Northwestern | INSTITUTE FOR SUSTAINABILITY AND ENERGY

Course Syllabus
ISEN 403 *Energy, Water, and Transportation System Economics*
Fall 2021
Tuesdays & Thursdays 11:00-12:20
Northwestern University

Instructors: Mark Witte and Lynne Kiesling
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Office Hours: After class on Thursdays in Tech M166, by Zoom on Wednesdays 2:00-3:00, and also at other times by appointment
Classroom: Tech M164

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.

- Build a basic understanding of the economics that govern energy, water and transportation systems
- Understand supply and demand in natural resource commodity markets
- Understand how market outcomes have many benefits but also some costs
- Understand the possible benefits and drawbacks of government regulation
- Understand varied ownership structures and economics for "utilities" (IOU, Muni, Co-op) and how this can influence decision making
- Develop analytical capabilities to compare and contrast substitutes (e.g. energy sources)
- Learn different rate structures and how they provide incentives or disincentives 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 prerequisite 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
- 30% on homework
- 25% on the take-home midterm
- 35% on the take-home final exam

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

Letter grade	Percentage
A	93–100%
A−	90–92.9%
B+	87–89.9%
B	83–87.9%
B−	80–82.9%
C+	77–79.9%
C	73–76.9%
C-	70–72.9%
D	60–69.9%
F	0–59.9%

Course Readings: Please be aware that this is a living document and we may find materials that would be important additions. When that happens, we will add them and announce it clearly.

For students who have not completed an undergraduate course in Microeconomics, we recommend giving a careful read to the included chapters from *Principles of Microeconomics*, OpenStax. We will also be drawing on *Markets and the Environment*, 2nd edition, Nathaniel O. Keohane and Sheila M. Olmstead, Island Press, 2016 (Available on Canvas).

CLASS OUTLINE

Week 1 (Sept. 21-23): Microeconomics - Perfect Competition, Supply & Demand, Welfare Analysis

Description/Topics:

- Microeconomics - Perfect competition, Supply & Demand, Welfare analysis, Ceilings & floors, Elasticity
- 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
- Substitute goods and demand rebound

Readings:

- Keohane & Olmstead pp. 11-30
- OpenStax Economics: Supply & Demand
- OpenStax Economics: Elasticity
- OpenStax Economics: Cost & Industry Structure

- OpenStax Economics: Perfect Competition
- Max Auffhammer. "High Wintertime Energy Prices Kill People" (2019)
- Severin Borenstein "Decarbonizing Will Require Pricing Reform" (2021)

Week 2 (Sept. 28-30): Microeconomics - Imperfect Competition, Regulation

Description/Topics:

- Microeconomics - Imperfect competition, Fixed versus Variable Costs, Natural monopoly theory (cost subadditivity), increasing returns (networks), Peak-load pricing, Ramsey Pricing, Regulatory responses
- Commodity pricing and marginal supply cost for exhaustible vs. renewable resources

Readings:

- OpenStax Economics: Monopoly
- OpenStax Economics: Oligopoly
- OpenStax Economics: Anti-Trust

Week 3 (Oct. 5-Oct. 7): Time Value of Money, Infrastructure Investment

Description/Topics:

- Social and private discount rates
- Net Present Value (NPV) versus Internal Rate of Return (IRR)

Readings:

- Keohane & Olmstead pp. 30-33.
- OpenStax Economics: Present Discounted Value
- Greenstone & Stock: "The Right Discount Rate for Regulatory Costs and Benefits" (2021)
- Newell & Siikamaki: "Individual Discount Rates and Energy Efficient Purchases" (2015)

Week 4 (Oct. 12-14): Environmental economics and non-market value

Description/Topics:

- Non-market values
- Cost-Benefit Analysis (CBA)
- Environmental Kuznets Curve
- Climate Change
- Risk

Readings:

- Keohane & Olmstead pp. 35-68.

