NREL Highlights RESEARCH & DEVELOPMENT

Advanced Wind Turbine Controls Reduce Loads

NREL's National Wind Technology Center provides the world's only dedicated turbine controls testing platforms.

Today's utility-scale wind turbine structures are more complex and their components more flexible and lighter weight. As the components become larger and more flexible, it is imperative to control the way they move and interact to prevent damage and possible system failures. The challenge facing wind turbine designers is to capture the maximum amount of energy, with minimal structural loading, for minimal cost.

Researchers at the National Wind Technology Center (NWTC) at the National Renewable Energy Laboratory (NREL) are studying conventional turbine component controls and new, advanced actuators and sensors to develop innovative control strategies that mitigate unwanted aerodynamic structural loads. Loads cause damage that increases maintenance costs and can shorten the life of a turbine.

Design of algorithms to control the dynamic systems of wind turbines must account for multiple complex, nonlinear objectives that are driven by aerodynamic, gravitational, inertial, centrifugal, and gyroscopic loads. Turbine rotors are subjected to complicated, three-dimensional, turbulent wind inflow, with embedded coherent vortices that drive fatigue loads and reduce the turbine's lifetime. Thus, multi-megawatt turbines require active control and damping systems that mitigate fatigue loads, maintain stability, and allow maximum energy capture.

Testing new control schemes is a critical step before new control systems can be implemented in commercial machines. Test facilities at the NWTC include two Controls Advanced Research Turbines (CARTs): the two-bladed CART2 and the three-bladed CART3. Both turbines are used to field-test advanced control systems and related technologies.

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Reference: Wright, A.; Fleming, P. (2010). "Refinements and Tests of an Advanced Controller to Mitigate Fatigue Loads in the Controls Advanced Research Turbine." Presented at the 49th AIAA Aerospace Sciences Meeting, Orlando, Florida, January 4–7, 2011. NREL Report No. CP-5000-50006.

The three-bladed Controls Advanced Research Turbine (CART3) and the two-bladed CART2 are used to test new control schemes and equipment for reducing loads on wind turbine components. Photo by Lee Jay Fingersh, NREL/PIX 19937

Key Research Results

Achievement

The Controls Advanced Research Turbines (CARTs) at the National Wind Technology Center (NWTC) provide the world's only dedicated turbine controls testing platforms.

Key Result

The CARTs allow industry to test new control systems like Garrad Hassan's independent pitch controller and an innovative state-space controller developed at the NWTC.

Potential Impact

Initial test results for the state-space controller show promise for the load mitigation capability of this controller compared to a standard industry baseline controller. NWTC researchers design, implement, and test advanced controls algorithms to maximize energy extraction and reduce structural dynamic loads. These controls can be incorporated into specialized modeling software used by wind turbine designers.

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