

Course Syllabus – **DRAFT**

ISEN 403 Energy, Water, and Transportation System Economics
Fall 2020

Northwestern University

Course Synopsis: This course will review the underlying economic theory driving core resource markets - including electricity, gas, water, and transportation. It will also include a discussion of issues that are unique to energy generation and environmental impact, as well as a deep dive by resource type.

Course Goals: This course will provide students with an understanding of consumer and supplier rationale for economic behavior in energy, water and transportation markets, as a basis for applying the tools of economic analysis to discrete decision-making.

- Understand varied ownership structures and economics for “utilities” (IOU, Muni, Co-op) and how this can influence decision making
- Build a basic understanding of the economics that govern water and transportation systems
- Understand supply and demand in natural resource commodity markets
- Develop analytical capabilities to compare and contrast substitutes (e.g. energy sources)
- Learn different rate structures and how they provide incentive or disincentive for investment and production
- Identify unrealized or non-market costs related to risk, environmental externalities, and climate
- Consider the short-term vs. long-term impacts of resource investment and production, and how different economic agents may behave differently under the same conditions
- Be able to identify market characteristics that are unique to specific resources

This course is a pre-requisite for *ISEN 404 - Resource Markets Design, Regulation, and Reform*.

Prerequisites: None

Grading/Assessment:

Grading will be based:

- 10% on class participation
 - Class participation will include attendance, class participation that demonstrates ownership and mastery of discussion topics
- 50% on written position assignments
 - Position papers will be assigned weekly (10 in total); papers will be 2-3 pages long (each worth 5% of total grade), addressing a current events manifestation of the week’s topics.
- 40% on a final exam

Letter grade	Percentage
A+	97–100%
A	93–96%
A–	90–92%
B+	87–89%
B	83–86%
B–	80–82%

All questions and problems regarding grades must be presented in writing within one week after the test, homework, or project has been returned. 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.

C+	77–79%
C	73–76%
C-	70–72%
D+	67–69%
D	63–66%
D-	60–62%
F	0–59%

Course Readings:

Weekly discussions will draw on materials for the below texts, reports, and primers:

- Travis Bradford, “The Energy System: Technology, Economics, Markets, and Policy” (MIT Press, 2018)
- David Feldman, “Water” (Polity Press, 2012)
- Small and Verhoef, “The Economics of Urban Transportation” (Routledge Press, 2007)

For students who have not completed an undergraduate course in Microeconomics, the following reading is also required BEFORE the first class

Acemoglu, D.; Liabson, D. Microeconomics, 2nd edition. April 2017. (selected chapters to be assigned by instructor)

Supplemental Reading List

- IEA World Energy Outlook 2018
- Marc Reisner, “Cadillac Desert: The American Desert and Its Disappearing Water” (Penguin Books, 1993)
- Charles Fishman, “The Big Thirst: The Secret Life and Turbulent Future of Water” (Free Press, 2012)

CLASS OUTLINE

<p>Week 1 (Date): Resource ownership, basic economics and applied economics fundamentals</p>
<p><u>Description/Topics:</u></p> <ul style="list-style-type: none"> • Overview of key stakeholders and typical ownership structures in energy, water and transportation (e.g. IOU, muni, co-op; vertically integrated vs. other utility structures) • Basics of supply, demand, and price formation in natural monopoly vs. competitive markets – how they apply to natural resources and transportation; discussion of “perfect” markets • Residential, commercial, and industrial demand elasticity for critical resources (gas, power, water & transportation) • Substitute goods and demand rebound <p>Writing Assignment #1 – (<i>Sample topic</i>) Assess a current resource market in the news & comment on how supply & demand OR demand elasticity are impacting stakeholders</p>
<p>Week 2 (Date): Forecasting, Production and Marginal Cost</p>
<p><u>Description/Topics:</u></p> <ul style="list-style-type: none"> • Discussion of critical applications of forecasting & marginal cost e.g. Peak Power & Public Transportation • Load forecasting - short and long-term • Commodity pricing and marginal supply cost for exhaustible vs. renewable resources • Levelized cost of production/use • Constrained optimization, market manipulation • Basic market pricing • Production costs for power, gas, water (fixed vs. variable costs, production, distribution/delivery) <p>Writing Assignment #2 – (<i>Sample topic</i>) Comment on a market where forecasting has a material impact on marginal cost and ultimately consumer / end user price</p>
<p>Week 3 (Date): Complexities of natural resource pricing</p>
<p><u>Description/Topics:</u></p> <ul style="list-style-type: none"> • Typical pricing structures for gas, power and water for end users • Rate base and guaranteed return on infrastructure investment • Price controls and subsidies • Specific electric pricing features – e.g. demand response, duck curve • Progressive, regressive, and flat pricing, service as a subscription, performance contracting • Policy modifiers – congestion pricing, regulating efficiency, decoupling, incentives/rebates, feed-in tariffs <p>Writing Assignment #3 – (<i>Sample topic</i>) Discuss the key influences on a unique approach to resource pricing in today’s market</p>

Week 4 (Date): Environmental economics and non-market value

Description/Topics:

