Northwestern | INSTITUTE FOR SUSTAINABILITY AND ENERGY

Course Syllabus – DRAFT

ISEN 441 Monetizing the Grid (1.0 credit)
Northwestern University

Course Synopsis:
This course seeks to answer the question: How can money be made from the grid? In this course, value creation and grid economics will be central themes. Using theoretical and economic tools, this course will assess the current and future states of the monetization of the grid.

Course Goals:

- Build a clear picture of current value drivers in the US electricity market
  - Understand key stakeholders
  - Learn the size of the market and profit pools by stakeholder and stage in the value chain
  - Review differences (regional, by supply source or end user) in economics of the grid
- Utilize economic tools to maximize efficiency and value
  - Define locational value and its relevance to the grid
  - Compare multiple operational and maintenance strategies—Predictive vs. Reactive vs. Preventive
- Assess the impact of emerging regulatory models, technology solutions and economic / financing models on monetizing the grid

Grading/Assessment:

Grading will be based on the following rubric:

Component	Weight	Details	Due
Effort and Attendance	10%	*Based on attendance and instructor assessment of preparations and participation in class; Instructor will use "warm call" method by listing names of those that he will call on at the beginning of class*	Ongoing
Response Papers / Cases	60%	*Written responses to questions about either: key topics covered in weekly lecture OR assigned case study (every 2 weeks)*	Weeks 2, 4, 6, 8
Final Exam	30%	*Final exam that tests key concepts covered in the course plus a short essay on a key topic in grid monetization*	Week 10

Grading Policy:

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%		

Required Course Materials:

- Strbac, Goran, Kirschen, Daniel S. Fundamentals of Power System Economics. United Kingdom: Wiley, 2018.
- To be completed / assigned by instructor

CLASS OUTLINE

Weekly Topic	Description

1: *Introduction to course and Overview on Electric Power Industry*	• Course Introduction & Expectations
	• Overview of the importance of energy in the global economy & its role in US market (GDP)
	• Geographic distribution of energy resources, trade flows, and different types of energy
	• Electricity market structure in the United States (# of utilities, utility models, vertical integration)
	  ○ Supply: fuel types, their carbon intensity & market share
	  ○ Demand: industrial, commercial, residential, agriculture
	  ○ Transmission & Distribution: players / ISOs; regional variety
	  ○ NERC and FERC grid management
	  ○ Deregulation of the power industry
	• Discussion on the unique aspects of electricity and the grid, including but not limited to:
	  ○ inability to inventory, regulation, lack of price transparency
	  ○ externalities like environmental impacts
	  ○ role of weather
	  ○ role of transmission and transmission losses
	  ○ market price-setting, time and locational value of power
	  ○ impacts of varied regulatory models

2: *Economics of supply*	○ Evaluate various fuel choices (coal, natural gas, nuclear, hydro, solar, wind, etc.) used in electricity generation in terms of the capital costs, fixed costs, variable costs, and environmental footprints of each source ○ Review unique pricing dynamics in the electricity market and identify strategic implications for operators (including duck curve, negative pricing etc) ○ Discuss participation in regulated vs. unregulated markets and other key issues in electricity supply ○ Overview of changes in electricity supply given the onset of DERs ○ O&M and its costs and benefits

3: *Economics of demand*	• Key stakeholders: producers, distribution companies, end users (commercial, industrial, residential and agricultural)
	• Brief review of power system economics (supply & demand, profit maximization, etc.)
	• Key tools that help us understand demand including metering
	• Key characteristics of each demand segment
	  ○ Typical load profile (intraweek, intraday)
	  ○ Seasonality
	  ○ Special considerations: reliability, resiliency, ancillary services
	• Technological changes and consumer preferences and their implications for energy markets.

4: *Pricing Carbon*	○ Evaluate the implications of climate change for the energy industry, and for the global economy overall ○ Review the urgency to address climate (IPCC) ○ Determine the role of carbon pricing in the US – now and potential ○ Carbon pricing models from abroad

5: *Evolution of the US electricity market & economic implications*	• New trends on the US Grid: DERs, role of renewables & storage
	• Growth of other elements that may change the equation:
	  ○ O&M strategies—Predictive, Preventative, Reactive
	  ○ Grid cost management & meeting demand
	  ○ Economic dispatch & Unit commitment
	• Identifying market price signals and applying optimal strategies
	• Maintenance strategies to maximize net gain from the grid

6: *Regional variations in monetization opportunities*	○ Regional overview of power prices, value of reliability & resilience, regulatory models, difference in supply-demand equation, variance in penetration of technology (e.g. smart meters, renewables, batteries, ZEV vs. non-ZEV states) ○ Locational value of power ○ Value of reliability & resiliency + other differences in consumer demand

7: *Current and Future Capital Models -- Energy as a Service / New Infrastructure Investing*	• What are new, emerging capital models to consider? • What is EaaS? Why are companies offering it? Why are other organizations buying Eaas? • Who are the leaders / key stakeholders? • What is the role of infrastructure funds? How to they create value? Why are they looking at energy markets? • Are there other emerging models?

8: *Additional concepts in value creation*	• Utility Level Master Planning
	  ○ Principles of Integrated Resource Planning
	  ○ Utility efficiency & goal setting
	• Pricing
	  ○ Uniform Market Clearing Prices (MCP) vs. Pay As Bid
	  ○ Locational Marginal Pricing (LMPs)
	• Simultaneous Feasibility Test
	• Revenue inadequacy
	• Energy Efficiency
	  ○ Opportunities to save annual operating cost via building energy management
	  ○ Market actors - EE services, ESCOs, EMCS, software, consulting
	  ○ Concept of Negawatts*:* energy saved as a direct result of energy conservation measures, such as reducing the use of heat or electricity
	• AI & Technology Tools to Create Value in today's market
	  ○ Proliferation of sensors / IoT
	  ○ "Smart Grid" – myths vs reality
	  ○ Linear programing — maximizing profits and minimizing cost through linear mathematical models

9: *Blue Ocean Opportunities & What's next*	• Overview of greatest opportunities for monetization in the near future.

*structured as 9 week syllabus given no Monday class in Spring 2021