CRN# 14367 CPET 58100-02 SmartGrid and Energy Management
(Variable Title Workshop in CPET)
A Specialty Course
for
Purdue University's M.S. in Technology:
Information Technology/Advanced Computer Apps Track, and
Industrial & Manufacturing Technology Track

Fall 2013

Course TITLE: CPET 581 Smart Grid and Energy Management (Various Title Workshop in CPET), 3 cr. hr.

Course Instructor:
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Office Hours:

- Monday 3:00 - 5:00 PM
- Tuesday 1:00 – 3:00 PM
- Wednesday 3:00 – 5:00 PM
- Thursday 1:00 - 3:00 PM
- Other weekday hours – by appointment

Lecture: Room ET 211, Tuesday & Thursday 4:30 P.M. to 5:45 P.M.
Course Web Site: http://www.etcs.ipfw.edu/~lin

Course Description
This course aims to study the broad subject of SmartGrid Technologies and Energy Management. This course will focus on the economic fundamentals, technology management, and energy management instead of on the electrical engineering aspects. In part (1), it introduces students to the fundamental of electric power generation, transmission, and distribution; electric power systems, grid, and interconnection; distributed & renewable energy resources (solar, wind, biomass, geothermal, etc.); economics of supply and demand, power energy business & markets in both regulated and unregulated environments. The part (2) of the course will focus on the various components of Smart Grid technologies and infrastructures, and their impact to the power energy providers, system operators, business, and consumers; energy management issues and opportunities. The part (3) will survey current U.S. Smart Grid technology implementation including smart meter, AMI (advanced metering infrastructure) and their penetration, and future opportunities.

In addition, the students are expected to study and present research papers and/or case studies from recent literature, to participate in class discussion actively, and complete a team-based, hands-on smartgrid and/or energy management application project with oral presentation and demonstration.

Prerequisites and the Level of the Course

This course will be self-contained, with minimal requirements on graduate-level training. All students enrolled in M.S. Technology program can be enrolled.

Course Objectives

This course has three main goals: (1) It will provide the students a system perspective of modern electric power & energy system and issues faced by the power industry sector. (2) It will provide an in-depth knowledge of emerging smart grid enabling technologies and their applications in connecting distributed renewable energy systems, and sustainable and efficient energy monitoring and management applications. (3) It will engage students with smartgrid and/or energy management related term projects (energy data analysis, system planning, new business and models, new energy efficiency and/or management issues, etc.) and prepare them for the future careers in the field of power industries, system operators and in today's competitive world.

Disabilities Statement: If you have a disability and need assistance, special arrangements can be made to accommodate most needs. Contact the Director of Services for Students with Disabilities (Walb, room 113, telephone number 481-6658), as soon as possible to work out the details. Once the Director has provided you with a letter attesting to your needs for modification, bring the letter to me. For more information, please visit the web site for SSD at http://new.ipfw.edu/disabilities/

Class Activities and Course Assessment

- The class format will be 3 hour lecture/discussion/demo/case presentation each week
- Active students participation in presenting case studies, articles and papers from the recent literature are expected
- Student assignments include assignments on research questions, case studies, reading technical papers and/or articles and writing short summary for each paper.
- Hands-on term project: students will complete a final project working in groups of 2 students, present projects in class and complete a written project report.

Grading policy (method of evaluation):

- Reading Assignments/homework (reading assignments from recent report & publications, magazines, proceedings, and journals): 40%
- Two Exams/Quiz: 10%
- Smart Grid Technologies and/or Energy Management related research project proposal and presentation (mid-term) -10 %
- A written research/project report with presentation - 30%
- Class participation (attendance, class discussion, collaboration activities, etc) – 10%

Grading Scale: A (90-100%), B (80-89%), C, (70-79%), D (60-69%), F (0-59%)

- No late assignment, report, etc. will be accepted.
- No makeup exam/quiz will be given

Tentative Topics of Discussion

Tentative Topics of Study include but not limited to

1. National Energy, Clean Air, Climate Change Policies, and Agencies
   - U.S. Energy Independence and Security Act of 2007
   - U.S. Energy Acts & Bills
   - U.S. Energy Policy and Competitiveness
   - U.S. Clean Air Act
   - Government Regulatory Agencies and their roles in Energy Technology, Federal Agencies: DOE, EPA, State Agencies
   - EPA
     - Mercury and Air Toxics
     - Carbon Pollution Standards
     - Emissions Tracking Highlights, http://www.epa.gov/airmarkets/quarterlytracking.html
     - Climate Change, http://www.epa.gov/climatechange/
   - Federal Energy Regulatory Commission (FERC), www.ferc.gov
   - U.S. Energy Information Administration (official energy statistics from U.S. government), www.eia.gov
   - Energy Programs
     - Energy Efficiency & Renewable Energy – Federal Energy Management Program (FEM), http://www1.eere.energy.gov/femp/

