

ENVIRONMENTAL & ENERGY ECONOMICS AND POLICY

BEPP/OIDD 263

Spring Semester 2018, Tu/Th 12:00-1:20PM, JMHH 245

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: Tuesdays 4:30-5:30PM, SHDH 1354
Phone: 215-898-3013
Email: arthurv@wharton.upenn.edu

Teaching Assistant: Thomas Buckingham
Office Hours: Wednesdays 5-6PM, JMHH G88
Email: thbuck@wharton.upenn.edu

Course overview. This course examines environmental and energy issues from an economist's perspective. Over the last several decades, energy markets have become some of the most dynamic markets of the world economy, as they experienced a shift from heavy regulation to market-driven incentives. First, we look at scarcity pricing and market power in electricity and gasoline markets. We then study oil and gas markets, with an emphasis on optimal extraction and pricing and geopolitical risks that investors in hydrocarbon resources face. We then shift gears to the sources of environmental problems, and how policy makers can intervene to solve some of these problems. We talk about the economic rationale for a broad range of possible policies: environmental taxes, subsidies, performance standards and cap-and-trade. In doing so, we discuss fundamental concepts in environmental economics, such as externalities, valuation of the environment and the challenge of designing international agreements. Next, we analyze the economics and finance of renewable energy and policies to foster its growth. Other topics include energy efficiency and transportation policies such as fuel-economy and electric vehicle standards.

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. BEPP 250 or an equivalent intermediate microeconomics course is recommended, but an introductory microeconomics course (ECON1, or another course approved by the instructor) will be sufficient in most cases.

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. Students must attend the three scheduled guest lectures. These lectures will be joint with the MBA course *Energy Markets and Policy* (BEPP/OIDD 763) and will take place in JMHH 265 from 3:00-4:20PM. These lectures will be videotaped if you have a scheduling conflict, but you need to notify me in advance at the beginning of the semester. The content of the guest lectures is fair game for questions on assignments and exams. You are welcome to attend any other MBA guest lectures if the topic fits your interests.

Assignments and grading. Three equally weighted assignments (30%), an exam (40%), the OPEC Game (10%), the Electricity Strategy Game (10%) 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 one other classmate. 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 Wharton/IGEL’s undergraduate concentration in Environmental Policy and Management, the Environmental Policy & Application major from the Earth & Environmental Science department, and in the University Interschool Minor in Sustainability and Environmental Management. 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

International Energy Agency, 2017. *World Energy Outlook*, Executive Summary.

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”.

(*) J. Mouawad, “A Fast-Growing Independent Strikes Gold in Oil Refining”, *New York Times*, 5/18/05.

(*) J. Mouawad, “Oil Refiners See Profits Sink as Consumption Falls”, *New York Times*, 5/14/08.

(*) C. Krauss, “Oil Refining’s Fortunes Rise”, *New York Times*, 10/24/12.

(*) L. Cook and B. Olson, “Hurricanes Stir Up Profits for Refiners”, *Wall Street Journal*, 9/17/17.

Lecture 3 (Jan 18): Market Power in Electricity Markets (1)

Topics: market power; deregulation.

(*) S. Borenstein, 2000. “Understanding Competitive Pricing and Market Power in Wholesale Electricity Markets”, *The Electricity Journal* 13(6): pp. 49-57.

(*) J. Griffin and S. Puller, 2005. “A Primer on Electricity and the Economics of Deregulation”, in *Electricity Deregulation: Choices and Challenges*, Griffin and Puller eds., Chicago: University of Chicago Press, pp. 1-4 and 12-23 (remainder is optional).

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

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

(*) S. Borenstein, 2002. “The Trouble with Electricity Markets: Understanding California's Restructuring Disaster”, *Journal of Economic Perspectives* 16(1): pp. 191-211.

(*) P. Healy and K. Palepu, 2003. “The Fall of Enron”, *Journal of Economic Perspectives* 17(2): pp. 3-12 (remainder is optional and less relevant for this course).

(* M. Slezak, “Energy Companies Withholding Supply to Blame for July Price Spike, Report Finds”, *The Guardian*, 8/17/16.

D. Fitzpatrick, R. Smith and R. Tracy. “J.P. Morgan Staring at Record Fine Over Energy”, *Wall Street Journal*, 7/17/13.

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).

R. Gold and A. Sider, “Long Promised, the Global Market for Natural Gas Has Finally Arrived”, *Wall Street Journal*, 6/6/17.

Lecture 6 (Jan 30): 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). Not in the course pack, but available at:
<http://search.proquest.com/docview/222033546/8FA09AFA95F4ED1PQ/3?accountid=14707>
(Note: this reading is old but still relevant!)

