Note: Due to potential guest speaker schedule changes, this syllabus will very likely be updated during the semester. Please check Canvas for the latest version.

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**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 and transportation sectors and their effectiveness, cap-and-trade markets, and energy efficiency. There is special emphasis on the economics and finance of renewable energy, including an introduction to energy storage.

**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 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.
**Attendance.** Attendance is mandatory. Please email me in advance if you have a good reason not to attend a particular session.

**Strategy games.** Students will participate in two strategy games. The OPEC game is a series of simulations of the world oil market. Student teams represent countries and try to maximize profits by making output decisions that determine the world oil price. 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.

**Guest lectures.** The course has six guest lecturers by various energy experts. This year’s emphasis will be on renewable energy finance, energy storage, sustainable investments, the role of the media in the energy debate, and energy politics. Attendance is mandatory and the content is fair game for questions on assignments and exams. Some guest lectures are followed by drinks (open to all students) and dinner (signup in advance; first-come-first-served) with the speaker.

**Assignments and grading.** Three equally weighted assignments (25%), an exam (35%), the OPEC game (15%), the Electricity Strategy Game (15%), 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 on your own or joint with at most two other classmates. The exam will be on the last day of class (in the evening). You should plan to attend the exam. Contact the MBA Program Office if you have a scheduling conflict with another class, a medical issue, or an emergency. No other exceptions. Please do not email me about alternative exam dates for other reasons as I have no flexibility to accommodate such requests out of fairness to other students.

**Practice questions.** An extensive set of practice questions and solutions will be posted early in the semester. You can discuss them with the TA or with me during office hours if needed.

**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 by 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).

**Electronics.** No phones, laptops, tablets or other electronics.

**Other details:** The course is included in the MBA major in Business, Energy, Environment and Sustainability and in the BEPP-Law School certificate. Non-Wharton students are welcome and encouraged to contact the professor in advance to discuss prerequisites.
ELECTRICITY MARKETS

Lecture 1 (Jan 17): Course Introduction & Energy Overview


Lecture 2 (Jan 22): 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 24): Market Power in Electricity Markets (1)

Topics: market power; deregulation.


Lecture 4 (Jan 29): Market Power in Electricity Markets (2)

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


**OIL AND GAS MARKETS**

Lecture 5 (Jan 31): *Oil and Natural Gas Extraction and Pricing (1) & Introduction to the OPEC Game*

*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 (Feb 5): *Oil and Natural Gas Extraction and Pricing (2)*

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

(*) J. Hamilton, 2009. “Understanding Crude Oil Prices.” *The Energy Journal* 30(2): pp. 179-188 (remainder is optional; link). (Note: this reading is old but still relevant!)


Lecture 7 (Feb 7): *Upstream Investment under Uncertainty*

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


Lecture 8 (Feb 12): **Global Climate Change**

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

(*) Lecture notes on climate change mitigation and discount rates (on Canvas).


Intergovernmental Panel on Climate Change, Summary for Policymakers, 2018 ([link](#)).

**ENERGY AND ENVIRONMENTAL POLICY**

Lecture 9 (Feb 14): **Externalities and Policy Instruments & OPEC Group Meetings**

*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.

(*) A. Lustgarten, “Palm Oil Was Supposed to Help Save the Planet. Instead It Unleashed a Catastrophe”, *New York Times*, 11/20/18 ([link](#)).

Lecture 10 (Feb 19): **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 (Feb 21): **Designing Real-World Environmental Markets**

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


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Lecture 12 (Feb 26): **Energy Policy and the Media**

**Guest speaker**: Lisa Friedman, Energy and Climate Reporter, The New York Times

*Topics*: recent environmental policy developments; regulatory rollbacks; public opinion and energy policy; the role of the media in the debate about energy and climate change.


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Lecture 13 (Feb 28): **U.S. and Global Policy Developments**

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


--- SPRING BREAK ---
Lecture 14 (Mar 12): International Environmental Agreements & Introduction to the Electricity Strategy Game

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

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


Lecture 15 (Mar 14): OPEC Game Debriefing

Lecture 16 (Mar 19): Electricity Strategy Game Auction

THE ECONOMICS AND FINANCE OF RENEWABLE ENERGY

Lecture 17 (Mar 21): The Economics of Renewable Energy

Topics: trends in renewable energy; levelized cost of electricity; environmental benefits of renewables.


