable-energy/mapping-and-data/renewable-energy-gis-data. [Accessed: 23-Feb-2023].
[104] "Two US Offshore Wind Ports Secure Nearly USD 50 Million in Federal Grants | Offshore Wind." [Online]. Available: https://www.offshorewind.biz/2021/12/24/two-us-offshore-wind-ports-secure-nearly-usd-50-million-in-federal-grants/. [Accessed: 28-Feb-2023].
[105] ABS, "OFFSHORE WIND REPORT POSITIONING FOR U.S. EXPANSION: U.S. PORTS AND VESSELS INNOVATION," ***2021***. [Online]. Available: https://absinfo.eagle.org/acton/attachment/16130/f-98f8192f-6ba8-4f7c-b2f6-a30a8c41209d/1/-/-/-/-/ABS-Offshore-Wind-Report-Positioning-for-US-Expansion-Ports-and-Vessels-Innovation.pdf?utm_term=Download Now&utm_campaign=ABS Publishes Landmark U.S. Offshore Wind Report&utm_content=email&utm_source=Act-On+Software&utm_medium=email&cm_mmc=Act-On Software-_-email-_-ABS Publishes Landmark U.S. Offshore Wind Report-_-Download Now&sid=TV2:sCxeosVCY. [Accessed: 28-Feb-2023].
[106] "State Approves $10.5 Million to Prepare the Port of Humboldt Bay for Offshore Wind." [Online]. Available: https://www.energy.ca.gov/news/2022-03/state-approves-105-million-prepare-port-humboldt-bay-offshore-wind. [Accessed: 28-Feb-2023].
[107] "Rhode Island Ports to Undergo Offshore Wind Upgrades with USD 95 Million State Support | Offshore Wind." [Online]. Available: https://www.offshorewind.biz/2022/03/21/rhode-island-ports-to-undergo-offshore-wind-upgrades-with-usd-95-million-state-support/. [Accessed: 28-Feb-2023].
[108] "Coos Bay Offshore Wind Port Infrastructure Study.".
[109] WindEurope, "Ports: a key enabler for the floating offshore wind sector | WindEurope," 2020.
[110] GL Garrad Hassan, "OPTIMIZATION OF INSTALLATION, OPERATION AND MAINTENANCE AT OFFSHORE WIND PROJECTS IN THE U.S.," 2014.
[111] A. P. Crowle and P. R. Thies, "Floating offshore wind turbines port requirements for construction," *Proc. Inst. Mech. Eng. Part M J. Eng. Marit. Environ.*, 236, 4, 1047–1056, Nov. 2022, doi: 10.1177/14750902221078425/ASSET/IMAGES/LARGE/10.1177_14750902221078425-FIG2.JPEG.
[112] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." [Online]. Available: https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_sum/html/rank_use.html&sid=US. [Accessed: 28-Feb-2023].
[113] "United States - U.S. Energy Information Administration (EIA)." [Online]. Available: https://www.eia.gov/beta/states/states/HI/overview. [Accessed: 28-Feb-2023].
[114] Mai T, Lopez A, Mowers M, Lantz E. Interactions of wind energy project siting, wind resource potential, and the evolution of the U.S. power system. Energy 2021;223:119998. https://doi.org/10.1016/J.ENERGY.2021.119998.
[115] Enevoldsen P, Valentine SV. Do onshore and offshore wind farm development patterns differ? Energy Sustain Dev 2016;35:41–51. https://doi.org/10.1016/j.esd.2016.10.002.
[116] Congressional Research Service, "Offshore Wind Provisions in the Inflation Reduction Act," 2022.
[117] "FACT SHEET: The Biden-Harris Action Plan for America's Ports and Waterways - The White House," 2021. [Online]. Available: https://www.whitehouse.gov/briefing-room/statements-releases/2021/11/09/fact-sheet-the-biden-harris-action-plan-for-americas-ports-and-waterways/. [Accessed: 28-Feb-2023].

Supplemental Information

United States offshore wind energy atlas: availability, potential, and economic insights based on wind speeds at different altitudes and thresholds and policy-informed exclusions

Anna-Katharina von Krauland*[a], Qirui Long[a], Peter Enevoldsen[b], Mark Z. Jacobson[a]

a. Department of Civil and Environmental Engineering, Stanford University, Stanford, CA, 94305-4020, United States
b. Center for Energy Technologies, Department of Business Technology and Development, Aarhus University, Birk Centerpark 15, 7400, Herning, Denmark

*Corresponding author. 473 Via Ortega, Stanford, CA 94305, United States.
Email address: krauland@stanford.edu

Introduction

This document provides information about the methods applied to determine the availability and potential for wind project development for fifteen regions off the coast of the United States. Additional results are presented, including the maximum possible nameplate capacity compared with 2050 target nameplate capacity (GW), potential annual energy output compared with 2021 U.S. annual energy consumption (TWh), and output energy density (TWh/km^2), as well as economic heatmaps for the East and West Coasts. Graphs show potential nameplate capacity (GW) versus turbine hub height (m) for different wind speed threshold scenarios (m/s), annual energy output (TWh) versus wind speed threshold (m/s) for different wake loss scenarios, and available area (%) versus wind speed threshold (m/s) for each region. It also supplies figures for visualizing mean wind speed at each hub height, available area with an additional atmospheric stability parameter, suitable foundation types in all areas, discrete and continuous economic heatmaps with relative cost values, and low-cost locations. Finally, a series of tables is provided detailing important results for all combinations of wind speed thresholds (no wind restriction and 6–12 m/s, every ½ m/s interval) and hub height scenarios (100 m, 150 m, 200 m, 250 m ASL).

Table of Contents

Supplemental Methods ... ***3***

1. Study Areas ... 3
2. Layer Descriptions ... 3
   - 2.1 Technical Restrictions ... 5
   - 2.2 Environmental Restrictions ... 6
   - 2.3 Conflicting Stakeholder Restrictions ... 7
   - 2.4 Wind Speed Thresholds ... 8
   - 2.5 Metocean Conditions ... 9
   - 2.6 Economic Parameters ... 10
3. Data Source and Setback Distance Selection Process ... 13
4. Geoprocessing ... 13
5. Data Analysis ... 16

Supplemental Results ... ***20***

1. Nameplate Capacity Analysis ... 20
2. Energy Output and Wake Loss Analysis ... 22
3. Cost Heatmap Analysis ... 24

Supplemental Figures ... ***28***

4. Available Area ... 28
5. Mean Wind Speed ... 30
6. Atmospheric Stability ... 32
7. Turbine Foundation Type ... 36
8. Economic Heatmaps ... 41
9. Low Cost Locations to Meet 30 GW by 2030 Target ... 56

Supplemental Tables ... ***58***

Table S3. Area Available for Offshore Wind Energy Development. ... 58
Table S4. Area Available for Development Without Wind Threshold. ... 63
Table S5. Number of Turbines within Available Area for Offshore Wind Energy Development. ... 64
Table S6. Potential Nameplate Capacity (GW). ... 69
Table S7. Number of Turbines in Available Area and Potential Nameplate Capacity (GW) Without Wind Threshold. ... 74
Table S8. Mean Wind Speed in Available Areas (m/s). ... 75
Table S9. Capacity Factor Used for Calculations. ... 80
Table S10. Potential Output Power Density (MW/km^2). ... 85
Table S11. Potential Energy Output (TWh)–Part 1. ... 90
Table S12. Potential Energy Output (TWh)–Part 2. ... 95
Table S13. Potential Output Energy Density (TWh/km^2)–Part 1. ... 100
Table S14. Potential Output Energy Density (TWh/km^2)–Part 2. ... 105

Supplemental References ... ***110***

Supplemental Methods

1. Study Areas

The West Coast is split at three latitudes–46.256, 41.998, and 35.795–based on the onshore state borders. The East Coast has borders between North Carolina and South Carolina, as well as between Virginia and North Carolina, which were created by extending the onshore borders. The New York border was created based on former New York maritime boundaries and existing offshore planning sites to divide the northern portion of the East Coast from the mid-Atlantic. The Gulf Coast regions are derived from the existing planning regions from BOEM with some revisions to extend connectivity to the Gulf Coast border.

2. Layer Descriptions

The layers in this atlas were chosen to represent as comprehensive a set of parameters as possible that are involved in offshore wind site selection. These include data that address technical restrictions (e.g., physical obstructions such as wrecks and cables, safety hazards such as airplane interference), environmental concerns (e.g., marine protected areas, important bird areas, reefs, kelp), interference with other ocean stakeholders (e.g., navigation and fishing, military use), and climate thresholds (e.g., wind speed). Beyond restrictions for development, the atlas also includes meteorological and ocean (metocean) conditions that play a role in siting, such as air stability for power output estimations, and bathymetry and seabed data, which together are used to determine appropriate turbine foundation types in all available locations. Finally, the atlas includes variables that can be used to make economic decisions (e.g., transmission infrastructure, viable ports, relative wage rates), which together account for a large portion of the capital expenditure costs of an offshore wind project.

Table S1. Summary of Layers, Setback/Threshold Values, and Data Sources

Layer Name	Description	Setback/Threshold Value	Source
Restrictions			
Airports	Aircraft landing facilities	13 km	NREL Wind Prospector [1]; EarthWorks [2]
Existing Energy Infrastructure	Oil & gas pipelines; wells; platforms; deep-water ports; and active leases	500 m (all except active leases)	BOEM [3]; Northeast Ocean Data [4]; Marine Cadastre [5]
Submarine Cables		30 m	MHK OpenEI [6]; Marine Cadastre [5]

Wrecks and Obstructions		150 m	NOAA Nautical Charts [7]
Disposal Sites		Excluded	OROWindMap [8]
Offshore Wind Turbines	7 turbines representing 42 MW of power generation capacity	200 m	Marine Cadastre [5]
Protected Marine Areas	IUCN categories Ia: Strict nature reserve, Ib: Wilderness area, and II: National park; Prohibited construction, industrial, drilling, and entry	Excluded	Protected Seas [9]
Birds	Offshore essential habitats for bird populations	Excluded	Audubon: Important Bird Area (IBA) [10]
Reefs and Kelp	High probability of suitable areas for deep-sea stony and soft coral habitat and shallow corals; Canopy-forming west coast kelp	Excluded	Marine Cadastre [5]; NOAA [11]
Navigation	Shipping lanes and annual vessel transit counts	Threshold of 50 ships/year in 100 m grid cell	Marine Cadastre (AIS Vessel Counts) [5]
Military	Danger Zones and Restricted Areas; Regulated Airspace; Unexploded Ordnance (Areas)	Unexploded Ordnance buffered 500 m	Marine Cadastre [5]
Aquaculture		Excluded	Digital Coast [12]
Wind Speed		Measured at four hub heights: 100 m, 150 m, 200 m, 250 m; Thresholds from 6 m/s–12 m/s (every ½ m/s interval)	Global Wind Atlas [13]
Metocean Conditions			
Atmospheric Stability	Used for visualization only	Stability > 30%	Vestas Climate Library
Bathymetry	Used to determine appropriate turbine foundation	Sorted into: 0-20 m; 20-25 m; 25-60 m; 60-70 m; 70-100	GEBCO [14]

		m; 100-200 m; 200-1,000 m depths	
Seabed	Used to determine appropriate turbine foundation	Sorted into: Mud to muddy sand; Sand; Coarse substrate; Mixed sediment; Rocks and boulders	USGS [15]
Economic			
Transmission	Substations; Transmission lines	Substations buffered 5 km	Marine Cadastre (Substations) [5]; Northeast Ocean Data (Block Island Transmission Cables) [4]
Ports	Viable staging ports likely requiring minimal investment	> 7.9 m channel depth and excellent, good, or fair shelter categorization included	World Port Index [16];
Wages	Electrician; Millwright; Structural Iron and Steel Workers; Operating Engineers and Other Construction Equipment Operators		Bureau of Labor Statistics [17]
Other			
Borders	15 regions encompassing all U.S. coastal areas	N/A	Marine Cadastre (Coast Guard Jurisdictions) [5]; Global Wind Atlas [13]

2.1 Technical Restrictions

Many technical restrictions are included as safety precautions to delineate areas that would be dangerous to build within or nearby. Turbines can have an impact on aviation, radar, and telecommunications [18], therefore the airports layer is buffered with a setback distance of 13 km, the most conservative choice for large turbines [19]. The existing energy infrastructure layer includes oil and gas pipes and cables, platforms, wells, and deep-water ports, each buffered with 500 m, as well as active leases [11], [20]. This infrastructure is heavily concentrated in the Gulf Coast, with some presence on the East Coast, and a much smaller footprint in other regions. Although oil and gas infrastructure might be decommissioned in the coming years, it is included in this atlas to enable decision-making based on current impediments so that offshore wind siting might be facilitated in the near future. Submarine cables, including for telecommunications and power, are another form of physical infrastructure that prevent wind turbine siting [21],

[22]. A 100 ft (~30 m) buffer was applied to each side of the cable to account for the legal right-of-way according to the Code of Federal Regulations (CFR 585.301) [23]. For a more conservative approach, either a 500 m or a depth-varying buffer of two or three times the water depth (2z or 3z) might be considered, as per the recommendations outlined by the International Cable Protection Committee (ICPC) of the North American Submarine Cable Association (NASCA) [23]. However, these setback distances are extremely restrictive, and should be considered on a case-by-case basis.

Also included as a technical restriction is a layer of nearly 9,000 wrecks and obstructions throughout the coastal waters of the U.S., predominantly off the East Coast, as these are considered navigational hazards. Wrecks are buffered with a distance of 500 ft (~150 m) [11]. The presence of a wreck does not necessarily halt offshore wind development; rather BOEM regulation states that renewable energy developers are required to provide the results of detailed site characterization surveys in order for the bureau to conduct the required technical and environmental review of an applicant's plan [24]. Disposal sites used for dumping and disposing of dredged material and explosives are excluded from available areas [25]. Finally, existing wind turbines are included, comprising of only two utility scale offshore wind farms with seven turbines in total. These farms are, namely, Block Island, a 30 MW, five-turbine farm off the coast of Rhode Island and the first commercial offshore wind farm in the U.S., and Coastal Virginia Offshore Wind, a 12 MW pilot project constructed in 2020. The turbines are buffered with a 200 m radius based on the Block Island turbine tip heights of 181.1 m multiplied by 1.1 to provide a safety margin in the case of collapse. Although these turbines have little impact on the available area for development, they have served as early proof-of-concept examples in the U.S. offshore wind industry.

2.2 Environmental Restrictions

Environmental restrictions include protected marine areas, important bird areas, and reef and kelp habitat. It is extremely important that these are considered when building new wind farms so that wildlife displacement and habitat disruption can be avoided [26]. For each of these layers, zones were carefully selected that directly intersect with offshore wind, rather than including the entirety of protected areas. This was done to elucidate locations where turbines would be prohibited, rather than places where construction might face pushback but ultimately be allowed. As opposed to the strategically selected areas described below, the Marine Protected Areas (MPA) database [27] restricts 26% of all U.S. waters from activities such as discharge and fishing, which are not relevant to offshore wind development. Further, the MPA classification system, as well as that of NOAA's Essential Fish Habitat, defined under the Magnuson-Stevens Act [28], [29], two common conservation databases, are not easily translated for offshore wind siting use.

Protected marine areas included in this atlas are defined by a subset of the International Union for Conservation of Nature (IUCN) protected areas [30] and specific use types identified by ProtectedSeas, a marine conservation organization that has compiled spatial boundary data and summarized regulations for over 4,000 managed areas in U.S. waters [9], [31]. The IUCN categories included here are Ia: "Strict nature reserve," described as strictly protected areas for biodiversity, Ib: “Wilderness area,” which requires minimal disturbance to preserve natural conditions, free of modern infrastructure, and II: “National Park,” which is a natural area protecting large-scale ecological processes that is unlikely to allow utility-scale turbines. Category III: “Natural monument or feature,” has only three very small features that would not be reflected in the 100 m rasterized data. Category IV onward allows specific extractive activities, such as renewable energy generation, and is therefore not excluded. Additionally, certain use categories are blocked from available development areas in the atlas, including areas where construction, industrial activity, drilling, and entry (i.e., vessels) are prohibited, due to their categorization as prohibited, and are therefore highly improbable to permit offshore wind.

Important Bird Areas (IBA) are defined by Audubon’s international effort to “identify, conserve, and monitor a network of sites that provide essential habitat for bird populations [10].” Although most bird species will not migrate more than 13 km from shore [32], well outside the range considered for upcoming U.S. wind projects, the study does not impose a minimum distance from shore as a restriction as not to unnecessarily limit viable wind farm locations, and therefore this data is included as a restriction [33], [34].

Corals and kelp create complex communities that provide habitat for a variety of invertebrate and fish species [35]. Coral reefs and kelp are included as sensitive habitats that offshore development should avoid. Areas that have a high probability of containing deep-sea stony and soft coral habitat and shallow corals, as well as canopy-forming West Coast kelp, are excluded in this study.

2.3 Conflicting Stakeholder Restrictions

Besides physical infrastructure and areas set aside for environmental conservation, there are also many groups of people who use the ocean for commerce, transit, defense, food production, and a myriad of other activities such as recreation and tourism. These uses are dynamic, yet predictable, and can be mapped in relation to offshore wind development. One of the most significant, in terms of footprint, is vessel traffic for navigation, including shipping and fishing. A dataset was selected that includes vessel transit counts over the course of a year using automatic identification systems (AIS) technology. The number of vessel track passes are compiled in 100 m grid cells, which are sorted according to a threshold that signifies a high concentration of vessel traffic that would be disrupted by the siting of a wind turbine. This threshold was determined to be 50 ships/year within each grid cell, after scaling and modifying the analysis of Moller [36], which recommends a density of 200-400 ships per year in a 1 km grid cell. This threshold also shows good alignment with high-density areas of the AIS Vessel Transit Counts layer on Marine Cadastre’s map [5]. Additionally, shipping lanes, which are specifically designated traffic lanes, precautionary areas, and safety fairways, are merged with vessel counts described above to present a complete representation of areas that are very likely to conflict with offshore wind development.

Offshore areas used by the military are also important to consider. The categories determined to directly conflict with wind turbines are "danger zones and restricted areas," defined as "water areas used for target practice, bombing, rocket firing or other especially hazardous operations" [37], "military regulated airspace," which are depicted by the Air Traffic Control Assigned Airspace (ATCAA) and Airspace Corridor areas [38], "unexploded ordnance areas", which are places that have explosive weapons that did not explode and still pose a risk of detonation [39], and "unexploded ordnance locations" that are buffered with a 500 m setback, as these are merely point locations and do not include the geographic extent of dangerous area [40]. Other categories, such as training areas and radar interference zones, might pose challenges for siting, but this will need to be considered on a project-by-project basis, as not all military areas are publicly available.

Marine aquaculture refers to farming species that live in the ocean and estuaries [41]. Aquaculture has been among the fastest growing global food production sectors for decades, and is therefore included in this atlas with over 3,500 features, mostly concentrated on the East Coast [11]. However, because these features are situated in nearshore or inshore areas, they are unlikely to conflict with offshore development.

2.4 Wind Speed Thresholds

The quality of the wind resource is the single most important determining factor in judging the suitability of a wind farm location [42], [43]. For this reason, generalized wind speed data was included in the atlas as a set of 13 wind speed thresholds, ranging from 6 m/s–12 m/s (at every ½ m/s interval), at four different hub heights: 100 m, 150 m, 200 m, and 250 m. When applied to all 15 study areas, this amounts to 780 different layers that depict the available area after considering all restrictions, in addition to wind speeds above each threshold. From this available area, several useful metrics can be calculated, including potential capacity and power density, as described below. Wind speed data was sourced from the Global Wind Atlas, which provides high-resolution (250 m horizonal grid spacing) maps of wind resource potential from a downscaling process [13]. Thresholds are set at ½ m/s intervals to capture the granular impact of increasing average wind speed on energy output, which often informs the economic feasibility of a project. Typically, 7 m/s is used as the economic cut-off point [1], [44], [45], however, the atlas includes two wind speed thresholds below this to widen the range of possible siting areas, particularly in regions such as the southeast U.S. and Puerto Rico, which have lower wind speeds in general, as wind developers have expressed interest in exploring these areas. A more detailed assessment of wind speed variability would likely need to be performed in a region of interest before a final siting decision is made. Finally, the three hub heights of modern wind turbines (100 m, 150 m, 200 m) are included from the Global Wind Atlas, as well as an extrapolated 250 m wind speed height. The hub height of an offshore wind turbine will depend on the substructure on which it is mounted, making it impossible to assign a single hub height for a wind turbine model; however, the trend, as with onshore wind turbines, is toward ever-larger turbines with taller towers, longer blades, and rated capacities [46]–[49]. For this reason, a 250 m height was added to the analysis to allow for future turbine configurations. Additionally, contemporary wind turbines have tip heights over 250 m [50]. It is increasingly important to account for the vertical profile of wind speed relative to the center of the blade, as the hub height is no longer an accurate measure of the power output since wind speed does not scale linearly with height [51]. For the V236-15 MW turbine used in this study, a minimum hub height of 140 m can be assumed. A typical hub height for this turbine is approximately 145 m, however, at specific sites the hub height might be greater than 160 m due to the height added by the jacket foundation. With a rotor diameter of 236 m, this turbine has a typical tip height of 263 m.

2.5 Metocean Conditions

Atmospheric stability can play an important role in the design, siting, and operation of an offshore wind farm. Stability can be calculated using a stability parameter, such as the Richardson number or the Brunt-Väisälä frequency. These stability parameters are based on atmospheric stratification and wind flow [52].

Stability is rarely accounted for in wind modelling studies, but nonetheless can have a significant influence on power output and wake impacts [52], [53], causing overestimations of the captured wind resource. The dominant impact of a stable atmosphere is that, in the absence of ambient turbulence, the wind turbine wake is much more persistent, meaning it does not dissipate as quickly as it normally would. Atmospheric stability can lead to contradictory effects in that wind speeds are typically higher in unstable atmospheric conditions, which can result in higher energy production, but can also increase the risk of turbulence, which can reduce the energy production [54], [55]. The dependency of the power curves on stability can cause significant miscalculations of instantaneous power production, long-term energy yields, and loads [56]–[59]. One investigation of power data for single offshore wind turbines showed differences of up to 20% between stable and unstable stratification for the same mean wind speed [56]. Particularly for large turbines with longer blades that operate in heights where stability is more relevant, it is important to include this parameter to avoid underperforming power curves, as well as additional stress on the turbines, which can impact maintenance costs and the overall turbine lifetime. The 30% threshold in this study is used to visualize where stability will have a noticeable effect on wake, as this is the value commonly used in the industry to signal a departure from expected energy output. Stability primarily impacts some areas around the Northern East Coast and Alaska, which is shown in Figures S6.1-6.6. Due to the complex nature of stability quantification in the context of wind farm siting, this parameter is not considered a restriction, but is included for illustrative purposes.

All of the layers described above delineate areas that are excluded from offshore wind planning. However, bathymetry (water depth) data, in tandem with seabed characteristics [60], [61], are used to map the most appropriate turbine foundation in all available areas. This determination is based on Vazquez et al. [62], which considers multiple metocean and geotechnical conditions to produce a decision matrix that has soil substrate on one axis and water depth on the other. Bathymetry data is sourced from GEBCO, a global terrain model for ocean and land [14] and sorted into the following water depth groupings: 0-20 m, 20-25 m, 25-60 m, 60-70 m, 70-100 m, 100-200 m, and 200-1,000 m.

This process is similar to that used to select relevant seabed characteristics from USGS US9_ONE file, a dataset that covers sediment texture from lab-based analyses, data mined logs, and derivative equations [15]. The four factors used to match the decision matrix were "facies," which included generic rock, metamorphic rock, and sedimentary rock, and the proportion of "sand," "gravel" and "mud," which were coded to create a mutually exclusive and completely exhaustive framework to translate the data into five categories: "Mud to muddy sand," "Sand," "Coarse substrate," "Mixed sediment," and "Rock & boulders." These characteristics were paired with depth categorizations to produce eight different possible combinations of foundation types that would be appropriate in each area, involving the following, or multiple of the following: monopile, gravity-based, jacket, tripod, semi-submersible, tension-leg-buoy, and spar. The resulting maps can be viewed in Figures S7.1-7.7.

2.6 Economic Parameters

Ultimately, siting decisions will be made based on projected profitability [63], of which capital expenditures (CapEx) are an important component. This atlas considers four variables used to estimate CapEx, including proximity to port and transmission interconnection infrastructure, turbine foundation costs, and relative labor costs pertaining to installation for different coastal states [64], [65]. Each variable is integrated into a heatmap that reveals the least-cost locations in all available areas (see Figure 9, Figures S8.1-8.30). Together, these variables account for ~30% of the CapEx, which equates to approximately 65.7% of the overall levelized cost of energy (LCOE) [66]. Only CapEx variables were included in this analysis, in part because these are most relevant to the siting stage of wind energy development and in part due to the complex and individualized nature of wind farm planning. The largest driver of the CapEx of installing an offshore wind turbine, besides the turbine itself, is the substructure [66], which is primarily a function of water depth. From 2019 to 2025, the capacity-weighted average depth of installed projects is expected to increase from an average of 31 m to 43 m. Similarly, the average distance from shore will increase from 47 km to 70 km by 2025 [67]. As projects are being sited in increasingly deep water and distances further from shore, costs will likely increase, depending on the pace of technology and supply chain advancements.

The next most influential cost parameter is the proximity from a proposed site to the nearest grid interconnection point [68]–[70]. Line losses in cables account for considerable costs, so it is better to limit the length of the cable as much as possible [71]. Sometimes developers choose to put turbines closer together despite wake losses because in some cases this is less expensive than the cost of the electrical infrastructure. However, offshore wind installations are also moving further from shore into deeper water, where better quality wind resources are available. Most projects commissioned to date have been within 50 km of shore, but several large projects in the pipeline are 100 km or more from shore [72]. This paper assumes an export cable that follows the shortest straight-line distance from the study area to shore and a uniform 5 km length for the onshore spur line that connects to the substation [73]. Substations are therefore buffered using a 5 km HVAC and HVDC threshold distance.

In the coming years, it will be critical to develop ports with the proper configuration and equipment requirements for constructing and assembling offshore turbines, as the lack of port readiness is a significant bottleneck [74], [75]. Some of the criteria for assessing port capabilities include quay length, quayside load bearing capacity, crane capacity, and channel depth and width [73], [75], [76], which will vary depending on the turbine size and foundation type deployed. Because the port acts as the supply chain hub through the entire manufacturing and installation process, the first step in the construction of a wind farm is the selection of the port(s). A layer was created that identifies ports with two of the important criteria for readiness: channel depth and degree of shelter. Only ports with greater than 7.9 m channel depth and "excellent," "good," or "fair" shelter categorization are included in the analysis. Of the major ports across the U.S. according to the World Port Index [16], 227 meet these criteria. A subset of these also have no overhead limitations, which is a requirement for configuring certain floating offshore platforms.

This study only considers the cost directly associated with the transit of turbine components to and from the project site. Although the cost for port transit is the parameter with the smallest influence on CapEx, the total port and staging costs involved in turbine installation are significantly higher, as the vessel cost alone is extremely expensive [77]. It is important to identify viable ports, as securing further investment into port infrastructure throughout the U.S. will enable offshore wind development [78], [79]. Recently, several ports have been slated for necessary upgrades [80]–[85]. The ports with funding secured are all either on the West or East Coast, heavily concentrated in the Northeast. Further investment will be needed in all regions to launch the initial batch of offshore wind projects.

The relative cost of labor between states is the final parameter that was studied in relation to CapEx. Wages account for a rising percentage of overall project costs and can vary greatly from state to state [86]. Despite being a small amount of the total, the impact of varying wage rates will be noticeable in states with higher-than-average wages, particularly New York, which has the highest relative wage rate of 33% higher than the national coastal average across relevant jobs. The Bureau of Labor Statistics categories related to offshore wind include "Electrician," "Millwright," "Structural Iron and Steel Workers," and "Operating Engineers and Other Construction Equipment Operators." For each coastal state and job type, the average hourly twelve-hour, seven-day weekly wage was recorded, which was then used to compute the labor cost as a percentage relative to the average of all states. This ratio was later used in the economic heatmap to represent the maximum wage cost variance.

Table S2: Average Wage in Each U.S. Coastal State

Region	State	Average Wage ($/hr)
Alaska	Alaska	34.79
Hawaii	Hawaii	36.53
Puerto Rico	Puerto Rico	11.82
North & South California Coast	California	35.31
Washington Coast	Washington	36.61
Oregon Coast	Oregon	33.88
Western Gulf Coast	Texas	23.51
Central Gulf Coast	Mississippi	21.34
	Alabama	22.02
	Louisiana	25.76
Eastern Gulf Coast	Florida	21.97
Southern East Coast	Florida	21.97
	Georgia	23.98
	South Carolina	21.88
North Carolina Coast	North Carolina	21.75
Mid-Atlantic Coast	New York	38.15
	Maryland	26.87
	New Jersey	37.45
	Connecticut	31.35
	Delaware	28.18
	Virginia	25.36
Northern East Coast	Rhode Island	31.88
	Massachusetts	34.1
	Maine	24.71
	New Hampshire	24.57
Great Lakes	Minnesota	31.41
	Wisconsin	30.67
	Illinois	37.56
	Indiana	28.30
	Michigan	29.95
	Ohio	28.17
	Pennsylvania	29.53
	New York	38.15
Overall Average		**28.69**
Max/Average Ratio		**1.33**

3. Data Source and Setback Distance Selection Process

Each data source, setback distance, and threshold value that appears in the atlas was selected after scrutiny of the literature and best practices, including inspection of hundreds of academic papers and industry reports, review of over 150 databases, and interviews with dozens of experts ranging across all fields intersecting with offshore wind siting. It was first necessary to determine which layers are relevant to the analysis, then to find appropriate data sources for each. Using QGIS, an open source Geographic Information System (GIS), layers were compared and assessed for spatial coverage, resolution, and pertinence as offshore development obstacles. Similarly, over 200 sources were evaluated to determine the buffer distance or threshold value that should be applied to each layer. These were modeled in GIS and subjected to sensitivity testing to understand the impact of varying levels of conservativeness on available area, and ultimately chosen to reflect the most realistic restrictions developers are likely to face.

To complement published knowledge, experts were contacted and interviewed to understand current practices, either pertaining directly to offshore wind or similar offshore activities, and to gather recommendations for insights to be built into the model. As the offshore wind industry in the U.S. is still immature, clear guidelines do not yet exist around siting allowances. Therefore, some of the setback distances are speculative, which is why expert guidance was particularly valuable for this study. Expert advice was solicited from a broad array of roles in different fields, ranging from geospatial analysts, marine ecologists, clean energy directors, market entry specialists, coastal resource specialists, portfolio siting specialists, lawyers, professors, and many others. Organizations represented in the interview process included national labs and scientific agencies (e.g., National Renewable Energy Laboratory (NREL), National Oceanic and Atmospheric Administration (NOAA)), state and federal government entities (e.g., Bureau of Ocean Energy Management (BOEM), California Energy Commission (CEC), U.S. Department of Defense/Navy, New York State Energy Research and Development Authority (NYSERDA)), conservation organizations and nonprofits (e.g., ProtectedSeas, Audubon, Smultea Sciences), universities (e.g., Duke University, Cornell University, Stanford University, West Point), industry (e.g., Vestas, Enel, James Fisher Renewables), and others (e.g., California Independent System Operator (CAISO), World Bank). These conversations were instrumental in shaping decisions around marine and bird protection areas, high-priority military exclusions, atmospheric and wind speed thresholds, wage estimations, necessary port characteristics, as well as understanding many of the complexities of offshore siting.

4. Geoprocessing

To match the study areas shown in Figure 1, each dataset was divided by region using QGIS tools such as Select by Location for polygon data, and Clip Raster by Mask Layer for raster data. In cases where more than one dataset was selected due to complementary characteristics or coverage areas, these were combined using the Merge tool. In other cases where data included onshore features (e.g., bird areas, substations), the data was sorted using various tools such as Clip Vector by Mask Layer using a United States border polygon, and Union to create a new layer without overlapping polygons. The Difference tool was used to find the resulting offshore areas. Because Alaska and Hawaii both cross the dateline, adjustments were necessary to create border layers that consisted of a single continuous polygon. This involved fixing the gaps near the dateline by editing vertices and using the Dissolve tool. Several other layers that crossed the dateline had to be similarly addressed using Fix Geometries or similar methods.

Layers were buffered according to the setback values indicated in Table S1. Each layer was then rasterized using the Rasterize tool to facilitate the calculation. Upon conversion to raster, each layer was resampled to a 100 m resolution to match the resolution of climate data (the conversion from vector to raster does not result in significant data loss). An exception is the relative cost layer, which has a resolution of 500 m due to the limited resolution of the bathymetry dataset and the limited computational capacity for the distance-to-port and substation layers. The North America Albers Equal Area Conic (NAD 1983 Albers North America) reference system was chosen for all continental offshore regions and Puerto Rico. Hawaii Albers Equal Area Conic (NAD 1983 Albers Hawaii) was selected for Hawaii. These projections minimize distortion across the large study areas, while maintaining area dimensions, which will be important when calculating available area after taking into account all restrictions. An uncertainty to note is that due to the use of QGIS and ArcGIS for the creation of data layers and the quantification of area, respectively, there is a small discrepancy between pixel size that results in maximum 0.015% difference between resulting areas. All layers were generated using a uniform method.

In total, 17 infrastructure and protected restriction layers were considered in the analysis. The restriction vector layers were either rasterized with a fixed value or the restricted raster layer areas were reclassified as 1s and unrestricted areas as 0s using a conditional statement in the Raster Calculator. To combine all 17 restriction layers, these restriction layers were subtracted from a reference raster layer of the study region (for which all pixels have values of 1). These output layers were converted to a binary format by changing values smaller than 1 to 0 to denote “unavailable” areas. Areas with “no data” values were removed as not to skew the results.

Next, layers with threshold values were processed. For the Navigation layer, Raster Calculator was used to sort layers greater than the threshold value of 50 ships/year, then convert each grid cell to binary values, where a value of 1 indicated exceedance of the threshold.

Wind speed data covering the United States and Puerto Rico was implemented from the Global Wind Atlas, which has a 250 m horizontal resolution and is derived by downscaling large scale atmospheric data to ultimately produce predicted wind climates accounting for high resolution topography [13]. Although the vast study area encompasses a broad array of dynamic wind conditions, it is appropriate to use generalized wind speed as an initial constraint here, as is regularly done in site selection analyses. Four different heights were assessed: 100 m, 150 m, 200 m, and 250 m above sea level, three of which came directly from Global Wind Atlas outputs, while the 250 m values were extrapolated based on wind speed at 150 m and 200 m to represent a full range of current and future offshore turbine hub heights, based on the power relationship:

$$\alpha = \frac{\ln\left(\frac{u_{150}}{u_{200}}\right)}{\ln\left(\frac{150}{200}\right)}; u_{250} = u_{200}\left(\frac{250}{200}\right)^{\alpha} \quad \text{(S1)}$$

where α is the empirical parameter and u_h is the wind speed at height h. Following this relationship, wind speed at 250 m was calculated using the Raster Calculator.

To validate the wind profile extrapolation, the power and log relationships were examined with the Vestas Climate Library 9-km data for 5 heights from 80-180 m. The Climate Library, which employs over two decades of climate observations at an hourly resolution, was chosen for validation since it has a more continuous profile than the Global Wind Atlas. Both relationships match ~99.5% of the measured profiles with r-square values > 0.9. The power relationship was chosen because of the lack of roughness length data and consistent stability data. The power relationship works well for most pixels [87], but it fails to resolve ~0.5% of the locations primarily due to persistent nocturnal jets observed in the annual mean wind profile, which mostly leads to an overestimation of wind speed at higher altitudes. These jets likely appear in onshore or near-shore locations due to moisture and temperature influence from the ocean [88]. To further validate extrapolation with only 2 heights, extrapolation using only 140 m and 180 m was tested. The 2-point extrapolation for wind speed at 250 m has a maximum error of ~4.5% compared with the fitted values from the power curve (5-point extrapolation).

Each of these wind speed datasets were clipped to individual regions and formatted to match the 100 m resolution of other restriction layers. They were then converted to binary format using the Raster Calculator. Using a conditional statement, pixels with wind speeds larger than the specified threshold were identified. Pixels in unrestricted areas above the threshold were designated as 0s and other pixels below the threshold as 1s. This step was then repeated for all 13 thresholds values, ranging from 6-12 m/s, at ½ m/s intervals.

All of the datasets with threshold values were combined with other restrictions by subtracting each from the border layer using a Raster Calculator expression. Outputs, including pixel counts, zonal areas, and average wind speed in available areas, were calculated using the Zonal Statistics tool for each of the different hub height and wind speed scenarios.

The following layers were not included in the final area analysis, but instead were used to gain other insights around energy production, substructure selection, and cost tradeoffs.

Atmospheric stability data was initially imported as two point datasets: one with a 3 km resolution that covered a majority of the study area, and a 9 km point layer that filled in the remainder further from shore. These stability datasets were rasterized using the Point to Raster tool and mosaicked using the Mosaick to New Raster tool to combine the two layers, prioritizing the 3 km data. These were then clipped to the border layer for each region. After this, the different raster resolutions were reprojected and resampled to a resolution of 100 m to match other layers for subsequent area calculations. Finally, a threshold value of 30% was applied to the stability layer to draw attention to regions with persistent wake effects. Rather than treating stability as an exclusion, which would be overly restrictive in regions with otherwise high wind speeds and favorable siting conditions, stability and exclusion layers were overlayed for visualization to suggest areas that should undergo additional scrutiny in the decision-making process to avoid overestimating wind farm energy production (see Figures S6.1-6.6).

The foundation type was classified based on bathymetry and sediment. The sediment layer was first imported as a point layer, which was converted to polygons using the Voronoi Polygons tool in order to provide a two-dimensional surface with which to match bathymetry values. Voronoi polygons are created by dividing spaces according to their proximity to each point, resulting in an irregular pattern of bordering polygons. Next, a raster layer was generated from the polygon layer and clipped to the study region. The appropriate foundation types were evaluated in conjunction to bathymetry using the Raster Calculator, based on the classification in Vazquez et al. [62].

The four components of the economic analysis were weighted and summed using the Raster Calculator based on bathymetry, distance to ports/substations, and wages. The raw bathymetry layers were directly used after being clipped to the study region. Distance layers were calculated using the Distance Accumulation tool with a source layer, a barrier layer, and a study region mask. The source layer uses the port/substation layer, while the barrier layer uses a land mask to make sure the distance is calculated over water rather than land. For the port/substation layer, a buffer of 5 km for substations and 20 km for ports was created before clipping the buffered region by the study region to ensure the source layer is within the study region. The 20 km buffer for ports was added back to the distance before calculating costs to account for inland ports. As for the land mask, the study region was buffered by 100 km, then erased to obtain a barrier layer around the study region. The capacity of transmission cables was not considered because a particular wind farm size or configuration was not assumed. Instead, it was assumed that the relevant substation will be upgraded wherever a wind farm is added to the grid. To generate the wage raster, a region-level average wage table was joined with the respective region polygons and rasterized to create the wage layer with the normalized average wage for each region.

5. Data Analysis

After determining how much area is available in each region by summing and converting the number of available grid cells, wind potential was calculated based on different wind speed thresholds and hub height scenarios, starting with the number of turbines that can be installed. The V236-15 MW turbine was used as the reference turbine throughout the analysis, representing the state-of-the-art technology that developers have indicated will be used for most U.S. projects [89]. The number of possible realizable wind turbine installations (N_{turb}) is based on the area required per wind turbine generator, as seen in the following calculation:

$$N_{turb} = \frac{Available\ Area\ (m^2)}{Turbine\ Spacing\ Density\ (m^2)} \quad \text{(S2)}$$

where *Turbine Spacing Density* = (*F* * *Rotor Diameter* (m))^2.

The turbine spacing density is a function of the turbine rotor diameter and a spacing factor, F, based on a study that analyzed the spacing density of global offshore multi-megawatt wind turbines (mean spacing factor of 5.98 times the rotor diameter for offshore wind farms) [90]. This number is then multiplied by the turbine nameplate capacity (rated power, P_r) in order to estimate the maximum possible nameplate wind capacity over an entire region.

$$Maximum\ Possible\ Nameplate\ Capacity = N_{turb} * P_r \quad \text{(S3)}$$

From here, it is possible to calculate many other useful metrics for decision-making, such as the energy output (TWh), both with and without array losses, or wake effects from other nearby turbines. Because this paper does not model a particular wind farm configuration, but rather the overall energy output over an entire region, it was assumed that array losses are uniform. Three different wake loss scenarios –5%, 10%, and 20%– were analyzed to encompass a range of possibilities. The low (5%) value was derived from a global model which shows the loss in wind power extracted when accounting for competition among wind turbines for available kinetic energy. At higher levels of installed power, higher loss up to 20% was found due to competition [91]. Other sources indicate average power losses due to wind turbine wakes on the order of 10-20% of power output in large offshore wind farms [92], [93].

It is also necessary to account for the capacity factor to have a more realistic assessment of energy output, rather than an idealized scenario. Instead of multiplying by a uniform capacity factor, the capacity factor for each region was calculated as a function of mean Rayleigh-distributed wind speed (V_m) in m/s, the rated power of the turbine (P_r) in kW, and the turbine blade diameter (D) in m. Equation S4 is accurate to within 1-3% for most wind turbines worldwide and to within 10% of all turbines tested [94]. To take into account changing air density with altitude in the standard atmosphere, each capacity factor value is multiplied by a ratio of the air density at that height to the air density at 100 m, 1.21328 kg/m^3 (100 m: 1; 150 m: 0.995203086; 200 m: 0.990414414; 250 m; 0.985650468) [95]. The outcome is a table containing a unique capacity factor for every region with each wind speed threshold at each hub height, for a total of 780 different capacity factor values (Table S9).

$$CF = 0.087 * V_m - \frac{P_r}{D^2} \quad \text{(S4)}$$

The capacity factor values fall in the range of 30-80%, with an average of 48.8% for wind speed thresholds under 8 m/s, which is in close agreement with the IEA, which concluded that the average capacity factor of a modern wind turbine is between 40-50% [72].

With calculated capacity factors, other metrics such as output power density (MW/km^2) and the output energy density (TWh/km^2) can be estimated. The output power density is the wind farm power output per unit area, or the installed power density multiplied by the capacity factor. The installed power density is the nameplate power capacity per turbine area, which is inversely proportional to the spacing area of the wind farm.

These metrics have important implications about coastal water use and subsequent project costs. One example is the tradeoff between the cost of transmission cabling within a wind farm and the negative impact of wake effects from turbine proximity. These costs will vary based on the specific location but are presented here as regional averages.

Finally, a series of heatmaps was created for each of the fifteen study regions to indicate where costs would be lowest within the available areas after accounting for restrictions and wind speeds. The cost variables included in this analysis were turbine substructure, transmission interconnection, port to project roundtrip transit distance, and relative wages of coastal states. Equation S5 shows the cost relationship between three different foundation types (monopile, floating, and jacket), as derived from Bosch et al [96]. This is a simplification from the methodology described in Section S2.6, where the foundation is a function of both depth and soil composition. Equation S6 shows the cost function for different transmission distances. Note that the distance to ports in Equation S7 is multiplied by 2 to account for the roundtrip distance from shore to the project site. Only the costs incurred from transit are included, not vessel costs or other installations costs.

$C_{W,max}/C_{W,mean}$ in Equation S8 is the normalized average wage for each state or all states bordering the study region. Throughout each of the cases, the wage value remains constant at 1.3 to represent the ratio between the most expensive state, New York ($38.15/hour), and average labor costs across states ($28.69/hour). The equation is not particularly sensitive to the wage ratio, as a change from 2 to 1 in value only results in approximately a 1% difference in the overall cost value [17].

