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

Professor Arthur van Benthem  
Office Hours: Thursdays 4:30-5:30PM, SHDH 1354  
Phone: 215-898-3013  
Email: arthurv@wharton.upenn.edu

Teaching Assistant: Bo Cheng  
Office Hours: Wednesdays 5-6PM, JMHH F94  
Email: bocheng1@wharton.upenn.edu

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.
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 five guest lecturers, who are experts from the energy industry. The guest lecturers’ emphasis will be on energy business models, renewable energy finance, and how energy policy affects their business. 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. No exceptions.

Practice questions. A 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 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.

Electronics. No phones, but you can use laptops and tablets to take notes during lectures.

Other details: The course is included in the MBA major in Environmental and Risk Management 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 11): Course Introduction & Energy Overview


Lecture 2 (Jan 16): 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 18): Market Power in Electricity Markets (1)

Topics: market power; deregulation.


Lecture 4 (Jan 23): Market Power in Electricity Markets (2)

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


**OIL AND GAS MARKETS**

Lecture 5 (Jan 25): **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 (Jan 30): **Oil and Natural Gas Extraction and Pricing (2)**

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


*(Note: this reading is old but still relevant!)*


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

Lecture 7 (Feb 1): **Upstream Investment under Uncertainty**

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

ENERGY AND ENVIRONMENTAL POLICY

Lecture 8 (Feb 6): Global Climate Change

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


Lecture 9 (Feb 8): Canceled due to Eagles Parade

Lecture 10 (Feb 13): 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.


Lecture 11 (Feb 15): The Changing Landscape for Global Oil Companies

Guest speaker: Felipe Arbelaez, Regional President Latin America, BP

Topics: investment decisions in turbulent oil markets, geopolitical challenges, expropriation risk, pathways to cleaner energy, carbon regulation.

Note: this lecture will be held in JMHH G60.
Lecture 12 (Feb 20): **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 13 (Feb 22): **Designing Real-World Environmental Markets**

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


Lecture 14 (Feb 27): **Electricity Market Design and Policy**

*Guest speaker*: Andrew Ott, CEO of PJM Interconnection

*Topics*: electricity market design; current developments in U.S. electricity markets; environmental policies for power markets.

*Note*: this lecture will be held in [to be announced].

Lecture 15 (Mar 1): **OPEC Game Debriefing**

--- SPRING BREAK ---

Lecture 16 (Mar 13): **U.S. and Global Policy Developments & Introduction to the Electricity Strategy Game**

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

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

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


Lecture 17 (Mar 15): **International Environmental Agreements**

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


**ENERGY EFFICIENCY**


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


Lecture 19 (Mar 22): **Energy Efficiency Entrepreneurship**

*Guest speaker*: Pier LaFarge, CEO, Sparkfund

*Topics*: energy efficiency business models; economic and behavioral incentives for energy savings; government regulations for energy efficiency.
Lecture 20 (Mar 27): Energy Efficiency (Continued)


THE ECONOMICS AND FINANCE OF RENEWABLE ENERGY

Lecture 21 (Mar 29): The Economics of Renewable Energy

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


Lecture 22 (April 3): Renewable Energy Finance

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


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


(*) J. Brady, “Solar Firms Plan To Return To Nevada After New Law Restores Incentives”, NPR, 6/7/17.

Lecture 23 (Apr 5): **Renewable Energy Business Models**

**Guest speaker:** Albert Luu, Principal, Global Capital Markets, Tesla

**Topics:** business and financing models for distributed solar energy; recent developments in renewable energy finance.


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


Lecture 25 (Apr 12): **Electricity Strategy Game Debriefing**

**TRANSPORTATION POLICY**

Lecture 26 (Apr 17): **Fuel-Economy Policy**

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


Lecture 27 (Apr 19): **Unintended Policy Consequences & Course Wrap Up**

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


Lecture 28 (Apr 24): **Exam**

*Note: the exam will be held outside the regular class time (6-8PM, JMH 365). Class will not meet during the regular hours from 3-4:20PM.*
PRELIMINARY DUE DATES

Assignment dates

Assignment 1: posted on February 1, due by February 15
Assignment 2: posted on March 1, due by March 22
Assignment 3: posted on April 5, due by April 19 (before class)

OPEC Game

January 25  Introduction to the OPEC game in class
January 31  Production quantities due by 10pm for phase 1, period 1
February 2   Production quantities due by 10pm for phase 1, period 2
February 6   Production quantities due by 10pm for phase 2, period 1
February 7   Production quantities due by 10pm for phase 2, period 2
February 8   Production quantities due by 10pm for phase 2, period 3
February 9   Production quantities due by 10pm for phase 2, period 4
February 13  OPEC group meetings in class
February 15  Production quantities due by 10pm for phase 3, period 1
February 19  Production quantities due by 10pm for phase 3, period 2
February 20  Production quantities due by 10pm for phase 3, period 3
February 21  Production quantities due by 10pm for phase 3, period 4
February 27  OPEC strategy memo due before class
March 1      OPEC game debriefing in class

Electricity Strategy Game

March 13     Introduction to the Electricity Strategy Game in class
March 17     Bids due for the ESG test run
March 20     First ESG divestiture auction, in class
March 21     ESG strategies due by 10pm for year 1, day 1
March 23     ESG strategies due by 10pm for year 1, day 2
March 26     ESG strategies due by 10pm for year 1, day 3
March 27     Sealed portfolio bids for year 2 due by 10pm
March 29     ESG strategies due by 10pm for year 2, day 1
April 2      ESG strategies due by 10pm for year 2, day 2
April 4      ESG strategies due by 10pm for year 2, day 3
April 12     ESG strategy memo due before class
April 12     ESG debriefing in class

Exam

Tuesday April 24, 6-8PM, JMHH 365