- Overview of environmental externalities in water, power, gas, transportation – including social equity issues
- Determining social costs of ESG issues; Cost-benefit analysis
- Stationary vs. mobile-source pollution
- Mechanisms to internalize environmental externalities (and purpose - behavioral change vs. revenue)
- Climate change and the evolving concept of risk management (physical & transitional)
- Natural capital and ecosystem services

Readings:

- “What is the Clean Power Plan” – NRDC [Policy Primer](#), Sept. 2017
- “The Future of US Carbon Pricing Policy” – Stavins, National Bureau of Economic Research, May 2019
- The Interchange Podcast. October 30, 2019. “How do we measure climate risk?”¹

Writing Assignment #4 – (Sample topic) Write an opinion paper on which externalities are most important for low income residents of the U.S. (urban or rural). Explain your position using the economic concepts covered in the course to date.

Week 5 (Date): Infrastructure lifespan, amortization, and time value of money

Description/Topics:

- Overview of capital projects and historical funding models for resource infrastructure efforts
- Review of modern-day infrastructure investment and emerging changes
- Consider public goods and role of public-private partnership
- Depreciation, amortization, and useful life as applied to energy, water and transportation
- Consider role of NPV, IRR, and project / asset risk in

Writing Assignment #5 - (Sample topic) Provide a pro-con analysis of the funding model for an infrastructure project

Week 6 (Date): Technology cost-curves

Description/Topics:

- The importance of technology in natural resources and example technology innovations
- Economic importance of technology
- Technology adoption S curves; Learning curve and economies of scale
- Soft costs; Replacement goods, e.g. demand response
- Importance of economies of scale

Writing Assignment #6 (Sample topic) Describe a natural resource technology that successfully navigated the S-curve and explain why this was possible

¹ <https://www.greentechmedia.com/articles/read/how-do-we-measure-climate-risk>

**Week 7 (Date): Fossil Fuels**Description/Topics:

- Supply Chain – extraction, refining, distribution, storage
- Coal v. oil v. natural gas markets
- Primary energy vs. final energy services
- Climate, carbon pricing, and stranded asset risk

Readings:

- LLNL Energy Flow Chart – [US, 2018](#)

Guest Speakers:

Writing Assignment #7 – (Sample topic) Discuss one of the economic challenges facing an oil major and explain how they propose to address / navigate it

Week 8 (Date): Gas & Power MarketsDescription/Topics:

- Electric Power markets
 - Rise of renewables
 - Impact of energy storage
 - Capacity factor, conversion efficiency and supply imbalance
 - Distributed vs. centralized, product value (e.g. net metering, RECs, etc)
 - Resource value deflation
- Gas markets
 - Major end use markets for gas
 - Impact of fracking in US
 - “Electrify everything” movement
 - International comparative case study – the UK and the North Sea – end of gas independence

Readings:

- Lazard LCOE v12 / LCOS v4 - [2018](#)

Guest Speakers:

Writing Assignment #8 - (Sample topic) Outline the impact of a market disruption from an economic point of view in gas or power markets (supply, demand, externalities other)

Week 9 (Date): WaterDescription/Topics:

- Water markets overview – stakeholders, supply, demand, cost / pricing
- Demand – end users, residential vs. industrial vs. agricultural and varying pricing structures
- Supply – Water sources, water rights and priority access
- Cost – Raw materials management, processing, distribution



- Pricing / Ownership - Social welfare and “basic rights”; water safety
- Privatization
- Food-Water-Energy Nexus

Readings:

- “Drought: 10 things to know about California water use” – Peterson, [KPCC](#), April 15, 2015
- “Basic Fairness: Access to Water & Sewer Service in Michigan” – Levine, [NRDC Blog](#), March 20, 2019
- “Cape Town’s ‘Day Zero’ Water Crisis, A Year Later” – Alexander, [CityLab](#), Apr 12, 2019

Guest Speakers:

Writing Assignment #9 - (Sample topic) Assess the economics of the Colorado River from the perspective of one of the stakeholders (one of the 7 states that is part of the compact, EPA, environmental activists, investors)

Week 10 (Date): Transportation

Description/Topics:

- Definition of “transportation”
- Key modes of transportation and variation in economic models
- Fuel source – oil, ethanol and next-gen biofuels, EVs
- Fuel economy standards
- Commerce Act – Movement of goods
- Infrastructure maintenance and taxation
- Urban planning considerations
 - Public Transportation in the US
 - Changing profile of individual car ownership (e.g. ride share, EVs)
 - Alternative transportation methods (e-bikes, autonomous, heli-car)

Readings:

- “Who Pays for Roads once Electric Vehicles Defund The Gas Tax?” – McMahon, [Forbes](#), June 4, 2018
- VW Settlement Clearing House. ²
- English, Jonathan. “How the US killed public transportation?”³ August 2018.

Guest Speakers:

Writing Assignment #10: (Sample topic) Opinion paper – What is the greatest economic disruption coming in the US transportation market coming in the next 10-15 years and why?

Week 11 (Date): Final Exam

² <https://vwclearinghouse.org/>

³ <https://www.citylab.com/transportation/2018/08/how-america-killed-transit/568825/> (or similar)