Once each of the CapEx components are computed independently, they are summed using Equation S9 to determine the relative weighted and normalized cost of each grid cell that can be used to draw conclusions about economic viability across all regions:

$$C_F = \begin{Bmatrix} For\ W_D \leq 0\ m, & 0 \\ For\ 0\ m < W_D \leq 50\ m, & -0.0102 * W_D + 0.6635 \\ For\ 50\ m < W_D, & -0.0013 * W_D + 1.1603 \end{Bmatrix} \quad (S5)$$

$$C_T = \begin{Bmatrix} For\ D_T \leq 50\ km, & 0.0176 * D_T + 0.1179 \\ For\ 50\ km < D_T, & 0.0046 * D_T + 0.8049 \end{Bmatrix} \quad (S6)$$

$$C_P = 2D_P/100 \quad (S7)$$

$$C_W = C_{W,max}/C_{W,mean} \quad \text{(S8)}$$

$$C_R = C_F * 0.605 + C_T * 0.203 + C_P * 0.019 + C_W * 0.074 \quad \text{(S9)}$$

where C_F = Cost of foundation,
W_D = Water depth (m),
C_T = Transmission cost (export cable system),
D_T = Transmission distance (km),
C_P = Port transit cost,
D_P = Port distance (km),
C_W = Wage cost,
$C_{W,max}$ = Maximum wage cost,
$C_{W,mean}$ = Mean wage cost,
C_R = Overall cost

The multipliers in Equation S9 are determined based on the capital cost classification from previous research [97]–[99], where the foundation cost and the transmission cost constitute 20% and 10% of the total capital cost, respectively. The allocation of the remaining two components is derived from an NREL report [66]. According to BVGA [100], transit represents a range of 0.28% to 0.975% of the total vessel cost. Vessel costs make up approximately 62.8% of the total installation cost. Therefore, it can be estimated that the distance to the port contributes approximately 0.6% of the overall cost. Furthermore, based on information from Vestas, wages account for nearly half of the installation cost, which is 4.9% of the capital cost. Summing up these figures, the resulting contribution is approximately 33% of the total capital cost.

The resulting unitless values from Equation S9 refer to the relative cost compared with a reference project from an NREL report [66] that considers a water depth of 34 m and a distance from ports and substations of 50 km, similar to the characteristics of the wind energy areas located in the North Atlantic region. It also assumes the use of a 6.1 MW turbine, in contrast to a 15 MW turbine used for other computations throughout the analysis. The reference value is 1, with values below considered relatively inexpensive. Values above 1 are categorized into three buckets:

1-2.2 (Typical Project Cost), computed using a maximum water depth of 1,000 m and transmission and port distance of 200 km, a common maximum assumed in the industry [44], [101]–[103]. These values represent areas that fall into a feasible range of parameters for current offshore siting standards;
2.2-3.8 (High Project Cost), computed using a water depth of 2,600 m, which is the deepest water depth of any proposed project in U.S. waters, and transmission and port distance of 370 m (equivalent to 200 nautical miles, or the outer bounder of the EEZ). These areas can technically be developed, but are likely too expensive to be targeted for siting using today's technology;
>3.8 (Cost Prohibitive), these areas are extremely expensive and unlikely to be developed in the near future.

Supplemental Results

1. Nameplate Capacity Analysis

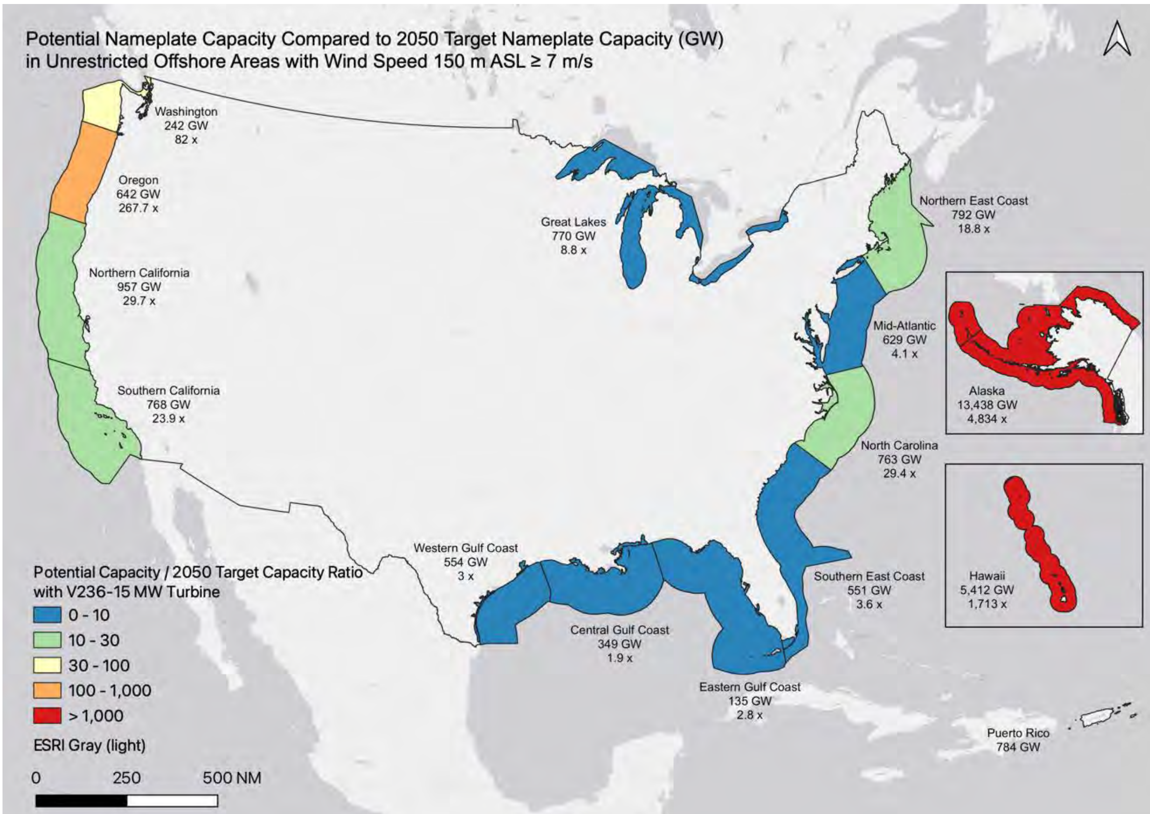

Figure S1.1: Potential Nameplate Capacity Compared to 2050 Target Nameplate Capacity (GW). Compares potential nameplate capacity (GW) in all unrestricted offshore areas (Table S1) calculated with V236-15 MW turbine and wind speed at 150 m ASL ≥ 7 m/s (row 1) to 2050 total nameplate capacity (GW) needed needed to match power demand with supply, storage, and demand response continuously during 2050-2051, as calculated in Jacobson et. al. [104], presented as a ratio (row 2). See Figure S1.2 and Tables S6-7 for all combinations of hub heights and wind speed thresholds.

For each region, the power requirements for all corresponding coastal states were summed to determine the cumulative offshore wind capacity that will be necessary in 2050, which is then compared to the maximum possible nameplate capacity that could be installed using today's technology and resources. Figure S1.1 shows that every region can fulfull offshore wind requirements, with at least a margin of 1.9 times the necessary capacity (no 2050 data was available for Puerto Rico). In the most extreme case, the nameplate capacity can fulfill 4,834 times the required 3 GW required in Alaska in 2050. Similarly, in Hawaii, there is an extreme margin of 1,713 times the necessary capacity. In most regions, the ratio between the potential capacity and 2050 target capacity is in the range of 3-30 times as much as needed.

Compared to the whole U.S., which has a projected 2050 total nameplate capacity requirement (existing plus new) across all wind, water, and solar resources of 5,855.03 GW, offshore wind energy alone could fulfill this several times over with 26,788.22 GW of possible nameplate capacity. When considering the contiguous U.S. alone, which has a 2050 cumulative nameplate capacity of 5,813.91 GW, offshore wind energy potential still exceeds requirements by a wide margin, with 7,153.53 GW of nameplate capacity.

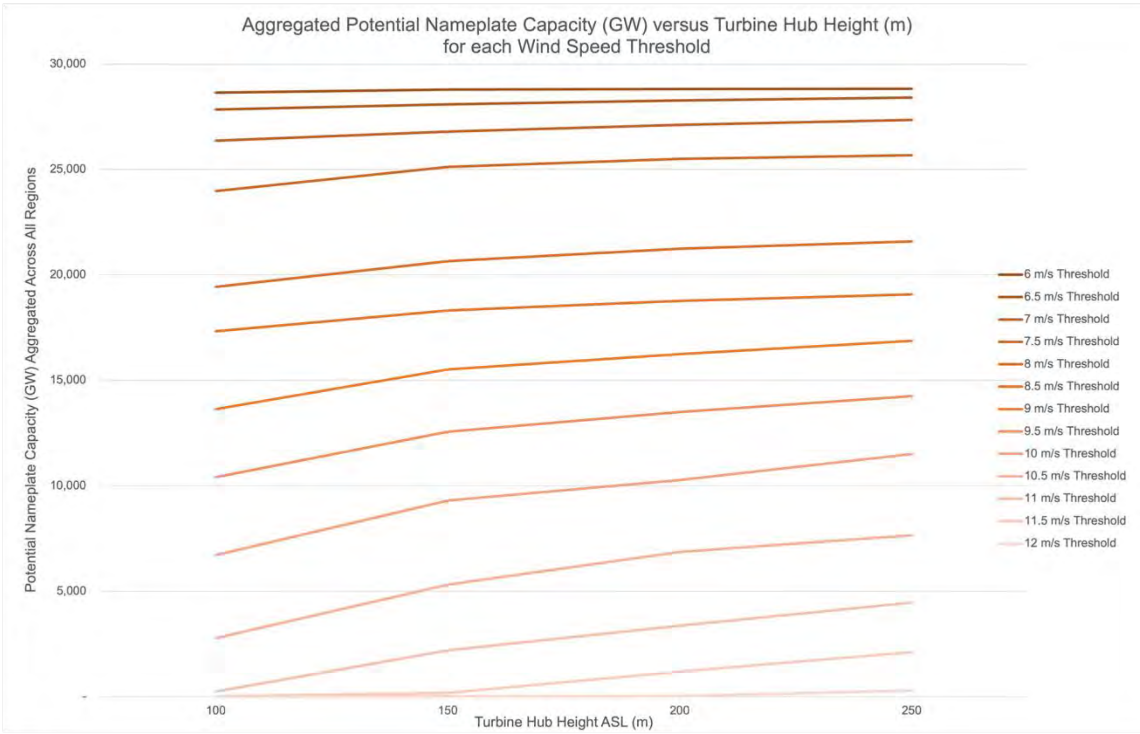

Figure S1.2: Aggregated Potential Nameplate Capacity (GW) versus Turbine Hub Height (m). See Tables S6-7 for a breakdown of potential nameplate capacity for each wind speed threshold and hub height scenario by region.

The highest aggregated potential nameplate capacities, up to 28,819.13 GW, can be achieved when the wind speed threshold is lowest, at 6 m/s, and decreases thereafter with increasing thresholds. At the highest wind speed threshold, 12 m/s, the nameplate capacity dips to only 0.05 GW in the 100 m hub height scenario due to the small amount of available area remaining. Although some values appear relatively flat with increasing hub height, each nameplate capacity is increasing, but to various degrees. The wind speed thresholds between 8 m/s-11.5 m/s show relatively sharper increases with turbine hub height.

2. Energy Output and Wake Loss Analysis

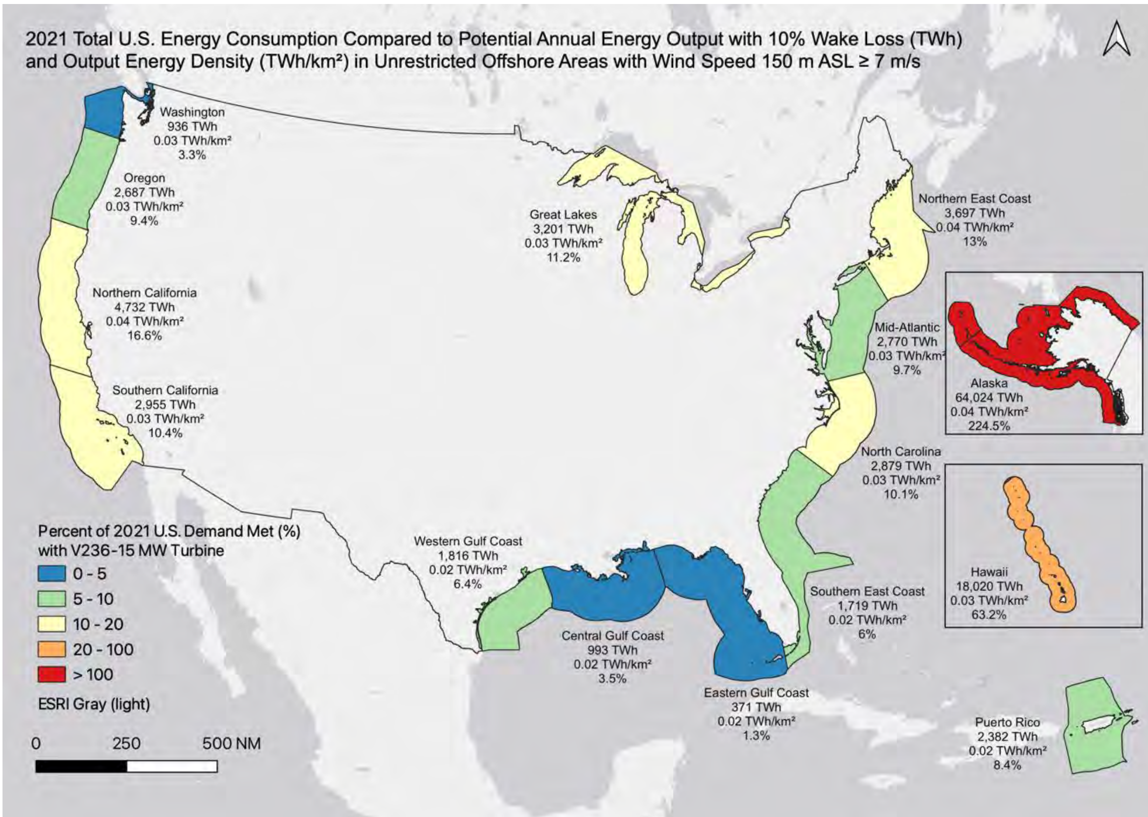

Figure S2.1: 2021 Total U.S. Energy Consumption Compared to Potential Annual Energy Output with 10% Wake Loss (TWh) and Output Energy Density (TWh/km^2). Regional potential energy output (TWh) (row 1) is divided by total U.S. all-purpose, end-use energy consumption across all sectors (commercial, residential, industrial, and transportation) in all 50 states, excluding Puerto Rico to compute Percent of 2021 U.S. Demand Met (%) (row 3). Also shown is output energy density (energy output divided by available area) (row 2). A wind speed threshold of 150 m ASL ≥ 7 m/s and 10% (medium) wake loss scenario are used to compute each value. See Tables S11-14 for all combinations of hub height, wind speed thresholds, and wake loss scenarios.

Here the potential annual energy output (TWh) of each region in relation to the total U.S. energy demand from 2021 [105] is analyzed. No region alone except Alaska could fulfill demand for all purposes, however, all regions can contribute a significant amount. This is a hypothetical exercise, as (1) offshore wind energy resources will be developed along multiple coasts simultaneously, as seen with the first leases on the East and West Coasts, (2) other forms of renewable energy, including onshore wind, solar energy, and hydropower, will also make up a significant portion of a 100% clean, renewable power grid, and (3) the U.S. is not entirely interconnected, but instead consists of multiple regional grids. However, Figure S2.1 gives a sense of the enormous magnitude of offshore energy potential across the country.

Additionally, despite increased energy demand due to electrification, overall energy demand will be substantially lower with the shift from the current mix of energy resources to a far more efficient use of wind, water, and solar energy. If the whole United

States makes a complete energy transition, the demand for energy will decrease by 56.7% [104], making the projected 2050 annual load significantly smaller than the 28,524 TWh used in 2021. In this scenario, the same installed offshore wind capacity can contribute roughly double the percentages indicated in Figure S2.1.

As noted, Alaska and Hawaii contribute a large portion of potential energy output, but are unlikely to fulfill a substantial amount of U.S. demand on a practical level. Considering only contiguous U.S. energy output with 10% wake losses, which amounts to 28,755.29 TWh, it is possible to fulfill 100.8% of end-use load using offshore wind alone. For comparison, when the “low” scenario of 5% wake loss is considered, 106.4% of total U.S. demand is fulfilled, whereas when the “high” scenario of 20% is applied, this amount is 89.6% (see Figure S2.2 for more details).

Output energy density is a measure of how much energy can be produced per unit of available offshore area. This value is fairly consistent, varying from 0.017-0.047 TWh/km^2 in a 10% wake loss scenario, depending largely on the quality of the wind resource in each region. This remains true with different wind speed thresholds. For instance, with a 6 m/s wind speed threshold at 150 m ASL, the output energy density ranges from 0.018 to 0.037 TWh/km^2. On the other extreme, with a 12 m/s wind speed threshold at 150 m ASL, the energy density ranges from 0.0459 to 0.0463 TWh/km^2.

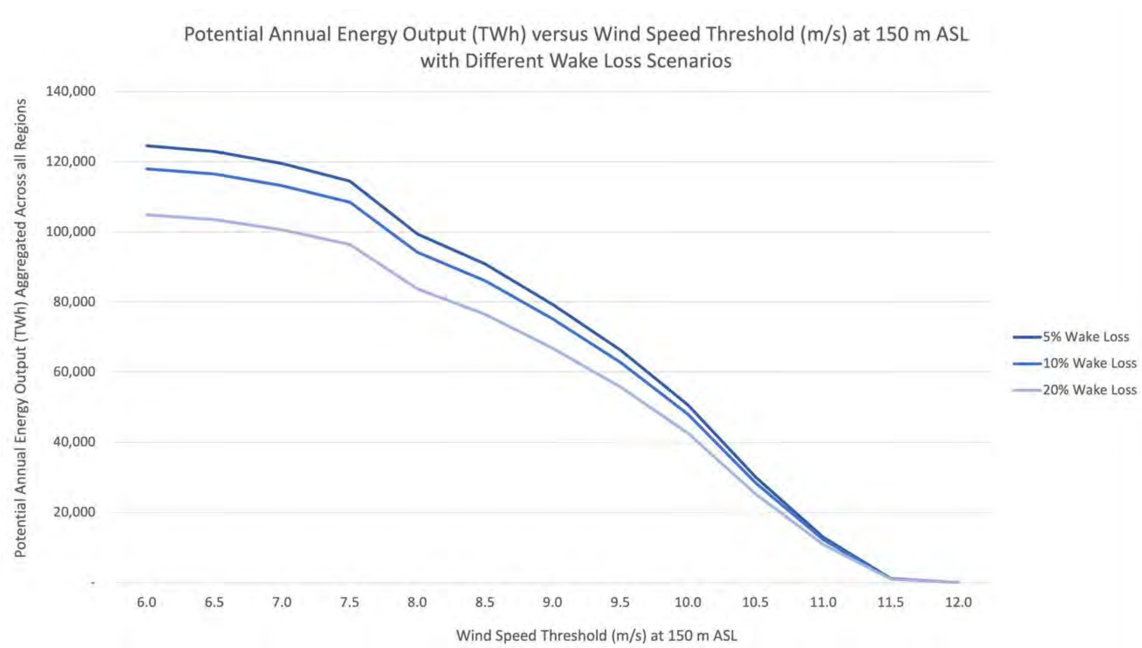

Figure S2.2: Potential Annual Energy Output (TWh) versus Wind Speed Threshold (m/s). Graph shows how cumulative energy output at 150 m ASL varies with wind speed thresholds for different wake loss scenarios (dark blue: 5%, medium blue: 10%, light blue: 20%). Not shown is no wake loss scenario. See Tables S11-12 for all hub height and wake loss combinations.

The aggregated potential annual energy output is highest when the lowest wake loss (5%) is assumed (124,551.33 TWh), and decreases with higher losses for each respective wind speed threshold. However, as the wind speed threshold increases, the estimated energy output values steadily converge, until they finally meet at 11.5 m/s, around 1,000 TWh. As previously seen, the overall output decreases due to increasingly restricted areas for wind development.

3. Cost Heatmap Analysis

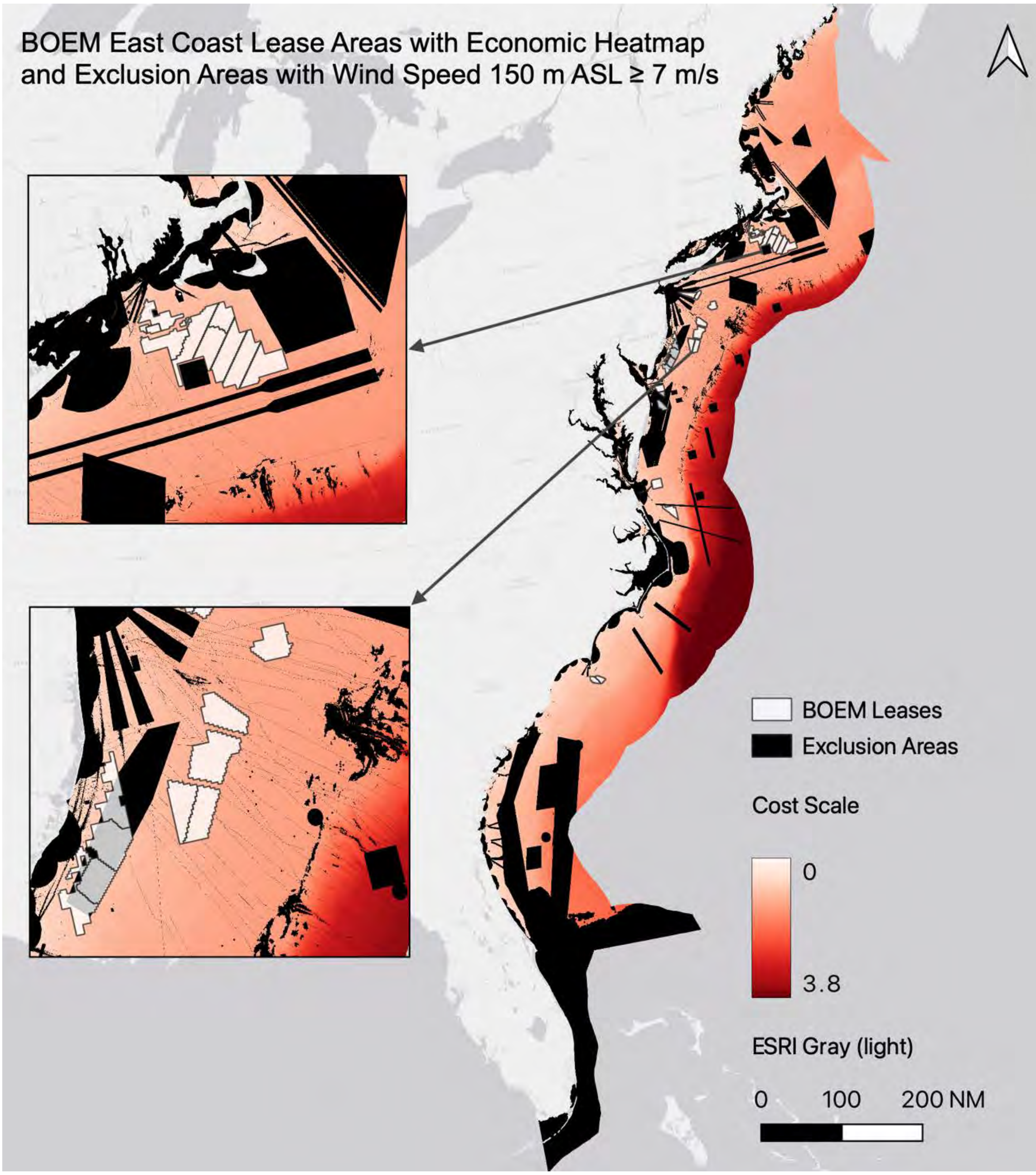

Figure 3.1: BOEM East Coast Lease Areas with Economic Heatmap and Exclusion Areas. Boundaries of offshore wind energy lease areas (top: Mayflower Wind Energy LLC, Beacon Wind, Vineyard Wind 1, Revolution Wind LLC, National Grid, South Fork Wind LLC, Sunrise Wind, Bay State Wind, New England Wind, Vineyard Northeast LLC, and bottom: Empire Offshore Wind, Attentive Energy LLC, Atlantic Shores Offshore Wind Bight LLC, OW Ocean Winds East LLC, Mid-

Atlantic Offshore Wind LLC, Community Offshore Wind LLC, Invenergy Wind Offshore LLC, Atlantic Shores North, Atlantic Shores South, Ocean Wind, Orsted North America, GSOE I Garden State, Skipjack, and US Wind), [106] shown in white. East Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project with a value of 1 (fixed-bottom 2018 baseline LCOE: $83/MWh, 2030 target LCOE: $51/MWh [66]). Cost accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Section S5 for details and Figures S8.1-S8.30 for continuous and discrete economic heatmaps of all regions.

Figure S3.1 shows that costs for the East Coast are close to typical compared to a reference project that represents current siting conditions, with most regions either just above or below the reference cost, which is given a value of 1. Only areas far from shore, shown in darker red, have significantly higher costs. Upon closer examination, the Northern East Coast and Mid-Atlantic Coast have the highest frequency around 1.3-1.4, with the vast majority of pixels falling under this value, while North Carolina has a bimodal distribution with values clustered around 0.8 and 3.3-4.1, which is reflected in the darker red regions. Similarly, the Southern East Coast displays a bimodal distribution, with most pixels falling around the reference case, and another group around the value 1.9 (although these are mostly excluded due to wind speeds below the threshold). All of the areas selected by BOEM for leasing are under the value 2.2, which is the threshold for higher costs, computed using a maximum water depth of 1,000 m and interconnection and port transit distance of 200 km, which are commonly applied.

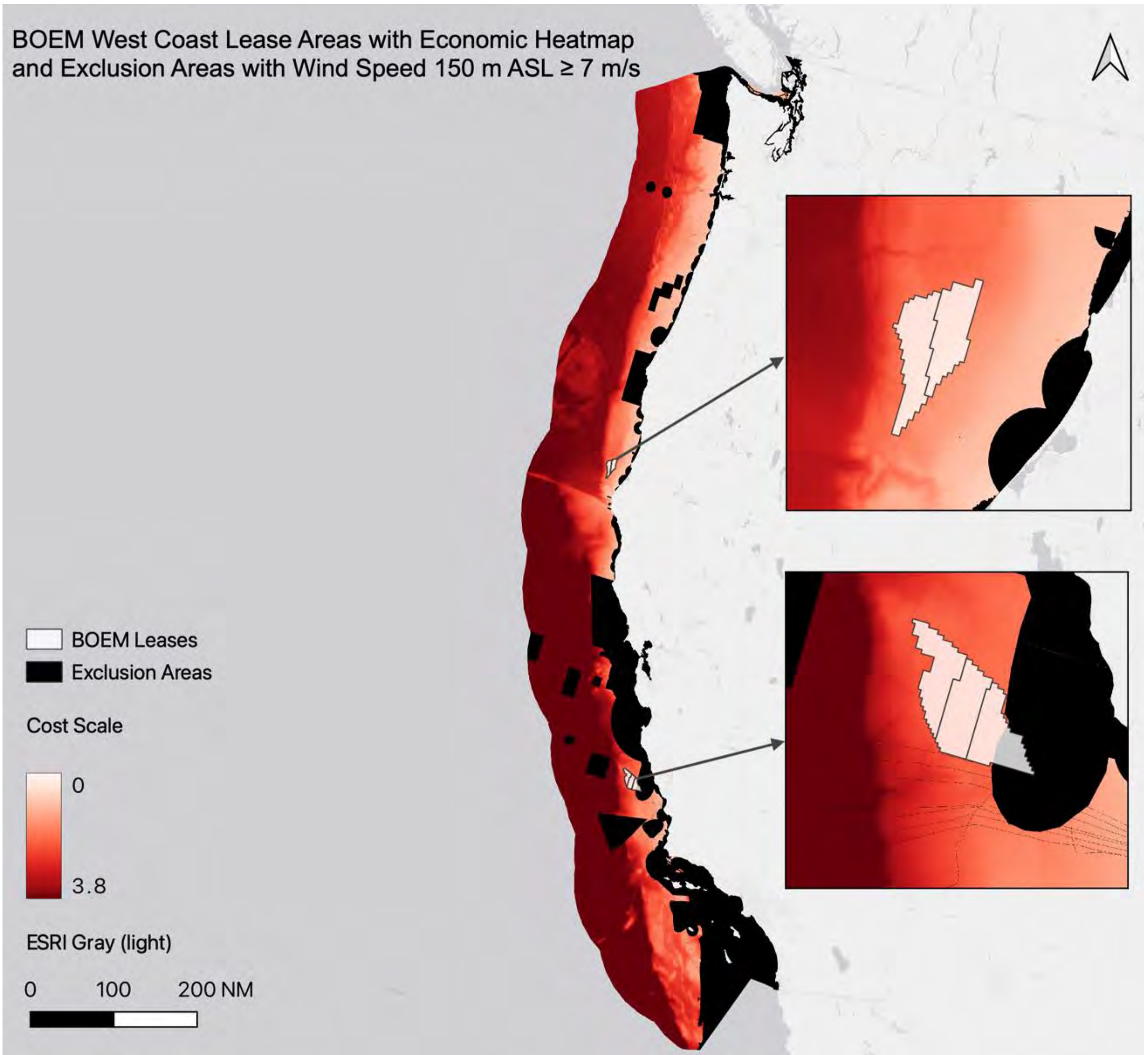

Figure S3.2: BOEM West Coast Lease Areas with Economic Heatmap and Exclusion Areas. Boundaries of offshore wind energy lease areas (top: Humboldt and bottom: Morro Bay) [106] shown in white. West Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project with a value of 1 (fixed-bottom 2018 baseline LCOE: $83/MWh, 2030 target LCOE: $51/MWh [66]). Cost accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Section S5 for details and Figures S8.1-S8.30 for continuous and discrete economic heatmaps of all regions.

Figure S3.2 shows that the West Coast has substantially higher costs than the East Coast, which is consistent with the finding that cost is most strongly affected by water depth. Off the coast of Washington state, cost values are heavily skewed above 2.5, with most in the range between 3-3.5, which is very high compared with the reference cost. The Oregon Coast displays a more tightly clustered distribution, with nearly all pixels centered around 3.4. Cost values off the Northern California Coast are more varied, ranging from 3.8-4.2, with a much higher percentage of pixels exceeding the 3.8 cost value threshold that signifies "cost prohibitive" zones, using contemporary measures and technology. Indeed, the Humboldt lease area in this region is located in one of the few light-colored areas, where values range from approximately 1.5-1.8. There appears to be an unusually limited amount of area in lower cost zones not excluded by restrictions in this region, even compared to Southern California, which has a much higher proportion of pixels below 3.8. In fact, Southern California displays a bimodal distribution, with a peak around 2, and another cluster of values between 4-4.9, as seen on the map with the sharp gradient between lighter and darker areas. Again, the Morro Bay lease area is found in a relatively lower cost region, where cost values range from 1.8-2.1.

Supplemental Figures

4. Available Area

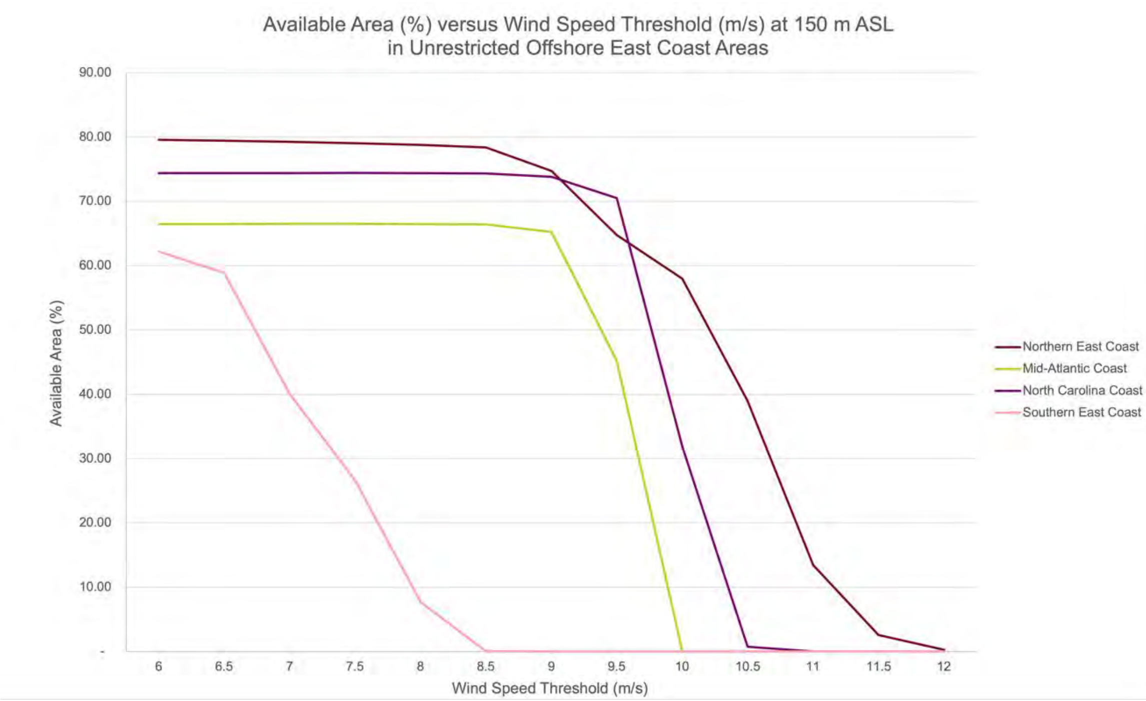

Figure S4.1: Available area (%) for each wind speed threshold (m/s) at 150 m ASL in each East Coast region (Northern East Coast, Mid-Atlantic Coast, North Carolina Coast, and Southern East Coast), after taking into account all restrictions in Table S1.

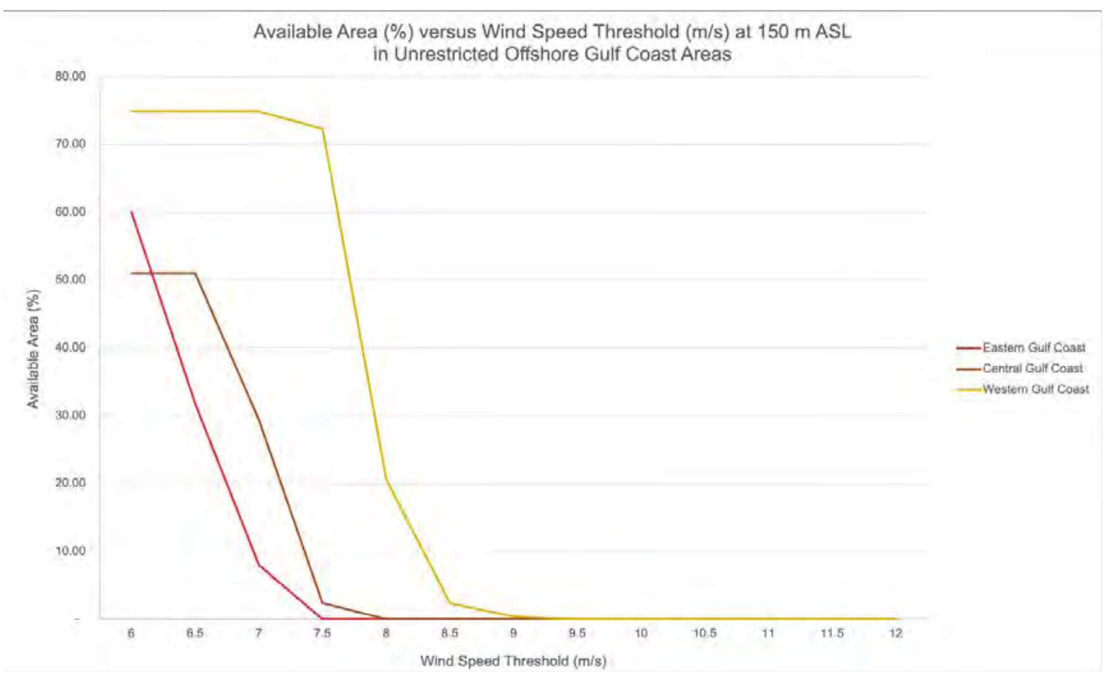

Figure S4.2: Available area (%) for each wind speed threshold (m/s) at 150 m ASL in each Gulf Coast region (Eastern Gulf Coast, Central Gulf Coast, and Western Gulf Coast), after taking into account all restrictions in Table S1.

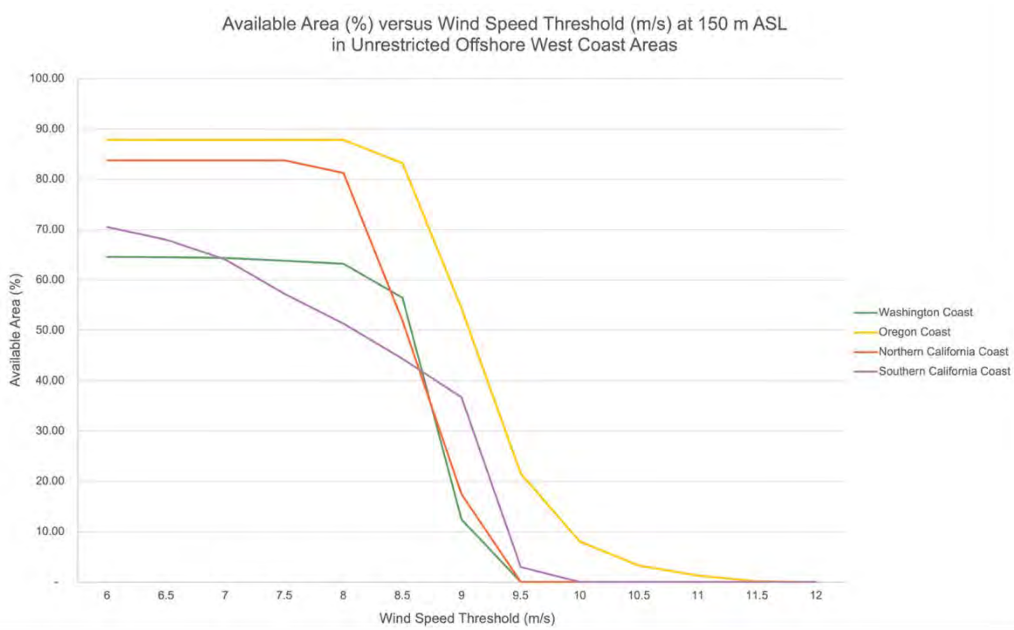

Figure S4.3: Available area (%) for each wind speed threshold (m/s) at 150 m ASL in each West Coast region (Washington Coast, Oregon Coast, Northern California Coast, and Southern California Coast), after taking into account all restrictions in Table S1.

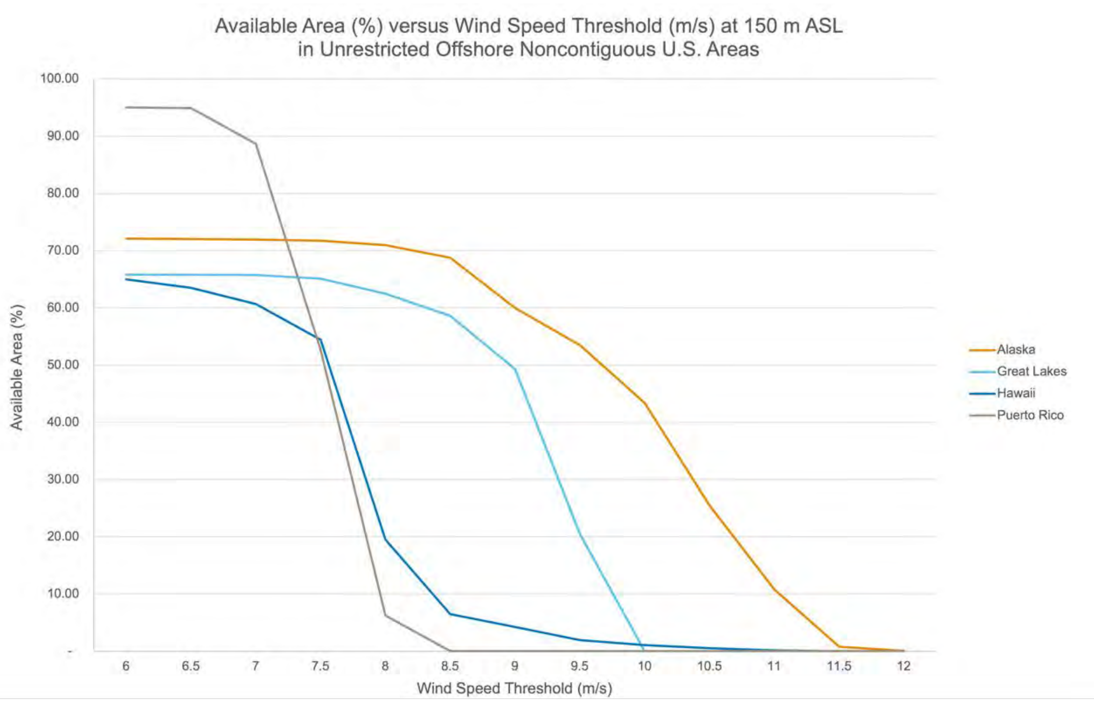

Figure S4.4: Available area (%) for each wind speed threshold (m/s) at 150 m ASL in each noncontiguous U.S. region (Alaska, Great Lakes, Hawaii, and Puerto Rico), after taking into account all restrictions in Table S1.

5. Mean Wind Speed

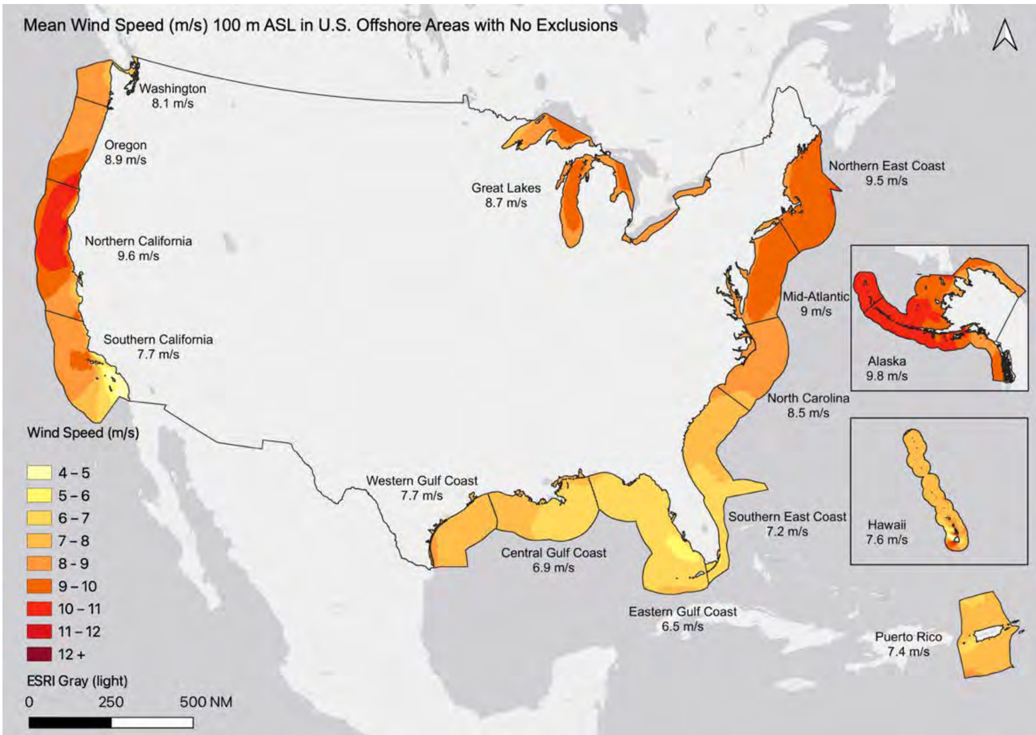

Figure S5.1: Mean wind speed (m/s) 100 m ASL in each region with no exclusions or wind speed restrictions. The color scale represents wind speed values between 4-12 m/s.

