Control, Modeling, and Optimization Challenges in the Smart Grid

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Target Audience

Graduate students and researchers interested in understanding the role of control, modeling, and optimization in meeting the challenges of the Smart Grid.

The Smart Grid

The Smart Grid is a vision of the future electric energy system. There are many visions of this future, but perhaps these are best summarized by US Energy Secretary Steven Chu who writes that ``the Smart Grid is the key enabler for: integration of renewable energy sources into the grid, management and deployment of energy storage, load management, system transparency, and cyber and physical security of the electric energy system''. Several drivers motivate this transformation of the electric grid: (1) The physical infrastructure of the electric grid is aging and over-burdened. Electricity demand continues to rise, while investments in transmission and distribution infrastructure remain insufficient. (2) Concerns over climate change and carbon emissions have led to aggressive goals for integration of large amounts of renewable generation – especially wind, and solar - to meet our electric energy needs. The confluence of these factors has led to increased stresses on the electric grid. The key idea is that the use of advanced communication, information, and control technologies in conjunction with advances in renewable generation, energy storage, materials, sensors, and power-electronics will allow us to reach the abovementioned vision of the Smart Grid.

Opportunities

Tools from systems and control theory have tremendous potential for the proper *evaluation, deployment, and operation* needed to enable the Smart Grid. Some of the challenging problems that researchers in the systems and control community are best equipped to address include, but are not limited to: optimal methods for integration of variable and uncertain renewable generation, optimal deployment and operation of distributed energy storage devices, scheduling of flexible demand such as PHEVs, enhanced power system stability using wide-area monitoring, intelligent distributed protection, cyber-security of the electricity grid.

Workshop Outline:

1. Electric Grid: Background
    a. Transmission, Generation, Distribution models
    b. Voltage and Frequency Control
    c. Grid operations and dispatch
    d. Stability, Protection
2. The Smart Grid Overview
    a. Drivers for the Smart Grid
    b. New components: renewable generation, synchrophasors, demand response, storage
    c. Smart grid opportunities
3. Distributed Communications in Smart Grid
    a. System architecture – requirements and issues
    b. Component technologies
    c. Synchrophasors as distributed sensors
4. Wide Area Control
    a. Event based control (protection)
    b. Oscillation detection/control
    c. Transient stability control
    d. State estimation and model based control
5. Integration of Renewable Generation
    a. Difficulties with current approach to renewable integration
    b. Strategies for efficient integration at high penetration levels
6. Responsive loads and distributed storage
    a. Methods for engaging loads and distributed storage in system operations
    b. The role of responsive load and storage in renewables integration
    c. Challenges for modeling and direct control
7. The Future of Electricity Markets
    a. Multiple recourse markets
    b. Risk limiting dispatch
    c. Interruptible power contracts