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Wind Farm Modeling and Control for Power Grid Support

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ABSTRACT:

Traditional wind farm modeling and control strategies have focused on layout design and maximizing wind power output. However, transitioning into the role of a major power system supplier necessitates new models and control designs that enable wind farms to provide the grid services that are often required of conventional generators. This talk introduces a model-based wind farm control approach for tracking a time-varying power signal such as a frequency regulation command. The underlying time-varying wake model extends commonly used static models to account for wake advection and lateral wake interactions. We perform numerical studies of the controlled wind farm using a large eddy simulation (LES) with actuator disks as a wind farm model with local turbine thrust coefficients ('synthetic pitch') as the control actuation. Our results show that embedding this type of dynamic wake model within a model-based receding horizon control framework leads to a controlled wind farm that qualifies to participate in markets for correcting short-term imbalances in active power generation and load on the power grid (frequency regulation). Accounting for the aerodynamic interactions between turbines within the proposed control strategy yields large increases in efficiency over prevailing approaches by achieving commensurate up-regulation with smaller derates (reductions in wind farm power set points). This potential for derate reduction has important economic implications because smaller derates directly correspond to reductions in the loss of bulk power revenue associated with participating in regulation markets.

BIOGRAPHY:

Dennice F. Gayme is an Assistant Professor and the Carol Croft Linde Faculty Scholar in Mechanical Engineering at the Johns Hopkins University. She earned her B. Eng. & Society from McMaster University in 1997 and an M.S. from the University of California at Berkeley in 1998, both in Mechanical Engineering. She received her Ph.D. in Control and Dynamical Systems in 2010 from the California Institute of Technology, where she was a recipient of the P.E.O. scholar award in 2007 and the James Irvine Foundation Graduate Fellowship in 2003. Her research interests are in modeling, analysis and control for spatially distributed and large-scale networked systems in applications such as wall-bounded turbulent flows, wind farms, power grids and vehicular networks. She was a recipient of the JHU Catalyst Award in 2015, a 2017 ONR Young Investigator award, and an NSF CAREER award in 2017.