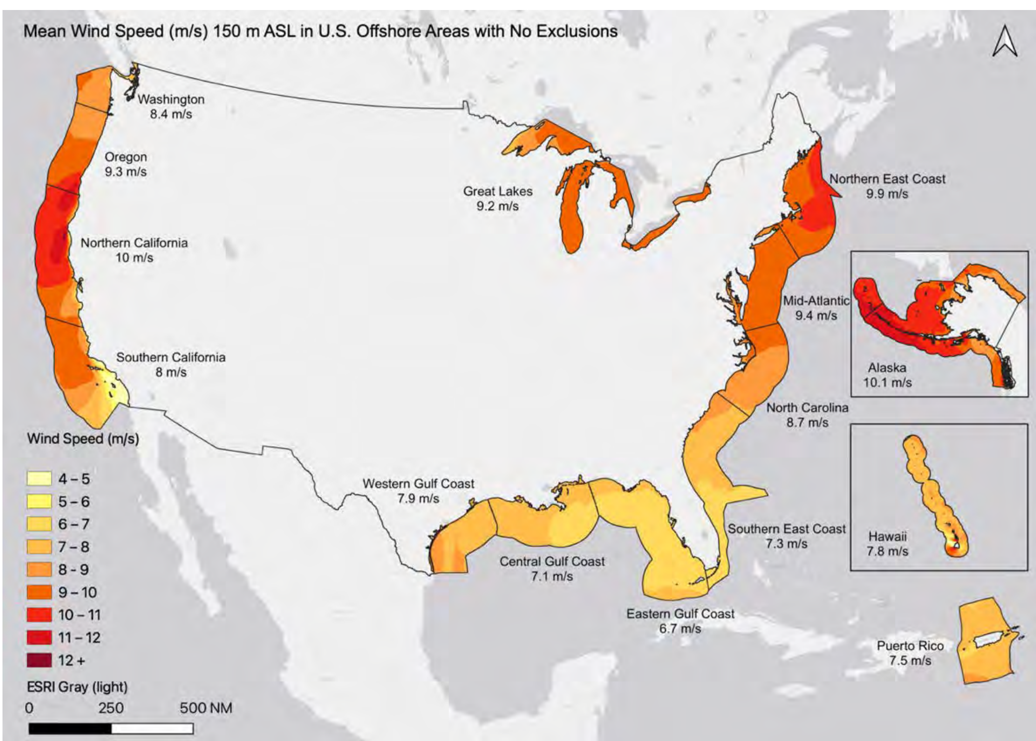

Figure S5.2: Mean wind speed (m/s) 150 m ASL in each region with no exclusions or wind speed restrictions. The color scale represents wind speed values between 4-12 m/s.

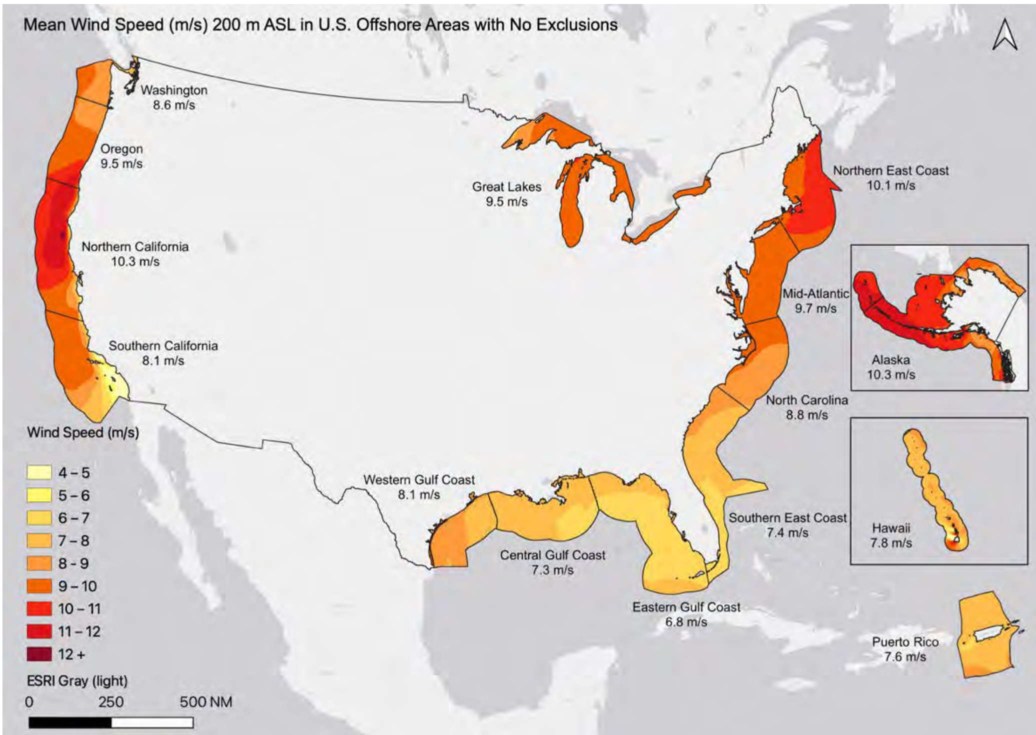

Figure S5.3: Mean wind speed (m/s) 200 m ASL in each region with no exclusions or wind speed restrictions. The color scale represents wind speed values between 4-12 m/s.

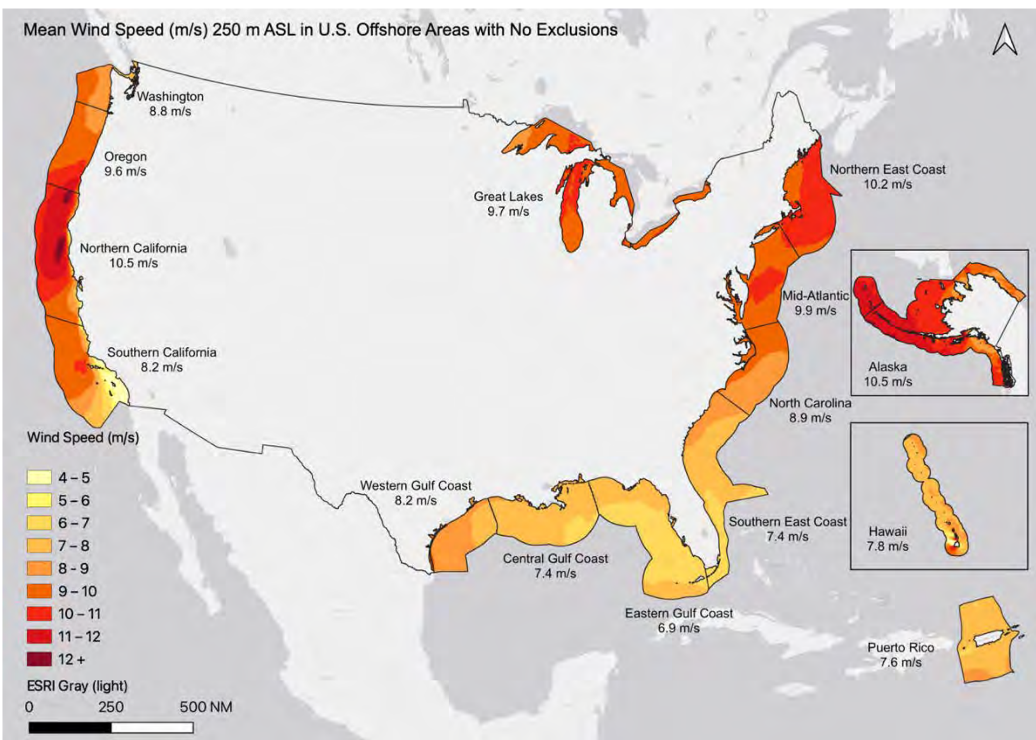

Figure S5.4: Mean wind speed (m/s) 250 m ASL in each region with no exclusions or wind speed restrictions. The color scale represents wind speed values between 4-12 m/s.

6. Atmospheric Stability

Figure S6.1: East Coast Stability Restriction (green) after accounting for all restrictions plus 150 m ASL ≥ 7 m/s wind speed threshold (see Table S1 for details about each restriction layer). 299,008 km^2 (52.4%) of total East Coast area would be available for wind turbine development using a 30% stability threshold. Across all regions, there is a 12.8% difference in available area when restricting stability < 30% versus not. The region accounting for the largest difference is the Northern East Coast (152.46% increase in available area without stability) because stability blocks otherwise available space.

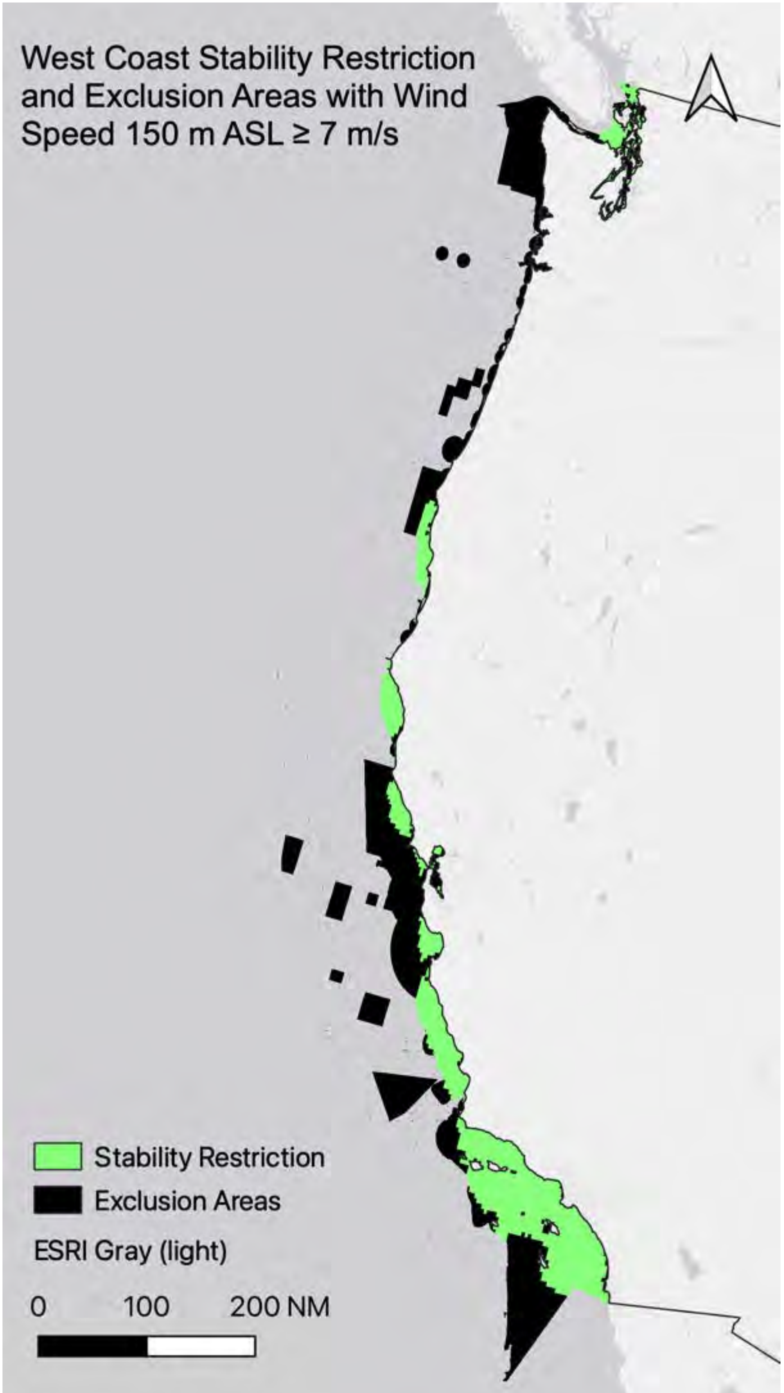

Figure S6.2: West Coast Stability Restriction (green) after accounting for all restrictions plus 150 m ASL ≥ 7 m/s wind speed threshold (see Table S1 for details about each restriction layer). 339,791 km^2 (72.8%) of total West Coast area would be available for wind turbine development using a 30% stability threshold. Off the coast of Southern California, stability accounts for much of the excluded area, but other restrictions layered underneath already excluded the area, so the percent difference between the two scenarios is not great (2.8% difference between stability restricted versus not).

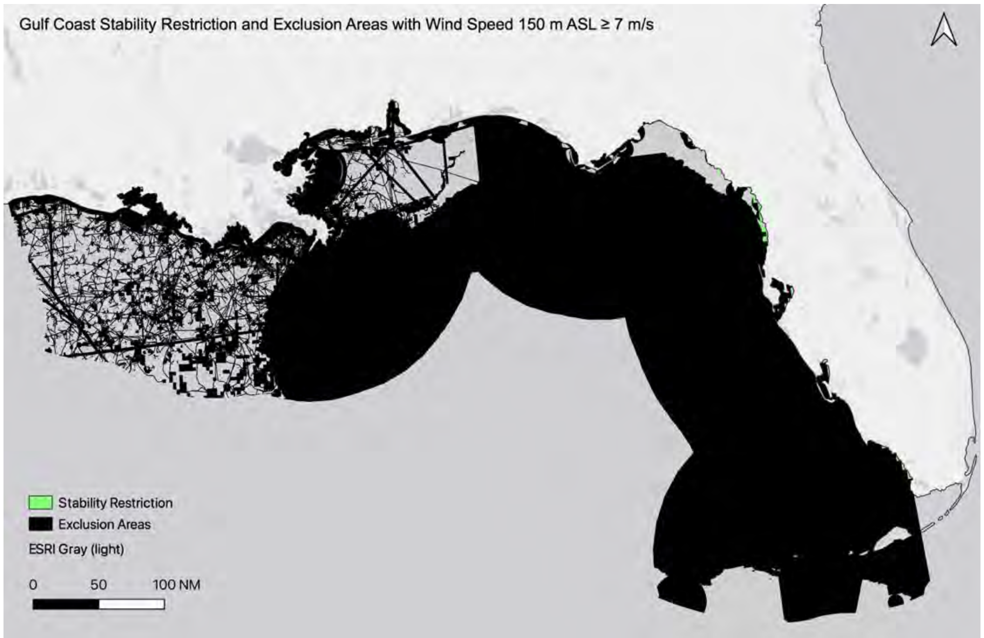

Figure S6.3: Gulf Coast Stability Restriction (green) after accounting for all restrictions plus 150 m ASL ≥ 7 m/s wind speed threshold (see Table S1 for details about each restriction layer). 137,675 km^2 (28.6%) of total Gulf Coast area would be available for wind turbine development using a 30% stability threshold. There is a 0.09% difference in available area when restricting stability versus not.

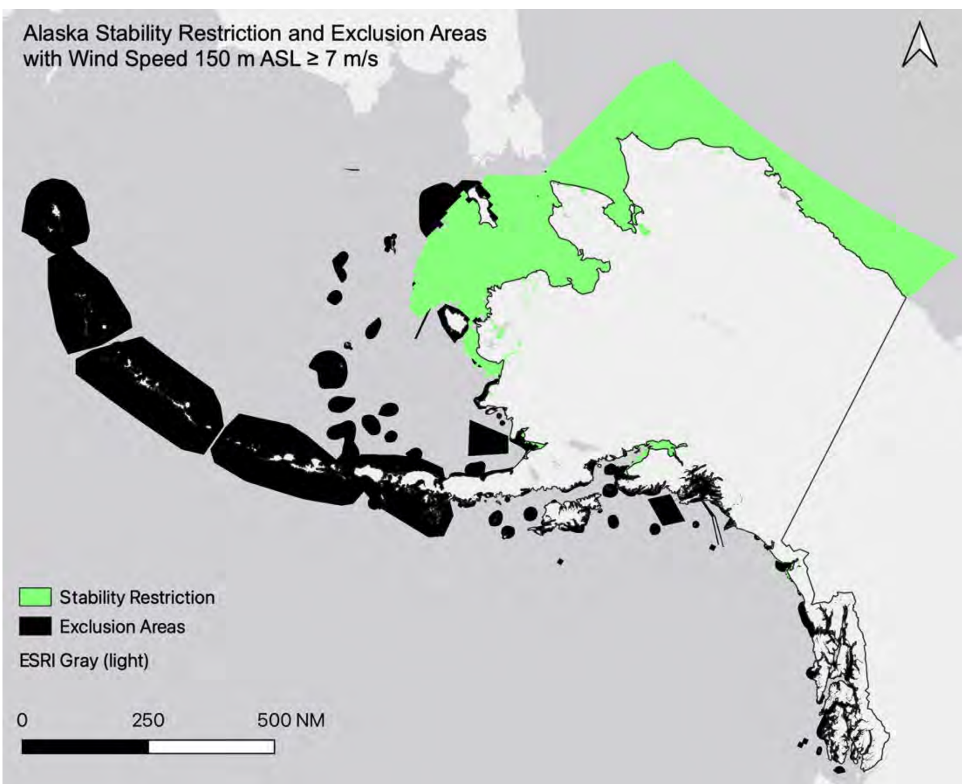

Figure S6.4: Alaska Stability Restriction (green) after accounting for all restrictions plus 150 m ASL ≥ 7 m/s wind speed threshold (see Table S1 for details about each restriction layer). 1,398,720 km^2 (56.4%) of total Alaska area would be available for wind turbine development using a 30% stability threshold. There is a 27.6% difference in available area when restricting stability versus not.

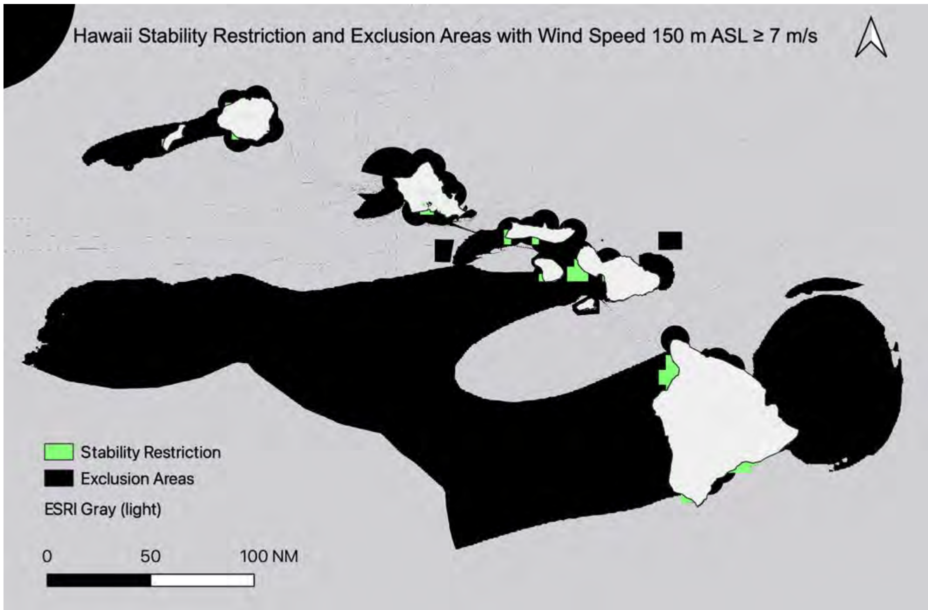

Figure S6.5: Hawaii Stability Restriction (green) after accounting for all restrictions plus 150 m ASL ≥ 7 m/s wind speed threshold (see Table S1 for details about each restriction layer). 718,462 km^2 (60.6%) of total Hawaii area would be available for wind turbine development using a 30% stability threshold. There is a 0.023% difference in available area when restricting stability versus not.

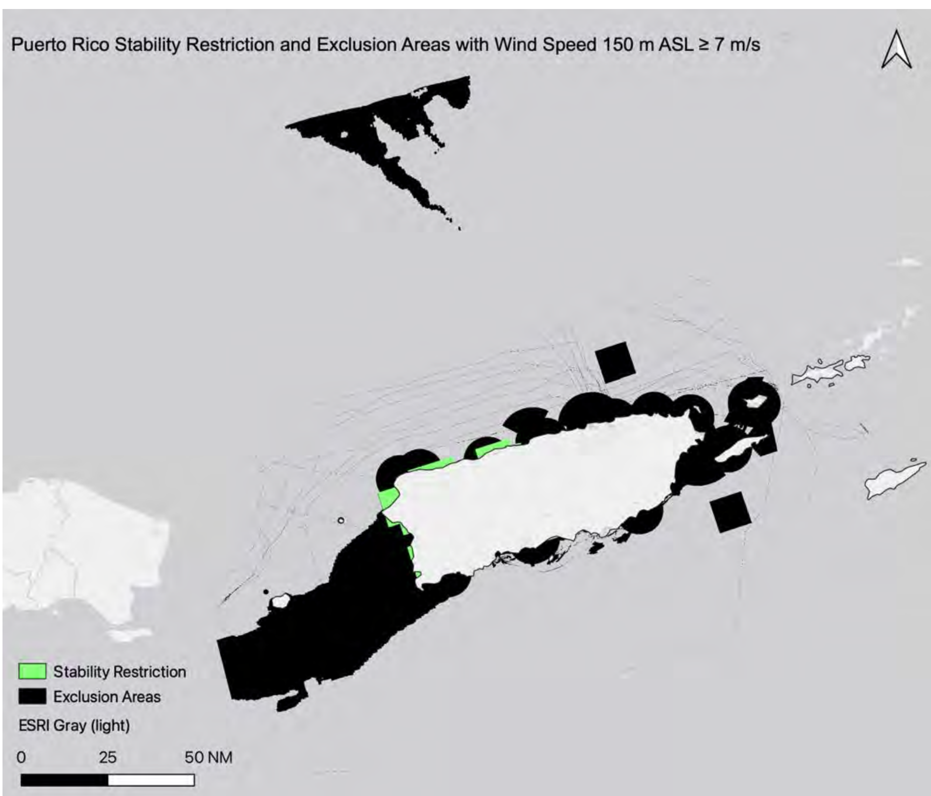

Figure S6.6: Puerto Rico Stability Restriction (green) after accounting for all restrictions plus 150 m ASL ≥ 7 m/s wind speed threshold (see Table S1 for details about each restriction layer). 104,102 km^2 (88.6%) of total Puerto Rico area would be available for wind turbine development using a 30% stability threshold. There is a 0.053% difference in available area when restricting stability versus not.

7. Turbine Foundation Type

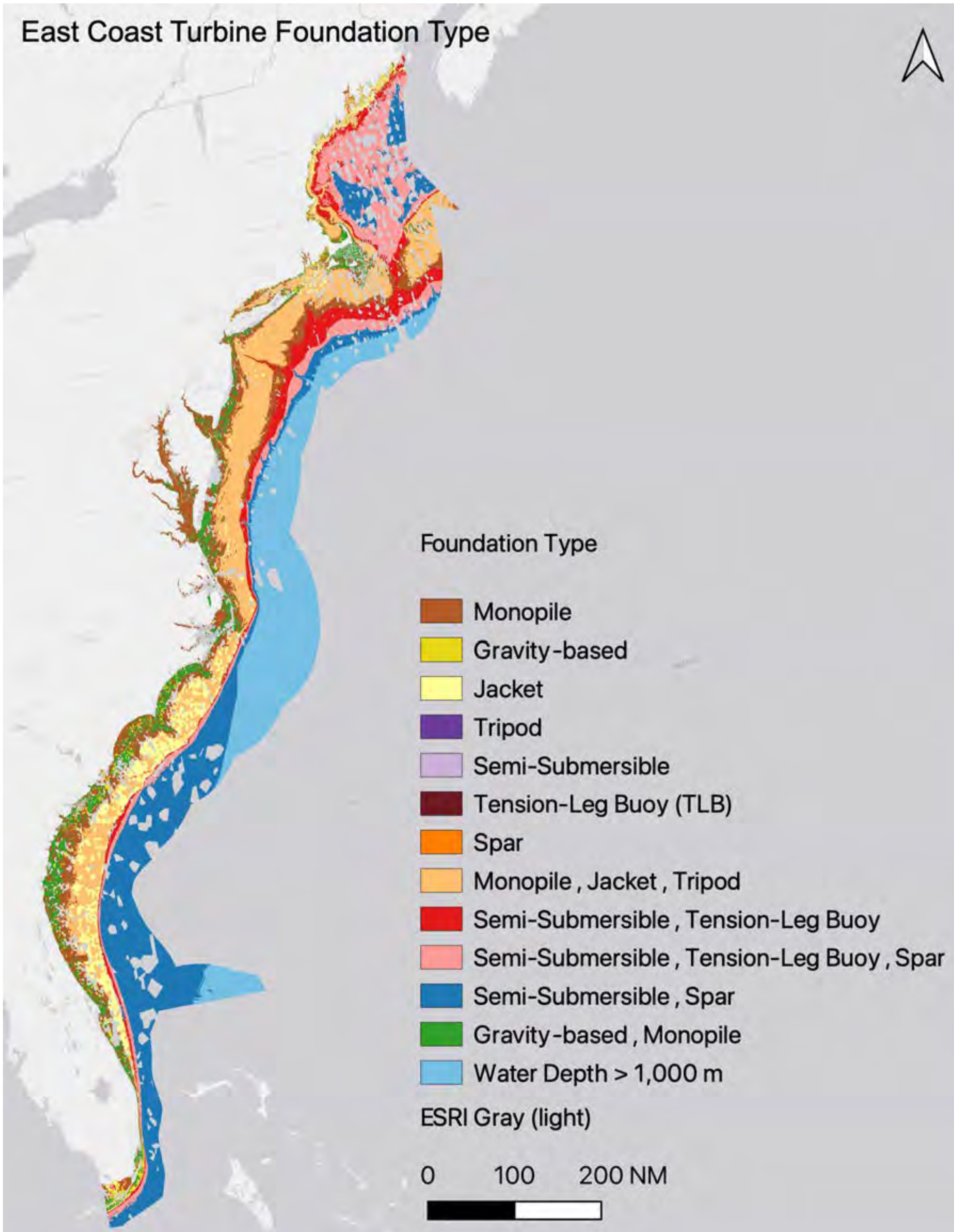

Figure S7.1: East Coast Turbine Foundation Type colored by appropriate turbine foundation(s), determined according to water depth and seabed composition.

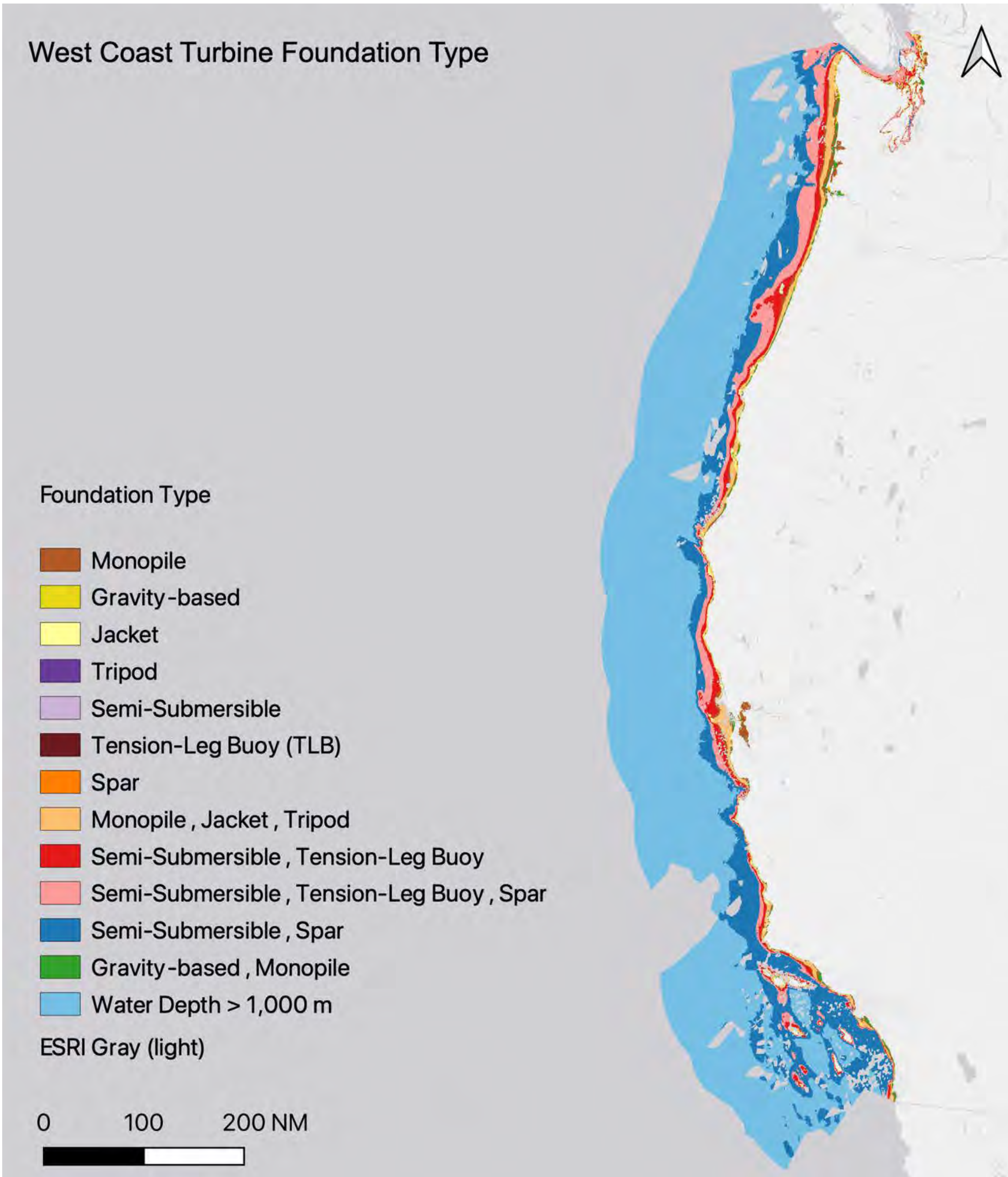

Figure S7.2: West Coast Turbine Foundation Type colored by appropriate turbine foundation(s), determined according to water depth and seabed composition.

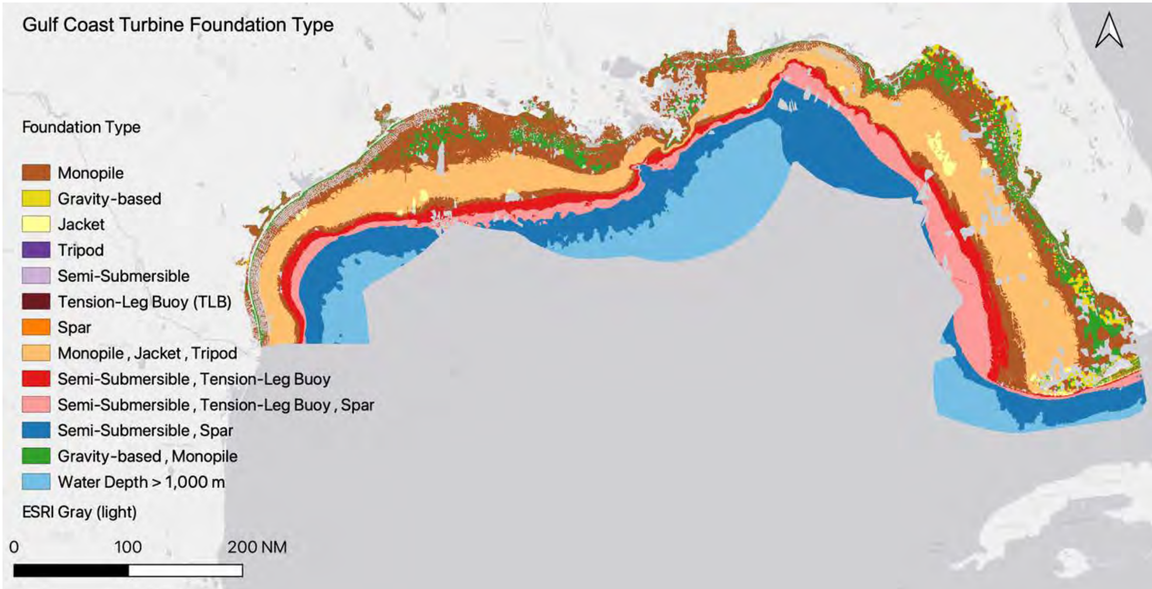

Figure S7.3: Gulf Coast Turbine Foundation Type colored by appropriate turbine foundation(s), determined according to water depth and seabed composition.

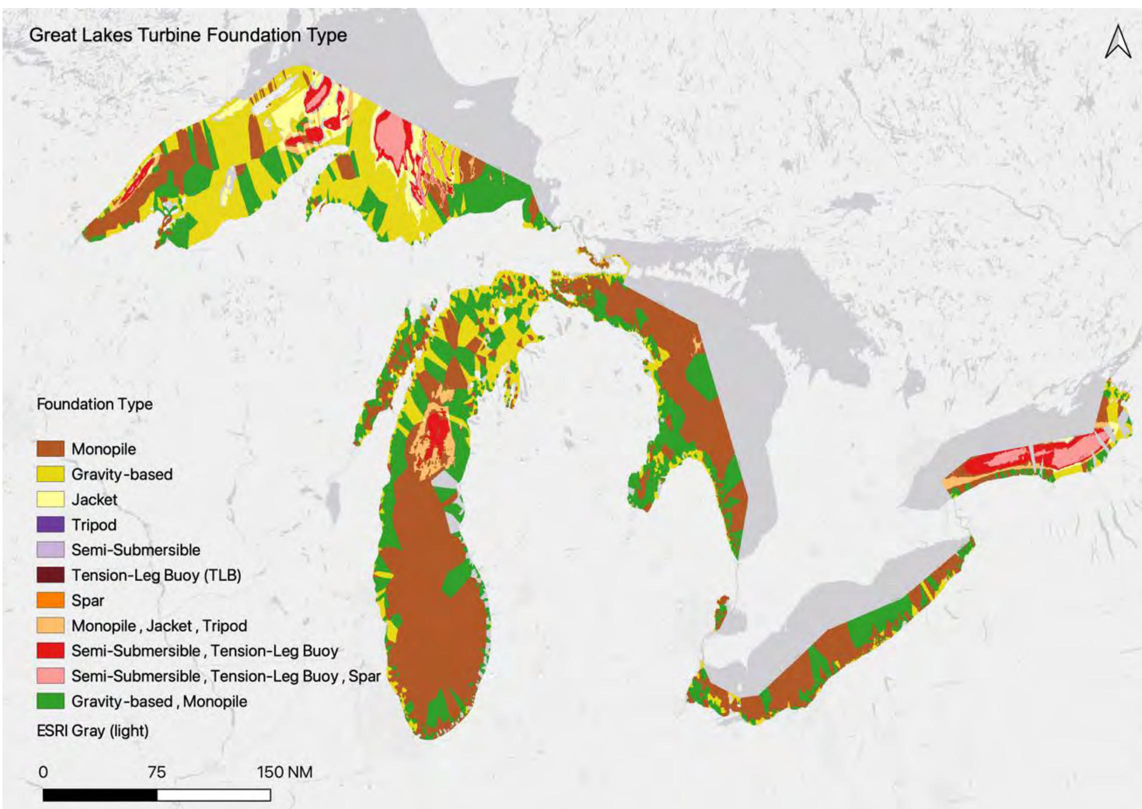

Figure S7.4: Great Lakes Turbine Foundation Type colored by appropriate turbine foundation(s), determined according to water depth and seabed composition.

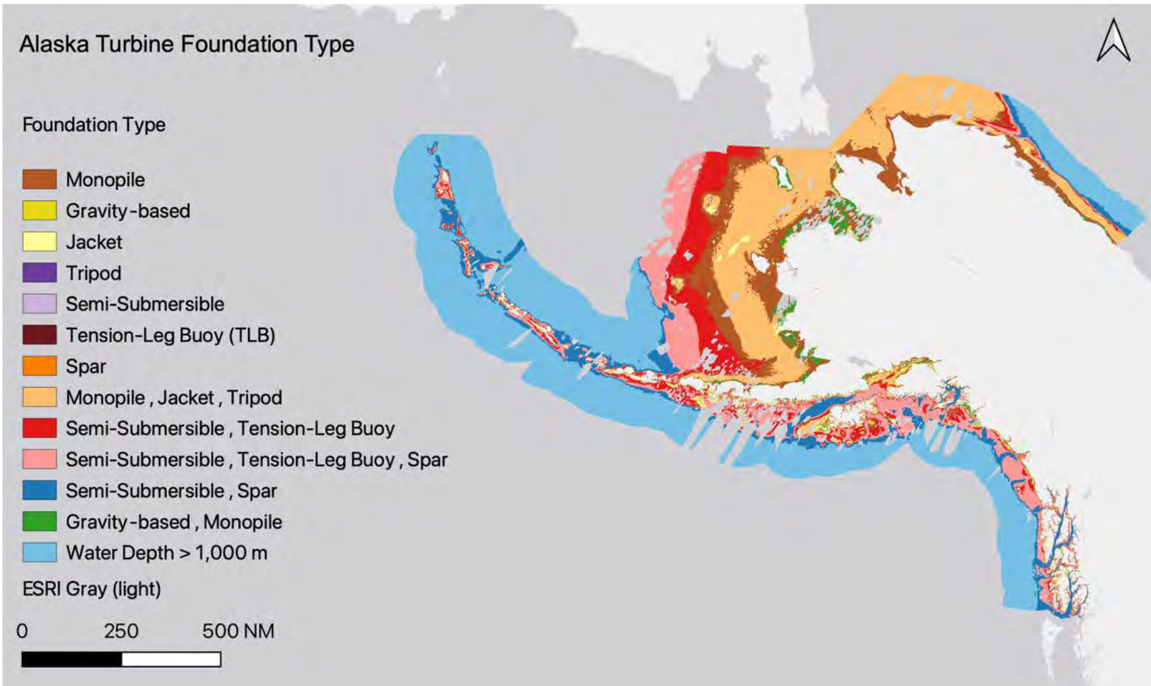

Figure S7.5: Alaska Turbine Foundation Type colored by appropriate turbine foundation(s), determined according to water depth and seabed composition.

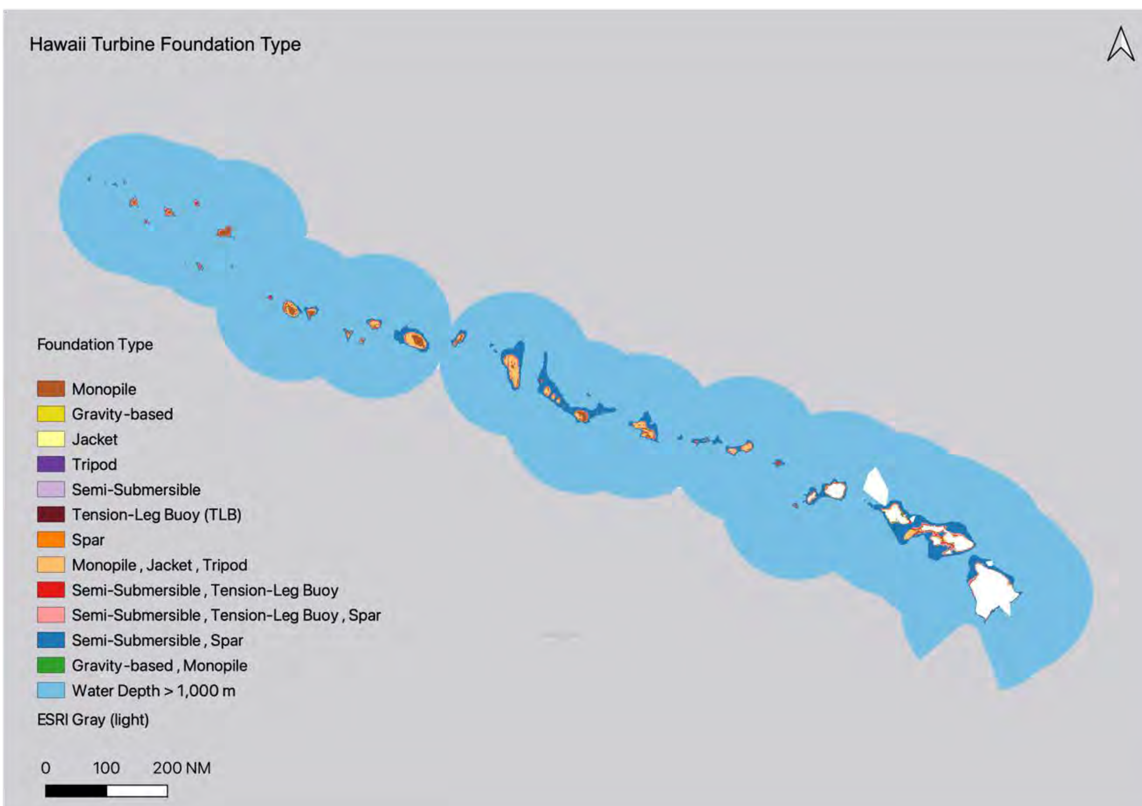

Figure S7.6: Hawaii Turbine Foundation Type colored by appropriate turbine foundation(s), determined according to water depth and seabed composition.

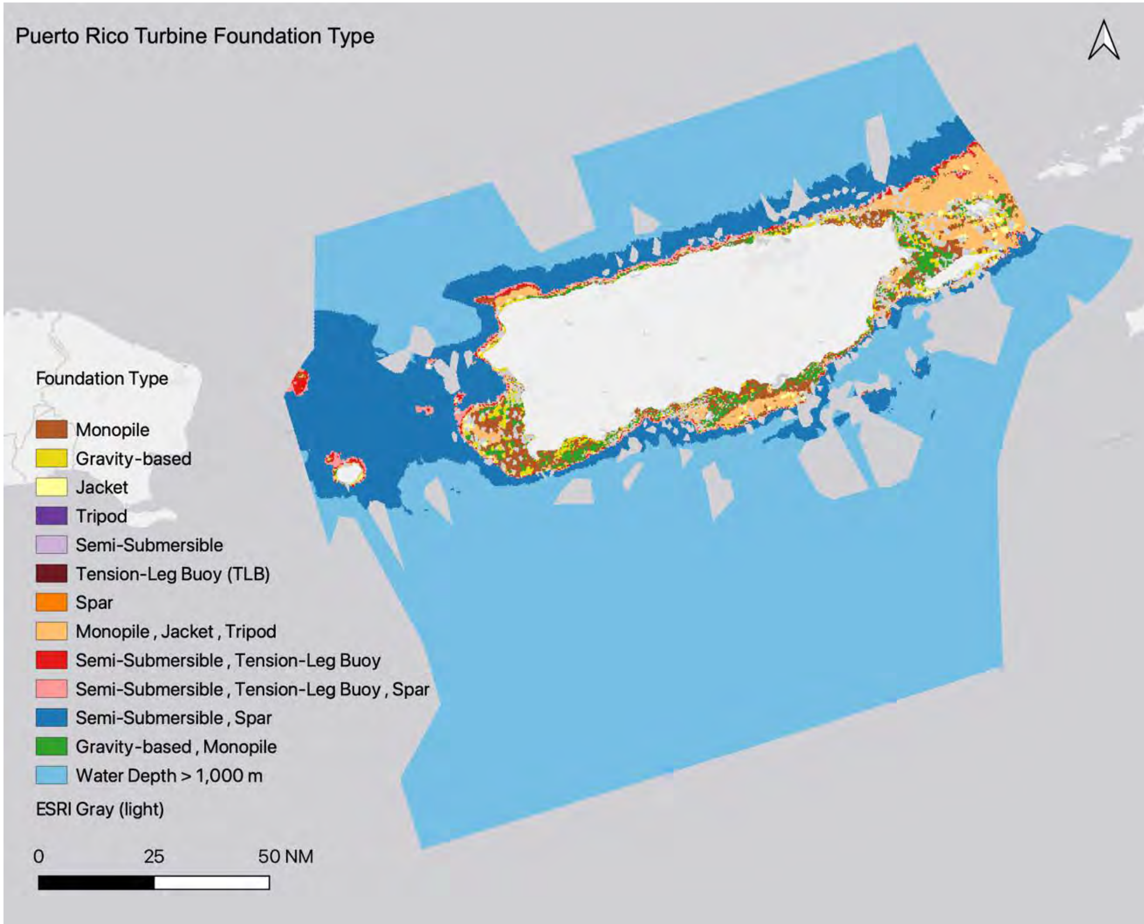

Figure S7.7: Puerto Rico Turbine Foundation Type colored by appropriate turbine foundation(s), determined according to water depth and seabed composition.