Lecture 18 (Mar 26): **Energy Storage**

**Guest speaker:** Ravi Manghani, Director Energy Storage, WoodMackenzie

**Topics:** the economics of storage; the various technologies; the connection between storage and large-scale renewables deployment.

Lecture 19 (Mar 28): **Renewable Energy Finance**

**Topics:** tax credits; tax equity; solar leasing; securitization; renewable portfolio standards; (S)RECs.


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


**Guest speaker:** Gianluca Signorelli, VP Finance at Lightsource

**Topics:** renewable energy project finance, capital structure, PPAs, hedging.


**Topics:** PACE; net metering; feed-in tariffs and tenders; import tariffs; green subsidies vs. carbon tax.


**Guest speaker:** Tom Burton, Chair of Energy & Sustainability Practice, Mintz

*Topics:* renewable energy project finance, tax equity contracts, legal issues around renewable energy procurement.

**TOPICS: INTERNATIONAL CLIMATE FINANCE AND TRANSPORTATION**

Lecture 23 (Apr 11): **Electricity Strategy Game Debriefing**

Lecture 24 (Apr 16): **International Climate Finance**

**Guest speaker:** Rachel Kyte, CEO of Sustainable Energy for All (SEforAll), and Special Representative of the United Nations Secretary-General

*Topics:* climate finance, international climate negotiations.

Lecture 25 (Apr 18): **Fuel-Economy Policy (1)**

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


(*) V. McConnell, 2013. “The New CAFE Standards: Are They Enough on Their Own?”, RFF Discussion Paper 13-14, pp. 1-14 (Sections I and II; remainder is optional and less relevant for this course; link).

Lecture 26 (Apr 23): **Fuel-Economy Policy (2)**

*Topics:* unintended consequences from fuel-economy standards; cost-benefit analysis.

(*) A. van Benthem and M. Reynaert, “Can Fuel-Economy Standards Save the Climate?”, The Economist, 7/16/15 (link).

Lecture 27 (Apr 25): Unintended Consequences of Transportation Policies & Course Wrap Up

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

T. Ying and A. Ho, “In China, the License Plates Can Cost More than the Car”, Bloomberg Businessweek, 4/25/13 (link).


“Day without a Daft Idea”, The Economist, 7/16/14 (link).

Lecture 28 (Apr 30): Exam

Note: the exam will be held outside the regular class time (6-8PM; location to be announced). Class will not meet during the regular hours from 3-4:20PM.
PRELIMINARY DUE DATES

Assignment dates

Assignment 1: posted on February 7, due by February 21
Assignment 2: posted on February 28, due by March 21
Assignment 3: posted on April 11, due by April 25 (before class)

OPEC Game

January 31  Introduction to the OPEC game in class
February 6  Production quantities due by 10pm for phase 1, period 1
February 8  Production quantities due by 10pm for phase 1, period 2
February 12 Production quantities due by 10pm for phase 2, period 1
February 13 Production quantities due by 10pm for phase 2, period 2
February 15 Production quantities due by 10pm for phase 2, period 3
February 18 Production quantities due by 10pm for phase 2, period 4
February 19  OPEC group meetings in class
February 21 Production quantities due by 10pm for phase 3, period 1
February 25 Production quantities due by 10pm for phase 3, period 2
February 26 Production quantities due by 10pm for phase 3, period 3
February 27 Production quantities due by 10pm for phase 3, period 4
March 14  OPEC strategy memo due before class
March 14  OPEC game debriefing in class

Electricity Strategy Game

March 12  Introduction to the Electricity Strategy Game in class
March 16  Bids due for the ESG test run
March 19  First ESG divestiture auction, in class
March 20  ESG strategies due by 10pm for year 1, day 1
March 22  ESG strategies due by 10pm for year 1, day 2
March 25  ESG strategies due by 10pm for year 1, day 3
March 26  Sealed portfolio bids for year 2 due by 10pm
March 28  ESG strategies due by 10pm for year 2, day 1
April 1  ESG strategies due by 10pm for year 2, day 2
April 3  ESG strategies due by 10pm for year 2, day 3
April 11 ESG strategy memo due before class
April 11 ESG debriefing in class

Exam

Tuesday April 30, 6-8PM, location to be announced.