Course overview. Over the last several decades, energy markets have become some of the most dynamic markets of the world economy. Traditional fossil fuel and electricity markets have seen a partial shift from heavy regulation to market-driven incentives, while rising environmental concerns have led to a wide array of new regulations and “environmental markets”. The growth of renewable energy is another source of rapid change, but brings with it a whole new set of technological and policy challenges. This changing energy landscape requires quick adaptation from energy companies, but also offers opportunities to turn regulations into new business. The objective of this course is to provide the economist’s perspective on a broad range of topics that professionals in the energy industry will encounter. Topics include the effect of competition, market power and scarcity on energy prices, extraction and pricing of oil and gas, geopolitical uncertainty and risk in hydrocarbon investments, the environmental policies related to the energy sector and their effectiveness, cap-and-trade markets, energy efficiency, the economics and finance of renewable energy, and recent developments in the transportation sector.

Readings. A mix of newspaper articles, academic papers, reports, plus the following textbook: Nathaniel Keohane and Sheila Olmstead (KO), Markets and the Environment, Washington, D.C.: Island Press, second edition, 2016. Starred (*) readings are required. Many starred readings are short. Non-starred readings are optional but I will discuss them in class, and you are highly encouraged to read them if you need or want further background on a specific topic. The best way to use the readings is as a supplement to the lectures, which overlap partially (but certainly not perfectly!) with the readings. You will be responsible for required readings not covered in class.

Prerequisites. Managerial Economics (MGEC 611/612) or an equivalent intermediate microeconomics course approved by the instructor.

Strategy game. The Electricity Strategy Game is a simulation of an electricity market. Student teams manage a portfolio of generation units (coal, natural gas, nuclear and renewables) and bid
into an electricity market. This game requires an initial in-class auction, six online electricity wholesale market bid submissions plus one additional round of auction bids in between class meetings.

**Assignments and grading.** Three equally weighted assignments (30%), an exam (40%), the Electricity Strategy Game (20%) and class participation (10%). The three assignments are take-home. You may discuss assignments with other students but you need to formulate and submit answers in teams of at most three. The exam will be given in class on the last scheduled class date. You should plan to attend the exam in person.

**Cheating policy.** It should not be necessary to say this – but for completeness: all students are expected to comply with the University of Pennsylvania’s Code of Academic Integrity. It is the policy of the Department, and this course, to immediately fail any student for the course who is in violation of the University’s Code of Academic Integrity. Cheating in any manner, on a graded assignment or exam, or violating the rules of the strategy games, will result in a failing grade for this course. Additional sanctions may be imposed of the Office of Student Conduct. The Code of Academic Integrity can be reviewed at: [http://provost.upenn.edu/policies/pennbook/2013/02/13/code-of-academic-integrity](http://provost.upenn.edu/policies/pennbook/2013/02/13/code-of-academic-integrity).

**ELECTRICITY MARKETS**

Lecture 1 (Jan 5): **Course Introduction & Energy Overview**


Lecture 2 (Jan 5): **Market Efficiency and Scarcity Pricing**

*Topics:* market efficiency; scarcity pricing; electricity markets; refined products markets.

(*) KO Chapter 4: “The Efficiency of Markets”.


Lecture 3 (Jan 6): **Market Power in Electricity Markets (1)**

*Topics:* market power; deregulation.


Lecture 4 (Jan 6): **Market Power in Electricity Markets (2)**

*Topics:* the California electricity crisis; the rise and fall of Enron.


**OIL AND GAS MARKETS**

Lecture 5 (Jan 12): **Oil and Natural Gas Extraction and Pricing (1)**

*Topics:* trends in oil and gas reserves; optimal extraction; Hotelling model.

(*) KO Chapter 6: “Managing Stocks: Natural Resources as Capital Assets”.

(*) Lecture notes on the Hotelling model for optimal resource extraction (on Canvas).


Lecture 6 (Jan 12): **Oil and Natural Gas Extraction and Pricing (2)**

*Topics:* oil price volatility; oil price forecasting; oil futures.

The Strange Geopolitics of Rising Oil Prices”, *The Economist*, 11/26/17.

Lecture 7 (Jan 13): **Upstream Investment under Uncertainty**

*Topics*: NOCs vs. IOCs; upstream contracts; drilling investment under uncertainty; geopolitical risk; expropriations.