8. Economic Heatmaps

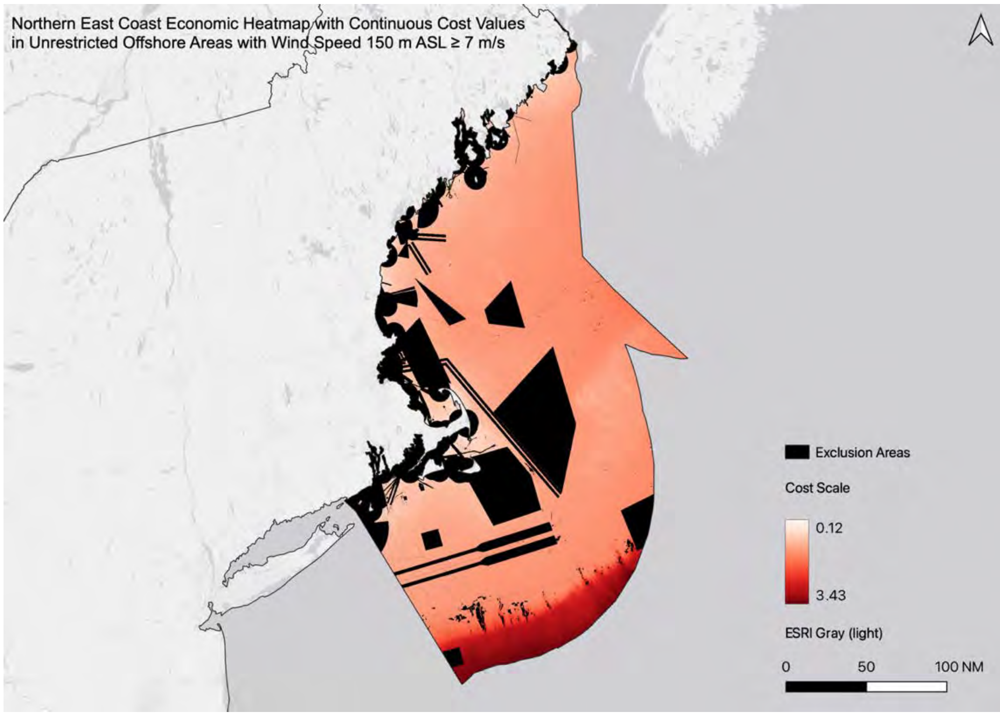

Figure S8.1: Northern East Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

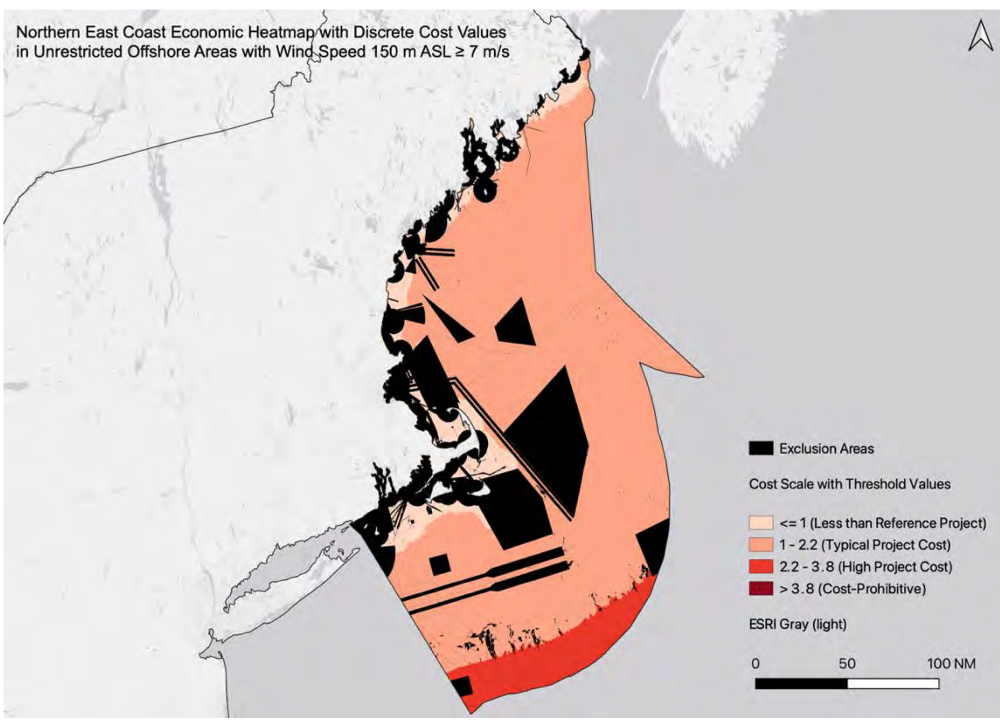

Figure S8.2: Northern East Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

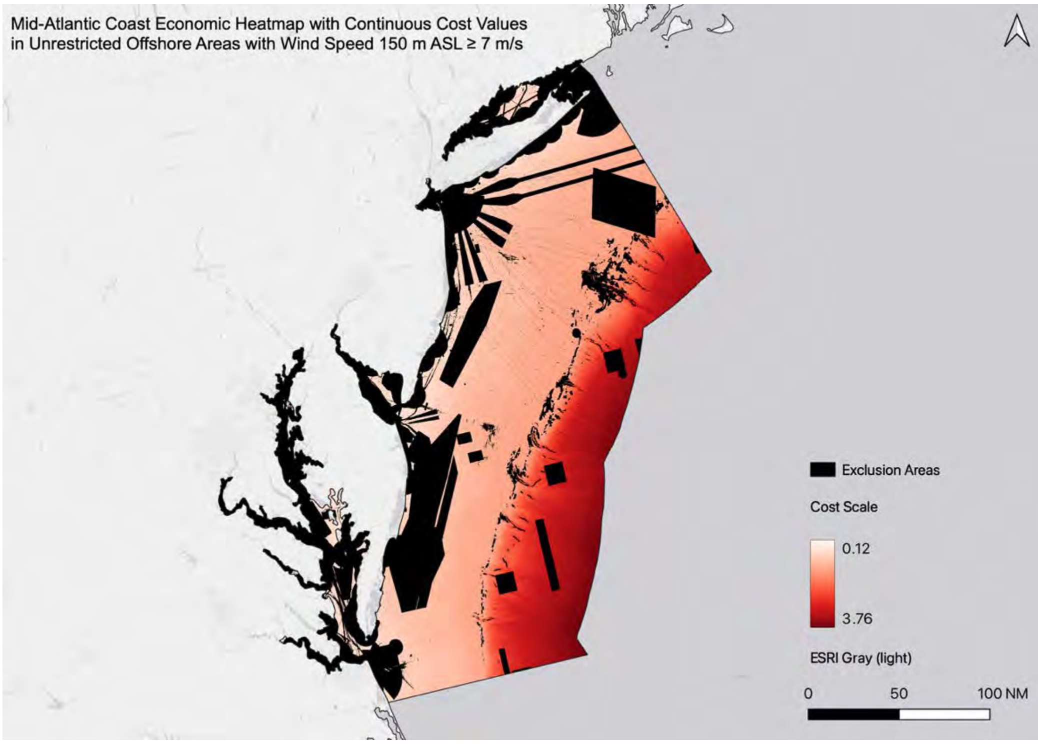

Figure S8.3: Mid-Atlantic Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

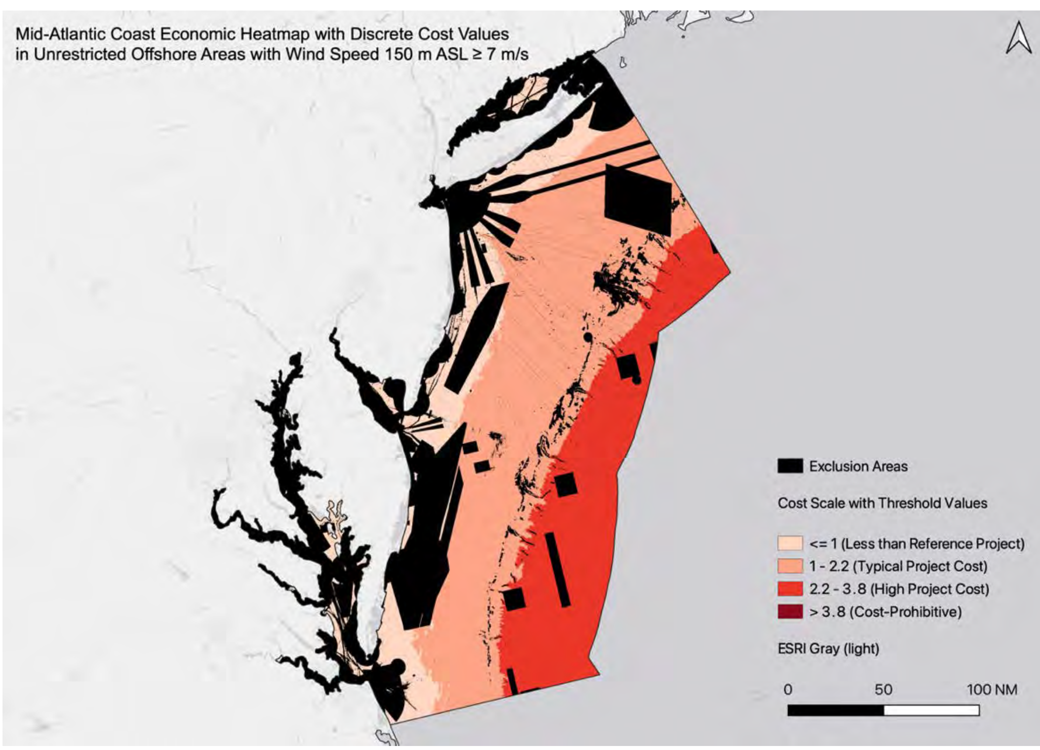

Figure S8.4: Mid-Atlantic Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

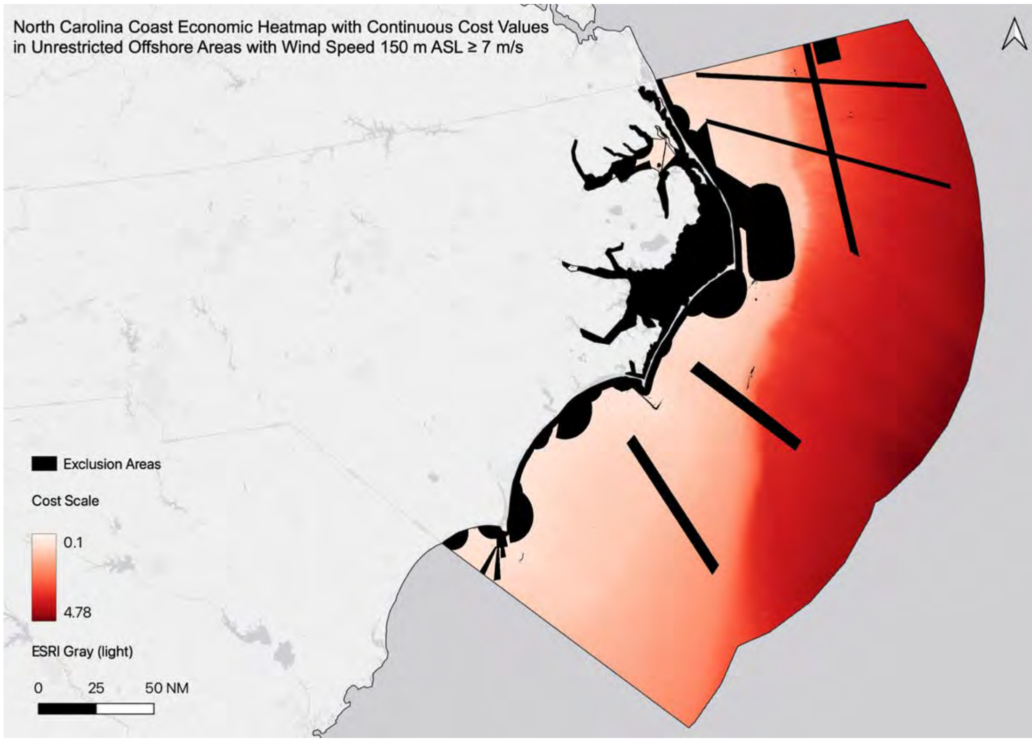

Figure S8.5: North Carolina Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

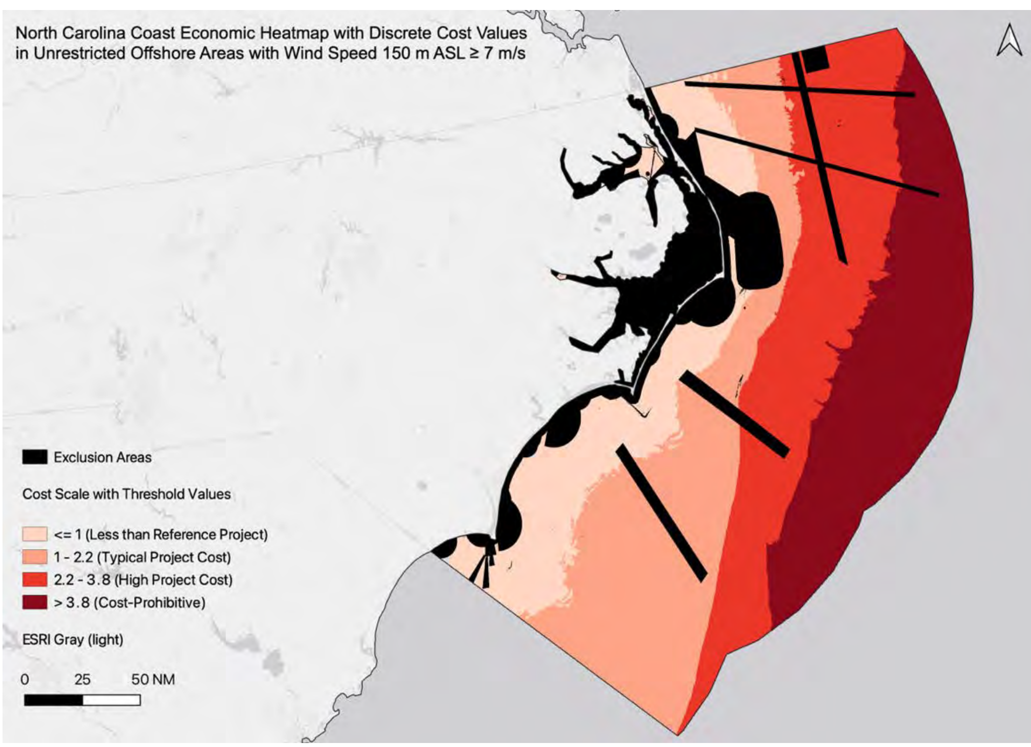

Figure S8.6: North Carolina Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

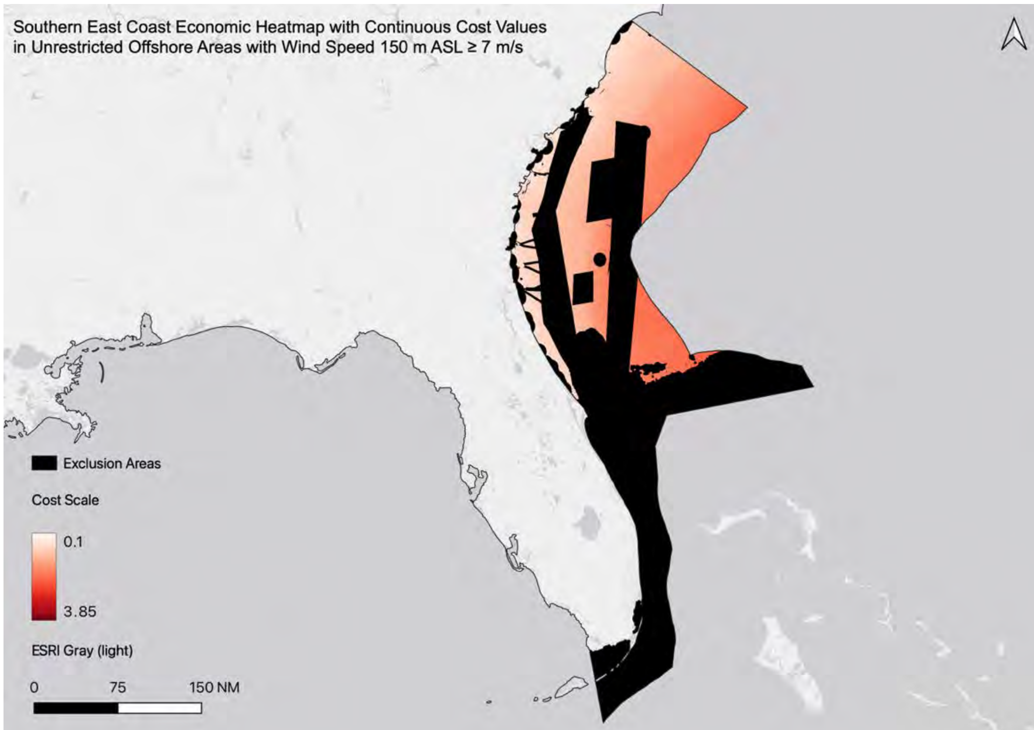

Figure S8.7: Southern East Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

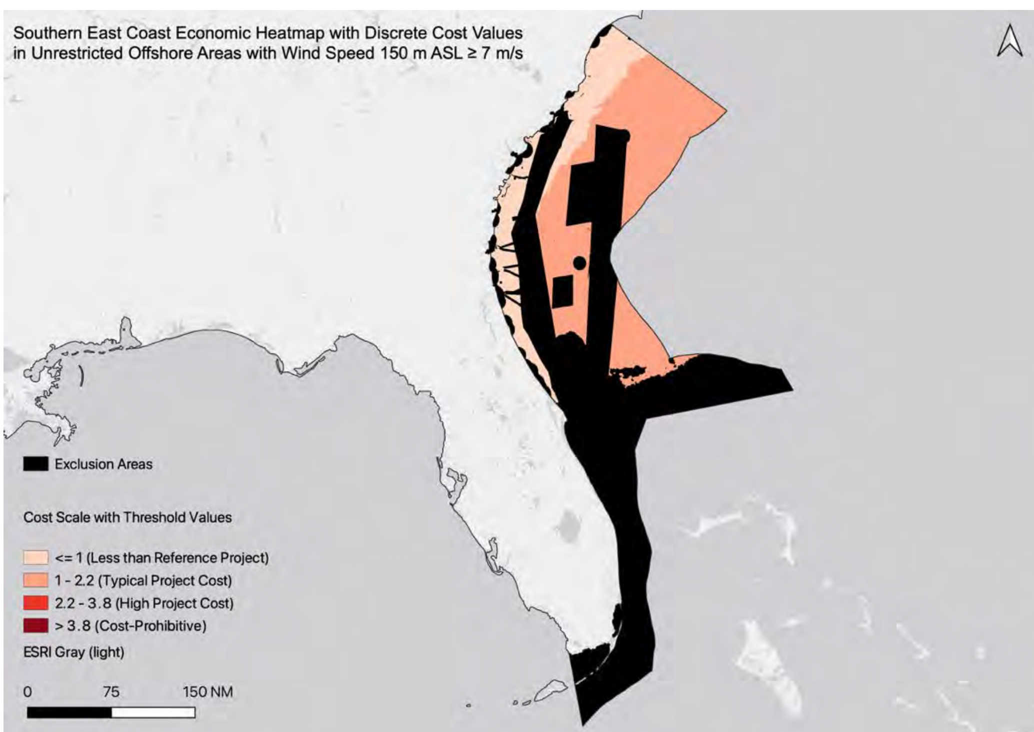

Figure S8.8: Southern East Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

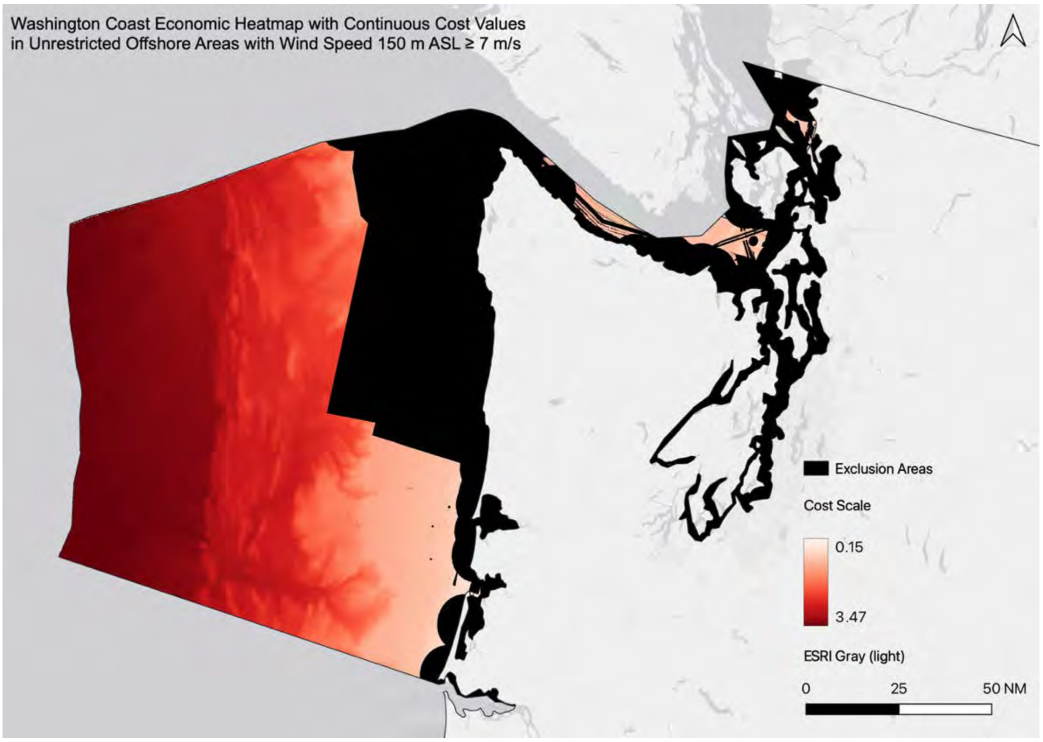

Figure S8.9: Washington Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

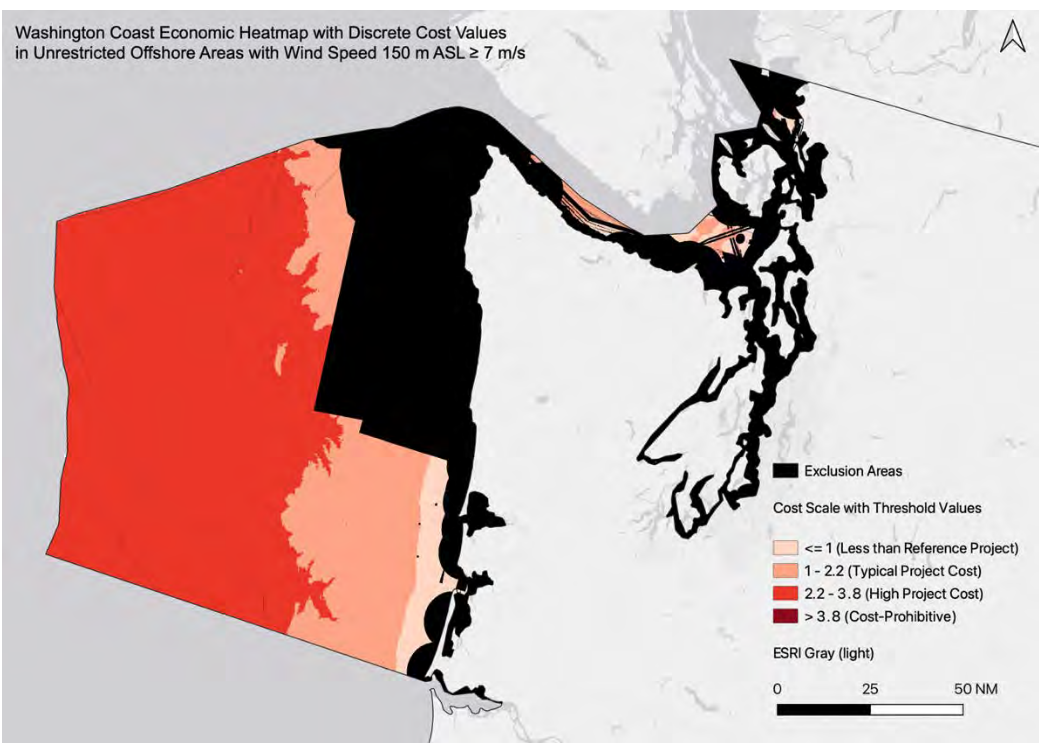

Figure S8.10: Washington Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

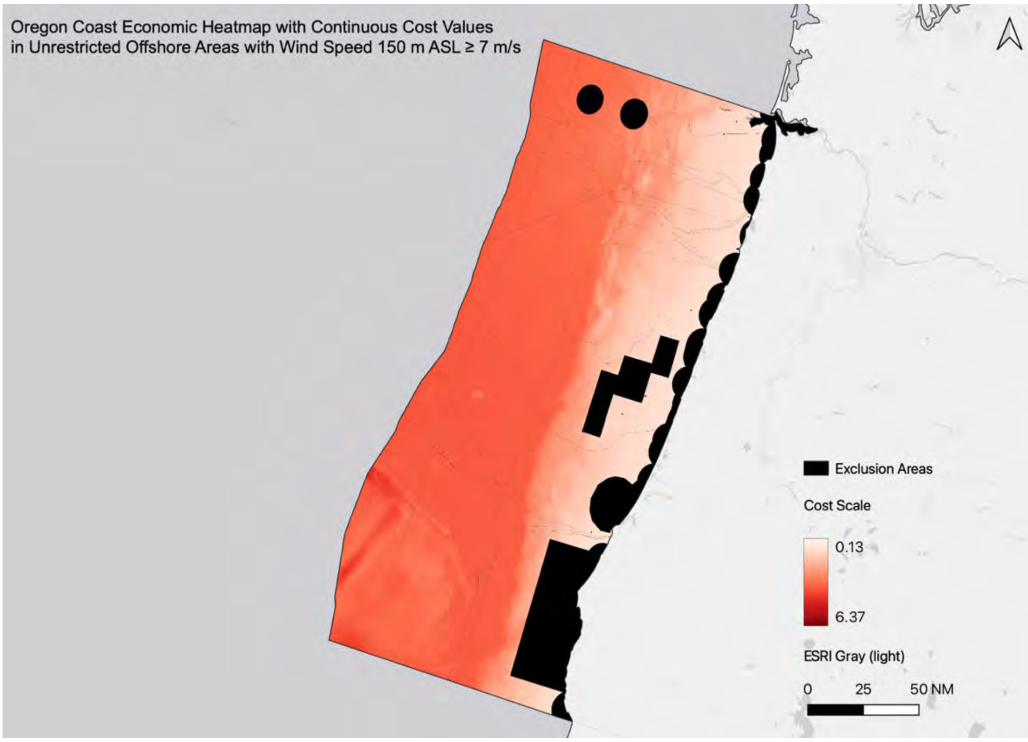

Figure S8.11: Oregon Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

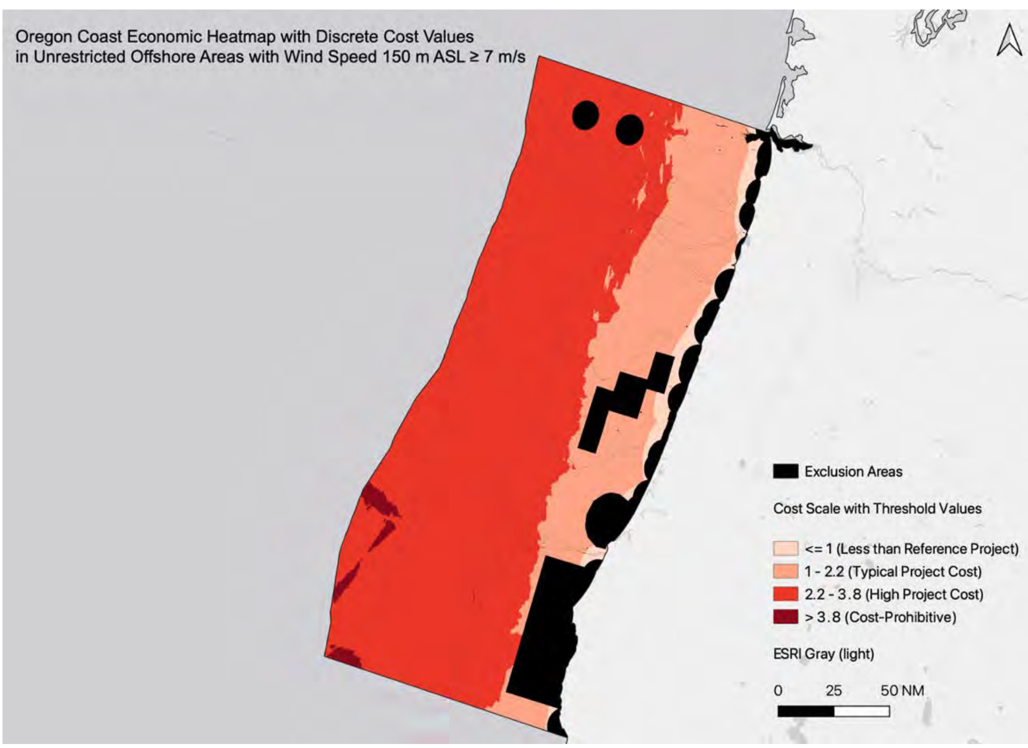

Figure S8.12: Oregon Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

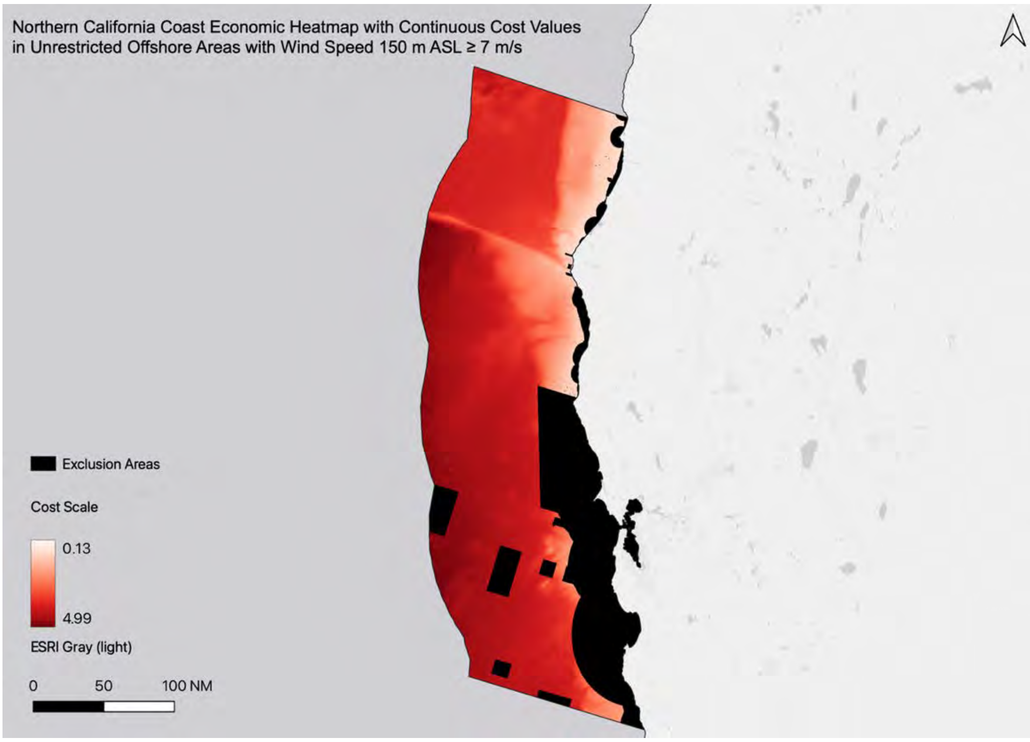

Figure S8.13: Northern California Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

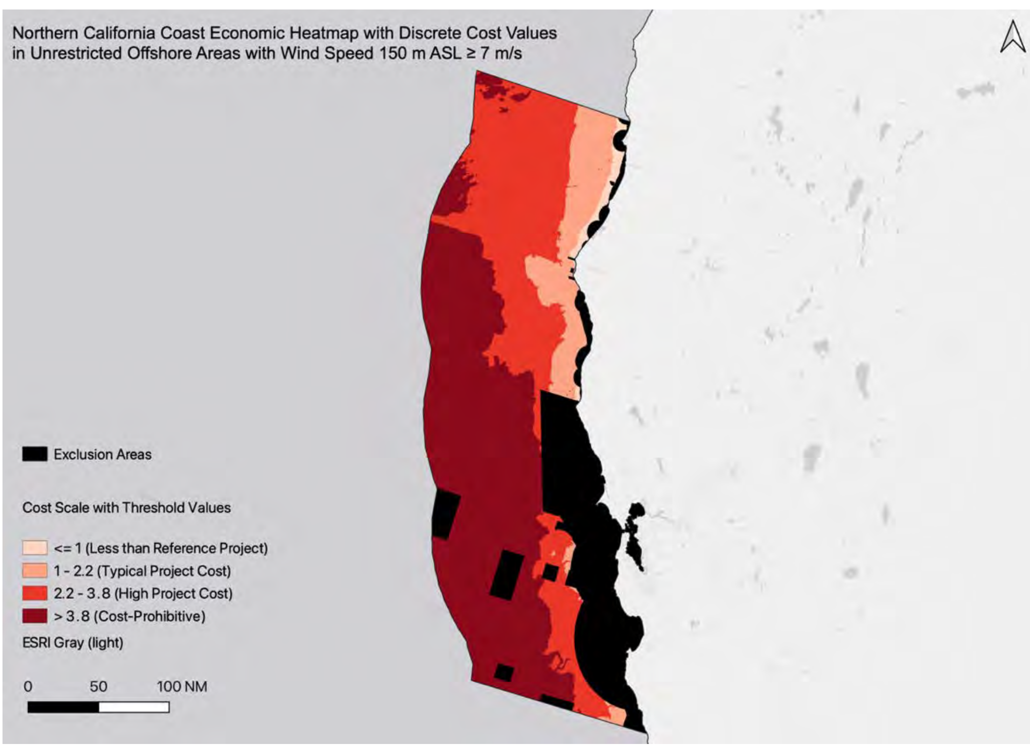

Figure S8.14: Northern California Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

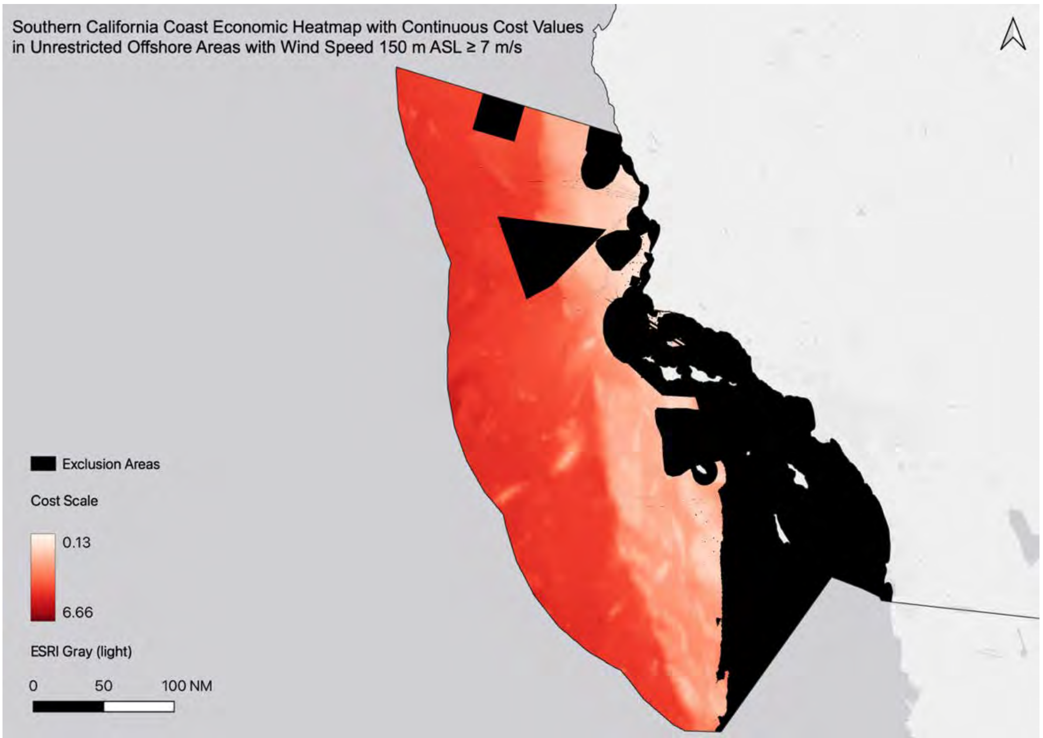

Figure S8.15: Southern California Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

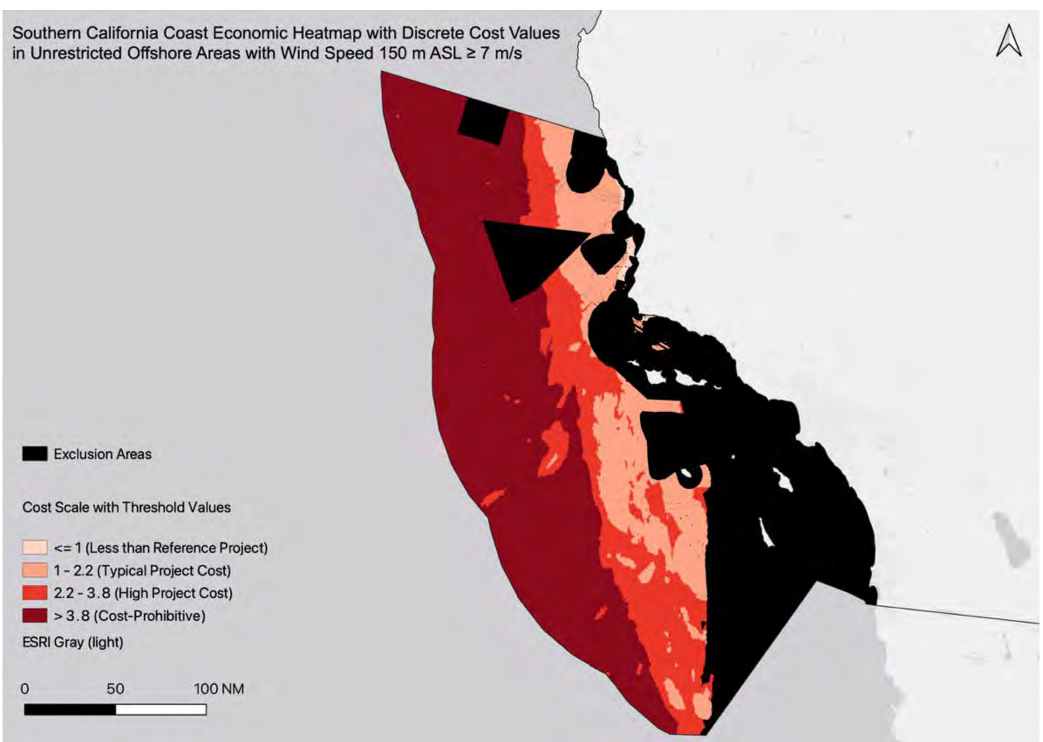

Figure S8.16: Southern California Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

