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RENEWABLE AND SUSTAINABLE ENERGY INSTITUTE

# BIG energy seminar series

Addressing global energy challenges in scale and complexity.

## *Integrated Physical and Control System Design: A Strategy for New Performance Levels in Renewable Energy Systems*

*James Allison*
*Associate Professor and the Jerry S. Dobrovolny Faculty Scholar at University of Illinois at Urbana–Champaign*

**Date:** Friday, March 1 at 2pm
**Location:** Koelbel Building, Classroom 230

## Abstract:

**Modern renewable energy systems rely on active electronic control to harvest energy economically from the environment. The rich interaction between resource (e.g., wind, water) and energy harvesting system dynamics presents a fantastic opportunity to design renewable energy systems with fundamentally new levels of performance. Realizing exceptional design improvement, however, is difficult precisely because of this richness. We have complex physics interactions to explore, as well as vast physical and control system design spaces to navigate. Non-obvious design solutions exist that resist discovery through expert intuition or application of established systems engineering methods. For example, in practice, control system design is performed by specialists, but normally only after the core physical design aspects are finalized. This sequential approach cannot fully capitalize on the coupling between physical and control system design decisions. While reductionist, sequential design processes render complex system design problems approachable, they typically produce only incremental improvements, limit the complexity of designable systems, and prevent discovery of true performance limits. 'Concurrent engineering' strategies have addressed this gap in part by applying design rules in earlier phases that account for considerations in later phases. This has been applied to active system design, including aspects of wind energy systems, by ensuring that physical system design decisions are informed by control concepts. Such approaches, however, account only partially for design coupling, and do not produce system-optimal solutions. In this seminar, we will explore recent advancements in fully-integrated co-design methods that achieve system optimality. An explicit, quantitative analysis of design coupling will be presented based on a simplified horizontal-axis wind turbine problem. A more complete treatment of wind turbine co-design will follow, including application of a new surrogate modeling method that supports higher-fidelity co-design. Finally, a study of integrated wind farm layout and hierarchical control design will be presented, including active power control for frequency regulation services and quantitative assessment of design synergy mechanisms.**

## Bio:

**James T. Allison is an associate professor and the Jerry S. Dobrovolny Faculty Scholar at UIUC. He is a faculty member of the Industrial and Enterprise Systems Engineering department, an affiliate faculty member of the Aerospace Engineering department, and is the director of the UIUC Engineering System Design Laboratory. Prof. Allison holds MS (2004) and PhD (2008) degrees in Mechanical Engineering, and an MS (2005) in Industrial and Operations Engineering, all from the University of Michigan. He also holds a BS in Mechanical Engineering (2003, University of Utah) and an AAS in Automotive Technology (1998, Weber State University). He is the co-author of over 100 research publications and the recipient of several awards, including the NSF CAREER Award, ASME Design Automation Young Investigator Award, ASME papers of distinction, and several teaching and advising awards. Previous experience includes work in the automotive (Ford and GM) and the engineering software (MathWorks) industries. Prof. Allison's work focuses on the creation and analysis of novel design methods for engineering systems, as well as producing new design knowledge for unprecedented systems. Specific topics of study include: integrated physical and control system design, system architecture design, topology optimization, design for additive manufacturing, and material system design. His investigations span a wide range of application domains, including wind energy systems, spacecraft design and attitude control systems, intelligent structures, vibration isolation and control, automotive systems, power electronics, manufacturing, and fluid systems.**

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