- OpenStax Economics: Environmental Protection & Negative Externalities
- Jonathan Lambert. "Study Finds **Racial Gap** Between Who Causes Air Pollution And Who Breathes It" (2019)
- Timothy Taylor. "Contingent Valuation and the Deepwater Horizon Spill"
- Timothy Taylor. "China and the Environmental Kuznets Curve"
- Joel Brammeier. "The Great Lakes Region is not a Climate Refuge" (2021)

Week 5 (Oct. 19-21): Complexities of Electricity Pricing

TAKE-HOME MIDTERM COVERING MATERIAL FROM WEEKS 1-4 (Midterm will be released on Wednesday, Oct. 20, and be due on Monday, Oct. 25)

Description/Topics:

- **Duck curve**
- **Demand Response**
- **Feed-in tariff**

Readings:

- David Roberts. "Utilities versus Rooftop Solar: What the fight is about."
- David Roberts. "Utilities for Dummies: How they work and why that needs to change."
- David Roberts: "Utilities for Dummies, Part 2: Why we need competitive electricity markets"
- Nadja Popovich. "How Does Your State Make Electricity?" (2018)

Week 6 (Oct. 26-28): Fossil Fuels

Description/Topics:

- Green paradox
- Hotelling extraction
- Carbon pricing
- Stranded assets

Readings:

- Keohane & Olmstead pp. 99-113, 139-162.
- Hans Rosling. Climate Change and Fossil Fuel Distribution (2:00 Video)
- David Roberts. "Americans are willing to pay $177 a year to avoid climate change" (2017)
- David Roberts. "Subsidies really do matter to the US oil & gas industry" (2021)
- Umair Irfan, "Can you really negate your carbon emissions? Carbon offsets, explained" (2020)
- Emily Pontecorvo. "For a Livable Future, 60% of Oil and Gas Must Stay in the Ground" (2021)

Week 7 (Nov. 2-4): Energy technologies and technological change

Description/Topics:

- How technologies compete with each other
- Economic history of energy technologies
- Technology cost curves, technology life cycle, S curves
- Case study: Hydraulic fracturing and natural gas
- Batteries and EVs, other storage

Readings:

- Keohane & Olmstead pp. 15-16.
- LLNL Energy Flow Chart – US 2020
- Oliver Schmidt, Adam Hawkes, Ajay Gambhir, and Iain Staffell. "The future cost of electrical energy storage based on experience rates." *Nature Energy* 2, no. 8 (2017): 1-8
- Catherine Hausman and Ryan Kellogg. "Welfare and Distributional Implications of Shale Gas." *Brookings Papers on Economic Activity* (2015)

Week 8 (Nov. 9-11): Electricity markets and their evolution

Description/Topics:

- Wholesale markets, market design -- load duration, CA, market monitoring, price caps, capacity mechanisms
- Retail markets, demand response, digitization, transactive energy
- Growth of renewables and DERs, LCOE, case study of TX wind, revisit duck curve question

Readings:

- Chassin, David P., and Lynne Kiesling. "Decentralized coordination through digital technology, dynamic pricing, and customer-driven control: The GridWise testbed demonstration project." *The Electricity Journal* 21, no. 8 (2008): 51-59
- Joskow, Paul L. "Comparing the costs of intermittent and dispatchable electricity generating technologies." *American Economic Review* 101, no. 3 (2011): 238-41
- Kaffine, Daniel T., Brannin J. McBee, and Jozef Lieskovsky. "Emissions savings from wind power generation in Texas." *The Energy Journal* 34, no. 1 (2013)
- Grist. "Report: These rarely used, dirty power plants could be cheaply replaced by batteries"

Week 9 (Nov. 16-18): Transportation

Description/Topics:

- Pricing
- Demsetz Auctions
- Free parking
- Fuel Economy Standards
- Ethanol

Readings:

- OpenStax Economics: Positive Externalities & Public Goods

- Containerization: Truck Driver Who Reinvented Shipping
- Shoup: The High Cost of Free Parking
- Arnott: A Bathtub Model of Downtown Traffic Congestion
- Tom Standage. "The lost history of the electric car – and what it tells us about the future of transport" (2021)

Week 10 (Nov. 16-18): Water

Description/Topics:

- Rights
- Ownership
- Privatization
- Perceptions of Risk

Readings:

- Keohane pp. 214-217, 221-223
- Timothy Taylor. "Some Economics of the Clean Water Act" (2019)
- Peter Coy. "California's Farms Face a Reckoning" (2021)
- Somini Sengupta. "It's Some of America's Richest Farmland. But What is it Without Water?" (2021)
- Sara Sutherland. "San Francisco's Water Steal" (2021)
- Elizabeth Wang Whitman. "Meet Arizona's Water One-Percenters" (2021)

Guest Speakers: TBD

Week 11 (Nov. 23): Review

CUMULATIVE TAKE-HOME FINAL EXAM - Released on Monday, Dec. 6, due Thursday, Dec. 9.