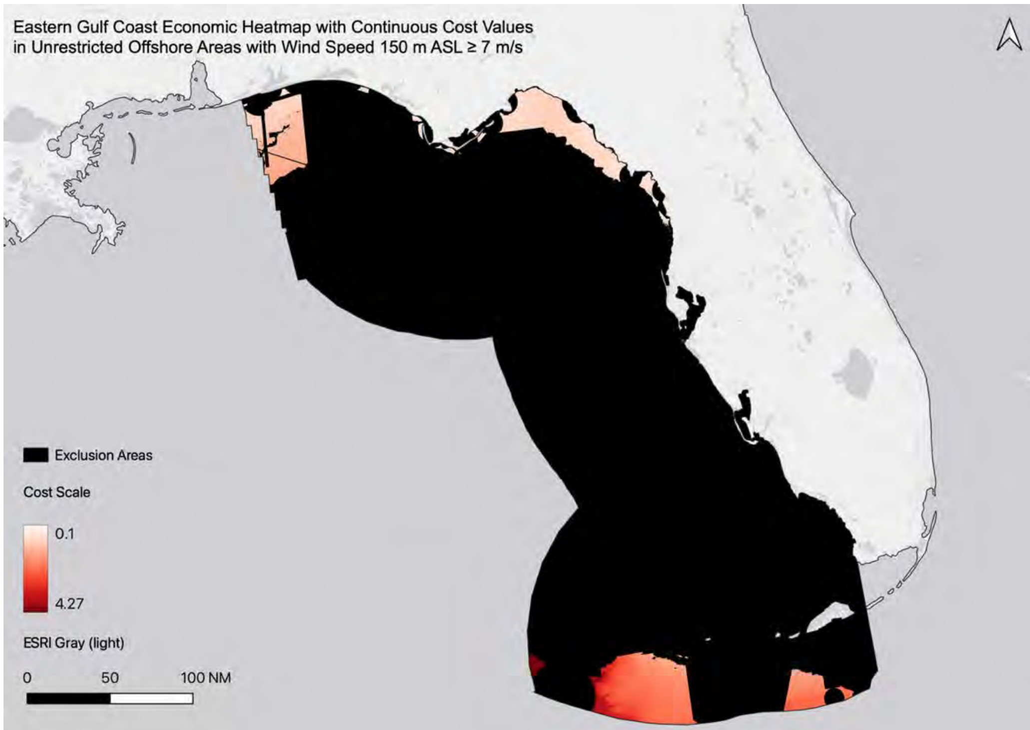

Figure S8.17: Eastern Gulf Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

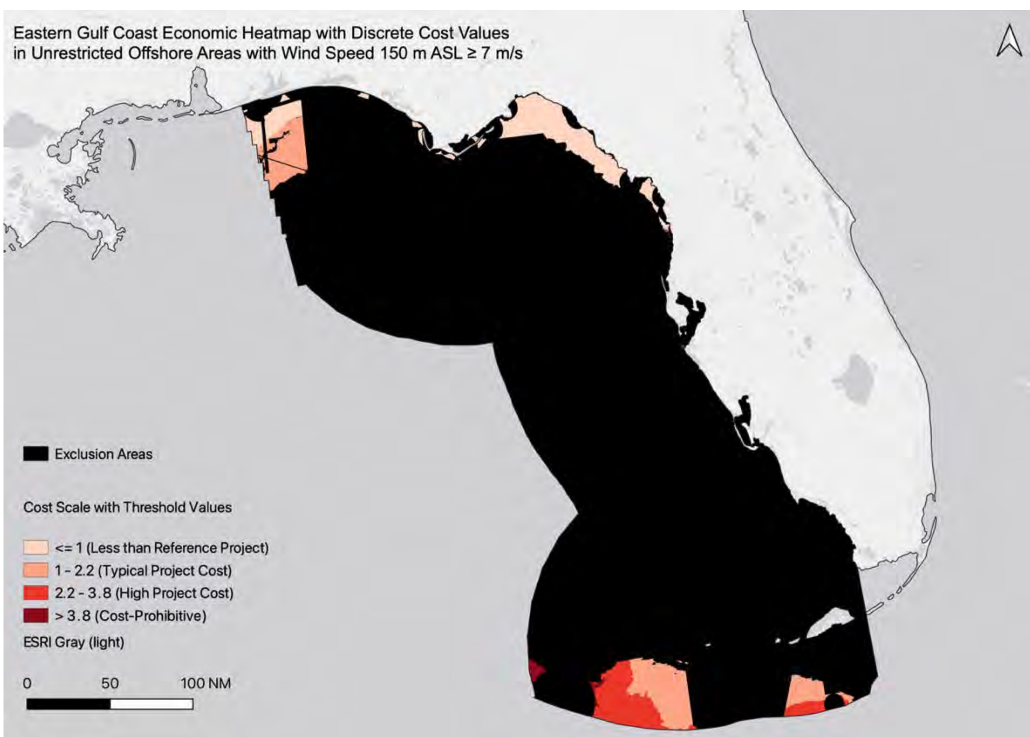

Figure S8.18: Eastern Gulf Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

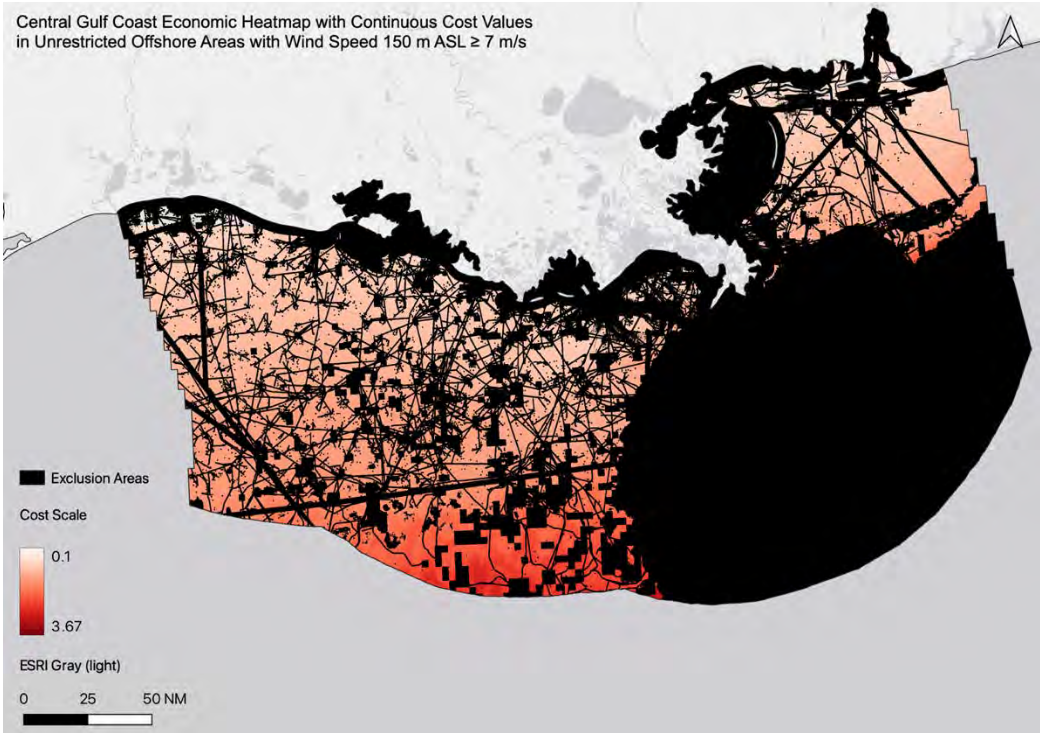

Figure S8.19: Central Gulf Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

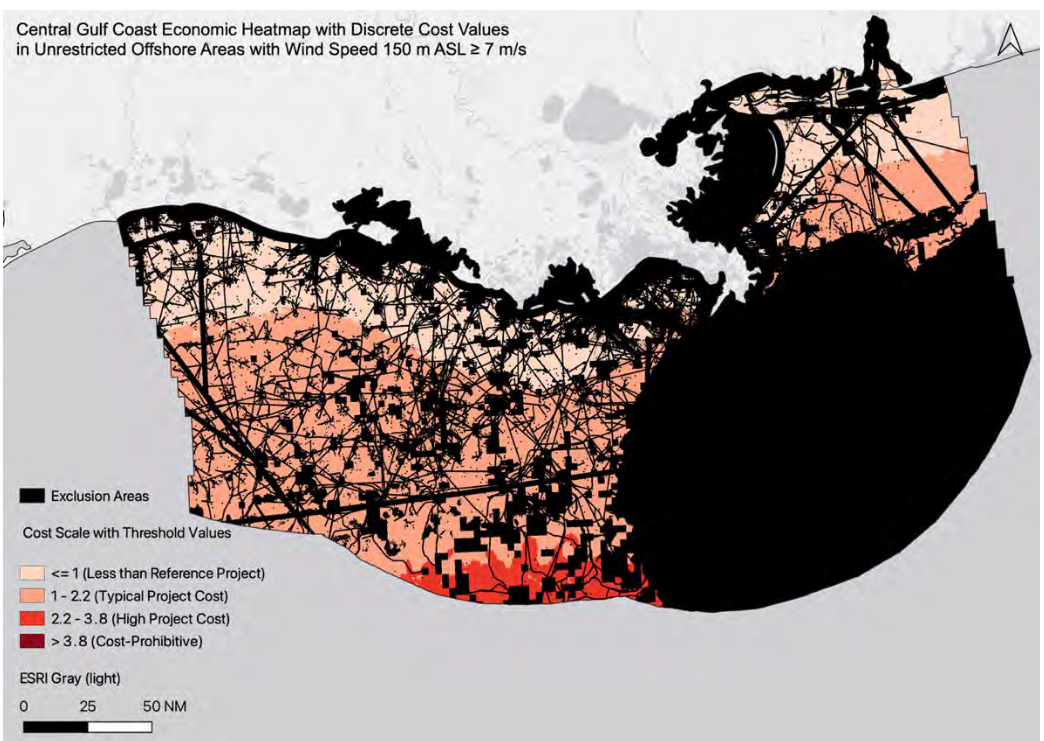

Figure S8.20: Central Gulf Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

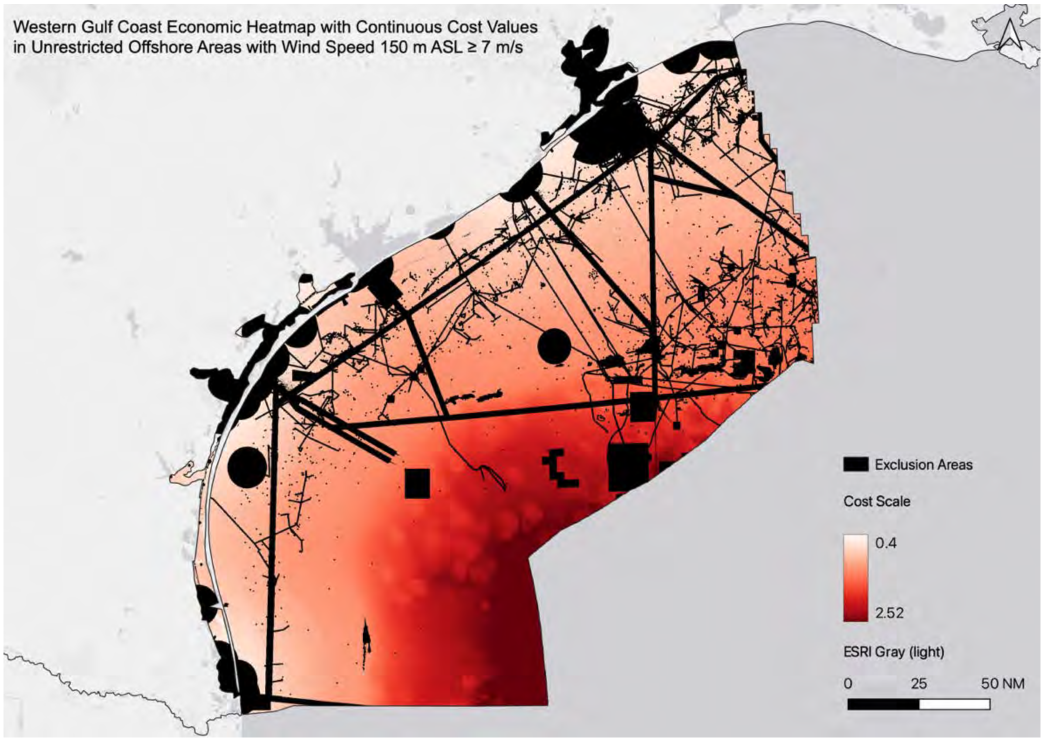

Figure S8.21: Western Gulf Coast economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

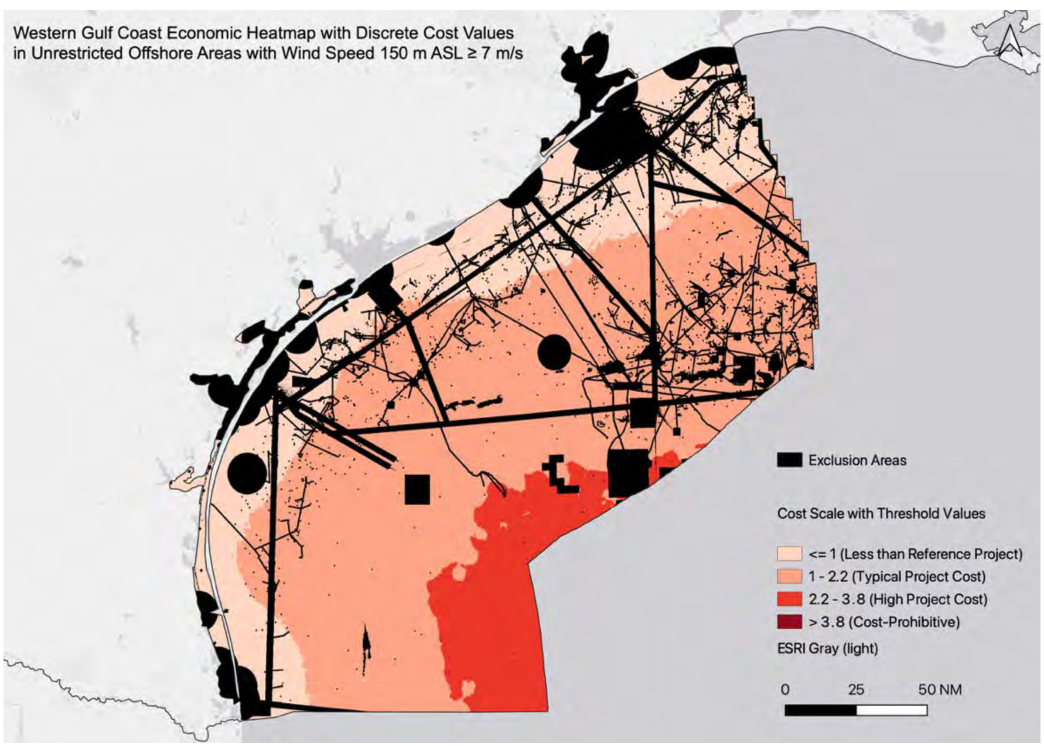

Figure S8.22: Western Gulf Coast economic heatmap with discrete color ramp in relation to exclusion areas in black.

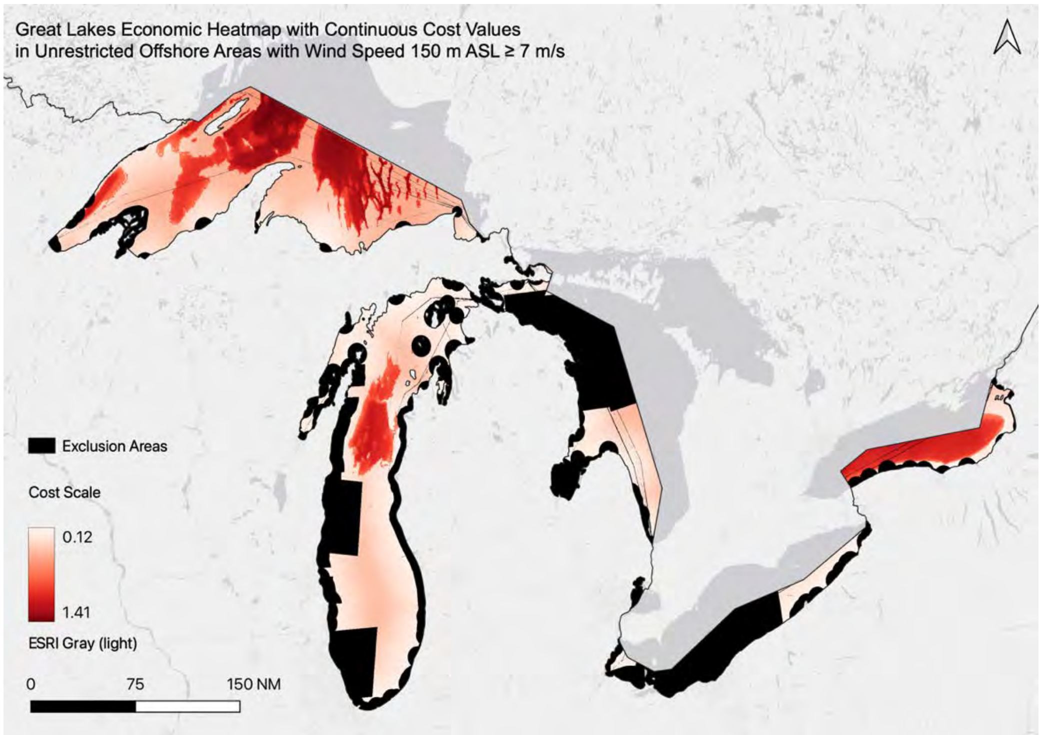

Figure S8.23: Great Lakes economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

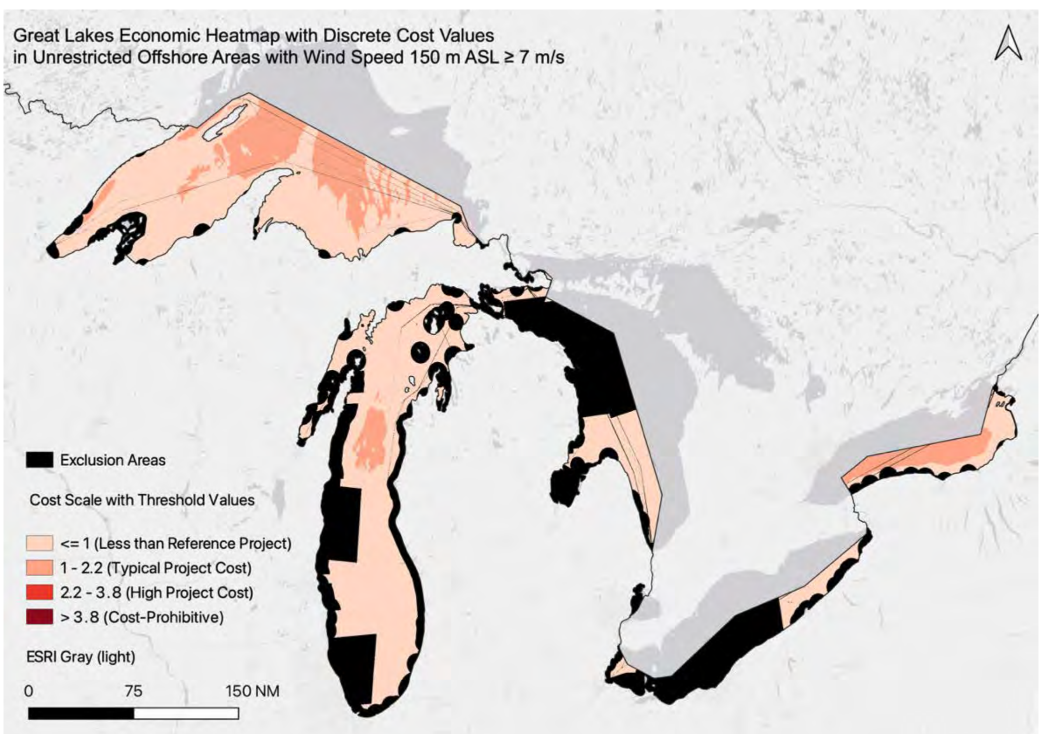

Figure S8.24: Great Lakes economic heatmap with discrete color ramp in relation to exclusion areas in black.

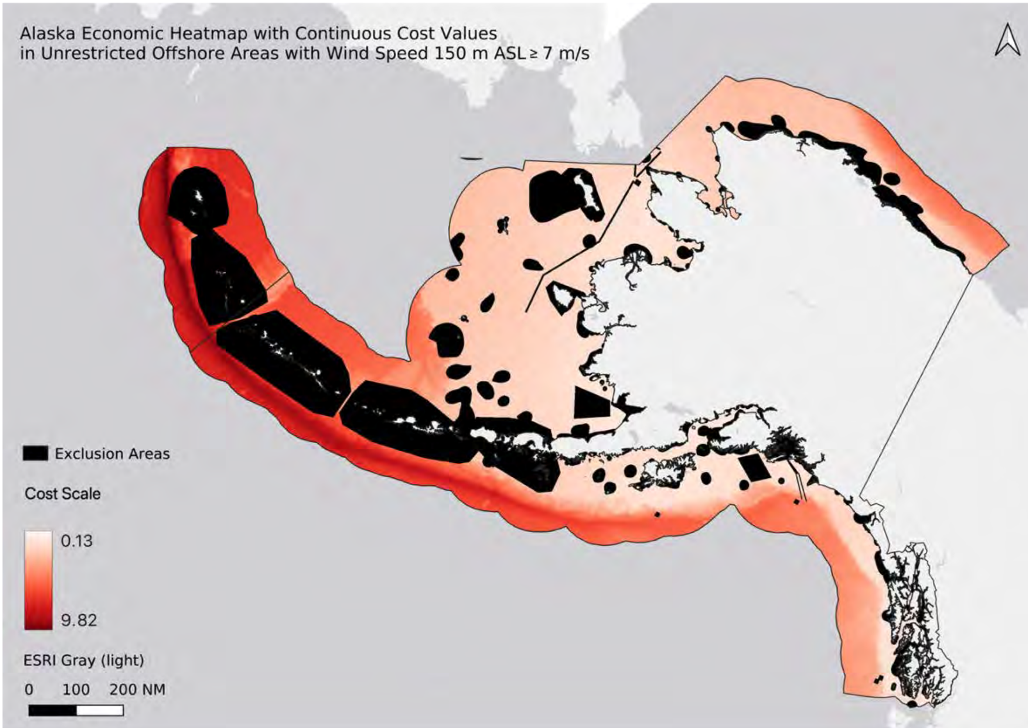

Figure S8.25: Alaska economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

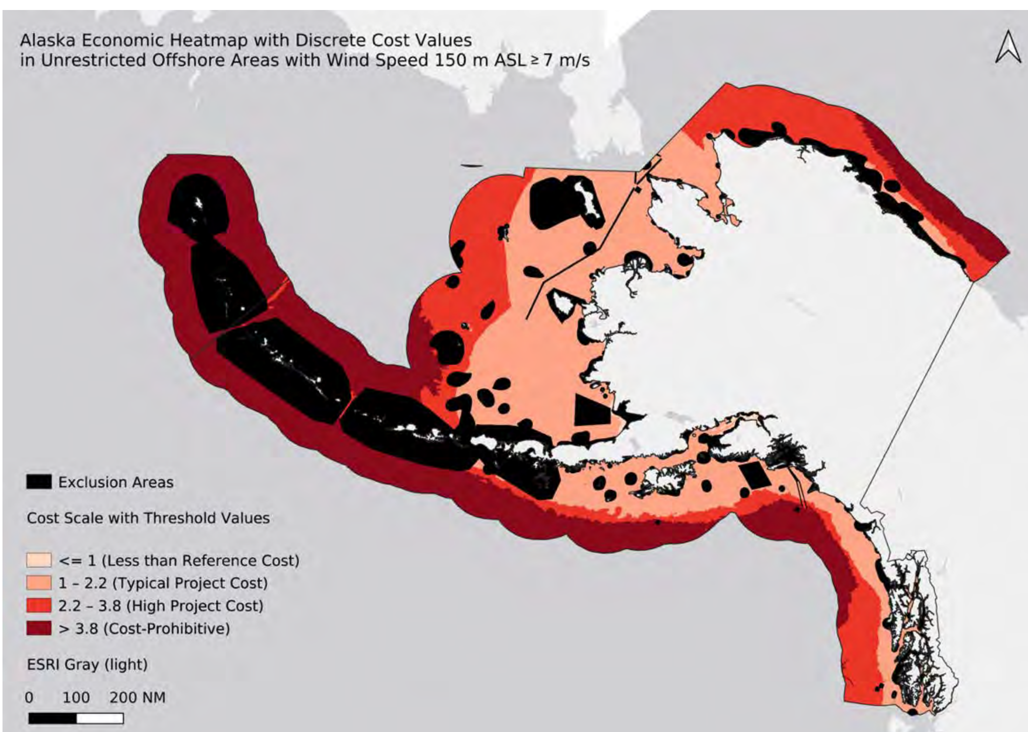

Figure S8.26: Alaska economic heatmap with discrete color ramp in relation to exclusion areas in black.

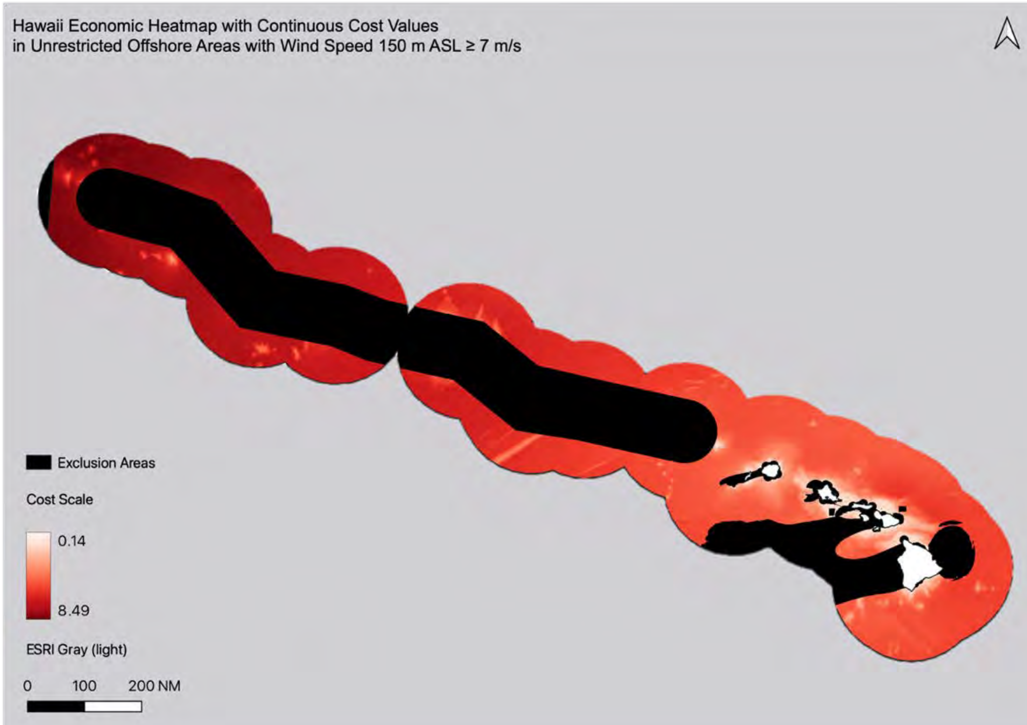

Figure S8.27: Hawaii economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

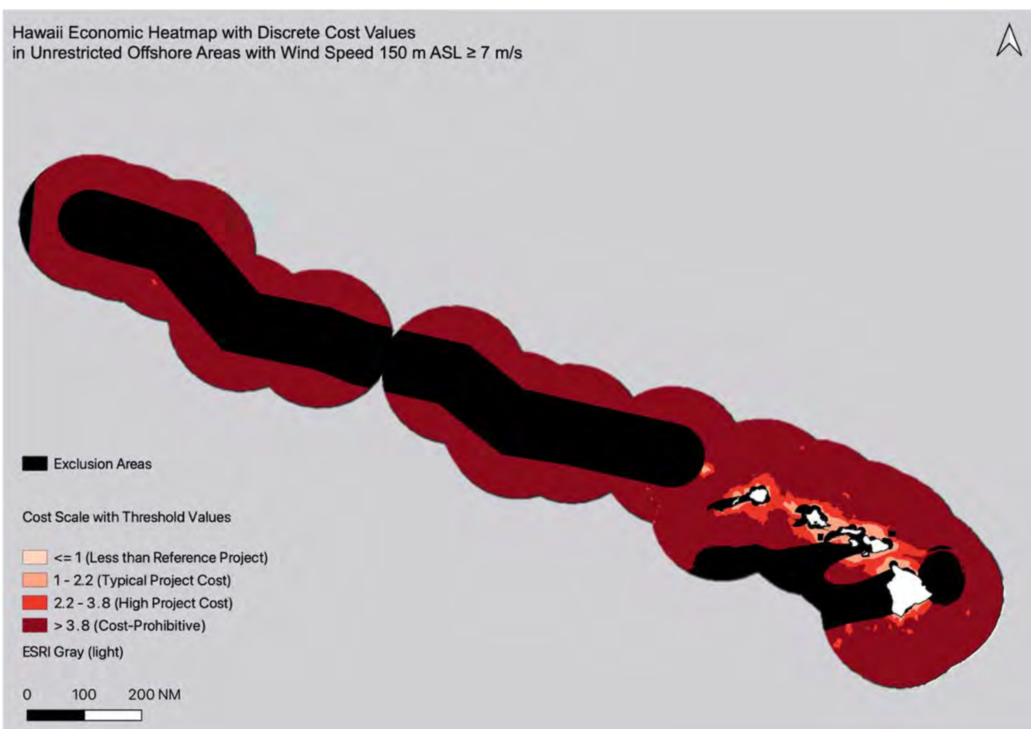

Figure S8.28: Hawaii economic heatmap with discrete color ramp in relation to exclusion areas in black.

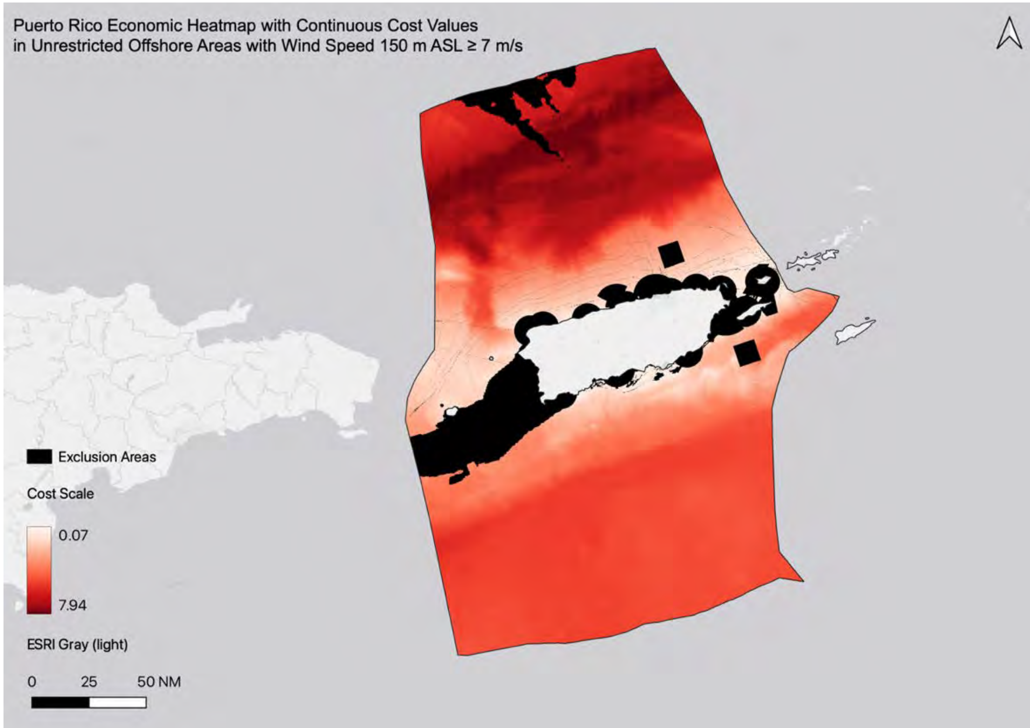

Figure S8.29: Puerto Rico economic heatmap with continuous color ramp in relation to exclusion areas in black. The unitless cost scale is the cost of a project relative to that of a reference project that accounts for water depth, transmission and port proximity, and wage rates of a typical coastal state. See Methods Section S5 for details.

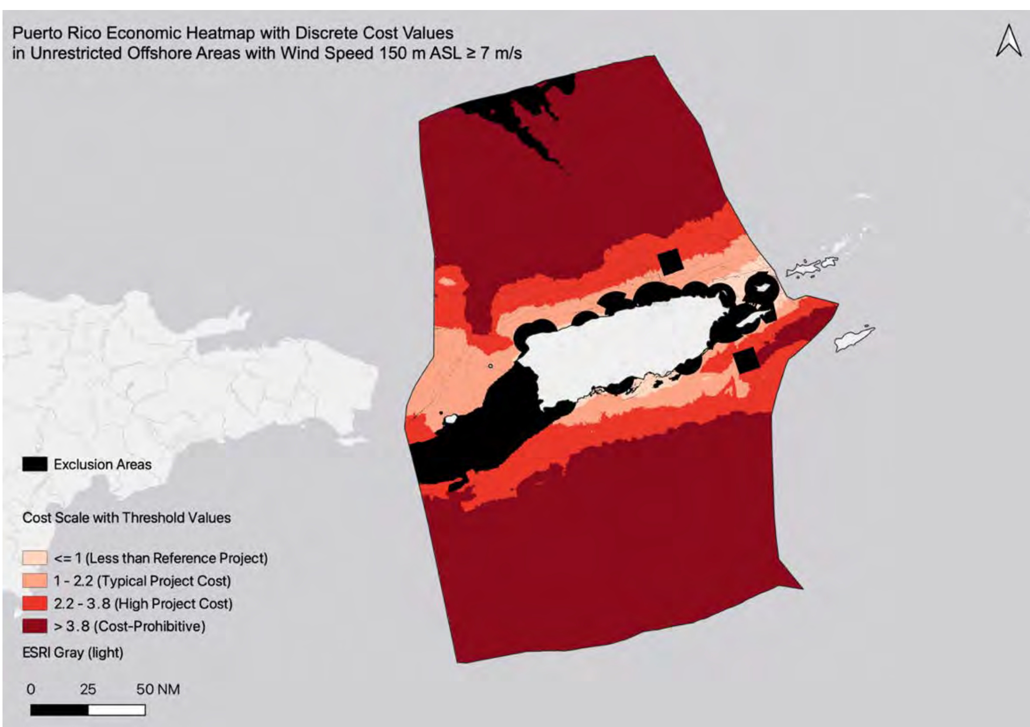

Figure S8.30: Puerto Rico economic heatmap with discrete color ramp in relation to exclusion areas in black.

9. Low Cost Locations to Meet 30 GW by 2030 Target

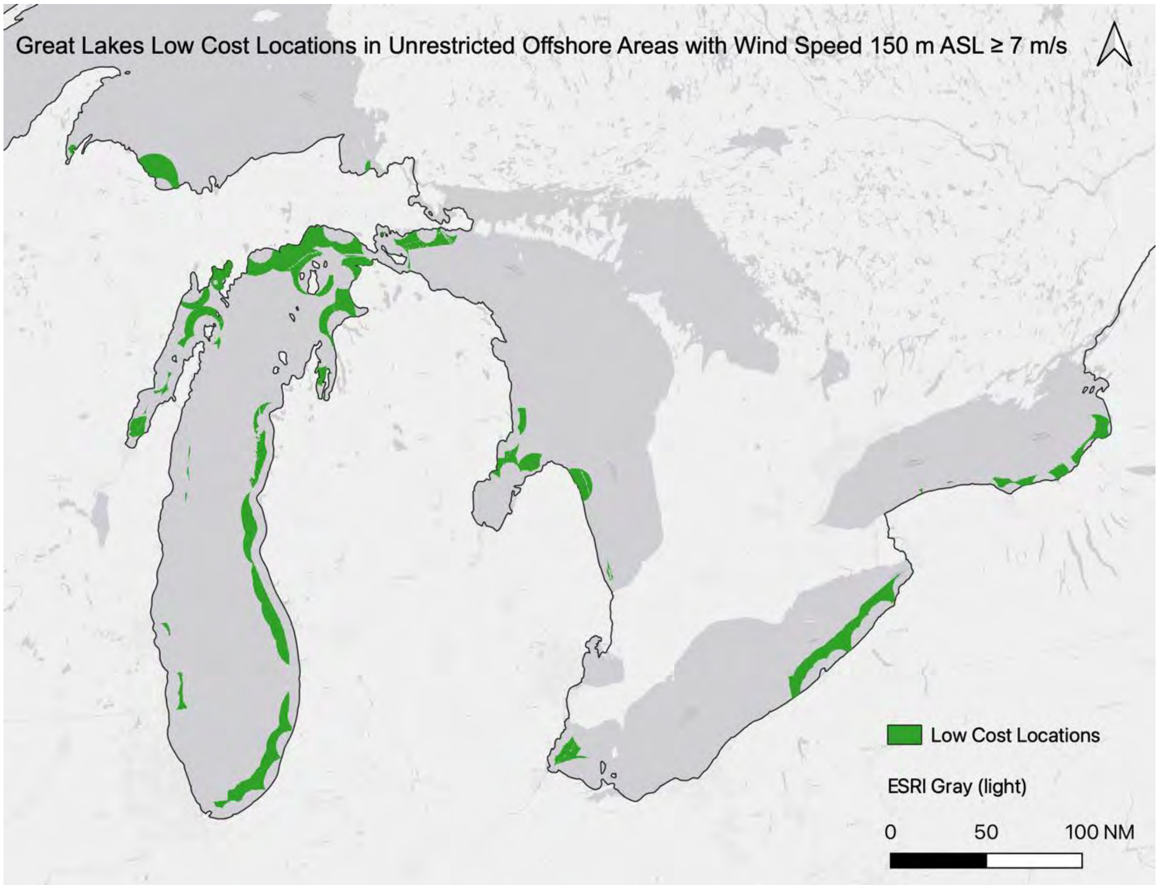

Figure S9.1: Great Lakes Low Cost Locations (Scenario 1). The areas shown in green can fulfill nearly the entire 30 GW by 2030 target set by the Biden Administration (very small areas on other coasts not shown) at the lowest cost. In total 11,727 km^2 are required. Areas shown exclude restrictions and wind speeds below 7 m/s at 150 m ASL. Available capacity is calculated assuming uniform 7 m/s wind speed and capacity factor across all pixels to compute output power density.

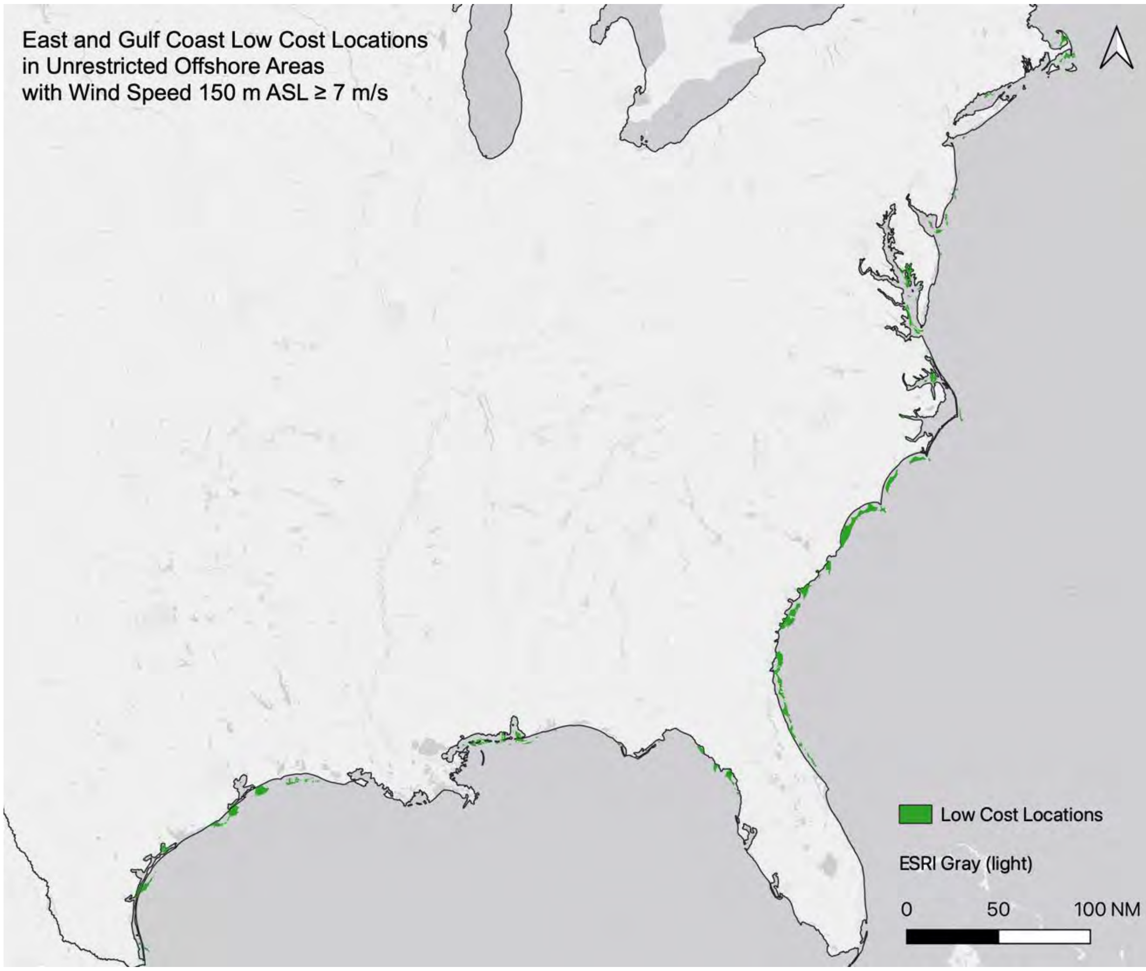

Figure S9.2: East and Gulf Coast Low Cost Locations (Scenario 2). A cost threshold of 0.68 was applied to exclude the Great Lakes. The areas shown in green can fulfill nearly the entire 30 GW by 2030 target set by the Biden Administration (very small areas on other coasts not shown) at the second lowest cost. In total 11,727 km^2 are required. Areas shown exclude restrictions and wind speeds below 7 m/s at 150 m ASL. Available capacity is calculated assuming uniform 7 m/s wind speed and capacity factor across all pixels to compute output power density.

Supplemental Tables

Table S3. Area Available for Offshore Wind Energy Development.

Area available (km^2 and %) in each region for offshore wind energy development, accounting for all restrictions in Table S1, for each wind speed threshold (6-12 m/s) and hub height scenario (100 m, 150 m, 200 m, and 250 m ASL).