2. Basics of Power Systems: From generation to customers
   - Electricity, Power, Energy
   - Power generation, transmission, distribution systems and networks
   - Electric loads and power flow
   - Fundamentals of power system equipment, apparatus such as generator, transformers, voltage regulators, power factor correction, metering and protection equipment
   - Electrical substations
   - Reading your electric bills (residential, commercial, and industrial users)
   - Energy efficiencies
   - Power transmission automation
   - Power distribution automation
     - Control center, SCADA (Supervisor Control and Data Acquisition), Remote Terminal Unit (RTU), IEC 16850 Intelligent Electronic Devices (IEDs), computer communications and networking, Web systems
   - Economic dispatch and unit commitment problems

3. Distributed & Renewable Energy Resources and Technologies
   - Carbon footprint
   - Renewable energy sources and technologies: solar power, wind power, biomass, geothermal, etc.
   - Micro-grid architecture
   - Investment options (generation capacities, transmission, renewables, demand-side resources, etc.)
   - Modeling and forecasting
   - Distributed storage and reserves
   - Integration of power resources

4. An Introduction to Utility Governance and Regulation, Power Industries and Markets Fundamentals

- Government Regulatory Agencies and their roles in Energy Technology, Federal Agencies: DOE, EPA, State Agencies
- Federal Energy Regulatory Commission (FERC), www.ferc.gov
- U.S. Energy Information Administration (official energy statistics from U.S. government), www.eia.gov
- Electricity industry and their regulated and deregulated environments
    - Regional Transmission Organization (RTO)
    - Independent System Operators (ISO) & Regional System Operators (RSO)
    - The three major Interconnections
    - Electric Power Reliability Management Corporations
- Major power industries
    - AEP, Duke Energy,
- Renewable energy suppliers/power industries
- Electric power markets, supply and demand, and asset optimization

5. Power & Energy Technology Research Lab and Institutes

- DOS Funded National Energy Research Labs, http://energy.gov/maps/doe-national-laboratories
- National Energy Technology Laboratories, www.netl.doe.gov
- National Renewable Energy Laboratory (NREL), www.nrel.gov
- Utilities Funded Research Institutes
    - Electric Power Research Institute (EPRI), www.epri.com
    - Edison Electric Institutes, www.eei.org
- Next generation power grid communication requirements
- Renewable energy resources (solar power, wind power, biomass, geothermal, etc.), their impacts, investment options (generation capacities, transmission, renewables, demand-side resources, etc.) and integration of power resources
- Power Grid Enhancement
- Power system interoperability

6. Energy Management Issues and Solution

- Energy data, http://www.data.gov/energy/community/energy
- The power energy information system
- The demand side of electricity
    - Load characteristics, load curve, load duration curve
    - Demand side management
- The economics of supply & demand in energy markets
    - Optimization (supply ≈ demand)
    - Modeling the electric power consumers & producers
    - Market equilibrium
    - Short-run vs. long-run costs
    - Energy market deregulation
- Transmission and distribution electric networks
    - Real-time, on-demand, optimal power flow and unit commitment models
    - Locational marginal prices
- System reliability
    - Ancillary services

    - Generation and transmission infrastructure investment
    - Long-term planning
- Renewable energies
    - Dealing with short-term needs and variations
    - Impacts on long-term reliability
    - Price forecast and investment valuation

7. Smart Grid Opportunities, and Challenges: Cost and Benefits
    - An overview of SmartGrid technologies
        - Two way communications
        - Network architectures
        - IP-based system
        - Power line communications
        - Advanced metering infrastructure
    - Key characteristics of Smart Grid
    - Smart Grid road map and standards
    - Economic costs, benefits, and market operations
    - Pricing and energy consumption scheduling
    - Demand response participation
        - Controllable load models, dynamics, and challenges
        - Electric vehicles and Vehicle-to-grid systems
        - Demand side ancillary services
    - The role of smart grid in the distributed generation, storage and distribution automation
    - The Challenges of Interoperability and CyberSecurity
        - Intelligent two-ways Communications for and through SmartGrid
        - The electric grid control architecture
        - Wide area measurement
            - Sensor networks
            - Phasor measurement
            - Communication infrastructure
            - Fault detection and self-healing
        - Traditional regulations and stakeholder politics
        - New challenges for system stability and reliability
        - The smartgrid and power energy consumers
        - Security and privacy
            - Cyber security challenges
            - Load altering attacks
            - False data injection attack
            - Defense mechanisms
            - Privacy challenges
8. SmartGrid and Energy Management Operations
    - Energy and reserve markets
    - Market power
    - Generation industries
    - Locational marginal prices
    - Financial transmission rights
    - Applications
        - Advanced Metering Infrastructure (AMI), Advanced Smart Metering
        - Home energy management system
        - Commercial/Industrial energy management

    - Building a Sustainable SmartGrid Technology and Communities
- Smart grid jobs and business opportunities

References: To Be Listed