Supplemental readings that you may find interesting and useful

- IEA World Energy Outlook
- Travis Bradford, "The Energy System: Technology, Economics, Markets, and Policy" (MIT 2018)
- Small and Verhoef, "The Economics of Urban Transportation" (Routledge Press, 2007)

- OECD "Technology Innovation, Development, and Diffusion." 2003

The following are questions that many of you will have about the class.

Q: Where should I look for posted Zoom recordings, slides, readings, and things like that?
A: The best place is on Canvas under "Pages." We will try to put everything there in an organized way.

Q: How will this class work?
A: Lynne and I will lecture twice per week, and post recordings of it on Pages in Canvas. If we have extra to say, we will post recordings of that too. We will have some speakers but their timing and availability are still somewhat in flux, so that will bump some lectures, which we will record separately and post. There will be some homework (submitted online) to prepare you for the midterm and final (which will both be take-home and submitted online). You can work together on the homework, but not on the exams.

Q: What is the deal with the homeworks?
A: There will be a bunch of these over the course of the quarter and they will usually follow what we did in lecture, and have some predictive value for what will be on the exam. Your first homework will be to get you familiarized with the use of Piazza, so you will need to post an interesting article relating to energy in the "post_to_piazza_homework " on Piazza (you can find the link on Pages in Canvas). When you post your article, don't send it to the whole class but rather only to Mark, and be sure to put your last name in the header so I know it's from you.

We will post questions and you will submit answers through Canvas. The computational problems will be graded by Canvas, and you will get three chances to get them right. You can collaborate with your peers on these and ask questions through Piazza (anonymously if you wish). Some of the homework may involve you submitting hand-drawn graphs or hand-written summaries of the lecture contents. [Piazza is a discussion forum that allows anonymous posts. The story about its creation is pretty cool.]

Q: What are the basic work expectations for the class?
A: I hope that you will do about two hours of study for every hour of lecture, and that you will get read the material assigned for the lecture before class (and catch up on the first lecture assigned reading too).

Q: What is your electronics communication policy?
A: **(1)** We expect you to have your preferred e-mail address entered into Canvas so that we can send messages to the class, and we expect you to check that e-mail on a daily basis. **(2)** Use Canvas's **Piazza** discussion forum (found in Canvas's "Modules") to post questions that would be of general use to your classmates. (Yes: "What does MR stand for?" No: "Can't I get more credit on the last assignment?") When you post on Piazza about specific homework questions, it's very helpful if you cut-and-paste the actual question into what you write in Piazza.

Q: What happens if I fall suddenly ill and am unable to do an assignment?
A: Just let me know in advance. (mwitte@northwestern.edu).

Q: Averaging my grades, I come out very close to a higher grade. How about if you give it to me?

A: No...unless you are deserving of special consideration.

Q: Am I deserving of special consideration?
A: That depends. I may feel you deserve a higher grade than you earn on the tests if I feel that your comments in class, Piazza, and office hours improve the education of your fellow students and show you are able to and have been thinking intelligently about the material.

Q: What is the most important thing?
A: Please be assured that I want students to learn and to receive the good grades they deserve. So please make an appointment with me should you have undue difficulty with your work in the course.

Any student with a documented disability needing accommodations is requested to speak directly to the Accessible NU (847-467-5530) and the instructor, as early as possible in the quarter (preferably within the first two weeks of class). All discussions will remain confidential. For resources on safety and mental and physical health, please visit the NUhelp website or phone app.

COVID-19 Classroom Expectations Statement

Students, faculty, and staff must comply with University expectations regarding appropriate classroom behavior, including those outlined below and in the COVID-19 Code of Conduct. With respect to classroom procedures, this includes:

- Policies regarding masking and social distancing evolve as the public health situation changes. Students are responsible for understanding and complying with current masking, testing, Symptom Tracking, and social distancing requirements.
- In some classes, masking and/or social distancing may be required as a result of an Americans with Disabilities Act (ADA) accommodation for the instructor or a student in the class even when not generally required on campus. In such cases, the instructor will notify the class.
- No food is allowed inside classrooms. Drinks are permitted, but please keep your face covering on and use a straw.
- Faculty may assign seats in some classes to help facilitate contact tracing in the event that a student tests positive for COVID-19. Students must sit in their assigned seats.

If a student fails to comply with the COVID-19 Code of Conduct or other University expectations related to COVID-19, the instructor may ask the student to leave the class. The instructor is asked to report the incident to the Office of Community Standards for additional follow-up.

