New study uses blizzard to measure wind turbine airflow (w/ Video)

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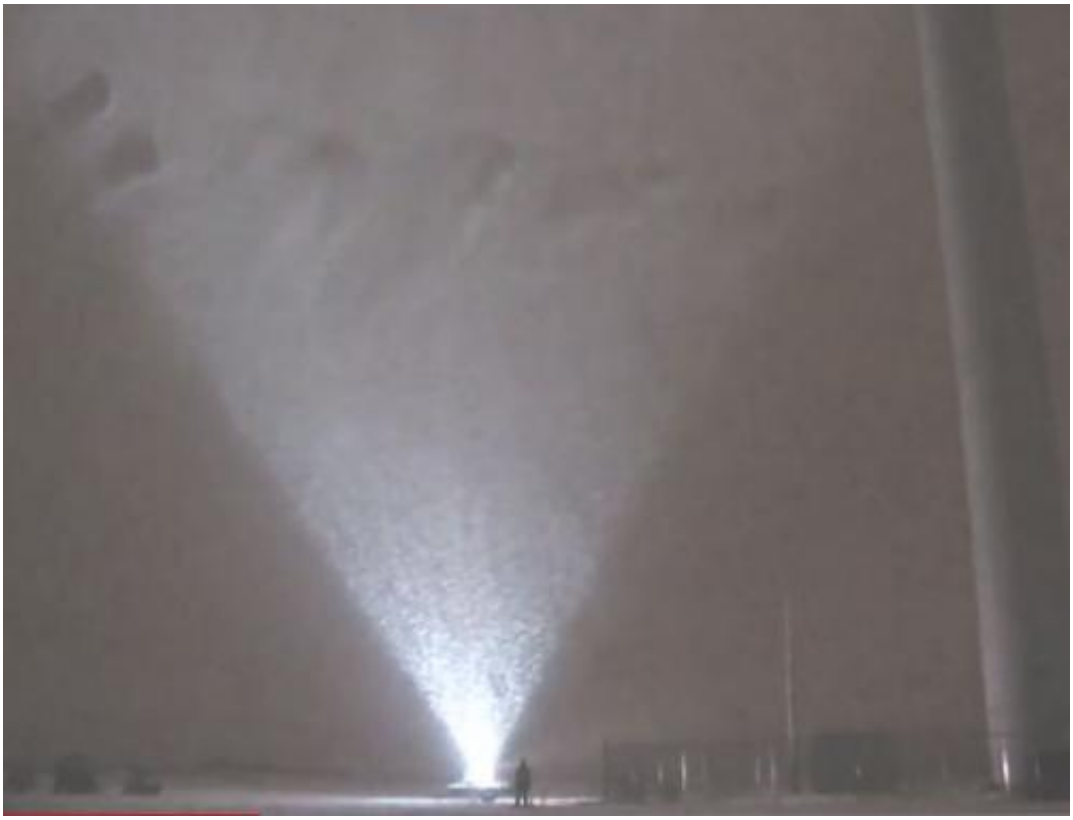

A first-of-its-kind study by researchers at the University of Minnesota (UMN) using snow during a Minnesota blizzard is giving researchers new insight into the airflow around large wind turbines. This research is essential to improving wind energy efficiency, especially in wind farms

where airflows from many large wind turbines interact with each other.

The study by researchers at the UMN College of Science and Engineering's St. Anthony Falls Lab was published today in *Nature Communications*, a major scientific journal.

Wind energy is one of the fastest-growing renewable energy sources. The U.S. Department of Energy estimates energy losses in wind farms to be as high as 10-20 percent and identifies complex airflows created by the turbines as the major culprit for such losses. As wind turbines have grown to more than 100 meters tall, field research in real-world settings has become more difficult.

"In the lab we use tracer particles to measure airflows of wind turbine models in wind tunnels, but our research was extremely constrained by an inability to measure flows at the large scale," said Jiarong Hong, a UMN mechanical engineering assistant professor and lead researcher on the study. "Most researchers thought measurements of this kind at the real-world scale were impossible."

Hong, who grew up in southwest China and received his Ph.D. at Johns Hopkins University, had only seen snow a few times in his life before moving to Minnesota in 2012. He wondered if snow might be the solution to their dilemma.

"We have everything we needed in Minnesota for this research," Hong said. "We have a fully-equipped large research wind turbine at the U.S. Department of Energy-funded Eolos Wind Energy Research Center run by the University. We also have snow to serve as the particulates to measure the airflows and committed researchers and engineers to carry out such an unprecedented effort."

After a number of previous attempts when the snow was poor quality or

the instruments malfunctioned in the cold weather, researchers headed to the Eolos 2.5 KW wind turbine in Rosemount, Minn., in the early morning hours of a snowstorm on Feb. 22, 2013.

They braved the harsh conditions in the middle of the night to set up a large searchlight with specially designed reflecting optics to generate a gigantic light sheet next to the 130-meter-tall wind turbine for illuminating the snow particles in a 36-meter-wide-by-36-meter-high area. The snow is easier to see in the light at night, much like the average person looks into a streetlight to see how much it is snowing during a snowstorm. Researchers videotaped the snow particles as the wind turbine spun to show airflow patterns. This video was digitized and synchronized with wake flow and load data from the fully instrumented research wind turbine.

Results of the experiment showed that this technique was successful in measuring the turbulence of the airflow structure around the wind turbine. It is a first step in showing significant differences in the patterns of airflows in the field at large scale compared to those measured in the lab.

"These measurements are extremely important in our efforts to improve the efficiency of wind energy that will reduce our reliance on fossil fuels," said Fotis Sotiropoulos, co-author of the study and director of the University's St. Anthony Falls Lab and the Eolos Wind Energy Research Center. "Who would have ever thought we'd use a Minnesota blizzard to help fight global warming."

More information: Natural snowfall reveals large-scale flow structures in the wake of a 2.5-MW wind turbine *Nature Communications* 5, Article number: 4216 DOI: 10.1038/ncomms5216