EE 693K, Spring 2015
Smart Grids and Renewable Energy Integration

Lectures: MW, 3:30–4:45pm, Holmes 248

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Office Hours: to be announced; until then, e-mail me to make an appointment

Textbooks:
- *The Smart Grid: Adapting the Power System to New Challenges* (Synthesis Lectures on Power Electronics), by Math H.J. Bollen (ISBN 978-1608458165)
- *Smart Grid: Integrating Renewable, Distributed & Efficient Energy,* edited by Fereidoon P. Sioshansi (ISBN 978-0123864529)
- Both textbooks are available from the campus bookstore. Used and Kindle/electronic versions are available on Amazon.com and bigwords.com. An electronic version of the Bollen textbook is also available from http://dx.doi.org/10.2200/S00385ED1V01Y201109PEL003
- Additional papers and chapters are listed in the course outline below, and will be available on the course website

Grading:
Homework: 60%
Instructional Presentation: 5%
Final Project: 25%
Final Project Presentations: 10%

This class focuses on the challenges of integrating intermittent renewable energy sources into the power system, with a focus on "smart grid" solutions to do this more effectively and less expensively. Class sessions will focus on discussing the key issues and methods of one or more of the assigned readings; these will generally be conducted by the instructor, but each week one student will conduct a 30-minute lecture/discussion on one of the assigned readings. There will also be some software tutorials and discussions of homework assignments.

There will be 3 homework assignments during the semester, mostly modeling and analysis projects to help understand and optimize renewable energy integration. These will rely on a variety of programming tools (e.g., cplex and Matlab). These are challenging but do not require advance knowledge of how to use these tools.

You will complete a group or individual project on a subject of your choosing. You will briefly present your topic to the class during the week after spring break, and then give a longer presentation of your final results late in the semester. A paper describing the work and findings will be due on the last day of class.

Learning objectives: After completing the course, students will be able to do the following:

- Identify challenges due to renewable energy adoption and effective mitigation measures, involving various
  - geographic scales (distribution or transmission),
  - time scales (seconds to years),
  - system properties (frequency, voltage),
  - technologies (wind power, solar power, electric vehicles, load-tap changers, consumer appliances, smart meters)
  - agents (electric utilities, customers, independent system operators, aggregation service providers), and
  - control/incentive structures (mandatory, voluntary turnover of control, or dynamic markets)
- Use several methods to forecast production from renewable resources, and set optimal spinning reserve targets based on the quality of these forecasts.
- Choose optimal power system generation expansion plans, based on the interaction of renewable power, demand response and conventional generation.
- Identify techniques to avoid voltage problems in distribution circuits with large shares of solar power.

Course Outline

1 Overview (1 week)
2 System-Level Energy Balance
  2.1 Introduction (1 week)
  2.2 Hourly Operation (3 weeks)
    2.2.1 Hourly Electricity Pricing
    2.2.2 Hourly Response by Appliances
    2.2.3 Hourly Response by Electric Vehicles
  2.3 Multi-Year Planning (1.5 weeks)
  2.4 Reserves and Frequency Control (3.5 weeks)
    2.4.1 Introduction
    2.4.2 Reserve Requirements with Renewable Energy
    2.4.3 Reserves and Frequency Response via Centralized Load Control
    2.4.4 Reserves and Frequency Response via Smart Devices
    2.4.5 Behavior of Renewables During Frequency Disturbances
3 Distribution System Voltage Regulation
  3.1 Transient overvoltage (1 week)
  3.2 Steady-state overvoltage and flicker (1 week)