Scientists bring efficiency to expanding offshore wind energy

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New Cornell research shows how to make offshore wind farms more efficient in the face of impending rapid expansion—crucial information as the U.S. Department of the Interior affirmed White House plans to

lease federal waters for several giant arrays of wind turbines along the waters of the East Coast.

This research appears in the Oct. 20 issue of the journal *Joule*.

"Massive upscaling of wind turbine deployments offshore is critical to achieving global and national goals to decarbonize the electricity supply," said Sara C. Pryor, professor of Earth and Atmospheric Sciences, a department shared by the College of Agricultural and Life Sciences, and the College of Engineering.

"The excellent wind resource and proximity to large markets along the East Coast means it is the focus of America's first-phase, offshore-wind projects, where thousands of physically larger and higher capacity wind turbines will be deployed over large areas (about 1.7 million acres of water, combined) at an unprecedented scale," Pryor said.

On Oct. 13, Secretary of the Interior Deb Haaland announced the path forward for offshore wind leasing agreements to meet the White House-announced goal to deploy 30 gigawatts—enough to power 90 million homes—of East Coast offshore wind energy by 2030.

At the New York State level, there are now five offshore wind projects in active development, according to the New York State Energy Research and Development Authority (NYSERDA). The state has an offshore goal of 9,000 megawatts by 2035. The current offshore projects total about 4,300 megawatts, enough to power approximately 2 million homes.

While the approaching federal rapid expansion of offshore turbine deployments brings a chance to reduce human-induced climate change, Pryor said, it presents challenges on how to optimally locate offshore turbines to efficiently achieve electricity-generation goals.

Low-turbulence conditions over water, plus the locations and size of the lease areas auctioned by the Interior Department's Bureau of Ocean Energy Management, mean that individual wind farms will experience each other's wake (disturbed air flow)—even when the turbine arrays are 15 to 50 miles apart. Thus, the wind turbines may fatigue earlier and a group of turbines may experience up to 30% lower power production due to wake effects, according to the new paper.

Pryor's simulations can help to optimize turbine spacing in these areas and assist plans for future deployments.

Industry trends are moving toward large wind turbines deployed over bigger areas. In Europe, as an example, wind farms have increased in capacity from 321 megawatts to 621 megawatts between 2010 and 2019. The Hornsea Project, a recent project off the eastern coast of the United Kingdom, comprises many more wind turbines and can produce 1.2 gigawatts of electrical power.

"These industry trends are causing an increased probability of large wake losses [of energy] within individual wind farms and an increased probability of wake interactions," Pryor said. "Improved understanding of wind turbine and wind-farm wake is essential to ensuring that financial investments in offshore wind achieves electricity-generation goals and do so at the lowest possible cost."

The scientists note the U.S. remains far below its wind energy potential. The entire U.S. uses more than 4,146 terawatts of electricity annually, according to the U.S. Energy Information Administration. Pryor said that offshore wind resources around the United States could potentially generate more than 7,000 terawatt hours per year—with the possibility of electricity generation exceeding demand.

Meanwhile, scientists and policymakers are looking toward COP26, the

2021 United Nations Climate Change Conference (Conference of the Parties) beginning Oct. 31.

"The proposed energy and infrastructure bill is on everyone's mind," Pryor said. "With the White House issuing commitments and briefing notes about offshore wind energy expansion and COP26 starting, decarbonizing our electricity supply is a key component of meeting any climate change goals."

In addition to Pryor, the research, "Wind Power Production From Very Large Offshore Wind Farms," was co-authored by Rebecca J. Barthelmie, professor in the Sibley School of Mechanical and Aerospace Engineering, in the College of Engineering; and Tristan J. Shepherd, postdoctoral research fellow in earth and atmospheric sciences. Both Pryor and Barthelmie are fellows in the Cornell Atkinson Center for Sustainability.

More information: Sara C. Pryor et al, Wind power production from very large offshore wind farms, *Joule* (2021). DOI: 10.1016/j.joule.2021.09.002

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