U.S. Department of Energy Competitiveness Improvement Project (CIP)

2022 Prototype Installation and Testing Awardee: Windward Engineering

Project Dates: Jan. 5, 2023–Sept. 19, 2024

Project Overview

Full-Span Pitch System Implementation To Reduce Cost of Turbine's Aerodynamic Brakes

Utility-scale wind turbines feature an independent pitch system to adjust the angle of the turbine's blades, control rotor speed, and act as an aerodynamic brake to prevent damage to the unit from excessive wind speeds. These pitch systems include a pitch bearing, a pitch drive, possibly a gear system, a power system for the pitch drive (hydraulic, electric, or pneumatic), a pitch control system, and other parts that must work together as a system. The integration of all these subsystems/components makes such pitch systems complex, which ultimately results in higher cost. Until now, high cost and complexity have meant that these pitch systems have not been widely adopted for distributed wind turbines.

The 60-kilowatt (kW) Zephyr 21/60 wind turbine from Windward Engineering uses a low-cost, full-span independent pitch system that can act as a redundant aerodynamic braking system. This design uses a relatively simple pneumatic rotary vane actuator, allowing each of the turbine's three blades to be pitched independently and any single blade to activate emergency braking for the entire turbine. A previous Competitiveness Improvement Project (CIP) funding award enabled Windward Engineering to design and develop the Zephyr 21/60 wind turbine's aeroelastic model and pitch system.

> "Prototype testing is costly and challenging for small businesses. The support of the CIP program is crucial to thoroughly test the Zephyr 21/60's new full-span pitch system for function, performance, and load reduction as we move toward production."
>
> *Dean Davis, president, Windward Engineering*

Project Outcomes and Deliverables

At the end of the project, a fully validated aeroelastic model will make it possible to certify Windward Engineering's Zephyr 21/60 design and quantify the technology's levelized cost of energy in preparation for certification and entry into the distributed wind market. The Zephyr 21/60 will feature an attractive levelized cost of energy, improved reliability, and a full-span pitch system for safe and redundant protection against rotor overspeed (which occurs when the rotor turns beyond its design limit).

Project Approach

The project involves constructing a prototype pneumatic pitch system and retrofitting it on an existing 60-kW wind turbine for thorough, full-scale testing of its performance, loading, and effectiveness in overspeed protection. To validate the accuracy of the aeroelastic model, the turbine's mass, inertia, and other properties of its critical components will be measured and the load predictions from the model will be compared to the observed field measurements.

Project Collaborators

Current and future project partners include:

- RRD Engineering—aeroelastic modeling and design
- All Energy Management—prototype wind turbine rebuild and controller redesign
- Viking West—prototype component fabrication and supply chain management.

Project Financial Information

Award Amount: $235,000

Awardee Share: $162,421

Total: $397,421

Prototype Testing Award

One of nine types of CIP awards, Prototype Testing projects validate a prototype turbine to determine the commercial readiness of the turbine system. These results are intended to confirm that turbine designs or improvements are ready for certification testing.

About the Competitiveness Improvement Project

The U.S. Department of Energy's (DOE's) CIP supports U.S. leadership in distributed wind technologies. Managed by NREL on behalf of DOE's Wind Energy Technologies Office, CIP supports innovation to advance wind energy as a low-cost, distributed generation technology option.

More Information

Visit NREL's website at www.nrel.gov/wind/competitiveness-improvement-project.html

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"Innovations like the pitch system in the Zephyr 21/60 design continue to increase the market viability and lower the cost for distributed wind turbines, which will make localized clean energy systems realistic options for many rural communities and businesses."

Dave Snowberg, technical monitor, National Renewable Energy Laboratory (NREL)

The 60-kW Zephyr 21/60 wind turbine from Windward Engineering uses a low-cost, full-span independent pitch system that can act as a redundant aerodynamic braking system. In this graphic, the wind turbine is shown with its blades pitched in its parked (brake) orientation. *Image from Dean Davis, Windward Engineering*

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15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nrel.gov

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