**ENERGY AND ENVIRONMENTAL POLICY**

Lecture 8 (Jan 13): **Global Climate Change**

*Topics*: climate change impacts; the climate change debate; discounting; risk and uncertainty.


Lecture 9 (Jan 26): **Externalities and Policy Instruments**

*Topics*: environmental externalities; tragedy of the commons; Coase Theorem; property rights; taxes vs. subsidies vs. standards; effect of regulations on business; double dividend.

(*) KO Chapter 5: “Market Failures in the Environmental Realm”.

(*) KO Chapter 8: “Principles of Market-Based Environmental Policy”, pp. 139-162.


Lecture 10 (Jan 26): **Cap-and-Trade**

*Topics*: basics of cap-and-trade; cost-effectiveness; introduction to market design issues.
Lecture notes on the economics of cap-and-trade (on Canvas).


Lecture 11 (Jan 27): **Designing Real-World Environmental Markets**

*Topics*: market design issues in cap-and-trade markets; EU Emissions Trading Scheme; RECLAIM; acid rain trading program.


Lecture 12 (Jan 27): **U.S. and Global Policy Developments**

*Topics*: U.S. climate change policy; global carbon trading developments; emissions leakage.

(*) “Up in Smoke”, The Economist, 10/10/17.


**ENERGY EFFICIENCY**

Lecture 13 (Feb 10): **Energy Efficiency: Puzzle and Policies**

*Topics*: the “energy efficiency puzzle”; informational barriers and market failures; rebound effect; energy efficiency policies.


Lecture 14 (Feb 10): **Energy Efficiency (Continued) & Introduction to the Electricity Strategy Game**


(*) Student instructions for the Electricity Strategy Game (on Canvas).

**ENERGY, POLITICS AND DIPLOMACY**

Lecture 15 (Mar 9): **Energy and Politics & Electricity Strategy Game Auction**

*Topics*: U.S. energy and climate politics; the role of the Environmental Protection Agency; federal policy vs. state and local interests; the Climate Solutions Caucus.

Lecture 16 (Mar 9): **International Environmental Agreements**

*Topics*: international climate agreements; Kyoto Protocol; Montreal Protocol; free-riding; carbon offsets.


**THE ECONOMICS AND FINANCE OF RENEWABLE ENERGY**

Lecture 17 (Mar 23): **The Economics of Renewable Energy**

*Topics*: trends in renewable energy; levelized cost of electricity; environmental benefits of renewables.
Lecture 18 (Mar 23): **Renewable Energy Finance**

*Topics*: tax credits; tax equity; solar leasing; PACE; net metering; (S)RECs.


(*) Lecture notes on renewable portfolio standards and RECs (on Canvas).


*Topics*: trade disputes; innovation subsidies; learning-by-doing; mix of subsidies; renewable portfolio standards; green subsidies vs. pollution taxes; regulatory uncertainty.


**TRANSPORTATION POLICY**

Lecture 20 (Mar 24): **Fuel-Economy Policy**

*Topics*: policy developments in the car industry; fuel-economy standards; gasoline tax; electric vehicle policy.


Lecture 21 (Apr 6): **Electricity Strategy Game Debriefing**

Lecture 22 (Apr 6): **Unintended Policy Consequences & Course Wrap Up**

*Topics*: congestion policies; enforcement; cheating; emissions leakage; course summary.


Lectures 23-24 (Apr 19): **Exam**
PRELIMINARY DUE DATES

Assignment dates

Assignment 1: posted on January 13, due by January 29
Assignment 2: posted on February 6, due by February 26
Assignment 3: posted on March 23, due by April 13

Electricity Strategy Game

February 10  Introduction to the Electricity Strategy Game in class
March  3  Bids due for the ESG test run by midnight EST
March  9  First ESG divestiture auction, in class
March 16  ESG strategies due by midnight EST for year 1, day 1
March 19  ESG strategies due by midnight EST for year 1, day 2
Match 21  ESG strategies due by midnight EST for year 1, day 3
March 24  Sealed portfolio bids for year 2 due by midnight EST
March 26  ESG strategies due by midnight EST for year 2, day 1
March 28  ESG strategies due by midnight EST for year 2, day 2
March 30  ESG strategies due by midnight EST for year 2, day 3
April  6  ESG strategy memo due before class
April  6  ESG debriefing in class

Exam

The exam will be in class on April 19.