NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL Advances Feedforward Control in Turbines

Highlights in Research and Development

Researchers use lidar and feedforward algorithms to improve rotor speed regulation and reduce costs of maintenance and operation.

Controlling rotor speed in response to changes in wind conditions is imperative to capturing the maximum amount of energy with minimal structural loading for the least cost. Current technology uses a feedback controller on the turbine to sense wind conditions and make turbine adjustments accordingly. However, there may be a time delay between the controller sensing a wind gust and the mechanical adjustment to the rotor torque response. Researchers from the National Wind Technology Center (NWTC) at the National Renewable Energy Laboratory (NREL) have developed a feedforward controller that is able to regulate turbines by "looking ahead" at incoming wind conditions, which potentially eliminates this delayed control response.

NREL's 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 19937

NREL researchers achieved this technology by using lidars, which use lasers to measure wind speed and direction ahead of the wind turbine. These lidars transmit data to a turbine controller, which then controls the wind turbine. The test turbines were the NWTC's two Controls Advanced Research Turbines (CARTs)—the two-bladed CART2 and the three-bladed CART3—which are the world's only dedicated turbine controls testing platforms.

Researchers at NREL collaborated with the University of Stuttgart to use a lidar and associated algorithms to measure the velocity of winds before they reach the turbine, a technology called advanced feedforward control. Advanced feedforward control through the lidar's previewed wind measurement allows the turbines to preemptively adjust their controls, instead of having to wait to react after the wind gust accelerates the rotor.

Field test results of the lidar coupled with advanced algorithms showed improved ability of the turbine controller to regular rotor speed, which will improve performance and allow for the feedback portion of the controller to be focused on load reduction. Loads cause damage that increases maintenance costs and can shorten the life of a turbine. The improvements offered by advanced feedforward control may extend turbine life and reduce energy cost.

Technical Contact: Alan Wright, *alan.wright@nrel.gov*

References: Fleming, P.A., et al. (2014). "Field-Test Results Using a Nacelle-Mounted Lidar for Improving Wind Turbine Power Capture by Reducing Yaw Misalignment." *Journal of Physics: Conference Series*, Vol. 524, 2014. *http://iopscience.iop.org/1742-6596/524/1/012002/pdf/1742-6596_524_1_012002.pdf*

Key Research Results

Achievement

NREL researchers tested the ability of lidar feedforward controls on its unique advanced research turbines to regulate wind turbine rotor speeds ahead of incoming wind conditions.

Key Result

Field tests found that lidar feedforward controls were able to "look ahead" to find incoming wind speed. Feedforward controls provided better rotor regulation than existing feedback setups, which have a delay between sensing wind conditions and controlling turbine dynamics.

Potential Impact

Optimal regulation of rotor speeds in response to wind conditions is essential to capturing maximum wind energy while causing minimum load. Feedforward response setups potentially offer more energy generation and longer lasting turbines, lowering the cost of wind energy and making it more commercially viable.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

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

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