		100 m ASL Turbine Height		150 m ASL Turbine Height		200 m ASL Turbine Height		250 m ASL Turbine Height	
Region	**Wind Speed Threshold (m/s)**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**
Alaska	6	1,786,044.7	72.0	1,788,145.3	72.1	1,789,008.7	72.1	1,789,377.9	72.2
	6.5	1,783,419.1	71.9	1,786,655.8	72.0	1,788,140.5	72.1	1,788,786.6	72.1
	7	1,778,011.4	71.7	1,784,326.3	71.9	1,786,506.6	72.0	1,787,767.5	72.1
	7.5	1,762,663.8	71.1	1,778,948.0	71.7	1,783,483.2	71.9	1,785,619.9	72.0
	8	1,729,953.9	69.7	1,759,612.8	70.9	1,770,437.2	71.4	1,778,390.0	71.7
	8.5	1,649,337.1	66.5	1,705,140.1	68.7	1,731,854.1	69.8	1,746,958.3	70.4
	9	1,406,325.5	56.7	1,487,921.5	60.0	1,532,371.1	61.8	1,578,822.7	63.7
	9.5	1,196,161.1	48.2	1,327,327.7	53.5	1,356,989.0	54.7	1,380,018.4	55.6
	10	808,708.0	32.6	1,076,317.3	43.4	1,165,882.3	47.0	1,254,354.2	50.6
	10.5	344,687.4	13.9	632,251.8	25.5	803,560.3	32.4	883,285.3	35.6
	11	29,523.4	1.2	267,615.3	10.8	392,333.9	15.8	516,505.4	20.8
	11.5	2,541.0	0.1	19,451.5	0.8	140,994.6	5.7	244,081.6	9.8
	12	6.0	0.0	1,189.7	0.0	3,464.6	0.1	30,279.2	1.2
Central Gulf Coast	6	80,523.9	51.0	80,523.9	51.0	80,523.9	51.0	80,523.9	51.0
	6.5	80,523.9	51.0	80,523.9	51.0	80,523.9	51.0	80,523.9	51.0
	7	31,228.6	19.8	46,361.5	29.4	57,067.3	36.1	64,776.5	41.0
	7.5	0.0	0.0	3,698.1	2.3	13,639.1	8.6	19,775.8	12.5
	8	0.0	0.0	0.0	0.0	6.5	0.0	427.3	0.3
	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eastern Gulf Coast	6	120,336.4	53.3	135,285.4	59.9	135,285.4	59.9	135,285.4	59.9
	6.5	47,560.4	21.1	71,745.4	31.8	89,989.3	39.9	105,934.3	46.9
	7	6,016.5	2.7	17,918.2	7.9	27,568.8	12.2	37,840.0	16.8
	7.5	0.0	0.0	0.0	0.0	1,410.3	0.6	3,640.1	1.6
	8	0.0	0.0	0.0	0.0	0.0	0.0	304.1	0.1
	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Great Lakes	6	102,318.2	65.8	102,349.1	65.8	102,349.1	65.8	102,349.1	65.8
	6.5	102,102.3	65.7	102,344.4	65.8	102,349.1	65.8	102,349.1	65.8
	7	101,170.3	65.0	102,254.6	65.8	102,348.9	65.8	102,349.1	65.8
	7.5	97,044.6	62.4	101,252.2	65.1	102,310.8	65.8	102,349.1	65.8
	8	91,620.6	58.9	97,136.4	62.5	100,996.8	64.9	102,315.5	65.8
	8.5	79,057.6	50.8	91,192.3	58.6	96,237.4	61.9	99,578.7	64.0
	9	41,677.0	26.8	76,719.5	49.3	86,271.5	55.5	92,540.4	59.5
	9.5	1,722.0	1.1	31,964.2	20.5	62,508.1	40.2	77,025.0	49.5
	10	0.0	0.0	0.0	0.0	623.3	0.4	22,815.2	14.7
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	47.1	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hawaii	6	767,779.0	64.8	769,932.6	65.0	771,505.9	65.1	772,470.8	65.2
	6.5	750,251.0	63.3	752,233.5	63.5	753,762.0	63.6	754,753.5	63.7
	7	712,206.4	60.1	718,625.3	60.7	724,864.5	61.2	728,631.1	61.5
	7.5	560,070.0	47.3	645,033.8	54.4	661,722.2	55.9	665,159.5	56.1
	8	147,694.1	12.5	230,900.7	19.5	252,751.0	21.3	268,275.0	22.6
	8.5	70,561.3	6.0	76,724.0	6.5	81,459.7	6.9	88,410.0	7.5
	9	44,283.9	3.7	50,155.1	4.2	54,049.8	4.6	56,542.4	4.8
	9.5	19,361.8	1.6	22,858.8	1.9	25,694.4	2.2	30,635.7	2.6
	10	10,429.8	0.9	12,602.5	1.1	14,265.3	1.2	15,607.1	1.3
	10.5	4,326.7	0.4	6,192.0	0.5	7,393.5	0.6	8,391.3	0.7
	11	408.5	0.0	1,574.9	0.1	2,736.8	0.2	3,635.3	0.3
	11.5	53.3	0.0	156.5	0.0	285.3	0.0	634.2	0.1
	12	0.0	0.0	8.9	0.0	45.4	0.0	86.2	0.0
Mid-Atlantic Coast	6	83,484.1	66.5	83,484.1	66.5	83,484.1	66.5	83,484.1	66.5
	6.5	83,484.1	66.5	83,484.1	66.5	83,484.1	66.5	83,484.1	66.5
	7	83,476.0	66.5	83,484.1	66.5	83,484.1	66.5	83,484.1	66.5
	7.5	83,442.4	66.5	83,484.1	66.5	83,484.1	66.5	83,484.1	66.5
	8	83,290.8	66.3	83,474.5	66.5	83,484.1	66.5	83,484.1	66.5
	8.5	82,172.2	65.4	83,397.3	66.4	83,482.6	66.5	83,484.1	66.5
	9	71,798.8	57.2	81,961.9	65.3	83,421.4	66.4	83,483.3	66.5
	9.5	0.0	0.0	56,785.4	45.2	75,707.4	60.3	81,766.8	65.1

	10	0.0	0.0	0.0	0.0	190.8	0.2	22,293.9	17.8
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern California Coast	6	127,556.4	79.6	127,591.6	79.6	127,658.7	79.6	127,685.8	79.6
	6.5	127,274.8	79.4	127,354.3	79.4	127,379.1	79.4	127,371.6	79.4
	7	126,942.8	79.2	127,093.5	79.3	127,120.4	79.3	127,082.5	79.3
	7.5	126,494.2	78.9	126,748.8	79.0	126,797.3	79.1	126,764.8	79.1
	8	125,842.0	78.5	126,318.7	78.8	126,387.2	78.8	126,347.5	78.8
	8.5	123,264.3	76.9	125,701.6	78.4	125,851.1	78.5	125,791.5	78.4
	9	106,375.2	66.3	119,877.7	74.8	124,142.7	77.4	124,630.4	77.7
	9.5	94,508.3	58.9	103,874.0	64.8	111,358.0	69.4	118,119.4	73.7
	10	67,472.6	42.1	92,986.4	58.0	99,844.8	62.3	103,685.7	64.7
	10.5	18,408.7	11.5	62,487.7	39.0	87,459.7	54.5	94,537.9	59.0
	11	2,586.4	1.6	21,571.5	13.5	49,165.6	30.7	68,675.9	42.8
	11.5	401.8	0.3	4,119.3	2.6	15,525.0	9.7	34,306.2	21.4
	12	0.0	0.0	463.3	0.3	869.2	0.5	7,674.3	4.8
Northern East Coast	6	105,156.2	74.4	105,156.2	74.4	105,156.2	74.4	105,156.2	74.4
	6.5	105,156.1	74.4	105,156.2	74.4	105,156.2	74.4	105,156.2	74.4
	7	105,135.1	74.4	105,156.2	74.4	105,156.2	74.4	105,156.2	74.4
	7.5	105,086.7	74.4	105,156.2	74.4	105,156.2	74.4	105,156.2	74.4
	8	104,970.1	74.3	105,129.8	74.4	105,156.2	74.4	105,156.2	74.4
	8.5	104,473.4	73.9	105,059.1	74.3	105,151.1	74.4	105,156.2	74.4
	9	101,775.9	72.0	104,319.9	73.8	105,082.1	74.4	105,153.5	74.4
	9.5	61,555.6	43.6	99,632.0	70.5	102,164.4	72.3	103,461.0	73.2
	10	2,258.3	1.6	45,043.2	31.9	68,868.3	48.7	84,546.2	59.8
	10.5	0.0	0.0	1,033.1	0.7	7,581.3	5.4	21,396.9	15.1
	11	0.0	0.0	0.0	0.0	0.0	0.0	63.5	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Carolina Coast	6	101,375.1	83.7	101,375.1	83.7	101,375.1	83.7	101,375.1	83.7
	6.5	101,374.9	83.7	101,375.1	83.7	101,375.1	83.7	101,375.1	83.7
	7	101,359.7	83.7	101,375.1	83.7	101,375.1	83.7	101,375.1	83.7
	7.5	101,338.9	83.7	101,375.1	83.7	101,375.1	83.7	101,375.1	83.7
	8	91,458.2	75.6	98,383.2	81.3	100,413.3	83.0	101,028.6	83.5
	8.5	47,290.2	39.1	62,823.0	51.9	70,532.5	58.3	76,389.3	63.1
	9	0.0	0.0	21,155.6	17.5	28,144.0	23.3	34,785.8	28.7
	9.5	0.0	0.0	0.0	0.0	631.2	0.5	6,242.2	5.2
	10	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oregon Coast	6	85,309.9	87.8	85,310.0	87.8	85,310.0	87.8	85,310.0	87.8
	6.5	85,309.7	87.8	85,309.9	87.8	85,310.0	87.8	85,310.0	87.8
	7	85,308.1	87.8	85,309.8	87.8	85,309.9	87.8	85,310.0	87.8
	7.5	85,304.2	87.8	85,308.8	87.8	85,309.7	87.8	85,309.8	87.8
	8	84,810.2	87.3	85,305.0	87.8	85,308.9	87.8	85,309.4	87.8
	8.5	64,845.9	66.7	80,841.4	83.2	84,730.1	87.2	85,304.3	87.8
	9	29,227.5	30.1	52,820.9	54.4	61,119.4	62.9	71,708.6	73.8
	9.5	9,122.6	9.4	20,963.2	21.6	33,562.8	34.5	43,157.4	44.4
	10	3,382.6	3.5	7,851.4	8.1	13,849.9	14.3	20,011.5	20.6
	10.5	1,186.1	1.2	3,198.6	3.3	5,294.8	5.4	7,846.3	8.1
	11	81.7	0.1	1,231.8	1.3	2,138.5	2.2	3,327.1	3.4
	11.5	0.0	0.0	121.9	0.1	574.8	0.6	1,163.3	1.2
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Puerto Rico	6	111,564.2	95.0	111,593.6	95.0	111,595.2	95.0	111,595.2	95.0
	6.5	111,032.1	94.5	111,479.9	94.9	111,593.5	95.0	111,595.2	95.0
	7	98,789.7	84.1	104,157.1	88.7	106,762.9	90.9	107,487.6	91.5
	7.5	45,926.3	39.1	61,813.9	52.6	69,976.0	59.6	74,682.4	63.6
	8	4,638.4	3.9	7,337.9	6.2	10,310.7	8.8	13,342.8	11.4
	8.5	0.0	0.0	0.0	0.0	38.8	0.0	198.1	0.2
	9	0.0	0.0	0.0	0.0	0.0	0.0	22.5	0.0
	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Southern California Coast	6	111,376.2	70.0	112,272.5	70.5	112,384.4	70.6	112,477.1	70.7
	6.5	106,420.9	66.8	108,286.2	68.0	108,895.2	68.4	109,230.8	68.6
	7	97,478.9	61.2	102,025.4	64.1	103,772.7	65.2	104,479.2	65.6
	7.5	86,185.2	54.1	91,118.7	57.2	93,634.5	58.8	95,583.8	60.0
	8	75,569.2	47.5	81,728.8	51.3	84,839.6	53.3	86,976.5	54.6
	8.5	63,456.6	39.9	70,596.5	44.3	75,151.3	47.2	77,441.4	48.6
	9	9,172.3	5.8	58,418.3	36.7	66,320.8	41.7	70,271.8	44.1
	9.5	0.0	0.0	4,711.7	3.0	22,587.8	14.2	49,253.7	30.9
	10	0.0	0.0	0.0	0.0	0.0	0.0	4,123.3	2.6
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Southern East Coast	6	113,773.7	62.2	113,773.7	62.2	113,773.7	62.2	113,773.7	62.2
	6.5	106,638.0	58.3	107,746.9	58.9	108,993.7	59.6	109,688.0	60.0
	7	66,824.2	36.5	73,227.4	40.0	82,656.3	45.2	89,659.9	49.0
	7.5	42,445.8	23.2	48,768.3	26.7	52,304.4	28.6	54,621.8	29.9
	8	3,323.6	1.8	14,126.2	7.7	22,864.4	12.5	28,596.3	15.6
	8.5	0.0	0.0	65.9	0.0	1,579.5	0.9	4,826.7	2.6
	9	0.0	0.0	0.0	0.0	0.0	0.0	171.6	0.1
	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Washington Coast	6	32,196.0	64.6	32,205.3	64.6	32,220.0	64.6	32,239.6	64.7
	6.5	32,174.2	64.5	32,190.0	64.5	32,201.0	64.6	32,206.6	64.6
	7	32,062.1	64.3	32,121.3	64.4	32,133.2	64.4	32,132.3	64.4
	7.5	31,754.8	63.7	31,840.1	63.8	31,838.9	63.8	31,813.6	63.8
	8	31,500.8	63.1	31,543.6	63.2	31,544.1	63.2	31,548.1	63.3
	8.5	15,701.7	31.5	28,172.8	56.5	31,543.0	63.2	31,544.0	63.2
	9	0.0	0.0	6,210.2	12.4	14,078.5	28.2	19,431.1	39.0
	9.5	0.0	0.0	0.0	0.0	0.0	0.0	2,305.1	4.6
	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Western Gulf Coast	6	73,521.5	74.9	73,521.5	74.9	73,521.5	74.9	73,521.5	74.9
	6.5	73,521.5	74.9	73,521.5	74.9	73,521.5	74.9	73,521.5	74.9
	7	73,521.3	74.9	73,521.5	74.9	73,521.5	74.9	73,521.5	74.9
	7.5	55,393.2	56.4	70,993.6	72.3	73,521.5	74.9	73,521.5	74.9
	8	4,724.5	4.8	20,213.2	20.6	46,195.7	47.0	54,982.4	56.0
	8.5	376.8	0.4	2,279.1	2.3	4,735.4	4.8	7,265.0	7.4
	9	0.0	0.0	346.9	0.4	821.4	0.8	1,803.7	1.8
	9.5	0.0	0.0	0.0	0.0	328.1	0.3	563.6	0.6
	10	0.0	0.0	0.0	0.0	0.0	0.0	273.1	0.3
	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table S4. Area Available for Development Without Wind Threshold.

Area available (km^2 and %) in each region for offshore wind energy development, accounting for all restrictions in Table S1 with no wind speed threshold.

	All Turbine Heights	
Region	**km^2**	**%**
Alaska	1,790,807.7	72.2
Central Gulf Coast	80,523.9	51.0
Eastern Gulf Coast	135,285.4	59.9
Great Lakes	102,349.1	65.8
Hawaii	805,778.0	68.0
Mid-Atlantic Coast	83,484.1	66.5
Northern California Coast	127,747.7	79.7
Northern East Coast	105,156.2	74.4
North Carolina Coast	101,375.1	83.7
Oregon Coast	85,310.0	87.8
Puerto Rico	111,595.2	95.0
Southern California Coast	125,360.6	78.7
Southern East Coast	113,773.7	62.2
Washington Coast	32,249.3	64.7
Western Gulf Coast	73,521.5	74.9

Table S5. Number of Turbines within Available Area for Offshore Wind Energy Development.

Maximum number of V236-15 MW turbines that fit within available area (accounting for all restrictions in Table S1) for each wind speed threshold (6-12 m/s) and hub height scenario (100 m, 150 m, 200 m, and 250 m ASL) in all regions.

Region	Wind Speed Threshold (m/s)	100 m ASL Turbine Height	150 m ASL Turbine Height	200 m ASL Turbine Height	250 m ASL Turbine Height
Alaska	6	896,739	897,793	898,227	898,412
	6.5	895,420	897,046	897,791	898,115
	7	892,705	895,876	896,971	897,604
	7.5	885,000	893,176	895,453	896,525
	8	868,577	883,468	888,903	892,895
	8.5	828,101	856,118	869,531	877,114
	9	706,089	747,057	769,374	792,697
	9.5	600,570	666,426	681,318	692,881
	10	406,037	540,398	585,367	629,787
	10.5	173,061	317,441	403,452	443,481
	11	14,823	134,364	196,983	259,327
	11.5	1,276	9,766	70,791	122,549
	12	3	597	1,740	15,203
Central Gulf Coast	6	40,429	40,429	40,429	40,429
	6.5	40,429	40,429	40,429	40,429
	7	15,679	23,277	28,652	32,523
	7.5	0	1,857	6,848	9,929
	8	0	0	3	215
	8.5	0	0	0	0
	9	0	0	0	0
	9.5	0	0	0	0
	10	0	0	0	0
	10.5	0	0	0	0
	11	0	0	0	0
	11.5	0	0	0	0
	12	0	0	0	0
Eastern Gulf Coast	6	60,419	67,924	67,924	67,924
	6.5	23,879	36,022	45,182	53,188
	7	3,021	8,996	13,842	18,999
	7.5	0	0	708	1,828
	8	0	0	0	153
	8.5	0	0	0	0
	9	0	0	0	0
	9.5	0	0	0	0
	10	0	0	0	0

	10.5	0	0	0	0
	11	0	0	0	0
	11.5	0	0	0	0
	12	0	0	0	0
Great Lakes	6	51,372	51,388	51,388	51,388
	6.5	51,264	51,385	51,388	51,388
	7	50,796	51,340	51,387	51,388
	7.5	48,724	50,837	51,368	51,388
	8	46,001	48,770	50,709	51,371
	8.5	39,693	45,786	48,319	49,997
	9	20,925	38,519	43,315	46,463
	9.5	865	16,049	31,384	38,673
	10	0	0	313	11,455
	10.5	0	0	0	24
	11	0	0	0	0
	11.5	0	0	0	0
	12	0	0	0	0
Hawaii	6	385,487	386,568	387,358	387,843
	6.5	376,687	377,682	378,449	378,947
	7	357,585	360,808	363,941	365,832
	7.5	281,200	323,859	332,238	333,964
	8	74,154	115,931	126,901	134,696
	8.5	35,427	38,522	40,899	44,389
	9	22,234	25,182	27,137	28,389
	9.5	9,721	11,477	12,901	15,382
	10	5,237	6,327	7,162	7,836
	10.5	2,172	3,109	3,712	4,213
	11	205	791	1,374	1,825
	11.5	27	79	143	318
	12	0	4	23	43
Mid-Atlantic Coast	6	41,916	41,916	41,916	41,916
	6.5	41,916	41,916	41,916	41,916
	7	41,912	41,916	41,916	41,916
	7.5	41,895	41,916	41,916	41,916
	8	41,819	41,911	41,916	41,916
	8.5	41,257	41,872	41,915	41,916
	9	36,049	41,151	41,884	41,915
	9.5	0	28,511	38,011	41,054
	10	0	0	96	11,193
	10.5	0	0	0	0
	11	0	0	0	0

	11.5	0	0	0	0
	12	0	0	0	0
Northern California Coast	6	64,044	64,061	64,095	64,109
	6.5	63,902	63,942	63,955	63,951
	7	63,736	63,811	63,825	63,806
	7.5	63,510	63,638	63,662	63,646
	8	63,183	63,422	63,457	63,437
	8.5	61,889	63,112	63,187	63,157
	9	53,409	60,188	62,330	62,575
	9.5	47,451	52,153	55,911	59,305
	10	33,877	46,687	50,130	52,059
	10.5	9,243	31,374	43,912	47,466
	11	1,299	10,831	24,685	34,481
	11.5	202	2,068	7,795	17,224
	12	0	233	436	3,853
Northern East Coast	6	52,797	52,797	52,797	52,797
	6.5	52,797	52,797	52,797	52,797
	7	52,786	52,797	52,797	52,797
	7.5	52,762	52,797	52,797	52,797
	8	52,703	52,784	52,797	52,797
	8.5	52,454	52,748	52,794	52,797
	9	51,100	52,377	52,760	52,796
	9.5	30,906	50,023	51,295	51,946
	10	1,134	22,615	34,577	42,449
	10.5	0	519	3,806	10,743
	11	0	0	0	32
	11.5	0	0	0	0
	12	0	0	0	0
North Carolina Coast	6	50,898	50,898	50,898	50,898
	6.5	50,898	50,898	50,898	50,898
	7	50,891	50,898	50,898	50,898
	7.5	50,880	50,898	50,898	50,898
	8	45,919	49,396	50,416	50,725
	8.5	23,743	31,542	35,413	38,354
	9	0	10,622	14,131	17,465
	9.5	0	0	317	3,134
	10	0	0	0	0
	10.5	0	0	0	0
	11	0	0	0	0
	11.5	0	0	0	0
	12	0	0	0	0

Oregon Coast	6	42,832	42,833	42,833	42,833
	6.5	42,832	42,832	42,833	42,833
	7	42,832	42,832	42,832	42,833
	7.5	42,830	42,832	42,832	42,832
	8	42,582	42,830	42,832	42,832
	8.5	32,558	40,589	42,541	42,830
	9	14,675	26,520	30,687	36,004
	9.5	4,580	10,525	16,851	21,668
	10	1,698	3,942	6,954	10,047
	10.5	596	1,606	2,658	3,939
	11	41	618	1,074	1,670
	11.5	0	61	289	584
	12	0	0	0	0
Puerto Rico	6	56,014	56,029	56,030	56,030
	6.5	55,747	55,972	56,029	56,030
	7	49,600	52,295	53,604	53,967
	7.5	23,059	31,036	35,134	37,497
	8	2,329	3,684	5,177	6,699
	8.5	0	0	19	99
	9	0	0	0	11
	9.5	0	0	0	0
	10	0	0	0	0
	10.5	0	0	0	0
	11	0	0	0	0
	11.5	0	0	0	0
	12	0	0	0	0
Southern California Coast	6	55,920	56,370	56,426	56,473
	6.5	53,432	54,368	54,674	54,843
	7	48,942	51,225	52,102	52,457
	7.5	43,272	45,749	47,012	47,991
	8	37,942	41,034	42,596	43,669
	8.5	31,860	35,445	37,732	38,882
	9	4,605	29,331	33,298	35,282
	9.5	0	2,366	11,341	24,729
	10	0	0	0	2,070
	10.5	0	0	0	0
	11	0	0	0	0
	11.5	0	0	0	0
	12	0	0	0	0
Southern East Coast	6	57,124	57,124	57,124	57,124
	6.5	53,541	54,098	54,724	55,072

	7	33,551	36,766	41,500	45,017
	7.5	21,311	24,486	26,261	27,425
	8	1,669	7,092	11,480	14,358
	8.5	0	33	793	2,423
	9	0	0	0	86
	9.5	0	0	0	0
	10	0	0	0	0
	10.5	0	0	0	0
	11	0	0	0	0
	11.5	0	0	0	0
	12	0	0	0	0
Washington Coast	6	16,165	16,170	16,177	16,187
	6.5	16,154	16,162	16,167	16,170
	7	16,098	16,127	16,133	16,133
	7.5	15,943	15,986	15,986	15,973
	8	15,816	15,837	15,838	15,840
	8.5	7,883	14,145	15,837	15,838
	9	0	3,118	7,069	9,756
	9.5	0	0	0	1,157
	10	0	0	0	0
	10.5	0	0	0	0
	11	0	0	0	0
	11.5	0	0	0	0
	12	0	0	0	0
Western Gulf Coast	6	36,914	36,914	36,914	36,914
	6.5	36,914	36,914	36,914	36,914
	7	36,914	36,914	36,914	36,914
	7.5	27,812	35,645	36,914	36,914
	8	2,372	10,149	23,194	27,606
	8.5	189	1,144	2,378	3,648
	9	0	174	412	906
	9.5	0	0	165	283
	10	0	0	0	137
	10.5	0	0	0	0
	11	0	0	0	0
	11.5	0	0	0	0
	12	0	0	0	0

Table S6. Potential Nameplate Capacity (GW).

Potential nameplate capacity (GW) using V236-15 MW turbines in available areas (accounting for all restrictions in Table S1) for each wind speed threshold (6-12 m/s) and hub height scenario (100 m, 150 m, 200 m, and 250 m ASL) in all regions.

Region	Wind Speed Threshold (m/s)	100 m ASL Turbine Height	150 m ASL Turbine Height	200 m ASL Turbine Height	250 m ASL Turbine Height
Alaska	6	13,451.08	13,466.90	13,473.40	13,476.18
	6.5	13,431.31	13,455.68	13,466.87	13,471.73
	7	13,390.58	13,438.14	13,454.56	13,464.06
	7.5	13,274.99	13,397.63	13,431.79	13,447.88
	8	13,028.65	13,252.02	13,333.54	13,393.43
	8.5	12,421.51	12,841.77	13,042.96	13,156.71
	9	10,591.34	11,205.85	11,540.61	11,890.45
	9.5	9,008.54	9,996.39	10,219.77	10,393.21
	10	6,090.55	8,105.97	8,780.51	9,446.81
	10.5	2,595.91	4,761.62	6,051.78	6,652.21
	11	222.35	2,015.47	2,954.75	3,889.91
	11.5	19.14	146.49	1,061.86	1,838.23
	12	0.05	8.96	26.09	228.04
Central Gulf Coast	6	606.44	606.44	606.44	606.44
	6.5	606.44	606.44	606.44	606.44
	7	235.19	349.16	429.79	487.85
	7.5	0.00	27.85	102.72	148.94
	8	0.00	0.00	0.05	3.22
	8.5	0.00	0.00	0.00	0.00
	9	0.00	0.00	0.00	0.00
	9.5	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00
Eastern Gulf Coast	6	906.28	1,018.86	1,018.86	1,018.86
	6.5	358.19	540.33	677.73	797.81
	7	45.31	134.95	207.63	284.98
	7.5	0.00	0.00	10.62	27.41
	8	0.00	0.00	0.00	2.29
	8.5	0.00	0.00	0.00	0.00
	9	0.00	0.00	0.00	0.00
	9.5	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00

	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00
Great Lakes	6	770.58	770.81	770.81	770.81
	6.5	768.95	770.78	770.81	770.81
	7	761.93	770.10	770.81	770.81
	7.5	730.86	762.55	770.52	770.81
	8	690.01	731.55	760.63	770.56
	8.5	595.40	686.79	724.78	749.95
	9	313.88	577.79	649.73	696.94
	9.5	12.97	240.73	470.76	580.09
	10	0.00	0.00	4.69	171.83
	10.5	0.00	0.00	0.00	0.35
	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00
Hawaii	6	5,782.31	5,798.53	5,810.37	5,817.64
	6.5	5,650.30	5,665.23	5,676.74	5,684.21
	7	5,363.78	5,412.12	5,459.11	5,487.48
	7.5	4,218.01	4,857.89	4,983.57	5,009.46
	8	1,112.32	1,738.96	1,903.52	2,020.44
	8.5	531.41	577.82	613.49	665.83
	9	333.51	377.73	407.06	425.83
	9.5	145.82	172.15	193.51	230.72
	10	78.55	94.91	107.44	117.54
	10.5	32.59	46.63	55.68	63.20
	11	3.08	11.86	20.61	27.38
	11.5	0.40	1.18	2.15	4.78
	12	0.00	0.07	0.34	0.65
Mid-Atlantic Coast	6	628.74	628.74	628.74	628.74
	6.5	628.74	628.74	628.74	628.74
	7	628.68	628.74	628.74	628.74
	7.5	628.42	628.74	628.74	628.74
	8	627.28	628.66	628.74	628.74
	8.5	618.86	628.08	628.73	628.74
	9	540.73	617.27	628.26	628.73
	9.5	0.00	427.66	570.17	615.80
	10	0.00	0.00	1.44	167.90
	10.5	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00

	12	0.00	0.00	0.00	0.00
Northern California Coast	6	960.65	960.92	961.42	961.63
	6.5	958.53	959.13	959.32	959.26
	7	956.03	957.17	957.37	957.09
	7.5	952.65	954.57	954.94	954.69
	8	947.74	951.33	951.85	951.55
	8.5	928.33	946.69	947.81	947.36
	9	801.13	902.82	934.94	938.62
	9.5	711.76	782.30	838.66	889.58
	10	508.15	700.30	751.95	780.88
	10.5	138.64	470.61	658.68	711.99
	11	19.48	162.46	370.28	517.21
	11.5	3.03	31.02	116.92	258.37
	12	0.00	3.49	6.55	57.80
Northern East Coast	6	791.95	791.95	791.95	791.95
	6.5	791.95	791.95	791.95	791.95
	7	791.80	791.95	791.95	791.95
	7.5	791.43	791.95	791.95	791.95
	8	790.55	791.75	791.95	791.95
	8.5	786.81	791.22	791.91	791.95
	9	766.50	785.66	791.40	791.93
	9.5	463.59	750.35	769.42	779.19
	10	17.01	339.23	518.66	636.74
	10.5	0.00	7.78	57.10	161.14
	11	0.00	0.00	0.00	0.48
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00
North Carolina Coast	6	763.48	763.48	763.48	763.48
	6.5	763.48	763.48	763.48	763.48
	7	763.36	763.48	763.48	763.48
	7.5	763.20	763.48	763.48	763.48
	8	688.79	740.94	756.23	760.87
	8.5	356.15	473.13	531.19	575.30
	9	0.00	159.33	211.96	261.98
	9.5	0.00	0.00	4.75	47.01
	10	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00
Oregon Coast	6	642.49	642.49	642.49	642.49

	6.5	642.49	642.49	642.49	642.49
	7	642.47	642.49	642.49	642.49
	7.5	642.44	642.48	642.49	642.49
	8	638.72	642.45	642.48	642.48
	8.5	488.37	608.83	638.12	642.44
	9	220.12	397.81	460.30	540.05
	9.5	68.70	157.88	252.77	325.03
	10	25.47	59.13	104.31	150.71
	10.5	8.93	24.09	39.88	59.09
	11	0.61	9.28	16.11	25.06
	11.5	0.00	0.92	4.33	8.76
	12	0.00	0.00	0.00	0.00
Puerto Rico	6	840.21	840.44	840.45	840.45
	6.5	836.21	839.58	840.43	840.45
	7	744.01	784.43	804.05	809.51
	7.5	345.88	465.53	527.00	562.45
	8	34.93	55.26	77.65	100.49
	8.5	0.00	0.00	0.29	1.49
	9	0.00	0.00	0.00	0.17
	9.5	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00
Southern California Coast	6	838.80	845.55	846.39	847.09
	6.5	801.48	815.53	820.11	822.64
	7	734.13	768.38	781.53	786.85
	7.5	649.08	686.23	705.18	719.86
	8	569.13	615.52	638.95	655.04
	8.5	477.90	531.68	565.98	583.23
	9	69.08	439.96	499.48	529.23
	9.5	0.00	35.49	170.11	370.94
	10	0.00	0.00	0.00	31.05
	10.5	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00
Southern East Coast	6	856.85	856.85	856.85	856.85
	6.5	803.11	811.46	820.85	826.08
	7	503.27	551.49	622.50	675.25

	7.5	319.67	367.28	393.92	411.37
	8	25.03	106.39	172.20	215.36
	8.5	0.00	0.50	11.90	36.35
	9	0.00	0.00	0.00	1.29
	9.5	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00
Washington Coast	6	242.47	242.54	242.66	242.80
	6.5	242.31	242.43	242.51	242.55
	7	241.47	241.91	242.00	242.00
	7.5	239.15	239.79	239.79	239.59
	8	237.24	237.56	237.57	237.60
	8.5	118.25	212.18	237.56	237.56
	9	0.00	46.77	106.03	146.34
	9.5	0.00	0.00	0.00	17.36
	10	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00
Western Gulf Coast	6	553.71	553.71	553.71	553.71
	6.5	553.71	553.71	553.71	553.71
	7	553.70	553.71	553.71	553.71
	7.5	417.18	534.67	553.71	553.71
	8	35.58	152.23	347.91	414.08
	8.5	2.84	17.16	35.66	54.71
	9	0.00	2.61	6.19	13.58
	9.5	0.00	0.00	2.47	4.24
	10	0.00	0.00	0.00	2.06
	10.5	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00

Table S7. Number of Turbines in Available Area and Potential Nameplate Capacity (GW) Without Wind Threshold.

Maximum number of V236-15 MW turbines that fit within available area (accounting for all restrictions in Table S1) and potential nameplate capacity (GW) in each region with no wind speed threshold.

	All Turbine Heights	
Region	**$N_{turbine}$**	**GW**
Alaska	899,130	13,486.95
Central Gulf Coast	40,429	606.44
Eastern Gulf Coast	67,924	1,018.86
Great Lakes	51,388	770.81
Hawaii	404,566	6,068.49
Mid-Atlantic Coast	41,916	628.74
Northern California Coast	64,140	962.10
Northern East Coast	52,797	791.95
North Carolina Coast	50,898	763.48
Oregon Coast	42,833	642.49
Puerto Rico	56,030	840.45
Southern California Coast	62,941	944.12
Southern East Coast	57,124	856.85
Washington Coast	16,192	242.88
Western Gulf Coast	36,914	553.71

Table S8. Mean Wind Speed in Available Areas (m/s).

Mean wind speed (m/s) in available areas (accounting for all restrictions in Table S1) for each wind speed threshold (6-12 m/s) and hub height scenario (100 m, 150 m, 200 m, and 250 m ASL) in all regions.

Region	Wind Speed Threshold (m/s)	100 m ASL Turbine Height	150 m ASL Turbine Height	200 m ASL Turbine Height	250 m ASL Turbine Height
Alaska	6	9.75	10.07	10.24	10.38
	6.5	9.75	10.07	10.24	10.38
	7	9.76	10.08	10.25	10.38
	7.5	9.78	10.08	10.25	10.39
	8	9.82	10.11	10.27	10.40
	8.5	9.90	10.17	10.31	10.44
	9	10.10	10.36	10.51	10.61
	9.5	10.24	10.50	10.67	10.81
	10	10.46	10.67	10.81	10.91
	10.5	10.77	10.95	11.07	11.18
	11	11.16	11.26	11.40	11.49
	11.5	11.67	11.65	11.68	11.78
	12	12.26	12.11	12.16	12.11
Central Gulf Coast	6	6.91	7.08	7.20	7.29
	6.5	6.91	7.08	7.20	7.29
	7	7.14	7.26	7.33	7.38
	7.5	N/A	7.57	7.61	7.68
	8	N/A	N/A	8.01	8.07
	8.5	N/A	N/A	N/A	8.56
	9	N/A	N/A	N/A	N/A
	9.5	N/A	N/A	N/A	N/A
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Eastern Gulf Coast	6	6.46	6.58	6.71	6.81
	6.5	6.77	6.82	6.87	6.91
	7	7.05	7.12	7.19	7.23
	7.5	N/A	N/A	7.62	7.72
	8	N/A	N/A	N/A	8.08
	8.5	N/A	N/A	N/A	N/A
	9	N/A	N/A	N/A	N/A
	9.5	N/A	N/A	N/A	N/A
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A

	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Great Lakes	6	8.77	9.18	9.46	9.67
	6.5	8.77	9.18	9.46	9.67
	7	8.79	9.18	9.46	9.67
	7.5	8.85	9.20	9.46	9.67
	8	8.92	9.26	9.48	9.68
	8.5	9.02	9.33	9.54	9.71
	9	9.23	9.43	9.62	9.78
	9.5	9.52	9.63	9.74	9.89
	10	N/A	N/A	10.04	10.10
	10.5	N/A	N/A	N/A	10.53
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Hawaii	6	7.76	7.88	7.92	7.94
	6.5	7.80	7.92	7.96	7.98
	7	7.85	7.97	8.00	8.03
	7.5	7.99	8.05	8.07	8.10
	8	8.70	8.55	8.57	8.58
	8.5	9.29	9.35	9.39	9.39
	9	9.61	9.67	9.72	9.77
	9.5	10.12	10.18	10.20	10.17
	10	10.47	10.54	10.59	10.63
	10.5	10.77	10.85	10.92	10.97
	11	11.22	11.19	11.23	11.29
	11.5	11.58	11.74	11.75	11.76
	12	N/A	12.03	12.11	12.17
Mid-Atlantic Coast	6	9.19	9.55	9.74	9.89
	6.5	9.19	9.55	9.74	9.89
	7	9.19	9.55	9.74	9.89
	7.5	9.19	9.55	9.74	9.89
	8	9.19	9.55	9.74	9.89
	8.5	9.21	9.55	9.74	9.89
	9	9.25	9.56	9.74	9.89
	9.5	N/A	9.65	9.78	9.90
	10	N/A	N/A	10.01	10.07
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A

	12	N/A	N/A	N/A	N/A
Northern California Coast	6	9.86	10.32	10.64	10.89
	6.5	9.87	10.33	10.65	10.90
	7	9.88	10.34	10.66	10.91
	7.5	9.88	10.35	10.66	10.92
	8	9.90	10.35	10.67	10.93
	8.5	9.93	10.36	10.68	10.94
	9	10.11	10.44	10.71	10.96
	9.5	10.22	10.62	10.87	11.05
	10	10.38	10.73	11.00	11.23
	10.5	10.76	10.93	11.11	11.33
	11	11.25	11.29	11.38	11.52
	11.5	11.59	11.71	11.71	11.80
	12	N/A	12.10	12.07	12.15
Northern East Coast	6	9.55	9.93	10.10	10.24
	6.5	9.55	9.93	10.10	10.24
	7	9.55	9.93	10.10	10.24
	7.5	9.55	9.93	10.10	10.24
	8	9.55	9.94	10.10	10.24
	8.5	9.56	9.94	10.10	10.24
	9	9.57	9.94	10.11	10.24
	9.5	9.72	9.97	10.13	10.25
	10	10.06	10.20	10.27	10.34
	10.5	N/A	10.55	10.60	10.63
	11	N/A	N/A	N/A	11.03
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
North Carolina Coast	6	8.46	8.62	8.73	8.81
	6.5	8.46	8.62	8.73	8.81
	7	8.46	8.62	8.73	8.81
	7.5	8.46	8.62	8.73	8.81
	8	8.52	8.64	8.73	8.82
	8.5	8.76	8.85	8.93	8.99
	9	9.00	9.11	9.21	9.28
	9.5	N/A	N/A	9.52	9.59
	10	N/A	N/A	N/A	10.00
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Oregon Coast	6	8.88	9.22	9.44	9.61

	6.5	8.88	9.22	9.44	9.61
	7	8.88	9.22	9.44	9.61
	7.5	8.88	9.22	9.44	9.61
	8	8.89	9.22	9.44	9.61
	8.5	9.06	9.27	9.44	9.61
	9	9.44	9.54	9.69	9.75
	9.5	9.97	10.01	10.04	10.10
	10	10.42	10.50	10.49	10.53
	10.5	10.79	10.93	10.97	11.00
	11	11.01	11.26	11.33	11.40
	11.5	N/A	11.52	11.64	11.71
	12	N/A	N/A	N/A	N/A
Puerto Rico	6	7.42	7.50	7.57	7.62
	6.5	7.42	7.50	7.57	7.62
	7	7.49	7.54	7.60	7.65
	7.5	7.72	7.74	7.78	7.81
	8	8.13	8.12	8.14	8.17
	8.5	N/A	N/A	8.65	8.71
	9	N/A	N/A	N/A	9.12
	9.5	N/A	N/A	N/A	N/A
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Southern California Coast	6	8.24	8.53	8.74	8.90
	6.5	8.33	8.62	8.82	8.98
	7	8.47	8.73	8.92	9.08
	7.5	8.63	8.91	9.10	9.25
	8	8.76	9.04	9.24	9.40
	8.5	8.85	9.16	9.36	9.54
	9	9.09	9.24	9.45	9.61
	9.5	N/A	9.61	9.66	9.73
	10	N/A	N/A	N/A	10.07
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Southern East Coast	6	7.23	7.35	7.43	7.50
	6.5	7.29	7.41	7.48	7.54
	7	7.57	7.66	7.68	7.70

	7.5	7.77	7.89	7.98	8.05
	8	8.09	8.16	8.22	8.28
	8.5	N/A	8.52	8.61	8.64
	9	N/A	N/A	N/A	9.06
	9.5	N/A	N/A	N/A	N/A
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Washington Coast	6	8.48	8.76	8.93	9.07
	6.5	8.48	8.76	8.93	9.07
	7	8.48	8.77	8.94	9.08
	7.5	8.50	8.78	8.95	9.09
	8	8.50	8.79	8.97	9.11
	8.5	8.69	8.83	8.97	9.11
	9	N/A	9.10	9.18	9.26
	9.5	N/A	N/A	N/A	9.55
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Western Gulf Coast	6	7.69	7.90	8.06	8.19
	6.5	7.69	7.90	8.06	8.19
	7	7.69	7.90	8.06	8.19
	7.5	7.79	7.92	8.06	8.19
	8	8.22	8.20	8.21	8.30
	8.5	8.63	8.73	8.84	8.88
	9	N/A	9.21	9.41	9.41
	9.5	N/A	N/A	9.73	9.95
	10	N/A	N/A	N/A	10.20
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A

Table S9. Capacity Factor Used for Calculations.

Unique capacity factor for each wind speed threshold (6-12 m/s) and hub height scenario (100 m, 150 m, 200 m, and 250 m ASL) in all regions.

Region	Wind Speed Threshold (m/s)	100 m ASL Turbine Height	150 m ASL Turbine Height	200 m ASL Turbine Height	250 m ASL Turbine Height
Alaska	6	0.579	0.604	0.616	0.625
	6.5	0.579	0.604	0.616	0.625
	7	0.580	0.604	0.616	0.625
	7.5	0.582	0.605	0.617	0.625
	8	0.585	0.607	0.618	0.626
	8.5	0.592	0.612	0.622	0.629
	9	0.609	0.629	0.639	0.644
	9.5	0.621	0.641	0.653	0.661
	10	0.641	0.656	0.665	0.670
	10.5	0.668	0.680	0.687	0.694
	11	0.702	0.707	0.716	0.720
	11.5	0.746	0.741	0.740	0.744
	12	0.798	0.780	0.781	0.773
Central Gulf Coast	6	0.332	0.345	0.353	0.360
	6.5	0.332	0.345	0.353	0.360
	7	0.352	0.361	0.365	0.367
	7.5	N/A	0.387	0.389	0.393
	8	N/A	N/A	0.423	0.426
	8.5	N/A	N/A	N/A	0.469
	9	N/A	N/A	N/A	N/A
	9.5	N/A	N/A	N/A	N/A
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Eastern Gulf Coast	6	0.292	0.301	0.311	0.318
	6.5	0.320	0.323	0.325	0.327
	7	0.344	0.348	0.353	0.354
	7.5	N/A	N/A	0.390	0.397
	8	N/A	N/A	N/A	0.428
	8.5	N/A	N/A	N/A	N/A
	9	N/A	N/A	N/A	N/A
	9.5	N/A	N/A	N/A	N/A
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A

	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Great Lakes	6	0.494	0.527	0.548	0.564
	6.5	0.494	0.527	0.548	0.564
	7	0.496	0.527	0.548	0.564
	7.5	0.501	0.529	0.548	0.564
	8	0.506	0.534	0.550	0.564
	8.5	0.515	0.539	0.555	0.567
	9	0.534	0.548	0.562	0.573
	9.5	0.559	0.566	0.573	0.582
	10	N/A	N/A	0.598	0.600
	10.5	N/A	N/A	N/A	0.638
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Hawaii	6	0.406	0.414	0.415	0.416
	6.5	0.409	0.418	0.419	0.419
	7	0.414	0.422	0.423	0.423
	7.5	0.426	0.429	0.429	0.429
	8	0.488	0.472	0.471	0.471
	8.5	0.539	0.541	0.542	0.539
	9	0.567	0.569	0.571	0.572
	9.5	0.611	0.613	0.612	0.607
	10	0.641	0.645	0.646	0.646
	10.5	0.668	0.672	0.674	0.676
	11	0.707	0.701	0.701	0.703
	11.5	0.738	0.748	0.746	0.743
	12	N/A	0.774	0.777	0.778
Mid-Atlantic Coast	6	0.530	0.559	0.572	0.583
	6.5	0.530	0.559	0.572	0.583
	7	0.530	0.559	0.572	0.583
	7.5	0.530	0.559	0.572	0.583
	8	0.531	0.559	0.572	0.583
	8.5	0.532	0.559	0.573	0.583
	9	0.535	0.560	0.573	0.583
	9.5	N/A	0.568	0.576	0.583
	10	N/A	N/A	0.595	0.598
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A

	12	N/A	N/A	N/A	N/A
Northern California Coast	6	0.588	0.626	0.650	0.668
	6.5	0.589	0.626	0.651	0.669
	7	0.590	0.627	0.651	0.670
	7.5	0.591	0.628	0.652	0.671
	8	0.592	0.629	0.653	0.672
	8.5	0.594	0.629	0.654	0.673
	9	0.610	0.636	0.656	0.674
	9.5	0.619	0.652	0.670	0.682
	10	0.634	0.661	0.681	0.698
	10.5	0.667	0.678	0.690	0.706
	11	0.709	0.709	0.714	0.723
	11.5	0.739	0.746	0.742	0.747
	12	N/A	0.780	0.773	0.776
Northern East Coast	6	0.561	0.592	0.604	0.613
	6.5	0.561	0.592	0.604	0.613
	7	0.561	0.592	0.604	0.613
	7.5	0.561	0.592	0.604	0.613
	8	0.561	0.592	0.604	0.613
	8.5	0.562	0.592	0.604	0.613
	9	0.564	0.593	0.604	0.613
	9.5	0.576	0.596	0.606	0.614
	10	0.606	0.615	0.618	0.621
	10.5	N/A	0.645	0.646	0.646
	11	N/A	N/A	N/A	0.680
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
North Carolina Coast	6	0.467	0.478	0.485	0.490
	6.5	0.467	0.478	0.485	0.490
	7	0.467	0.478	0.485	0.490
	7.5	0.467	0.478	0.485	0.490
	8	0.472	0.480	0.486	0.490
	8.5	0.492	0.498	0.503	0.505
	9	0.514	0.521	0.527	0.530
	9.5	N/A	N/A	0.554	0.557
	10	N/A	N/A	N/A	0.592
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Oregon Coast	6	0.504	0.530	0.547	0.559

	6.5	0.504	0.530	0.547	0.559
	7	0.504	0.530	0.547	0.559
	7.5	0.504	0.530	0.547	0.559
	8	0.504	0.530	0.547	0.559
	8.5	0.519	0.534	0.547	0.559
	9	0.552	0.558	0.568	0.571
	9.5	0.598	0.599	0.598	0.600
	10	0.637	0.641	0.637	0.637
	10.5	0.669	0.678	0.678	0.678
	11	0.688	0.707	0.710	0.712
	11.5	N/A	0.730	0.736	0.739
	12	N/A	N/A	N/A	N/A
Puerto Rico	6	0.376	0.381	0.385	0.388
	6.5	0.376	0.381	0.385	0.388
	7	0.382	0.385	0.388	0.390
	7.5	0.403	0.402	0.403	0.405
	8	0.438	0.435	0.435	0.435
	8.5	N/A	N/A	0.479	0.482
	9	N/A	N/A	N/A	0.516
	9.5	N/A	N/A	N/A	N/A
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Southern California Coast	6	0.448	0.471	0.486	0.498
	6.5	0.455	0.478	0.493	0.504
	7	0.468	0.488	0.502	0.513
	7.5	0.482	0.503	0.517	0.527
	8	0.492	0.515	0.529	0.540
	8.5	0.501	0.525	0.540	0.552
	9	0.522	0.532	0.547	0.559
	9.5	N/A	0.564	0.565	0.569
	10	N/A	N/A	N/A	0.598
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Southern East Coast	6	0.359	0.368	0.374	0.378
	6.5	0.365	0.373	0.378	0.381
	7	0.389	0.395	0.395	0.395

	7.5	0.406	0.415	0.421	0.425
	8	0.434	0.439	0.442	0.445
	8.5	N/A	0.470	0.475	0.475
	9	N/A	N/A	N/A	0.511
	9.5	N/A	N/A	N/A	N/A
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Washington Coast	6	0.468	0.491	0.503	0.512
	6.5	0.468	0.491	0.503	0.512
	7	0.469	0.491	0.503	0.513
	7.5	0.470	0.492	0.505	0.514
	8	0.470	0.493	0.506	0.515
	8.5	0.487	0.496	0.506	0.515
	9	N/A	0.520	0.525	0.528
	9.5	N/A	N/A	N/A	0.554
	10	N/A	N/A	N/A	N/A
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A
Western Gulf Coast	6	0.399	0.416	0.428	0.437
	6.5	0.399	0.416	0.428	0.437
	7	0.399	0.416	0.428	0.437
	7.5	0.408	0.417	0.428	0.437
	8	0.446	0.442	0.441	0.446
	8.5	0.481	0.488	0.495	0.496
	9	N/A	0.530	0.544	0.541
	9.5	N/A	N/A	0.572	0.587
	10	N/A	N/A	N/A	0.609
	10.5	N/A	N/A	N/A	N/A
	11	N/A	N/A	N/A	N/A
	11.5	N/A	N/A	N/A	N/A
	12	N/A	N/A	N/A	N/A

Table S10. Potential Output Power Density (MW/km^2).

