Course Syllabus – DRAFT

ISEN 430 - System Engineering Principles of Sustainable Technologies: Grid Planning & Operations (0.5 credit)

Northwestern University

Course Synopsis:
This course serves as a graduate entry-level introduction to the broad subject of grid planning and operations. The course will concentrate on introducing the purpose of the grid, its critical operations and optimization now and in the future. Topics covered will include grid management fundamentals, short-term system dispatch, long-term asset investments and the changing nature of electricity transmission and distribution. The course will evaluate the impact of changes such as renewables integration, PHEV penetration, demand side management, and greenhouse gas (GHG) emissions reductions on grid planning and operations.

Course Goals:

- Understand the overall goals, constraints and opportunities associated with grid operations and optimization
- Learn the key players, tools and terms of grid operations
- Assess the trade-off between key metrics in grid operations ranging from economics to reliability, resiliency of an electric power system. Consider value of power quality / power factor, ancillary services etc
- Understand the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid.
- Understand the key concepts and principles of today's grid and likely future grid structures
    - DER visualization and modelling
    - Forecasting and scheduling dispatch
    - Grid integration and transmission
    - Fault detection
    - Resource Assessment and Management Optimization vs. IRPs

Grading/Assessment:
Grading will be based on the following rubric:

Component	Weight	Details	Due
Homework	20%	*Weekly assignments to be returned before first class of each week (x5)*	Ongoing
Site Visit & Reaction Paper	20%	*Reaction paper to visit to grid operations center (likely MISO)*	Ongoing

Midterm	20%	*Exam on first half concepts; offered in second class of third week*	Weeks 1-4
Final Paper	40%	*5-8 page paper analyzing and providing evidence on topic question provided by instructor. Questions provided to students at end of Week 4.*	Week 5

<u>Grading Policy</u>:

Grades will be assigned based on all the work you have completed during the semester following the traditional practice of A=90-100, B=80-89, C=70-79, D=60-69, F<60.

Letter Grade	Percentages	Letter Grade	Percentages
A	93 - 100 %	C+	77 - 79.9 %
A-	90 - 92.9 %	C	70 - 76.9 %
B+	87 - 89.9 %	D	60 - 69.9 %
B	83 - 86.9 %	F	< 60 %
B-	80 - 82.9%		

<u>Required Course Materials</u>:

- Fundamentals of Power System Economics, by D. S. Kirschen and G. Strbac. Reprinted edition. John Wiley & Sons Ltd. 2009.
- Renewable and Efficient Electric Power Systems, by G. M. Masters. John Wiley & Sons, Inc. 2004
- Electric Power System Basics for the Nonelectrical Professional, by S. W. Blume, Wiley-Interscience, 2007.
- Optimization Principles: Practical Applications to the Operation and Markets of the Electric Power Industry, by N. S. Rau. Wiley-IEEE Press, 2003

<u>Additional Course Materials</u>:

To be assigned

CLASS OUTLINE

Weekly Topic	Description
1: T&D Basics, Overview of current US grid	• Review of the component parts, key players, equipment and regulatory structures that make up the grid • Key roles in grid operations, facilities & controls • Review of how the grid works and the critical risks and opportunities • Overview of key technologies in grid ops (e.g. feeders) • The US Grid today and its regional differences – PJM, MISO, ERCOT etc • Typical goals and concerns of grid operators – what keeps them up at night? **Homework**

2: Power system Fundamentals	*Short Term Issues: Day(s), hours, minutes, seconds, real time.* • Transmission and Losses • Role of pricing e.g. Marginal Cost Prices (LMP) • Balancing (Real Time Supply/Demand, frequency control) • Line Losses, Transformers, Converters and Power Electronics • Reserve Requirements (Frequency, Regulation, Operating) – what are they & do they exist? **Homework**
3: Long Term Planning & System Reliability	• Integrated Resource Plans (IRP) and its role for utility planning • Long-term planning – annual load loss probability • Long term capacity markets; Ancillary services • Investments in generation and transmission • Financial Transmission Rights **Midterm**
4: The Changing Grid	• Renewable integration: dealing with short-term variation and impacts on long-term reliability • PHEV penetration, demand side management • Greenhouse gas (GHG) emissions reductions • Collective impact on grid planning and operations • Impact on price forecasts and investment valuation • Grid infrastructure vs. distributed investments – impact on operations, reliability and resilience • (if time allows) What exactly is a "smart grid"? **Site visit to control center + reaction paper**
5: Tools & Technologies for the Grid	• Strongest historical tools, technologies & methods to manage and optimized the grid (e.g. SCADA, EMS) • Emergence of new tools and how they impact grid management (e.g. ADMS) • The future – what is on the horizon for the grid (e.g. AI) **Final Paper Due**