Offshore wind turbines vulnerable to Category 5 hurricane gusts

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Offshore wind turbines built according to current standards may not be able to withstand the powerful gusts of a Category 5 hurricane, creating potential risk for any such turbines built in hurricane-prone areas, new

University of Colorado Boulder-led research shows.

The study, which was conducted in collaboration with the National Center for Atmospheric Research in Boulder, Colorado and the U.S. Department of Energy's National Renewable Energy Laboratory in Golden, Colorado, highlights the limitations of current turbine design and could provide guidance for manufacturers and engineers looking to build more hurricane-resilient turbines in the future.

Offshore wind-energy development in the U.S. has ramped up in recent years, with projects either under consideration or already underway in most Atlantic coastal states from Maine to the Carolinas, as well as the West Coast and Great Lakes. The country's first utility-scale offshore wind farm, consisting of five turbines, began commercial operation in December 2016 off the coast of Rhode Island.

Turbine design standards are governed by the International Electrotechnical Commission (IEC). For offshore turbines, no specific guidelines for hurricane-force winds exist. Offshore turbines can be built larger than land-based turbines, however, owing to a manufacturer's ability to transport larger molded components such as blades via freighter rather than over land by rail or truck.

For the study, CU Boulder researchers set out to test the limits of the existing design standard. Due to a lack of observational data across the height of a wind turbine, they instead used large-eddy simulations to create a powerful hurricane with a computer.

"We wanted to understand the worst-case scenario for offshore wind turbines, and for hurricanes, that's a Category 5," said Rochelle Worsnop, a graduate researcher in CU Boulder's Department of Atmospheric and Oceanic Sciences (ATOC) and lead author of the study.

These uniquely high-resolution simulations showed that under Category 5 conditions, mean wind speeds near the storm's eyewall reached 90 meters-per-second, well in excess of the 50 meters-per-second threshold set by current standards.

"Wind speeds of this magnitude have been observed in hurricanes before, but in only a few cases, and these observations are often questioned because of the hazardous conditions and limitations of instruments," said George Bryan of NCAR and a co-author of the study. "By using large-eddy simulations, we are able to show how such winds can develop and where they occur within hurricanes."

Furthermore, current standards do not account for veer, a measure of the change in wind direction across a vertical span. In the simulation, wind direction changed by as much as 55 degrees between the tip of the rotor and its hub, creating a potentially dangerous strain on the blade.

The findings could be used to help wind farm developers improve design standards as well as to help stakeholders make informed decisions about the costs, benefits and risks of placing turbines in hurricane-prone areas.

"The study will help inform design choices before offshore wind energy development ramps up in hurricane-prone regions," said Worsnop, who received funding from the National Science Foundation Graduate Research Fellowship Program to conduct this research. "We hope that this research will aid wind turbine manufacturers and developers in successfully tapping into the incredibly powerful wind resource just beyond our coastlines."

"Success could mean either building turbines that can survive these extreme conditions, or by understanding the overall risk so that risks can be mitigated, perhaps with financial instruments like insurance," said Professor Julie Lundquist of ATOC and CU Boulder's Renewable and

Sustainable Energy Institute (RASEI), a co-author of the study. "The next stage of this work would be to assess how often these extreme winds would impact an offshore wind farm on the Atlantic coast over the 20-to-30-year lifetime of a typical wind farm."

The findings were recently published online in the journal *Geophysical Research Letters*, a publication of the American Geophysical Union.

More information: Rochelle P. Worsnop et al, Gusts and Shear Within Hurricane Eyewalls Can Exceed Offshore Wind-Turbine Design Standards, *Geophysical Research Letters* (2017). DOI: 10.1002/2017GL073537

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