Potential output power density (MW/km^2) in available areas (accounting for all restrictions in Table S1) for each wind speed threshold (6-12 m/s) and hub height scenario (100 m, 150 m, 200 m, and 250 m ASL) in all regions.

Region	Wind Speed Threshold (m/s)	100 m ASL Turbine Height	150 m ASL Turbine Height	200 m ASL Turbine Height	250 m ASL Turbine Height
Alaska	6	4.359	4.546	4.637	4.704
	6.5	4.363	4.548	4.639	4.705
	7	4.369	4.551	4.641	4.707
	7.5	4.383	4.557	4.644	4.709
	8	4.408	4.573	4.655	4.716
	8.5	4.457	4.611	4.684	4.740
	9	4.587	4.740	4.810	4.851
	9.5	4.680	4.829	4.918	4.982
	10	4.826	4.939	5.009	5.048
	10.5	5.031	5.121	5.172	5.224
	11	5.283	5.322	5.391	5.419
	11.5	5.616	5.578	5.574	5.606
	12	6.008	5.876	5.883	5.821
Central Gulf Coast	6	2.502	2.599	2.662	2.708
	6.5	2.502	2.599	2.662	2.708
	7	2.650	2.716	2.746	2.767
	7.5	0.000	2.916	2.933	2.960
	8	0.000	0.000	3.188	3.211
	8.5	0.000	0.000	0.000	3.530
	9	0.000	0.000	0.000	0.000
	9.5	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000
Eastern Gulf Coast	6	2.202	2.271	2.342	2.396
	6.5	2.408	2.432	2.451	2.462
	7	2.588	2.623	2.656	2.669
	7.5	0.000	0.000	2.934	2.988
	8	0.000	0.000	0.000	3.221
	8.5	0.000	0.000	0.000	0.000
	9	0.000	0.000	0.000	0.000
	9.5	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000

	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000
Great Lakes	6	3.717	3.969	4.127	4.249
	6.5	3.720	3.969	4.127	4.249
	7	3.732	3.971	4.127	4.249
	7.5	3.773	3.983	4.128	4.249
	8	3.814	4.021	4.142	4.249
	8.5	3.880	4.062	4.180	4.274
	9	4.019	4.130	4.236	4.319
	9.5	4.208	4.264	4.313	4.386
	10	0.000	0.000	4.504	4.522
	10.5	0.000	0.000	0.000	4.804
	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000
Hawaii	6	3.058	3.121	3.129	3.131
	6.5	3.081	3.147	3.154	3.157
	7	3.116	3.181	3.184	3.184
	7.5	3.205	3.231	3.230	3.231
	8	3.672	3.558	3.551	3.545
	8.5	4.057	4.078	4.083	4.062
	9	4.268	4.287	4.298	4.307
	9.5	4.605	4.616	4.613	4.568
	10	4.829	4.855	4.865	4.868
	10.5	5.028	5.058	5.078	5.089
	11	5.325	5.277	5.280	5.294
	11.5	5.562	5.634	5.616	5.597
	12	0.000	5.826	5.852	5.862
Mid-Atlantic Coast	6	3.994	4.209	4.312	4.388
	6.5	3.994	4.209	4.312	4.388
	7	3.994	4.209	4.312	4.388
	7.5	3.994	4.209	4.312	4.388
	8	3.996	4.209	4.312	4.388
	8.5	4.003	4.210	4.312	4.388
	9	4.032	4.218	4.312	4.388
	9.5	0.000	4.275	4.335	4.394
	10	0.000	0.000	4.484	4.505
	10.5	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000

	12	0.000	0.000	0.000	0.000
Northern California Coast	6	4.432	4.713	4.895	5.033
	6.5	4.437	4.717	4.901	5.040
	7	4.442	4.722	4.906	5.046
	7.5	4.448	4.728	4.912	5.052
	8	4.456	4.733	4.918	5.059
	8.5	4.477	4.740	4.924	5.067
	9	4.595	4.788	4.941	5.080
	9.5	4.665	4.909	5.046	5.137
	10	4.771	4.975	5.132	5.256
	10.5	5.021	5.106	5.198	5.317
	11	5.341	5.343	5.376	5.442
	11.5	5.565	5.618	5.590	5.622
	12	0.000	5.871	5.825	5.845
Northern East Coast	6	4.226	4.460	4.548	4.613
	6.5	4.226	4.460	4.548	4.613
	7	4.226	4.460	4.548	4.613
	7.5	4.227	4.460	4.548	4.613
	8	4.228	4.460	4.548	4.613
	8.5	4.232	4.461	4.548	4.613
	9	4.245	4.466	4.549	4.613
	9.5	4.339	4.485	4.564	4.622
	10	4.562	4.634	4.654	4.679
	10.5	0.000	4.861	4.868	4.863
	11	0.000	0.000	0.000	5.122
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000
North Carolina Coast	6	3.514	3.602	3.655	3.692
	6.5	3.514	3.602	3.655	3.692
	7	3.514	3.602	3.655	3.692
	7.5	3.514	3.602	3.655	3.692
	8	3.552	3.615	3.660	3.694
	8.5	3.709	3.753	3.785	3.804
	9	3.869	3.922	3.969	3.994
	9.5	0.000	0.000	4.172	4.193
	10	0.000	0.000	0.000	4.461
	10.5	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000
Oregon Coast	6	3.793	3.995	4.116	4.207

	6.5	3.793	3.995	4.116	4.207
	7	3.793	3.995	4.116	4.207
	7.5	3.793	3.995	4.116	4.207
	8	3.796	3.995	4.116	4.207
	8.5	3.909	4.025	4.120	4.207
	9	4.157	4.202	4.277	4.299
	9.5	4.507	4.508	4.504	4.522
	10	4.796	4.829	4.801	4.800
	10.5	5.040	5.106	5.107	5.107
	11	5.182	5.325	5.346	5.360
	11.5	0.000	5.496	5.542	5.565
	12	0.000	0.000	0.000	0.000
Puerto Rico	6	2.831	2.872	2.903	2.924
	6.5	2.834	2.873	2.903	2.924
	7	2.878	2.901	2.923	2.941
	7.5	3.032	3.029	3.039	3.048
	8	3.300	3.276	3.276	3.275
	8.5	0.000	0.000	3.605	3.627
	9	0.000	0.000	0.000	3.889
	9.5	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000
Southern California Coast	6	3.370	3.545	3.661	3.748
	6.5	3.430	3.600	3.713	3.799
	7	3.524	3.673	3.778	3.864
	7.5	3.627	3.788	3.895	3.972
	8	3.709	3.875	3.985	4.069
	8.5	3.770	3.956	4.068	4.159
	9	3.929	4.005	4.121	4.210
	9.5	0.000	4.247	4.257	4.284
	10	0.000	0.000	0.000	4.506
	10.5	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000
Southern East Coast	6	2.706	2.774	2.815	2.844
	6.5	2.746	2.811	2.846	2.872
	7	2.929	2.977	2.974	2.972

	7.5	3.061	3.129	3.169	3.198
	8	3.272	3.304	3.328	3.349
	8.5	0.000	3.539	3.580	3.580
	9	0.000	0.000	0.000	3.852
	9.5	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000
Washington Coast	6	3.526	3.694	3.788	3.857
	6.5	3.527	3.695	3.789	3.859
	7	3.531	3.698	3.792	3.862
	7.5	3.538	3.706	3.802	3.874
	8	3.543	3.713	3.809	3.881
	8.5	3.666	3.738	3.809	3.881
	9	0.000	3.918	3.951	3.980
	9.5	0.000	0.000	0.000	4.169
	10	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000
Western Gulf Coast	6	3.008	3.133	3.223	3.290
	6.5	3.008	3.133	3.223	3.290
	7	3.008	3.133	3.223	3.290
	7.5	3.074	3.143	3.223	3.290
	8	3.360	3.330	3.321	3.362
	8.5	3.626	3.673	3.726	3.738
	9	0.000	3.988	4.097	4.077
	9.5	0.000	0.000	4.307	4.424
	10	0.000	0.000	0.000	4.587
	10.5	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000

Table S11. Potential Energy Output (TWh)–Part 1.

Potential energy output (TWh) in available areas (accounting for all restrictions in Table S1) for each wind speed threshold (6-12 m/s) and two hub height scenarios (100 m and 150 m ASL) in all regions.

		100 m ASL Turbine Height				150 m ASL Turbine Height			
Region	**Wind Speed Threshold (m/s)**	**No Loss**	**5% Loss**	**10% Loss**	**20% Loss**	**No Loss**	**5% Loss**	**10% Loss**	**20% Loss**
Alaska	6	68,207.13	64,796.77	61,386.41	54,565.70	71,213.60	67,652.92	64,092.24	56,970.88
	6.5	68,159.17	64,751.21	61,343.25	54,527.34	71,186.58	67,627.25	64,067.92	56,949.26
	7	68,044.70	64,642.47	61,240.23	54,435.76	71,137.72	67,580.84	64,023.95	56,910.18
	7.5	67,674.85	64,291.11	60,907.37	54,139.88	71,009.14	67,458.68	63,908.22	56,807.31
	8	66,797.75	63,457.86	60,117.97	53,438.20	70,489.24	66,964.78	63,440.32	56,391.39
	8.5	64,391.53	61,171.95	57,952.38	51,513.22	68,868.47	65,425.04	61,981.62	55,094.77
	9	56,505.67	53,680.39	50,855.11	45,204.54	61,775.90	58,687.11	55,598.31	49,420.72
	9.5	49,037.60	46,585.72	44,133.84	39,230.08	56,146.66	53,339.33	50,532.00	44,917.33
	10	34,185.86	32,476.57	30,767.28	27,348.69	46,564.49	44,236.27	41,908.04	37,251.59
	10.5	15,190.65	14,431.12	13,671.59	12,152.52	28,363.74	26,945.55	25,527.36	22,690.99
	11	1,366.39	1,298.07	1,229.75	1,093.11	12,476.51	11,852.68	11,228.86	9,981.21
	11.5	125.00	118.75	112.50	100.00	950.43	902.91	855.39	760.34
	12	0.32	0.30	0.29	0.25	61.24	58.18	55.11	48.99
Central Gulf Coast	6	1,764.57	1,676.34	1,588.11	1,411.65	1,833.63	1,741.95	1,650.27	1,466.90
	6.5	1,764.57	1,676.34	1,588.11	1,411.65	1,833.63	1,741.95	1,650.27	1,466.90
	7	724.80	688.56	652.32	579.84	1,102.99	1,047.84	992.69	882.39
	7.5	0.00	0.00	0.00	0.00	94.47	89.75	85.02	75.58
	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Gulf Coast	6	2,321.02	2,204.97	2,088.92	1,856.82	2,690.82	2,556.28	2,421.74	2,152.66
	6.5	1,003.07	952.92	902.77	802.46	1,528.22	1,451.81	1,375.40	1,222.58
	7	136.42	129.60	122.78	109.14	411.70	391.12	370.53	329.36
	7.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Lakes	6	3,331.27	3,164.71	2,998.15	2,665.02	3,558.66	3,380.72	3,202.79	2,846.93
	6.5	3,327.29	3,160.93	2,994.56	2,661.83	3,558.57	3,380.64	3,202.71	2,846.85
	7	3,307.43	3,142.06	2,976.69	2,645.95	3,556.65	3,378.82	3,200.98	2,845.32
	7.5	3,207.32	3,046.95	2,886.59	2,565.86	3,532.46	3,355.84	3,179.22	2,825.97
	8	3,061.44	2,908.37	2,755.30	2,449.15	3,421.65	3,250.56	3,079.48	2,737.32
	8.5	2,687.28	2,552.92	2,418.55	2,149.82	3,245.28	3,083.02	2,920.75	2,596.22
	9	1,467.38	1,394.01	1,320.64	1,173.90	2,775.47	2,636.70	2,497.93	2,220.38
	9.5	63.48	60.30	57.13	50.78	1,193.97	1,134.28	1,074.58	955.18
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hawaii	6	20,566.99	19,538.64	18,510.29	16,453.59	21,053.29	20,000.62	18,947.96	16,842.63
	6.5	20,250.18	19,237.67	18,225.16	16,200.15	20,735.74	19,698.95	18,662.16	16,588.59
	7	19,438.07	18,466.17	17,494.27	15,550.46	20,021.79	19,020.70	18,019.61	16,017.43
	7.5	15,726.21	14,939.90	14,153.59	12,580.97	18,259.58	17,346.60	16,433.62	14,607.66
	8	4,750.59	4,513.06	4,275.53	3,800.47	7,196.47	6,836.65	6,476.82	5,757.18
	8.5	2,507.80	2,382.41	2,257.02	2,006.24	2,740.75	2,603.71	2,466.67	2,192.60
	9	1,655.66	1,572.88	1,490.09	1,324.53	1,883.73	1,789.55	1,695.36	1,506.99
	9.5	781.07	742.02	702.97	624.86	924.38	878.16	831.94	739.50
	10	441.17	419.11	397.06	352.94	536.00	509.20	482.40	428.80
	10.5	190.58	181.05	171.52	152.47	274.37	260.65	246.93	219.49
	11	19.05	18.10	17.15	15.24	72.81	69.17	65.53	58.25
	11.5	2.60	2.47	2.34	2.08	7.72	7.34	6.95	6.18
	12	0.00	0.00	0.00	0.00	0.45	0.43	0.41	0.36
Mid-Atlantic Coast	6	2,920.53	2,774.51	2,628.48	2,336.43	3,078.01	2,924.11	2,770.21	2,462.41
	6.5	2,920.53	2,774.51	2,628.48	2,336.43	3,078.01	2,924.11	2,770.21	2,462.41
	7	2,920.36	2,774.34	2,628.32	2,336.29	3,078.01	2,924.11	2,770.21	2,462.41
	7.5	2,919.57	2,773.59	2,627.61	2,335.65	3,078.01	2,924.11	2,770.21	2,462.41
	8	2,915.44	2,769.67	2,623.90	2,332.36	3,077.75	2,923.86	2,769.98	2,462.20
	8.5	2,881.83	2,737.74	2,593.64	2,305.46	3,075.45	2,921.67	2,767.90	2,460.36
	9	2,535.71	2,408.92	2,282.14	2,028.57	3,028.41	2,876.99	2,725.57	2,422.73
	9.5	0.00	0.00	0.00	0.00	2,126.57	2,020.24	1,913.91	1,701.25
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern California Coast	6	4,952.09	4,704.48	4,456.88	3,961.67	5,267.22	5,003.86	4,740.50	4,213.78
	6.5	4,947.00	4,699.65	4,452.30	3,957.60	5,262.95	4,999.80	4,736.65	4,210.36
	7	4,940.01	4,693.01	4,446.01	3,952.01	5,257.49	4,994.61	4,731.74	4,205.99
	7.5	4,929.29	4,682.82	4,436.36	3,943.43	5,249.29	4,986.82	4,724.36	4,199.43
	8	4,911.81	4,666.22	4,420.63	3,929.45	5,237.83	4,975.94	4,714.05	4,190.26
	8.5	4,834.39	4,592.67	4,350.95	3,867.51	5,219.58	4,958.60	4,697.62	4,175.67
	9	4,281.96	4,067.86	3,853.76	3,425.57	5,027.85	4,776.45	4,525.06	4,022.28
	9.5	3,862.53	3,669.40	3,476.27	3,090.02	4,467.25	4,243.89	4,020.52	3,573.80
	10	2,820.09	2,679.08	2,538.08	2,256.07	4,052.53	3,849.91	3,647.28	3,242.03
	10.5	809.70	769.21	728.73	647.76	2,794.97	2,655.22	2,515.48	2,235.98
	11	121.01	114.96	108.91	96.81	1,009.61	959.13	908.65	807.69
	11.5	19.58	18.61	17.63	15.67	202.72	192.58	182.45	162.18
	12	0.00	0.00	0.00	0.00	23.83	22.64	21.45	19.06
Northern East Coast	6	3,892.98	3,698.33	3,503.69	3,114.39	4,108.04	3,902.64	3,697.24	3,286.44
	6.5	3,892.98	3,698.33	3,503.68	3,114.38	4,108.04	3,902.64	3,697.24	3,286.44
	7	3,892.53	3,697.90	3,503.28	3,114.02	4,108.04	3,902.64	3,697.24	3,286.44
	7.5	3,891.38	3,696.81	3,502.24	3,113.10	4,108.04	3,902.64	3,697.24	3,286.44
	8	3,888.22	3,693.81	3,499.40	3,110.58	4,107.32	3,901.96	3,696.59	3,285.86
	8.5	3,873.37	3,679.70	3,486.03	3,098.70	4,105.24	3,899.97	3,694.71	3,284.19
	9	3,784.71	3,595.48	3,406.24	3,027.77	4,080.91	3,876.87	3,672.82	3,264.73
	9.5	2,339.73	2,222.75	2,105.76	1,871.79	3,914.38	3,718.66	3,522.94	3,131.51
	10	90.24	85.73	81.22	72.19	1,828.43	1,737.01	1,645.59	1,462.75
	10.5	0.00	0.00	0.00	0.00	43.99	41.80	39.60	35.20
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Carolina Coast	6	3,120.29	2,964.28	2,808.26	2,496.23	3,198.98	3,039.03	2,879.08	2,559.18
	6.5	3,120.29	2,964.27	2,808.26	2,496.23	3,198.98	3,039.03	2,879.08	2,559.18
	7	3,119.96	2,963.97	2,807.97	2,495.97	3,198.98	3,039.03	2,879.08	2,559.18
	7.5	3,119.47	2,963.50	2,807.53	2,495.58	3,198.98	3,039.03	2,879.08	2,559.18
	8	2,845.60	2,703.32	2,561.04	2,276.48	3,115.89	2,960.09	2,804.30	2,492.71
	8.5	1,536.50	1,459.68	1,382.85	1,229.20	2,065.48	1,962.20	1,858.93	1,652.38
	9	0.00	0.00	0.00	0.00	726.78	690.45	654.11	581.43
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Oregon Coast	6	2,834.37	2,692.65	2,550.93	2,267.49	2,985.51	2,836.23	2,686.96	2,388.41
	6.5	2,834.37	2,692.65	2,550.93	2,267.49	2,985.51	2,836.23	2,686.95	2,388.40
	7	2,834.33	2,692.62	2,550.90	2,267.47	2,985.50	2,836.23	2,686.95	2,388.40
	7.5	2,834.24	2,692.53	2,550.81	2,267.39	2,985.48	2,836.21	2,686.93	2,388.38
	8	2,820.43	2,679.40	2,538.38	2,256.34	2,985.38	2,836.11	2,686.84	2,388.30
	8.5	2,220.41	2,109.39	1,998.37	1,776.33	2,850.26	2,707.74	2,565.23	2,280.20
	9	1,064.26	1,011.04	957.83	851.41	1,944.15	1,846.94	1,749.74	1,555.32
	9.5	360.17	342.16	324.15	288.13	827.92	786.52	745.13	662.34
	10	142.11	135.00	127.90	113.69	332.16	315.55	298.94	265.73
	10.5	52.37	49.75	47.13	41.90	143.07	135.92	128.76	114.45
	11	3.71	3.52	3.34	2.97	57.46	54.58	51.71	45.97
	11.5	0.00	0.00	0.00	0.00	5.87	5.58	5.28	4.69
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Puerto Rico	6	2,766.79	2,628.45	2,490.11	2,213.43	2,807.86	2,667.47	2,527.08	2,246.29
	6.5	2,756.90	2,619.05	2,481.21	2,205.52	2,805.69	2,665.41	2,525.12	2,244.55
	7	2,490.20	2,365.69	2,241.18	1,992.16	2,647.21	2,514.85	2,382.49	2,117.77
	7.5	1,219.88	1,158.89	1,097.89	975.90	1,640.15	1,558.15	1,476.14	1,312.12
	8	134.08	127.38	120.67	107.26	210.61	200.08	189.55	168.49
	8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Southern California Coast	6	3,288.43	3,124.01	2,959.59	2,630.75	3,486.65	3,312.32	3,137.99	2,789.32
	6.5	3,197.88	3,037.99	2,878.09	2,558.30	3,414.51	3,243.79	3,073.06	2,731.61
	7	3,008.77	2,858.33	2,707.89	2,407.02	3,282.87	3,118.72	2,954.58	2,626.29
	7.5	2,738.32	2,601.40	2,464.48	2,190.65	3,023.75	2,872.56	2,721.38	2,419.00
	8	2,455.02	2,332.27	2,209.52	1,964.01	2,774.23	2,635.52	2,496.81	2,219.39
	8.5	2,095.88	1,991.09	1,886.29	1,676.71	2,446.55	2,324.22	2,201.90	1,957.24
	9	315.68	299.90	284.11	252.54	2,049.48	1,947.01	1,844.54	1,639.59
	9.5	0.00	0.00	0.00	0.00	175.30	166.54	157.77	140.24
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Southern East Coast	6	2,696.66	2,561.83	2,427.00	2,157.33	2,764.23	2,626.02	2,487.81	2,211.39
	6.5	2,565.55	2,437.27	2,308.99	2,052.44	2,652.89	2,520.25	2,387.60	2,122.31

	7	1,714.43	1,628.71	1,542.99	1,371.54	1,909.69	1,814.21	1,718.72	1,527.76
	7.5	1,138.22	1,081.31	1,024.40	910.58	1,336.83	1,269.99	1,203.15	1,069.46
	8	95.27	90.51	85.75	76.22	408.80	388.36	367.92	327.04
	8.5	0.00	0.00	0.00	0.00	2.04	1.94	1.84	1.64
	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Washington Coast	6	994.45	944.73	895.01	795.56	1,042.17	990.06	937.96	833.74
	6.5	994.05	944.35	894.65	795.24	1,041.89	989.80	937.70	833.51
	7	991.66	942.07	892.49	793.32	1,040.42	988.40	936.38	832.34
	7.5	984.26	935.05	885.84	787.41	1,033.72	982.03	930.35	826.97
	8	977.62	928.74	879.86	782.10	1,025.94	974.64	923.35	820.75
	8.5	504.28	479.06	453.85	403.42	922.51	876.38	830.26	738.01
	9	0.00	0.00	0.00	0.00	213.12	202.47	191.81	170.50
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Western Gulf Coast	6	1,937.01	1,840.16	1,743.31	1,549.61	2,017.98	1,917.09	1,816.19	1,614.39
	6.5	1,937.01	1,840.16	1,743.31	1,549.61	2,017.98	1,917.09	1,816.19	1,614.39
	7	1,937.01	1,840.16	1,743.31	1,549.61	2,017.98	1,917.09	1,816.19	1,614.39
	7.5	1,491.50	1,416.93	1,342.35	1,193.20	1,954.89	1,857.14	1,759.40	1,563.91
	8	139.06	132.11	125.16	111.25	589.55	560.07	530.60	471.64
	8.5	11.97	11.37	10.77	9.57	73.34	69.67	66.00	58.67
	9	0.00	0.00	0.00	0.00	12.12	11.51	10.91	9.70
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table S12. Potential Energy Output (TWh)–Part 2.

Potential energy output (TWh) in available areas (accounting for all restrictions in Table S1) for each wind speed threshold (6-12 m/s) and two hub height scenarios (200 m and 250 m ASL) in all regions.

		200 m ASL Turbine Height				250 m ASL Turbine Height			
Region	Wind Speed Threshold (m/s)	No Loss	5% Loss	10% Loss	20% Loss	No Loss	5% Loss	10% Loss	20% Loss
Alaska	6	72,675.03	69,041.28	65,407.52	58,140.02	73,742.00	70,054.90	66,367.80	58,993.60
	6.5	72,659.35	69,026.38	65,393.41	58,127.48	73,731.35	70,044.78	66,358.21	58,985.08
	7	72,625.21	68,993.95	65,362.69	58,100.17	73,710.14	70,024.63	66,339.13	58,968.11
	7.5	72,553.13	68,925.48	65,297.82	58,042.51	73,659.36	69,976.39	66,293.42	58,927.49
	8	72,201.45	68,591.38	64,981.30	57,761.16	73,465.88	69,792.59	66,119.30	58,772.71
	8.5	71,059.52	67,506.55	63,953.57	56,847.62	72,544.09	68,916.89	65,289.68	58,035.27
	9	64,564.43	61,336.21	58,107.99	51,651.54	67,092.33	63,737.71	60,383.10	53,673.86
	9.5	58,459.28	55,536.32	52,613.35	46,767.43	60,222.66	57,211.53	54,200.39	48,178.13
	10	51,156.61	48,598.78	46,040.95	40,925.29	55,471.37	52,697.80	49,924.23	44,377.09
	10.5	36,404.27	34,584.06	32,763.85	29,123.42	40,420.02	38,399.02	36,378.02	32,336.01
	11	18,529.44	17,602.97	16,676.50	14,823.55	24,518.82	23,292.88	22,066.94	19,615.06
	11.5	6,884.08	6,539.88	6,195.67	5,507.26	11,985.58	11,386.30	10,787.02	9,588.46
	12	178.56	169.63	160.71	142.85	1,543.90	1,466.71	1,389.51	1,235.12
Central Gulf Coast	6	1,877.67	1,783.78	1,689.90	1,502.13	1,910.05	1,814.55	1,719.05	1,528.04
	6.5	1,877.67	1,783.78	1,689.90	1,502.13	1,910.05	1,814.55	1,719.05	1,528.04
	7	1,372.95	1,304.31	1,235.66	1,098.36	1,570.36	1,491.85	1,413.33	1,256.29
	7.5	350.38	332.86	315.34	280.31	512.80	487.16	461.52	410.24
	8	0.18	0.17	0.16	0.15	12.02	11.42	10.82	9.62
	8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Gulf Coast	6	2,776.06	2,637.26	2,498.45	2,220.85	2,840.01	2,698.01	2,556.01	2,272.01
	6.5	1,931.75	1,835.17	1,738.58	1,545.40	2,285.01	2,170.76	2,056.51	1,828.01
	7	641.33	609.26	577.19	513.06	884.77	840.53	796.29	707.81
	7.5	36.25	34.43	32.62	29.00	95.29	90.52	85.76	76.23
	8	0.00	0.00	0.00	0.00	8.58	8.15	7.72	6.86
	8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Lakes	6	3,700.57	3,515.55	3,330.52	2,960.46	3,809.58	3,619.10	3,428.62	3,047.66
	6.5	3,700.57	3,515.55	3,330.52	2,960.46	3,809.58	3,619.10	3,428.62	3,047.66
	7	3,700.57	3,515.54	3,330.51	2,960.45	3,809.58	3,619.10	3,428.62	3,047.66
	7.5	3,699.65	3,514.66	3,329.68	2,959.72	3,809.58	3,619.10	3,428.62	3,047.66
	8	3,664.15	3,480.95	3,297.74	2,931.32	3,808.66	3,618.23	3,427.80	3,046.93
	8.5	3,523.82	3,347.63	3,171.44	2,819.06	3,727.88	3,541.48	3,355.09	2,982.30
	9	3,200.96	3,040.92	2,880.87	2,560.77	3,501.14	3,326.08	3,151.03	2,800.91
	9.5	2,361.73	2,243.65	2,125.56	1,889.39	2,959.13	2,811.17	2,663.22	2,367.30
	10	24.59	23.36	22.13	19.67	903.73	858.55	813.36	722.99
	10.5	0.00	0.00	0.00	0.00	1.98	1.88	1.78	1.59
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hawaii	6	21,144.80	20,087.56	19,030.32	16,915.84	21,184.42	20,125.20	19,065.98	16,947.54
	6.5	20,828.63	19,787.20	18,745.77	16,662.91	20,870.36	19,826.84	18,783.33	16,696.29
	7	20,218.11	19,207.20	18,196.30	16,174.49	20,321.17	19,305.11	18,289.05	16,256.93
	7.5	18,725.20	17,788.94	16,852.68	14,980.16	18,824.91	17,883.66	16,942.42	15,059.92
	8	7,861.57	7,468.49	7,075.41	6,289.25	8,330.52	7,913.99	7,497.46	6,664.41
	8.5	2,913.56	2,767.88	2,622.20	2,330.85	3,145.89	2,988.59	2,831.30	2,516.71
	9	2,035.23	1,933.47	1,831.70	1,628.18	2,133.47	2,026.80	1,920.12	1,706.78
	9.5	1,038.27	986.36	934.44	830.62	1,225.99	1,164.69	1,103.39	980.79
	10	607.92	577.52	547.13	486.34	665.50	632.22	598.95	532.40
	10.5	328.91	312.46	296.02	263.13	374.05	355.35	336.64	299.24
	11	126.59	120.26	113.93	101.27	168.60	160.17	151.74	134.88
	11.5	14.03	13.33	12.63	11.23	31.09	29.54	27.98	24.87
	12	2.33	2.21	2.09	1.86	4.43	4.20	3.98	3.54
Mid-Atlantic Coast	6	3,153.17	2,995.51	2,837.85	2,522.54	3,208.78	3,048.34	2,887.90	2,567.02
	6.5	3,153.17	2,995.51	2,837.85	2,522.54	3,208.78	3,048.34	2,887.90	2,567.02
	7	3,153.17	2,995.51	2,837.85	2,522.54	3,208.78	3,048.34	2,887.90	2,567.02
	7.5	3,153.17	2,995.51	2,837.85	2,522.54	3,208.78	3,048.34	2,887.90	2,567.02
	8	3,153.17	2,995.51	2,837.85	2,522.54	3,208.78	3,048.34	2,887.90	2,567.02
	8.5	3,153.13	2,995.47	2,837.81	2,522.50	3,208.78	3,048.34	2,887.90	2,567.02
	9	3,151.12	2,993.57	2,836.01	2,520.90	3,208.75	3,048.32	2,887.88	2,567.00
	9.5	2,875.15	2,731.39	2,587.64	2,300.12	3,147.20	2,989.84	2,832.48	2,517.76
	10	7.50	7.12	6.75	6.00	879.89	835.90	791.91	703.92
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern California Coast	6	5,473.49	5,199.82	4,926.14	4,378.79	5,629.51	5,348.04	5,066.56	4,503.61
	6.5	5,468.48	5,195.06	4,921.64	4,374.79	5,623.88	5,342.69	5,061.49	4,499.10
	7	5,463.10	5,189.94	4,916.79	4,370.48	5,617.91	5,337.01	5,056.12	4,494.33
	7.5	5,455.44	5,182.67	4,909.90	4,364.35	5,610.43	5,329.91	5,049.39	4,488.34
	8	5,444.56	5,172.33	4,900.11	4,355.65	5,599.41	5,319.44	5,039.47	4,479.53
	8.5	5,428.80	5,157.36	4,885.92	4,343.04	5,583.16	5,304.01	5,024.85	4,466.53
	9	5,373.11	5,104.46	4,835.80	4,298.49	5,545.67	5,268.38	4,991.10	4,436.53
	9.5	4,921.91	4,675.81	4,429.72	3,937.53	5,315.74	5,049.95	4,784.17	4,252.59
	10	4,488.80	4,264.36	4,039.92	3,591.04	4,774.12	4,535.42	4,296.71	3,819.30
	10.5	3,982.76	3,783.63	3,584.49	3,186.21	4,403.29	4,183.12	3,962.96	3,522.63
	11	2,315.30	2,199.53	2,083.77	1,852.24	3,274.15	3,110.44	2,946.73	2,619.32
	11.5	760.23	722.22	684.21	608.19	1,689.65	1,605.16	1,520.68	1,351.72
	12	44.36	42.14	39.92	35.48	392.95	373.30	353.65	314.36
Northern East Coast	6	4,189.89	3,980.39	3,770.90	3,351.91	4,249.51	4,037.03	3,824.55	3,399.60
	6.5	4,189.89	3,980.39	3,770.90	3,351.91	4,249.51	4,037.03	3,824.55	3,399.60
	7	4,189.89	3,980.39	3,770.90	3,351.91	4,249.51	4,037.03	3,824.55	3,399.60
	7.5	4,189.89	3,980.39	3,770.90	3,351.91	4,249.51	4,037.03	3,824.55	3,399.60
	8	4,189.89	3,980.39	3,770.90	3,351.91	4,249.51	4,037.03	3,824.55	3,399.60
	8.5	4,189.73	3,980.24	3,770.76	3,351.78	4,249.51	4,037.03	3,824.55	3,399.60
	9	4,187.49	3,978.11	3,768.74	3,349.99	4,249.42	4,036.94	3,824.47	3,399.53
	9.5	4,084.22	3,880.01	3,675.80	3,267.37	4,189.02	3,979.57	3,770.12	3,351.22
	10	2,807.44	2,667.06	2,526.69	2,245.95	3,465.26	3,292.00	3,118.73	2,772.21
	10.5	323.29	307.13	290.96	258.63	911.54	865.97	820.39	729.24
	11	0.00	0.00	0.00	0.00	2.85	2.70	2.56	2.28
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Carolina Coast	6	3,245.61	3,083.33	2,921.05	2,596.49	3,278.54	3,114.61	2,950.69	2,622.83
	6.5	3,245.61	3,083.33	2,921.05	2,596.49	3,278.54	3,114.61	2,950.69	2,622.83
	7	3,245.61	3,083.33	2,921.05	2,596.49	3,278.54	3,114.61	2,950.69	2,622.83
	7.5	3,245.61	3,083.33	2,921.05	2,596.49	3,278.54	3,114.61	2,950.69	2,622.83
	8	3,219.00	3,058.05	2,897.10	2,575.20	3,268.98	3,105.54	2,942.09	2,615.19
	8.5	2,338.38	2,221.46	2,104.54	1,870.70	2,545.34	2,418.08	2,290.81	2,036.28
	9	978.51	929.58	880.66	782.81	1,217.15	1,156.29	1,095.43	973.72
	9.5	23.07	21.91	20.76	18.45	229.28	217.82	206.35	183.43
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Oregon Coast	6	3,075.94	2,922.14	2,768.35	2,460.75	3,143.64	2,986.46	2,829.27	2,514.91
	6.5	3,075.94	2,922.14	2,768.35	2,460.75	3,143.64	2,986.46	2,829.27	2,514.91
	7	3,075.94	2,922.14	2,768.34	2,460.75	3,143.64	2,986.46	2,829.27	2,514.91
	7.5	3,075.93	2,922.14	2,768.34	2,460.75	3,143.63	2,986.45	2,829.27	2,514.91
	8	3,075.91	2,922.12	2,768.32	2,460.73	3,143.62	2,986.44	2,829.26	2,514.90
	8.5	3,058.22	2,905.31	2,752.40	2,446.58	3,143.47	2,986.30	2,829.12	2,514.78
	9	2,289.79	2,175.30	2,060.81	1,831.83	2,700.67	2,565.63	2,430.60	2,160.53
	9.5	1,324.13	1,257.92	1,191.71	1,059.30	1,709.60	1,624.12	1,538.64	1,367.68
	10	582.45	553.33	524.21	465.96	841.48	799.40	757.33	673.18
	10.5	236.88	225.04	213.19	189.50	351.00	333.45	315.90	280.80
	11	100.14	95.13	90.13	80.11	156.22	148.41	140.60	124.97
	11.5	27.90	26.51	25.11	22.32	56.71	53.88	51.04	45.37
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Puerto Rico	6	2,838.14	2,696.23	2,554.33	2,270.51	2,858.44	2,715.52	2,572.60	2,286.75
	6.5	2,838.11	2,696.20	2,554.30	2,270.49	2,858.44	2,715.52	2,572.60	2,286.75
	7	2,733.43	2,596.76	2,460.08	2,186.74	2,769.08	2,630.62	2,492.17	2,215.26
	7.5	1,862.75	1,769.61	1,676.47	1,490.20	1,993.92	1,894.22	1,794.53	1,595.13
	8	295.94	281.14	266.35	236.75	382.77	363.63	344.49	306.21
	8.5	1.23	1.16	1.10	0.98	6.29	5.98	5.67	5.04
	9	0.00	0.00	0.00	0.00	0.77	0.73	0.69	0.61
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Southern California Coast	6	3,604.20	3,423.99	3,243.78	2,883.36	3,692.83	3,508.18	3,323.54	2,954.26
	6.5	3,541.52	3,364.44	3,187.36	2,833.21	3,634.89	3,453.15	3,271.40	2,907.91
	7	3,434.73	3,262.99	3,091.26	2,747.79	3,536.07	3,359.27	3,182.47	2,828.86
	7.5	3,194.44	3,034.72	2,875.00	2,555.56	3,325.73	3,159.44	2,993.16	2,660.58
	8	2,961.85	2,813.76	2,665.67	2,369.48	3,099.95	2,944.95	2,789.95	2,479.96
	8.5	2,678.16	2,544.25	2,410.34	2,142.53	2,821.36	2,680.29	2,539.22	2,257.09
	9	2,394.08	2,274.38	2,154.67	1,915.26	2,591.60	2,462.02	2,332.44	2,073.28
	9.5	842.27	800.16	758.05	673.82	1,848.55	1,756.12	1,663.69	1,478.84
	10	0.00	0.00	0.00	0.00	162.75	154.61	146.47	130.20
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Southern East Coast	6	2,805.38	2,665.11	2,524.84	2,244.31	2,834.49	2,692.76	2,551.04	2,267.59
	6.5	2,717.29	2,581.42	2,445.56	2,173.83	2,759.33	2,621.37	2,483.40	2,207.47

	7	2,153.06	2,045.40	1,937.75	1,722.44	2,334.03	2,217.33	2,100.63	1,867.22
	7.5	1,451.90	1,379.30	1,306.71	1,161.52	1,530.21	1,453.70	1,377.19	1,224.17
	8	666.61	633.28	599.95	533.29	838.82	796.87	754.93	671.05
	8.5	49.53	47.05	44.58	39.62	151.37	143.80	136.23	121.09
	9	0.00	0.00	0.00	0.00	5.79	5.50	5.21	4.63
	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Washington Coast	6	1,069.12	1,015.67	962.21	855.30	1,089.25	1,034.79	980.33	871.40
	6.5	1,068.79	1,015.35	961.91	855.03	1,088.67	1,034.23	979.80	870.93
	7	1,067.34	1,013.97	960.61	853.87	1,087.07	1,032.71	978.36	869.65
	7.5	1,060.36	1,007.35	954.33	848.29	1,079.52	1,025.55	971.57	863.62
	8	1,052.66	1,000.03	947.39	842.13	1,072.58	1,018.95	965.32	858.06
	8.5	1,052.63	999.99	947.36	842.10	1,072.46	1,018.84	965.22	857.97
	9	487.26	462.89	438.53	389.80	677.48	643.60	609.73	541.98
	9.5	0.00	0.00	0.00	0.00	84.18	79.98	75.77	67.35
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Western Gulf Coast	6	2,075.60	1,971.82	1,868.04	1,660.48	2,118.60	2,012.67	1,906.74	1,694.88
	6.5	2,075.60	1,971.82	1,868.04	1,660.48	2,118.60	2,012.67	1,906.74	1,694.88
	7	2,075.60	1,971.82	1,868.04	1,660.48	2,118.60	2,012.67	1,906.74	1,694.88
	7.5	2,075.60	1,971.82	1,868.04	1,660.48	2,118.60	2,012.67	1,906.74	1,694.88
	8	1,343.86	1,276.67	1,209.47	1,075.09	1,619.39	1,538.42	1,457.45	1,295.51
	8.5	154.56	146.83	139.11	123.65	237.91	226.01	214.11	190.32
	9	29.48	28.01	26.53	23.59	64.41	61.19	57.97	51.53
	9.5	12.38	11.76	11.14	9.90	21.84	20.75	19.66	17.47
	10	0.00	0.00	0.00	0.00	10.97	10.42	9.87	8.78
	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table S13. Potential Output Energy Density (TWh/km^2)–Part 1.

Potential output energy density (TWh/km^2) in available areas (accounting for all restrictions in Table S1) for each wind speed threshold (6-12 m/s) and two hub height scenarios (100 m and 150 m ASL) in all regions.

