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Wind Resource Estimates

Annual average wind speeds are closely related to the available energy at a particular location and are categorized in the database by their value at a height of 90 m above the surface. The offshore wind resources of the United States were first estimated by NREL in 2003 (Musial and Butterfield 2004). Since then, updated offshore wind mapping projects (e.g. Elliott and Schwartz 2006) are gradually being completed. The updated maps provide a better estimate of the offshore wind resource than was previously available. At present, updated maps are available for the offshore areas of Georgia, Texas/Louisiana, northern New England (Massachusetts, New Hampshire, and Maine) and the states bordering the Great Lakes.

The updated wind resource maps were produced using a physics-based numerical computer model that provided preliminary estimates of the annual average wind resource. The modeling was developed by AWS Truepower (AWST) of Albany, New York, under subcontract to NREL, using their proprietary MesoMap system. The horizontal resolution of the model output is 200 m. The preliminary model estimates were validated by NREL using data from a variety of sources including ocean buoys, marine automated stations, Coast Guard stations and lighthouses, and satellite-derived 10 m wind speeds over the ocean estimated from the "state of the sea" as measured by microwave imaging. The wind measurements from the stations or grid points (in the case of satellite measurements) were extrapolated to 50 m above the surface and compared to the model estimates at the same height using sheer exponents from the Power Law Equation (Elliott et. al. 1987). The results of the validation model-measurement comparison were assembled into a spreadsheet and reviewed by AWST. In addition, NREL also produced qualitative comments on the validation results including recommended modifications to the preliminary resource estimates. Final modifications were agreed to after consultations between NREL and AWST. AWST adjusted the model output to reflect the modifications. There were not sufficient tall tower data to perform a high-quality validation at 90 m. Therefore, the modifications to the preliminary 90 m wind speed model output were based on the 50 m validation results. This adds some uncertainty to the final potential estimates, but should not significantly affect the scope of the offshore potential. NREL converted the final data into wind resource maps. The wind resource data were re-sampled from 200 m to 100 m horizontal resolution for inclusion in the database.

Calculations of the offshore wind resource estimates for states with older offshore wind maps (originally completed as part of an onshore wind mapping project) were done in two ways. For eight states, data from an older non-validated preliminary (model estimate) offshore wind map and a validated older final map were combined to calculate the offshore resource. Preliminary non-validated maps were used because: 1) older final wind maps extended only 5-10 nm offshore, while the preliminary maps extended further off the coast, thus reducing the area extrapolated to 50 nm; and 2) using the preliminary data resulted in more realistic offshore wind speed gradients than the gradients produced by extrapolating the older final map values from their seaward edges out to an additional 40-45 nm to the 50 nm line. Older final maps for five states (including the Atlantic coast of New York) extended either to the 50 nm line or the state boundary. In these cases, the data from the older final map was used to calculate the offshore potential without extrapolation. The complete listing of the older and updated offshore maps used for this project is in Appendix A. The states of Florida, Alabama, and Mississippi did not have any preliminary or final wind maps available. The lack of tall tower wind measurement data and offshore wind maps for this region made an estimate of the 90 m wind speeds problematic. Therefore, the offshore wind resource for these states was not included in this report. They will be included in the database once updated offshore maps for these states are complete.

The 90 m average wind speeds were calculated in several ways depending on the available height of the older preliminary and final map data. The states along the Atlantic coast from Rhode Island to North Carolina, and the state of Hawaii had offshore map wind speed values at 70 m and 100 m above the surface. For these states, the 90 m wind speed was calculated by a linear interpolation between the 70 m and 100 m wind speeds. The states of South Carolina, Washington, and Oregon had only 50 m map wind speeds available. The 90 m wind speeds for these states were calculated using a power law wind speed shear exponent (Elliott et. al. 1987) of 0.11. This exponent value was chosen based on the validation experience with the updated offshore wind maps and because other analyses of offshore wind resources indicate that the shear exponent is most often in the range from 0.08 to 0.14 for the offshore regions of the United States. The wind speeds at 90 m were about 6.5% higher than the 50 m wind speeds using the 0.11 shear exponent. Wind speed maps at 50 m and 70 m were available for California. The 90 m speed off the California coast was calculated assuming the speed shear exponent calculated between the 50 m and 70 m levels was also valid for the wind speeds between 70 m and 90 m.

For eight states (the Pacific coast and the Atlantic Coast from New Jersey to North Carolina), where both the older preliminary and final maps were used to estimate the wind resource, a blend of the calculated 90 m speeds from the preliminary and final maps was used to extrapolate the offshore potential to 50 nm. Speed values from the final maps were used to calculate the wind resource from close to shore out to the boundary between the final and preliminary maps. The speed at this boundary was calculated as a blend of the two final and preliminary map values. The preliminary map wind speeds were used from this boundary to the seaward edge of the preliminary map data. The wind speed values at the seaward edge of the preliminary map were held constant and expanded to the 50 nm line. The extrapolation from the edge of the preliminary map is a source of uncertainty in the final results for these eight states.

Horizontal discontinuities (seams) in the wind resource are present at several state boundaries. The discontinuities result from offshore data that is based on different versions of the numerical model used for the different onshore mapping projects and the way the extrapolation software interprets the data on either side of the seam. The most prominent seam appears near the border of Oregon and California. The resulting wind speed gradients in that region are not realistic. Other noticeable seams are located on the borders of New York and New Jersey and North Carolina and South Carolina. These seams in the maps and data interpretations further demonstrate the need to complete the updated offshore wind resource maps along the Atlantic and Pacific coasts.

Individual state and regional datasets were combined to form a composite image, based on 2009 map estimates, of the national offshore wind resource (Figure 1). The datasets are listed in Appendix A. The wind resource information is categorized by wind speed. However, for this initial report only areas with annual average wind speeds of 7.0 m/s and greater are included in the wind potential estimates. Economic factors make development of areas with less than 7.0 m/s average wind speeds unlikely. This delineation may be adjusted in future versions of the database as warranted. Examinations of the offshore wind resource distribution show an abundant wind resource pool, with wind resources greater than 7.0 m/s, located in many offshore areas of the country.