Class Recording

This class or portions of this class will be recorded by the instructor for educational purpose and available to the class during the quarter. Your instructor will communicate how you can access the recordings. Portions of the course that contain images, questions or commentary/discussion by students will be edited out of any recordings that are saved beyond the current term.

Unauthorized student recording of classroom or other academic activities (including advising sessions or office hours) is prohibited. Unauthorized recording is unethical and may also be a violation of University policy and state law. Students requesting the use of assistive technology as an accommodation should contact AccessibleNU. Unauthorized use of classroom recordings – including distributing or posting them – is also prohibited. Under the University's Copyright Policy, faculty own the copyright to instructional materials – including those resources created specifically for the purposes of instruction, such as syllabi, lectures and lecture notes, and presentations. Students cannot copy, reproduce, display, or distribute these materials. Students who engage in unauthorized recording, unauthorized use of a recording, or unauthorized distribution of instructional materials will be referred to the appropriate University office for follow-up.

Expectations for Class Participation

Being prepared for class is about more than just showing up, it's also about making sure you've completed the readings, homework, etc. so that you are able to make thoughtful contributions during class. Sitting silently and/or being unprepared can damage your participation grade. When in a virtual class, we expect students to keep their camera and mute on as much as possible. When in the classroom, we expect students to keep their phones off and put away.

Academic Integrity

Academic integrity is taken very seriously at Northwestern. Students are responsible for reading and understanding Northwestern's Academic Integrity policies. All suspected violations will be reported to the McCormick College of Engineering's Dean's Office. These include cheating, plagiarism, fabrication, unfair advantage, unauthorized collaboration, and aiding and abetting of academic dishonesty. Students found in violation of academic integrity may receive a zero on the assignment or a failing grade for the course and may be suspended or permanently expelled from the University. See Academic Integrity: A Basic Guide for more information.

The Writing Place

When working on writing assignments for this class, I encourage you to visit the Writing Place, Northwestern's peer writing center. You will work with juniors and seniors who have been trained to provide you feedback and assistance on any type of writing at any stage in the writing process. They will not edit your work. Rather, they will work with you to brainstorm ideas, organize or outline an essay, clarify your argument, document your sources correctly, or refine grammar and style.

Accessibility Statement

Northwestern University is committed to providing the most accessible learning environment as possible for students with disabilities. Should you anticipate or experience disability-related barriers in the academic setting, please contact AccessibleNU to move forward with the university's established accommodation process (e: accessiblenu@northwestern.edu; p: 847-467-5530). If you already have established accommodations with AccessibleNU, please let me know as soon as possible, preferably within the first two weeks of the term, so we can work together to implement your disability accommodations. Disability information, including academic accommodations, is confidential under the Family Educational Rights and Privacy Act.

Illness and Medical Leave of Absence

Review the University's policy on missing academic work due to illness. Your instructor cannot waive an assignment missed due to illness unless the illness can be verified (e.g., by University Health Services or other licensed health professionals).

Discrimination and Sexual Harassment

Northwestern's Policies on Discrimination, Harassment, and Sexual Harassment apply to all members of the University community, including students, staff, faculty, and third parties. Any student, staff, faculty member, or third party who believes that they have been discriminated against or harassed on the basis of their race, color, religion, national origin, sex, sexual orientation, gender identity, gender expression, pregnancy, parental status, marital status, age, disability, citizenship, veteran status, genetic information or any other classification protected by law, should contact the Office of Equity at (847) 467- 6571. Additional information about the University's discrimination and harassment policies, including the campus resources available to assist individuals with discrimination or harassment concerns, is available online on the Office of Equity Website. Students, staff, and faculty who report harassment, discrimination, or sexual misconduct are also protected under the University's Policy on Non-Retaliation.

Sexual Misconduct and Reporting

Northwestern University is committed to fostering an environment where students are safe and free from sexual misconduct. Confidential resources are available to those who have experienced sexual misconduct. Faculty and instructors are not confidential resources and are required to report incidents of sexual misconduct, whether discussed in your assignments or in person, to the Office of Equity, which can provide information about resources and options. We encourage students who have experienced sexual misconduct to talk with someone to get support. For more information, including how to request interim protective measures and academic accommodations or file a complaint, see the Get Help page.

Other Resources

Students can find useful resources for safety and security, academic support, and mental and physical health and well-being at the NUhelp website.