		100 m ASL Turbine Height				150 m ASL Turbine Height			
Region	**Wind Speed Threshold (m/s)**	**No Loss**	**5% Loss**	**10% Loss**	**20% Loss**	**No Loss**	**5% Loss**	**10% Loss**	**20% Loss**
Alaska	6	0.038	0.036	0.034	0.031	0.040	0.038	0.036	0.032
	6.5	0.038	0.036	0.034	0.031	0.040	0.038	0.036	0.032
	7	0.038	0.036	0.034	0.031	0.040	0.038	0.036	0.032
	7.5	0.038	0.036	0.035	0.031	0.040	0.038	0.036	0.032
	8	0.039	0.037	0.035	0.031	0.040	0.038	0.036	0.032
	8.5	0.039	0.037	0.035	0.031	0.040	0.038	0.036	0.032
	9	0.040	0.038	0.036	0.032	0.042	0.039	0.037	0.033
	9.5	0.041	0.039	0.037	0.033	0.042	0.040	0.038	0.034
	10	0.042	0.040	0.038	0.034	0.043	0.041	0.039	0.035
	10.5	0.044	0.042	0.040	0.035	0.045	0.043	0.040	0.036
	11	0.046	0.044	0.042	0.037	0.047	0.044	0.042	0.037
	11.5	0.049	0.047	0.044	0.039	0.049	0.046	0.044	0.039
	12	0.053	0.050	0.047	0.042	0.051	0.049	0.046	0.041
Central Gulf Coast	6	0.022	0.021	0.020	0.018	0.023	0.022	0.020	0.018
	6.5	0.022	0.021	0.020	0.018	0.023	0.022	0.020	0.018
	7	0.023	0.022	0.021	0.019	0.024	0.023	0.021	0.019
	7.5	0.000	0.000	0.000	0.000	0.026	0.024	0.023	0.020
	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Eastern Gulf Coast	6	0.019	0.018	0.017	0.015	0.020	0.019	0.018	0.016
	6.5	0.021	0.020	0.019	0.017	0.021	0.020	0.019	0.017
	7	0.023	0.022	0.020	0.018	0.023	0.022	0.021	0.018
	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Great Lakes	6	0.033	0.031	0.029	0.026	0.035	0.033	0.031	0.028
	6.5	0.033	0.031	0.029	0.026	0.035	0.033	0.031	0.028
	7	0.033	0.031	0.029	0.026	0.035	0.033	0.031	0.028
	7.5	0.033	0.031	0.030	0.026	0.035	0.033	0.031	0.028
	8	0.033	0.032	0.030	0.027	0.035	0.033	0.032	0.028
	8.5	0.034	0.032	0.031	0.027	0.036	0.034	0.032	0.028
	9	0.035	0.033	0.032	0.028	0.036	0.034	0.033	0.029
	9.5	0.037	0.035	0.033	0.029	0.037	0.035	0.034	0.030
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hawaii	6	0.027	0.025	0.024	0.021	0.027	0.026	0.025	0.022
	6.5	0.027	0.026	0.024	0.022	0.028	0.026	0.025	0.022
	7	0.027	0.026	0.025	0.022	0.028	0.026	0.025	0.022
	7.5	0.028	0.027	0.025	0.022	0.028	0.027	0.025	0.023
	8	0.032	0.031	0.029	0.026	0.031	0.030	0.028	0.025
	8.5	0.036	0.034	0.032	0.028	0.036	0.034	0.032	0.029
	9	0.037	0.036	0.034	0.030	0.038	0.036	0.034	0.030
	9.5	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	10	0.042	0.040	0.038	0.034	0.043	0.040	0.038	0.034
	10.5	0.044	0.042	0.040	0.035	0.044	0.042	0.040	0.035
	11	0.047	0.044	0.042	0.037	0.046	0.044	0.042	0.037
	11.5	0.049	0.046	0.044	0.039	0.049	0.047	0.044	0.039
	12	0.000	0.000	0.000	0.000	0.051	0.048	0.046	0.041
Mid-Atlantic Coast	6	0.035	0.033	0.031	0.028	0.037	0.035	0.033	0.029
	6.5	0.035	0.033	0.031	0.028	0.037	0.035	0.033	0.029
	7	0.035	0.033	0.031	0.028	0.037	0.035	0.033	0.029
	7.5	0.035	0.033	0.031	0.028	0.037	0.035	0.033	0.029
	8	0.035	0.033	0.032	0.028	0.037	0.035	0.033	0.029
	8.5	0.035	0.033	0.032	0.028	0.037	0.035	0.033	0.030
	9	0.035	0.034	0.032	0.028	0.037	0.035	0.033	0.030
	9.5	0.000	0.000	0.000	0.000	0.037	0.036	0.034	0.030
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Northern California Coast	6	0.039	0.037	0.035	0.031	0.041	0.039	0.037	0.033
	6.5	0.039	0.037	0.035	0.031	0.041	0.039	0.037	0.033
	7	0.039	0.037	0.035	0.031	0.041	0.039	0.037	0.033
	7.5	0.039	0.037	0.035	0.031	0.041	0.039	0.037	0.033
	8	0.039	0.037	0.035	0.031	0.041	0.039	0.037	0.033
	8.5	0.039	0.037	0.035	0.031	0.042	0.039	0.037	0.033
	9	0.040	0.038	0.036	0.032	0.042	0.040	0.038	0.034
	9.5	0.041	0.039	0.037	0.033	0.043	0.041	0.039	0.034
	10	0.042	0.040	0.038	0.033	0.044	0.041	0.039	0.035
	10.5	0.044	0.042	0.040	0.035	0.045	0.042	0.040	0.036
	11	0.047	0.044	0.042	0.037	0.047	0.044	0.042	0.037
	11.5	0.049	0.046	0.044	0.039	0.049	0.047	0.044	0.039
	12	0.000	0.000	0.000	0.000	0.051	0.049	0.046	0.041
Northern East Coast	6	0.037	0.035	0.033	0.030	0.039	0.037	0.035	0.031
	6.5	0.037	0.035	0.033	0.030	0.039	0.037	0.035	0.031
	7	0.037	0.035	0.033	0.030	0.039	0.037	0.035	0.031
	7.5	0.037	0.035	0.033	0.030	0.039	0.037	0.035	0.031
	8	0.037	0.035	0.033	0.030	0.039	0.037	0.035	0.031
	8.5	0.037	0.035	0.033	0.030	0.039	0.037	0.035	0.031
	9	0.037	0.035	0.033	0.030	0.039	0.037	0.035	0.031
	9.5	0.038	0.036	0.034	0.030	0.039	0.037	0.035	0.031
	10	0.040	0.038	0.036	0.032	0.041	0.039	0.037	0.032
	10.5	0.000	0.000	0.000	0.000	0.043	0.040	0.038	0.034
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
North Carolina Coast	6	0.031	0.029	0.028	0.025	0.032	0.030	0.028	0.025
	6.5	0.031	0.029	0.028	0.025	0.032	0.030	0.028	0.025
	7	0.031	0.029	0.028	0.025	0.032	0.030	0.028	0.025
	7.5	0.031	0.029	0.028	0.025	0.032	0.030	0.028	0.025
	8	0.031	0.030	0.028	0.025	0.032	0.030	0.029	0.025
	8.5	0.032	0.031	0.029	0.026	0.033	0.031	0.030	0.026
	9	0.034	0.032	0.031	0.027	0.034	0.033	0.031	0.027
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Oregon Coast	6	0.033	0.032	0.030	0.027	0.035	0.033	0.031	0.028
	6.5	0.033	0.032	0.030	0.027	0.035	0.033	0.031	0.028
	7	0.033	0.032	0.030	0.027	0.035	0.033	0.031	0.028
	7.5	0.033	0.032	0.030	0.027	0.035	0.033	0.031	0.028
	8	0.033	0.032	0.030	0.027	0.035	0.033	0.031	0.028
	8.5	0.034	0.033	0.031	0.027	0.035	0.033	0.032	0.028
	9	0.036	0.035	0.033	0.029	0.037	0.035	0.033	0.029
	9.5	0.039	0.038	0.036	0.032	0.039	0.038	0.036	0.032
	10	0.042	0.040	0.038	0.034	0.042	0.040	0.038	0.034
	10.5	0.044	0.042	0.040	0.035	0.045	0.042	0.040	0.036
	11	0.045	0.043	0.041	0.036	0.047	0.044	0.042	0.037
	11.5	0.000	0.000	0.000	0.000	0.048	0.046	0.043	0.039
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Puerto Rico	6	0.025	0.024	0.022	0.020	0.025	0.024	0.023	0.020
	6.5	0.025	0.024	0.022	0.020	0.025	0.024	0.023	0.020
	7	0.025	0.024	0.023	0.020	0.025	0.024	0.023	0.020
	7.5	0.027	0.025	0.024	0.021	0.027	0.025	0.024	0.021
	8	0.029	0.027	0.026	0.023	0.029	0.027	0.026	0.023
	8.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Southern California Coast	6	0.030	0.028	0.027	0.024	0.031	0.030	0.028	0.025
	6.5	0.030	0.029	0.027	0.024	0.032	0.030	0.028	0.025
	7	0.031	0.029	0.028	0.025	0.032	0.031	0.029	0.026
	7.5	0.032	0.030	0.029	0.025	0.033	0.032	0.030	0.027
	8	0.032	0.031	0.029	0.026	0.034	0.032	0.031	0.027
	8.5	0.033	0.031	0.030	0.026	0.035	0.033	0.031	0.028
	9	0.034	0.033	0.031	0.028	0.035	0.033	0.032	0.028
	9.5	0.000	0.000	0.000	0.000	0.037	0.035	0.033	0.030
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	6	0.024	0.023	0.021	0.019	0.024	0.023	0.022	0.019

Southern East Coast	6.5	0.024	0.023	0.022	0.019	0.025	0.023	0.022	0.020
	7	0.026	0.024	0.023	0.021	0.026	0.025	0.023	0.021
	7.5	0.027	0.025	0.024	0.021	0.027	0.026	0.025	0.022
	8	0.029	0.027	0.026	0.023	0.029	0.027	0.026	0.023
	8.5	0.000	0.000	0.000	0.000	0.031	0.029	0.028	0.025
	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Washington Coast	6	0.031	0.029	0.028	0.025	0.032	0.031	0.029	0.026
	6.5	0.031	0.029	0.028	0.025	0.032	0.031	0.029	0.026
	7	0.031	0.029	0.028	0.025	0.032	0.031	0.029	0.026
	7.5	0.031	0.029	0.028	0.025	0.032	0.031	0.029	0.026
	8	0.031	0.029	0.028	0.025	0.033	0.031	0.029	0.026
	8.5	0.032	0.031	0.029	0.026	0.033	0.031	0.029	0.026
	9	0.000	0.000	0.000	0.000	0.034	0.033	0.031	0.027
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Western Gulf Coast	6	0.026	0.025	0.024	0.021	0.027	0.026	0.025	0.022
	6.5	0.026	0.025	0.024	0.021	0.027	0.026	0.025	0.022
	7	0.026	0.025	0.024	0.021	0.027	0.026	0.025	0.022
	7.5	0.027	0.026	0.024	0.022	0.028	0.026	0.025	0.022
	8	0.029	0.028	0.026	0.024	0.029	0.028	0.026	0.023
	8.5	0.032	0.030	0.029	0.025	0.032	0.031	0.029	0.026
	9	0.000	0.000	0.000	0.000	0.035	0.033	0.031	0.028
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table S14. Potential Output Energy Density (TWh/km²)–Part 2.
Potential output energy density (TWh/km²) in available areas (accounting for all restrictions in Table S1) for each wind speed threshold (6-12 m/s) and two hub height scenarios (200 m and 250 m ASL) in all regions.

		200 m ASL Turbine Height				250 m ASL Turbine Height			
Region	Wind Speed Threshold (m/s)	No Loss	5% Loss	10% Loss	20% Loss	No Loss	5% Loss	10% Loss	20% Loss
Alaska	6	0.041	0.039	0.037	0.032	0.041	0.039	0.037	0.033
	6.5	0.041	0.039	0.037	0.033	0.041	0.039	0.037	0.033
	7	0.041	0.039	0.037	0.033	0.041	0.039	0.037	0.033
	7.5	0.041	0.039	0.037	0.033	0.041	0.039	0.037	0.033
	8	0.041	0.039	0.037	0.033	0.041	0.039	0.037	0.033
	8.5	0.041	0.039	0.037	0.033	0.042	0.039	0.037	0.033
	9	0.042	0.040	0.038	0.034	0.042	0.040	0.038	0.034
	9.5	0.043	0.041	0.039	0.034	0.044	0.041	0.039	0.035
	10	0.044	0.042	0.039	0.035	0.044	0.042	0.040	0.035
	10.5	0.045	0.043	0.041	0.036	0.046	0.043	0.041	0.037
	11	0.047	0.045	0.043	0.038	0.047	0.045	0.043	0.038
	11.5	0.049	0.046	0.044	0.039	0.049	0.047	0.044	0.039
	12	0.052	0.049	0.046	0.041	0.051	0.048	0.046	0.041
Central Gulf Coast	6	0.023	0.022	0.021	0.019	0.024	0.023	0.021	0.019
	6.5	0.023	0.022	0.021	0.019	0.024	0.023	0.021	0.019
	7	0.024	0.023	0.022	0.019	0.024	0.023	0.022	0.019
	7.5	0.026	0.024	0.023	0.021	0.026	0.025	0.023	0.021
	8	0.028	0.027	0.025	0.022	0.028	0.027	0.025	0.023
	8.5	0.000	0.000	0.000	0.000	0.031	0.029	0.028	0.025
	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Eastern Gulf Coast	6	0.021	0.019	0.018	0.016	0.021	0.020	0.019	0.017
	6.5	0.021	0.020	0.019	0.017	0.022	0.020	0.019	0.017
	7	0.023	0.022	0.021	0.019	0.023	0.022	0.021	0.019
	7.5	0.026	0.024	0.023	0.021	0.026	0.025	0.024	0.021
	8	0.000	0.000	0.000	0.000	0.028	0.027	0.025	0.023
	8.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Great Lakes	6	0.036	0.034	0.033	0.029	0.037	0.035	0.033	0.030
	6.5	0.036	0.034	0.033	0.029	0.037	0.035	0.033	0.030
	7	0.036	0.034	0.033	0.029	0.037	0.035	0.033	0.030
	7.5	0.036	0.034	0.033	0.029	0.037	0.035	0.033	0.030
	8	0.036	0.034	0.033	0.029	0.037	0.035	0.034	0.030
	8.5	0.037	0.035	0.033	0.029	0.037	0.036	0.034	0.030
	9	0.037	0.035	0.033	0.030	0.038	0.036	0.034	0.030
	9.5	0.038	0.036	0.034	0.030	0.038	0.036	0.035	0.031
	10	0.039	0.037	0.036	0.032	0.040	0.038	0.036	0.032
	10.5	0.000	0.000	0.000	0.000	0.042	0.040	0.038	0.034
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hawaii	6	0.027	0.026	0.025	0.022	0.027	0.026	0.025	0.022
	6.5	0.028	0.026	0.025	0.022	0.028	0.026	0.025	0.022
	7	0.028	0.026	0.025	0.022	0.028	0.026	0.025	0.022
	7.5	0.028	0.027	0.025	0.023	0.028	0.027	0.025	0.023
	8	0.031	0.030	0.028	0.025	0.031	0.029	0.028	0.025
	8.5	0.036	0.034	0.032	0.029	0.036	0.034	0.032	0.028
	9	0.038	0.036	0.034	0.030	0.038	0.036	0.034	0.030
	9.5	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	10	0.043	0.040	0.038	0.034	0.043	0.041	0.038	0.034
	10.5	0.044	0.042	0.040	0.036	0.045	0.042	0.040	0.036
	11	0.046	0.044	0.042	0.037	0.046	0.044	0.042	0.037
	11.5	0.049	0.047	0.044	0.039	0.049	0.047	0.044	0.039
	12	0.051	0.049	0.046	0.041	0.051	0.049	0.046	0.041
Mid-Atlantic Coast	6	0.038	0.036	0.034	0.030	0.038	0.037	0.035	0.031
	6.5	0.038	0.036	0.034	0.030	0.038	0.037	0.035	0.031
	7	0.038	0.036	0.034	0.030	0.038	0.037	0.035	0.031
	7.5	0.038	0.036	0.034	0.030	0.038	0.037	0.035	0.031
	8	0.038	0.036	0.034	0.030	0.038	0.037	0.035	0.031
	8.5	0.038	0.036	0.034	0.030	0.038	0.037	0.035	0.031
	9	0.038	0.036	0.034	0.030	0.038	0.037	0.035	0.031
	9.5	0.038	0.036	0.034	0.030	0.038	0.037	0.035	0.031
	10	0.039	0.037	0.035	0.031	0.039	0.037	0.036	0.032

	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Northern California Coast	6	0.043	0.041	0.039	0.034	0.044	0.042	0.040	0.035
	6.5	0.043	0.041	0.039	0.034	0.044	0.042	0.040	0.035
	7	0.043	0.041	0.039	0.034	0.044	0.042	0.040	0.035
	7.5	0.043	0.041	0.039	0.034	0.044	0.042	0.040	0.035
	8	0.043	0.041	0.039	0.034	0.044	0.042	0.040	0.035
	8.5	0.043	0.041	0.039	0.035	0.044	0.042	0.040	0.036
	9	0.043	0.041	0.039	0.035	0.044	0.042	0.040	0.036
	9.5	0.044	0.042	0.040	0.035	0.045	0.043	0.041	0.036
	10	0.045	0.043	0.040	0.036	0.046	0.044	0.041	0.037
	10.5	0.046	0.043	0.041	0.036	0.047	0.044	0.042	0.037
	11	0.047	0.045	0.042	0.038	0.048	0.045	0.043	0.038
	11.5	0.049	0.047	0.044	0.039	0.049	0.047	0.044	0.039
	12	0.051	0.048	0.046	0.041	0.051	0.049	0.046	0.041
Northern East Coast	6	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	6.5	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	7	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	7.5	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	8	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	8.5	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	9	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	9.5	0.040	0.038	0.036	0.032	0.040	0.038	0.036	0.032
	10	0.041	0.039	0.037	0.033	0.041	0.039	0.037	0.033
	10.5	0.043	0.041	0.038	0.034	0.043	0.040	0.038	0.034
	11	0.000	0.000	0.000	0.000	0.045	0.043	0.040	0.036
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
North Carolina Coast	6	0.032	0.030	0.029	0.026	0.032	0.031	0.029	0.026
	6.5	0.032	0.030	0.029	0.026	0.032	0.031	0.029	0.026
	7	0.032	0.030	0.029	0.026	0.032	0.031	0.029	0.026
	7.5	0.032	0.030	0.029	0.026	0.032	0.031	0.029	0.026
	8	0.032	0.030	0.029	0.026	0.032	0.031	0.029	0.026
	8.5	0.033	0.031	0.030	0.027	0.033	0.032	0.030	0.027
	9	0.035	0.033	0.031	0.028	0.035	0.033	0.031	0.028
	9.5	0.037	0.035	0.033	0.029	0.037	0.035	0.033	0.029
	10	0.000	0.000	0.000	0.000	0.039	0.037	0.035	0.031
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Oregon Coast	6	0.036	0.034	0.032	0.029	0.037	0.035	0.033	0.029
	6.5	0.036	0.034	0.032	0.029	0.037	0.035	0.033	0.029
	7	0.036	0.034	0.032	0.029	0.037	0.035	0.033	0.029
	7.5	0.036	0.034	0.032	0.029	0.037	0.035	0.033	0.029
	8	0.036	0.034	0.032	0.029	0.037	0.035	0.033	0.029
	8.5	0.036	0.034	0.032	0.029	0.037	0.035	0.033	0.029
	9	0.037	0.036	0.034	0.030	0.038	0.036	0.034	0.030
	9.5	0.039	0.037	0.036	0.032	0.040	0.038	0.036	0.032
	10	0.042	0.040	0.038	0.034	0.042	0.040	0.038	0.034
	10.5	0.045	0.043	0.040	0.036	0.045	0.042	0.040	0.036
	11	0.047	0.044	0.042	0.037	0.047	0.045	0.042	0.038
	11.5	0.049	0.046	0.044	0.039	0.049	0.046	0.044	0.039
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Puerto Rico	6	0.025	0.024	0.023	0.020	0.026	0.024	0.023	0.020
	6.5	0.025	0.024	0.023	0.020	0.026	0.024	0.023	0.020
	7	0.026	0.024	0.023	0.020	0.026	0.024	0.023	0.021
	7.5	0.027	0.025	0.024	0.021	0.027	0.025	0.024	0.021
	8	0.029	0.027	0.026	0.023	0.029	0.027	0.026	0.023
	8.5	0.032	0.030	0.028	0.025	0.032	0.030	0.029	0.025
	9	0.000	0.000	0.000	0.000	0.034	0.032	0.031	0.027
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Southern California Coast	6	0.032	0.030	0.029	0.026	0.033	0.031	0.030	0.026
	6.5	0.033	0.031	0.029	0.026	0.033	0.032	0.030	0.027
	7	0.033	0.031	0.030	0.026	0.034	0.032	0.030	0.027
	7.5	0.034	0.032	0.031	0.027	0.035	0.033	0.031	0.028
	8	0.035	0.033	0.031	0.028	0.036	0.034	0.032	0.029
	8.5	0.036	0.034	0.032	0.029	0.036	0.035	0.033	0.029
	9	0.036	0.034	0.032	0.029	0.037	0.035	0.033	0.030
	9.5	0.037	0.035	0.034	0.030	0.038	0.036	0.034	0.030
	10	0.000	0.000	0.000	0.000	0.039	0.037	0.036	0.032
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Southern East Coast	6	0.025	0.023	0.022	0.020	0.025	0.024	0.022	0.020
	6.5	0.025	0.024	0.022	0.020	0.025	0.024	0.023	0.020
	7	0.026	0.025	0.023	0.021	0.026	0.025	0.023	0.021
	7.5	0.028	0.026	0.025	0.022	0.028	0.027	0.025	0.022
	8	0.029	0.028	0.026	0.023	0.029	0.028	0.026	0.023
	8.5	0.031	0.030	0.028	0.025	0.031	0.030	0.028	0.025
	9	0.000	0.000	0.000	0.000	0.034	0.032	0.030	0.027
	9.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Washington Coast	6	0.033	0.032	0.030	0.027	0.034	0.032	0.030	0.027
	6.5	0.033	0.032	0.030	0.027	0.034	0.032	0.030	0.027
	7	0.033	0.032	0.030	0.027	0.034	0.032	0.030	0.027
	7.5	0.033	0.032	0.030	0.027	0.034	0.032	0.031	0.027
	8	0.033	0.032	0.030	0.027	0.034	0.032	0.031	0.027
	8.5	0.033	0.032	0.030	0.027	0.034	0.032	0.031	0.027
	9	0.035	0.033	0.031	0.028	0.035	0.033	0.031	0.028
	9.5	0.000	0.000	0.000	0.000	0.037	0.035	0.033	0.029
	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Western Gulf Coast	6	0.028	0.027	0.025	0.023	0.029	0.027	0.026	0.023
	6.5	0.028	0.027	0.025	0.023	0.029	0.027	0.026	0.023
	7	0.028	0.027	0.025	0.023	0.029	0.027	0.026	0.023
	7.5	0.028	0.027	0.025	0.023	0.029	0.027	0.026	0.023
	8	0.029	0.028	0.026	0.023	0.029	0.028	0.027	0.024
	8.5	0.033	0.031	0.029	0.026	0.033	0.031	0.029	0.026
	9	0.036	0.034	0.032	0.029	0.036	0.034	0.032	0.029
	9.5	0.038	0.036	0.034	0.030	0.039	0.037	0.035	0.031
	10	0.000	0.000	0.000	0.000	0.040	0.038	0.036	0.032
	10.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	11.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Supplemental References

[1] “Geospatial Data Science Applications and Visualizations.” [Online]. Available: https://maps.nrel.gov/?da=wind-prospector. [Accessed: 27-Jan-2023].

[2] “Airports: United States and Territories, 2011 in EarthWorks.” [Online]. Available: https://earthworks.stanford.edu/catalog/stanford-vf590kv7988. [Accessed: 25-Feb-2023].

[3] “Pacific Cadastral Data | Bureau of Ocean Energy Management.” [Online]. Available: https://www.boem.gov/oil-gas-energy/mapping-and-data/pacific-cadastral-data. [Accessed: 25-Feb-2023].

[4] “Data Download | Northeast Ocean Data Portal.” [Online]. Available: https://www.northeastoceandata.org/data-download/. [Accessed: 27-Jan-2023].

[5] “Marine Cadastre National Viewer.” [Online]. Available: https://marinecadastre.gov/nationalviewer/. [Accessed: 27-Jan-2023].

[6] “MHKDR: Competing Use Analysis for Offshore Renewables and Subsea Cables.” [Online]. Available: https://mhkdr.openei.org/submissions/314. [Accessed: 25-Feb-2023].

[7] “U.S. Office of Coast Survey.” [Online]. Available: https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html. [Accessed: 25-Feb-2023].

[8] “OROWindMap Data Portal - Marine Planner.” [Online]. Available: https://offshorewind.westcoastoceans.org/visualize/#x=-118.14&y=34.95&z=5&logo=true&controls=true&dls%5B%5D=false&dls%5B%5D=0.5&dls%5B%5D=173&basemap=ocean&themes%5Bids%5D%5B%5D=4&themes%5Bids%5D%5B%5D=5&tab=active&legends=false&layers=true. [Accessed: 25-Feb-2023].

[9] “Navigator Download Data — ProtectedSeas.” [Online]. Available: https://protectedseas.net/mpa-download-data/. [Accessed: 25-Feb-2023].

[10] Audubon Society, “Important Bird Areas Polygon Public View.” [Online]. Available: https://library-audubon.hub.arcgis.com/datasets/9217fd74cf8b4e47bd2d77720a757873/explore?layer=0&location=39.491747%2C-82.018828%2C3.58. [Accessed: 25-Feb-2023].

[11] K. L. Riley *et al.*, “An Aquaculture Opportunity Area Atlas for the U.S. Gulf of Mexico,” 2021, doi: 10.25923/8cb3-3r66.

[12] “Digital Coast Data.” [Online]. Available: https://coast.noaa.gov/digitalcoast/data/. [Accessed: 25-Feb-2023].

[13] “Global Wind Atlas.” [Online]. Available: https://globalwindatlas.info/en. [Accessed: 23-Feb-2023].

[14] “GEBCO Gridded Bathymetry Data.” [Online]. Available: https://www.gebco.net/data_and_products/gridded_bathymetry_data/. [Accessed: 23-Feb-2023].

[15] “USGS usSEABED: interactive map.” [Online]. Available: https://cmgds.marine.usgs.gov/usseabed/#search-results. [Accessed: 28-Oct-2022].

[16] “Maritime Safety Information.” [Online]. Available: https://msi.nga.mil/Publications/WPI. [Accessed: 23-Feb-2023].

[17] BLS, “Occupational Employment and Wage Statistics.” [Online]. Available: https://www.bls.gov/oes/current/oes472061.htm. [Accessed: 28-Feb-2023].

[18] R. P. Walker and A. Swift, “Wind Energy’s Impact on Aviation, Radar, and Telecommunications,” *Wind Energy Essentials*, 175–193, May 2015, doi: 10.1002/9781119040934.CH10.

[19] S. B. Barrett, P. M. DeVita, and J. R. Lambert, “Guidebook for Energy Facilities Compatibility with Airports and Airspace,” *Guideb. Energy Facil. Compat. with Airports Airsp.*, Apr. 2014, doi: 10.17226/22399.

[20] S. Jay, “Planners to the rescue: Spatial planning facilitating the development of offshore wind energy,” *Mar. Pollut. Bull.*, 60, 4, 493–499, Apr. 2010, doi: 10.1016/J.MARPOLBUL.2009.11.010.

[21] B. Best and L. Kilcher, “Submarine Cable Analysis for U.S. Marine Renewable Energy Development,” 2019.

[22] United States Department of Interior Bureau of Safety and Environmental Enforcement, “Offshore Wind Submarine Cable Spacing Guidance,” 2014.

[23] B. D. Best and L. F. Kilcher, “Submarine Cable Analysis for US Marine Renewable Energy Development,” 2018.

[24] “Historic Preservation Activities and Offshore Renewable Energy | Bureau of Ocean Energy Management.” [Online]. Available: https://www.boem.gov/renewable-energy/state-activities/historic-preservation-activities-and-offshore-renewable-energy. [Accessed: 09-Mar-2023].
[25] “Ocean Disposal Sites | US EPA.” [Online]. Available: https://www.epa.gov/ocean-dumping/ocean-disposal-sites. [Accessed: 09-Mar-2023].
[26] “DRAFT ENVIRONMENTAL ASSESSMENT Commercial Wind Lease and Grant Issuance and Site Assessment Activities on the Pacific Outer OCS EIS/EA Bureau of Ocean Energy Management BOEM 2021-87 Pacific Region.”
[27] “The MPA Inventory | National Marine Protected Areas Center.” [Online]. Available: https://marineprotectedareas.noaa.gov/dataanalysis/mpainventory/. [Accessed: 09-Mar-2023].
[28] “Habitat Areas of Particular Concern within Essential Fish Habitat | NOAA Fisheries.” [Online]. Available: https://www.fisheries.noaa.gov/southeast/habitat-conservation/habitat-areas-particular-concern-within-essential-fish-habitat. [Accessed: 28-Feb-2023].
[29] “Essential Fish Habitat - Data Inventory.” [Online]. Available: https://www.habitat.noaa.gov/protection/efh/newInv/index.html. [Accessed: 28-Feb-2023].
[30] J. Day *et al.*, “Guidelines for applying the IUCN protected area management categories to marine protected areas Second edition.”
[31] J. Sletten *et al.*, “Beyond the boundaries: How regulation-centered marine protected area information improves ocean protection assessments,” *Mar. Policy*, 124, 104340, Feb. 2021, doi: 10.1016/J.MARPOL.2020.104340.
[32] J. Lynn Wisman, “Potential Interaction Analysis of Offshore Wind Energy Areas and Breeding Avian Species on the US Mid-Atlantic Coast Breeding Avian Species on the US Mid-Atlantic Coast,” 2018.
[33] BOEM, “Modeling At-Sea Density of Marine Birds to Support Renewable Energy Planning on the Pacific Outer Continental Shelf of the Contiguous United States,” 2021.
[34] J. R. Willmott, G. Forcey, and A. Kent, “The Relative Vulnerability of Migratory Bird Species to Offshore Wind Energy Projects on the Atlantic Outer Continental Shelf: An Assessment Method and Database,” 2013.
[35] “Coral reef ecosystems | National Oceanic and Atmospheric Administration.” [Online]. Available: https://www.noaa.gov/education/resource-collections/marine-life/coral-reef-ecosystems. [Accessed: 09-Mar-2023].
[36] B. Möller Bernd, “Continuous spatial modelling to analyse planning and economic consequences of offshore wind energy,” *Energy Policy*, 39, 2, 511–517, Feb. 2011, doi: 10.1016/J.ENPOL.2010.10.031.
[37] “Danger Zones and Restricted Areas | InPort.” [Online]. Available: https://www.fisheries.noaa.gov/inport/item/48876. [Accessed: 28-Feb-2023].
[38] “Military Regulated Airspace within the Atlantic and Gulf of Mexico | InPort.” [Online]. Available: https://www.fisheries.noaa.gov/inport/item/48897. [Accessed: 28-Feb-2023].
[39] “Unexploded Ordnance Areas | InPort.” [Online]. Available: https://www.fisheries.noaa.gov/inport/item/66206. [Accessed: 28-Feb-2023].
[40] “Unexploded Ordnance Locations | InPort.” [Online]. Available: https://www.fisheries.noaa.gov/inport/item/66208. [Accessed: 28-Feb-2023].
[41] N. O. and A. A. US Department of Commerce, “What is aquaculture?”
[42] A. Adelaja, C. McKeown, B. Calnin, and Y. Hailu, “Assessing offshore wind potential,” *Energy Policy*, 42, 191–200, Mar. 2012, doi: 10.1016/J.ENPOL.2011.11.072.
[43] L. I. Tegou, H. Polatidis, and D. A. Haralambopoulos, “Environmental management framework for wind farm siting: Methodology and case study,” *J. Environ. Manage.*, 91, 11, 2134–2147, Nov. 2010, doi: 10.1016/J.JENVMAN.2010.05.010.
[44] “Discover the potential for offshore wind around the world - Global Wind Energy Council.” [Online]. Available: https://gwec.net/discover-the-potential-for-offshore-wind-around-the-world/. [Accessed: 25-Oct-2022].
[45] M. Schwartz, D. Heimiller, S. Haymes, and W. Musial, “Assessment of Offshore Wind Energy Resources for the United States,” 2009.
[46] H. Díaz and C. Guedes Soares, “Review of the current status, technology and future trends of offshore wind farms,” *Ocean Eng.*, 209, 107381, Aug. 2020, doi:

10.1016/J.OCEANENG.2020.107381.
[47] P. Enevoldsen and G. Xydis, “Examining the trends of 35 years growth of key wind turbine components,” *Energy for Sustainable Development*, 50. Elsevier B.V., 18–26, 01-Jun-2019, doi: 10.1016/j.esd.2019.02.003.
[48] “Wind Turbines: the Bigger, the Better | Department of Energy.” [Online]. Available: https://www.energy.gov/eere/articles/wind-turbines-bigger-better. [Accessed: 28-Feb-2023].
[49] R. Wiser *et al.*, “2016 Wind Technologies Market Report,” 2016.
[50] “World’s Most Powerful Offshore Wind Platform: Haliade-X | GE Renewable Energy.” [Online]. Available: https://www.ge.com/renewableenergy/wind-energy/offshore-wind/haliade-x-offshore-turbine. [Accessed: 28-Feb-2023].
[51] F. Bañuelos-Ruedas, C. Angeles-Camacho, and S. Rios-Marcuello, “Analysis and validation of the methodology used in the extrapolation of wind speed data at different heights,” *Renew. Sustain. Energy Rev.*, 14, 8, 2383–2391, Oct. 2010, doi: 10.1016/J.RSER.2010.05.001.
[52] M. Dörenkämper, B. Witha, G. Steinfeld, D. Heinemann, and M. Kühn, “The impact of stable atmospheric boundary layers on wind-turbine wakes within offshore wind farms,” *J. Wind Eng. Ind. Aerodyn.*, 144, 146–153, Sep. 2015, doi: 10.1016/J.JWEIA.2014.12.011.
[53] C. M. S. Martin, J. K. Lundquist, A. Clifton, G. S. Poulos, and S. J. Schreck, “Wind turbine power production and annual energy production depend on atmospheric stability and turbulence,” *Wind Energy Sci.*, 1, 2, 221–236, Jul. 2016, doi: 10.5194/WES-1-221-2016.
[54] D. Y. Kim, Y. H. Kim, and B. S. Kim, “Changes in wind turbine power characteristics and annual energy production due to atmospheric stability, turbulence intensity, and wind shear,” *Energy*, 214, 119051, 2021, doi: 10.1016/J.ENERGY.2020.119051.
[55] N. S. Ghaisas, C. L. Archer, S. Xie, S. Wu, and E. Maguire, “Evaluation of layout and atmospheric stability effects in wind farms using large-eddy simulation,” *Wind Energy*, 20, 7, 1227–1240, Jul. 2017, doi: 10.1002/WE.2091.
[56] M. Dörenkämper, J. Tambke, G. Steinfeld, D. Heinemann, and M. Kühn, “Atmospheric Impacts on Power Curves of Multi-Megawatt Offshore Wind Turbines,” *J. Phys. Conf. Ser.*, 555, 1, 012029, Dec. 2014, doi: 10.1088/1742-6596/555/1/012029.
[57] C. Pérez Albornoz, M. A. Escalante Soberanis, V. Ramírez Rivera, and M. Rivero, “Review of atmospheric stability estimations for wind power applications,” *Renew. Sustain. Energy Rev.*, 163, 112505, Jul. 2022, doi: 10.1016/J.RSER.2022.112505.
[58] M. F. Howland *et al.*, “Influence of atmospheric conditions on the power production of utility-scale wind turbines in yaw misalignment,” *J. Renew. Sustain. Energy*, 12, 6, 063307, Dec. 2020, doi: 10.1063/5.0023746.
[59] R. J. A. M. Stevens and C. Meneveau, “Flow Structure and Turbulence in Wind Farms,” *https://doi.org/10.1146/annurev-fluid-010816-060206*, 49, 311–339, Jan. 2017, doi: 10.1146/ANNUREV-FLUID-010816-060206.
[60] S. Horwath, J. Hassrick, R. Grismala, and E. Diller, “Comparison of Environmental Effects from Different Offshore Wind Turbine Foundations,” 2020.
[61] “Offshore wind turbines foundations - Iberdrola.” [Online]. Available: https://www.iberdrola.com/sustainability/offshore-wind-turbines-foundations. [Accessed: 27-Jan-2023].
[62] A. VAZQUEZ, U. Izquierdo, P. Enevoldsen, F.-H. Andersen, and J. M. Blanco, “A Macroscale Optimal Substructure Selection for Europe’s Offshore Wind Farms,” *SSRN Electron. J.*, May 2022, doi: 10.2139/SSRN.4111111.
[63] H. Cetinay, F. A. Kuipers, and A. N. Guven, “Optimal siting and sizing of wind farms,” *Renew. Energy*, 101, 51–58, Feb. 2017, doi: 10.1016/J.RENENE.2016.08.008.
[64] M. J. Kaiser and B. F. Snyder, “Modeling offshore wind installation costs on the U.S. Outer Continental Shelf,” *Renew. Energy*, 50, 676–691, Feb. 2013, doi: 10.1016/J.RENENE.2012.07.042.
[65] “Special Initiative on Offshore Wind Supply Chain Contracting Forecast for U.S. Offshore Wind Power-The Updated and Expanded 2021 Edition,” 2021.
[66] T. Stehly, P. Beiter, and P. Duffy, “2019 Cost of Wind Energy Review,” 2019.
[67] “Data Show Big Gains for Offshore Wind | News | NREL.” [Online]. Available: https://www.nrel.gov/news/program/2020/2019-offshore-wind-data.html. [Accessed: 16-Feb-2023].
[68] W. Kempton, “Mid-Atlantic Offshore Wind Interconnection and Transmission (MAOWIT),” Apr.

2016, doi: 10.2172/1329370.
[69] A. Sajadi, K. A. Loparo, R. D'Aquila, K. Clark, J. G. Waligorski, and S. Baker, "Great Lakes O shore Wind Project: Utility and Regional Integration Study," Jun. 2016, doi: 10.2172/1328159.
[70] C. Fallon *et al.*, "Carolina Offshore Wind Integration Case Study: Phases I and II Final Technical Report," Apr. 2015, doi: 10.2172/1339103.
[71] Q. Jiang, B. Li, and T. Liu, "Tech-Economic Assessment of Power Transmission Options for Large-Scale Offshore Wind Farms in China," *Process. 2022,* 10, 5, 979, May 2022, doi: 10.3390/PR10050979.
[72] "Offshore Wind Outlook 2019 – Analysis - IEA." [Online]. Available: https://www.iea.org/reports/offshore-wind-outlook-2019. [Accessed: 16-Mar-2023].
[73] P. Beiter *et al.*, "The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032 Cost and Performance Results Data."
[74] W. Musial and J. Nunemaker, "2018 Offshore Wind Technologies Market Report," 2018.
[75] S. B. Parkison and W. Kempton, "Marshaling ports required to meet US policy targets for offshore wind power," *Energy Policy*, 163, 112817, Apr. 2022, doi: 10.1016/J.ENPOL.2022.112817.
[76] "Offshore Wind Development Program: Roadmap for Vietnam | ESMAP." [Online]. Available: https://esmap.org/offshore-wind-devprogram_wind-roadmap-for-vietnam. [Accessed: 18-Feb-2023].
[77] M. J. Kaiser and B. F. Snyder, "Modeling offshore wind installation vessel day-rates in the United States," *Marit. Econ. Logist.*, 14, 2, 220–248, Jun. 2012, doi: 10.1057/MEL.2012.5/METRICS.
[78] "Assessment of Vessel Requirements for the U.S. Offshore Wind Sector | Department of Energy." [Online]. Available: https://www.energy.gov/eere/wind/articles/assessment-vessel-requirements-us-offshore-wind-sector. [Accessed: 20-Mar-2023].
[79] A. C. Elkinton, A. Blatiak, and H. Ameen, "ASSESSMENT OF PORTS FOR OFFSHORE WIND DEVELOPMENT IN THE UNITED STATES," 2014.
[80] ABS, "OFFSHORE WIND REPORT POSITIONING FOR U.S. EXPANSION: U.S. PORTS AND VESSELS INNOVATION," *2021*. [Online]. Available: https://absinfo.eagle.org/acton/attachment/16130/f-98f8192f-6ba8-4f7c-b2f6-a30a8c41209d/1/-/-/-/-/ABS-Offshore-Wind-Report-Positioning-for-US-Expansion-Ports-and-Vessels-Innovation.pdf?utm_term=Download Now&utm_campaign=ABS Publishes Landmark U.S. Offshore Wind Report&utm_content=email&utm_source=Act-On+Software&utm_medium=email&cm_mmc=Act-On Software-_-email-_-ABS Publishes Landmark U.S. Offshore Wind Report-_-Download Now&sid=TV2:sCxeosVCY. [Accessed: 28-Feb-2023].
[81] "State Approves $10.5 Million to Prepare the Port of Humboldt Bay for Offshore Wind." [Online]. Available: https://www.energy.ca.gov/news/2022-03/state-approves-105-million-prepare-port-humboldt-bay-offshore-wind. [Accessed: 28-Feb-2023].
[82] "Two US Offshore Wind Ports Secure Nearly USD 50 Million in Federal Grants | Offshore Wind." [Online]. Available: https://www.offshorewind.biz/2021/12/24/two-us-offshore-wind-ports-secure-nearly-usd-50-million-in-federal-grants/. [Accessed: 28-Feb-2023].
[83] "Rhode Island Ports to Undergo Offshore Wind Upgrades with USD 95 Million State Support | Offshore Wind." [Online]. Available: https://www.offshorewind.biz/2022/03/21/rhode-island-ports-to-undergo-offshore-wind-upgrades-with-usd-95-million-state-support/. [Accessed: 28-Feb-2023].
[84] "Coos Bay Offshore Wind Port Infrastructure Study."
[85] "Three US Ports Secure Federal Financing for Offshore Wind Projects | Offshore Wind." [Online]. Available: https://www.offshorewind.biz/2022/10/31/three-us-ports-secure-federal-financing-for-offshore-wind-projects/. [Accessed: 09-Mar-2023].
[86] E. Mayfield, J. Jenkins, G. M. Wilson, M. Al-Jassim, and W. K. Metzger, "Influence of high road labor policies and practices on renewable energy costs, decarbonization pathways, and labor outcomes," *Environ. Res. Lett.*, 16, 12, 124012, Nov. 2021, doi: 10.1088/1748-9326/AC34BA.
[87] J. S. Touma, "Dependence of the wind profile power law on stability for various locations," *J. Air Pollut. Control Assoc.*, 27, 9, 863–866, 1977, doi: 10.1080/00022470.1977.10470503.
[88] A. J. Thorpe and T. H. Guymer, "The nocturnal jet," *Q. J. R. Meteorol. Soc.*, 103, 438, 633–653, Oct. 1977, doi: 10.1002/QJ.49710343809.
[89] W. Musial *et al.*, "Offshore Wind Market Report: 2022 Edition," 2022.

[90] P. Enevoldsen and S. Victor Valentine, “Do onshore and offshore wind farm development patterns differ?,” *Energy Sustain. Dev.*, 35, 41–51, 2016, doi: 10.1016/j.esd.2016.10.002.
[91] C. L. A. Z. J. Research; M, “Saturation wind power potential and its implications for wind energy,” 109, 39, 15679–15684, 2012, doi: 10.1073/pnas.1208993109/-/DCSupplemental.
[92] R. J. Barthelmie *et al.*, “Modelling and measuring flow and wind turbine wakes in large wind farms offshore,” *Wind Energy*, 12, 5, 431–444, Jul. 2009, doi: 10.1002/WE.348.
[93] C. L. Archer *et al.*, “Review and evaluation of wake loss models for wind energy applications,” *Appl. Energy*, 226, 1187–1207, Sep. 2018, doi: 10.1016/J.APENERGY.2018.05.085.
[94] M. Z. Jacobson, *100 Percent Clean, Renewable Energy and Storage for Everything*, Cambridge University Press, New York, 427 pp., 2020.
[95] “1976 Standard Atmosphere Calculator.” [Online]. Available: https://www.digitaldutch.com/atmoscalc/. [Accessed: 28-Mar-2023].
[96] J. Bosch, I. Staffell, and A. D. Hawkes, “Global levelised cost of electricity from offshore wind,” *Energy*, 189, 116357, Dec. 2019, doi: 10.1016/J.ENERGY.2019.116357.
[97] B. R. Sarker and T. I. Faiz, “Minimizing transportation and installation costs for turbines in offshore wind farms,” *Renew. Energy*, 101, 667–679, Feb. 2017, doi: 10.1016/J.RENENE.2016.09.014.
[98] C. A. Irawan, X. Song, D. Jones, and N. Akbari, “Layout optimisation for an installation port of an offshore wind farm,” *Eur. J. Oper. Res.*, 259, 1, 67–83, May 2017, doi: 10.1016/J.EJOR.2016.09.032.
[99] H. H. Neve, S. Wandahl, S. Lindhard, J. Teizer, and J. Lerche, “Determining the Relationship between Direct Work and Construction Labor Productivity in North America: Four Decades of Insights,” *J. Constr. Eng. Manag.*, 146, 9, 04020110, Jun. 2020, doi: 10.1061/(ASCE)CO.1943-7862.0001887.
[100] The Crown Estate Offshore Renewable Energy Catapult, “Guide to an offshore wind farm Updated and extended ,” 2019.
[101] W. Musial, D. Heimiller, P. Beiter, G. Scott, and C. Draxl, “2016 Offshore Wind Energy Resource Assessment for the United States,” 2016.
[102] W. Musial, P. Beiter, S. Tegen, and A. Smith, “Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs,” 2016.
[103] A. Moore, J. Price, and M. Zeyringer, “The role of floating offshore wind in a renewable focused electricity system for Great Britain in 2050,” *Energy Strateg. Rev.*, 22, 270–278, Nov. 2018, doi: 10.1016/J.ESR.2018.10.002.
[104] M. Z. Jacobson, A.-K. von Krauland, S. J. Coughlin, F. C. Palmer, and M. M. Smith, “Zero air pollution and zero carbon from all energy at low cost and without blackouts in variable weather throughout the U.S. with 100% wind-water-solar and storage,” *Renewable Energy*, 184, 430-444, doi: 10.1016/j.segy.2021.100009, 2022.
[105] “Use of energy explained - U.S. Energy Information Administration (EIA).” [Online]. Available: https://www.eia.gov/energyexplained/use-of-energy/. [Accessed: 28-Feb-2023].
[106] “Renewable Energy GIS Data | Bureau of Ocean Energy Management.” [Online]. Available: https://www.boem.gov/renewable-energy/mapping-and-data/renewable-energy-gis-data. [Accessed: 23-Feb-2023].