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Operational Impacts of Large Deployments of Offshore Wind

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Abstract

- The potential operational impacts of deploying 54 GW of offshore wind in the United States were examined.
- The capacity was not evenly distributed; instead, it was concentrated in regions with better wind quality and close to load centers (Table 1).
- A statistical analysis of offshore wind power time series was used to assess the effect on the power system.
- The behavior of offshore wind resembled that of onshore wind, despite the former presenting higher capacity factors, more consistent power output across seasons, and higher variability levels.
- Thus, methods developed to manage onshore wind variability can be extended and applied to offshore wind.

Table 1. Installed Capacity by Region

Interconnection	Region	Capacity (GW)
Eastern	PJM	18.2
	New England	13.1
	Carolinas	8.3
	MISO	6.0
Western	Northern California	2.9
	NWPP	2.9
Texas	ERCOT	2.8

Offshore Wind Capacity Factor

The western regions (Northern California and NWPP) presented the highest capacity factors (above 55%; Fig. 1), although the installed capacity was relatively low (less than 3 GW). The profiles in those regions were also the most unique, with consistent high power generation during the summer months.

The capacity factor in New England, where more than 13 GW of wind were installed, was almost 50%. The capacity factors in the remaining regions averaged from 40% to 42%. Wind generation in the eastern regions, ERCOT, and the Great Lakes was higher during nights and spring months. Some regions, such as the Carolinas and PJM, presented singular daily profiles during the summer, with consistent positive ramps in the afternoon as a result of sea breezes.

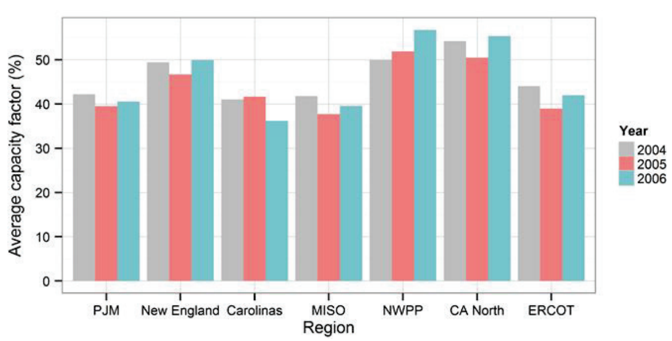

Figure 1. Average capacity factors by region and year

Variability

Wind variability was typically small (Fig. 2), with most of the hourly ramps below 3% of nameplate capacity. That dropped to 1% for the 10-minute ramps. However, extreme values were much larger, from 10% to 35%, but rare.

Overall, Northern California and NWPP had small variability, especially during the summer, when wind output is high and sustained. Other regions presented less relative variability, with more installed capacity or more geographic diversity.

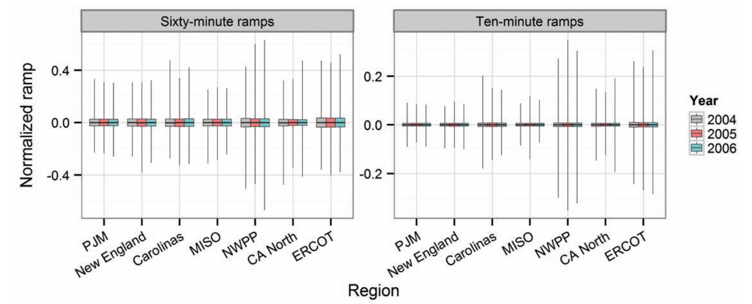

Figure 2. Box plots showing hourly and 10-minute ramps by region

The impacts on net load (Fig. 3) were largest in New England, where almost 40% of the load could be provided by wind. There were a few hours when wind power surpassed load levels.

In other regions, the change was moderate. Northern California is the only region in which high loads and high wind aligned. All other regions experienced higher drops in net load during low-load hours.

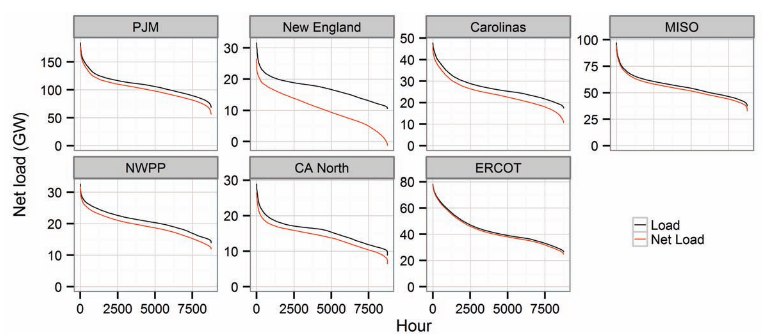

Figure 3. Load and net load power duration curves

Other Results

- The effects on net load variability were relatively small for most of the year, even in New England.
- The most significant changes were typically increases in rare and extreme ramp values.
- Load and wind hourly variability were found to be independent, although the relative magnitude of both varied across regions.
- An initial estimation of reserve requirements was performed. The biggest increase in requirement was found in New England, where it more than doubled, followed by the Carolinas.

More information: J. Daniel, S. Liu, E. Ibanez, K. Pennock, G. Reed, and S. Hanes. (2014). *National Offshore Wind Energy Grid Interconnection Study: Final Technical Report.* Washington, D.C.: U.S. Department of Energy.

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