(* R. Rowling and J. Blas, “Oil Traders Empty Key Crude Storage Hub”, *Bloomberg*, 9/20/17.

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.

(* A. Ulmer and C. Pons, “Venezuela Ordered to Pay Exxon \$1.6 Billion for Nationalization”, *Reuters*, 10/9/14.

(*) J. Wernau, “As Venezuela’s Default Risk Rises, Battle Heats Up for Control of Refiner Citgo”, *Wall Street Journal*, 5/14/17.

ENERGY AND ENVIRONMENTAL POLICY

Lecture 8 (Feb 6): Global Climate Change

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

(*) B. Litterman, 2013. “What Is the Right Price for Carbon Emissions?”, *Regulation* 36(2): pp. 38-43.

“In the Balance”, *The Economist*, 4/5/14.

Intergovernmental Panel on Climate Change. *Climate Change 2014: Synthesis Report*, Summary for Policymakers.

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.

(*) “A Dirty Little Secret”, *The Economist*, 7/23/16.

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 outside the regular class time (3-4:20PM; 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).

(* KO Chapter 9: “The Case for Market-Based Instruments in the Real World” pp. 168-184.

(* “Carbon Tax v Cap-and-Trade: Which is Better?”, *The Guardian*, 1/31/13.

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.

(* KO Chapter 9: “The Case for Market-Based Instruments in the Real World” pp. 190-198.

(* KO Chapter 10: “Market-Based Instruments in Practice”, pp. 199-207, 208-210 and 217-220.

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 outside the regular class time (3-4:20PM; location TBA).

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.

(*) A. van Benthem and R. Martin, “Europe’s Carbon-Trading System Is Better Than Thought, and Could Be Better Still”, *The Economist*, 12/11/15.

(*) C. Buckley, “Xi Jinping Is Set for a Big Gamble With China’s Carbon Trading Market”, *New York Times*, 6/23/17.

“California Shows How States Can Lead on Climate Change”, *New York Times*, 7/24/17.

J. Eilperin and S. Mufson, “Everything You Need to Know About the EPA’s Proposed Rule on Coal Plants”, *Washington Post*, 6/2/14.

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

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

(*) C. Davenport, “Nations Approve Landmark Accord in Paris”, *New York Times*, 12/12/15.

(*) “Inside the Paris Climate Deal”, *New York Times*, 12/12/15.

N. Mandhana, “U.S.-China Climate Deal Puts India in Spotlight”, *Wall Street Journal*, 11/18/14.

ENERGY EFFICIENCY

Lecture 18 (Mar 20): **Energy Efficiency: Puzzle and Policies & Electricity Strategy Game Auction**

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

(*) D. Owen, “The Efficiency Dilemma”, *The New Yorker*, 12/20/10.

T. Gerarden, R. Newell and R. Stavins, 2017. “Assessing the Energy Efficiency Gap”, *Journal of Economic Literature* 55(4): pp. 1486-1525.

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

(*) S. Ori, “Why Government Energy-Efficiency Programs Sound Great–But Often Don’t Work”, *Wall Street Journal*, 11/13/17.

(*) G. Ip, “Energy-Efficiency Programs ‘Nudge’ Consumers in the Wrong Direction”, *Wall Street Journal*, 6/23/15.

THE ECONOMICS AND FINANCE OF RENEWABLE ENERGY

Lecture 20 (Mar 27): The Economics of Renewable Energy

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

(*) S. Borenstein, 2012. “The Private and Public Economics of Renewable Electricity Generation”, *Journal of Economic Perspectives* 26(1): pp. 67-92. (*Note: the solar application on pp. 85-86 is based on outdated numbers.*)

(*) T. Andresen, “Offshore Wind Farms Offer Subsidy-Free Power for First Time”, *Bloomberg*, 4/13/17.

D. Callaway, M. Fowlie, G. McCormick, 2018. “Location, Location, Location: The Variable Value of Renewable Energy and Demand-Side Efficiency Resources”, *Journal of the Association of Environmental and Resource Economists* 5(1): pp. 39-75. (*Note: this article is more technical.*)

Lecture 21 (Mar 29): Renewable Energy Finance

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

(*) E. Crooks and L. Hornby, “Sunshine Revolution: The Age of Solar Power”, *Financial Times*, 11/5/15.

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

(*) J. Dizard, “Tricky Tax Equity Erodes U.S. Infrastructure Boom”, *Financial Times*, 1/6/17.

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

D. Cardwell, “Bonds Backed by Solar Power Payments Get Nod”, *New York Times*, 11/14/13.

Lecture 22 (Apr 3): **Renewable Energy Policy**

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

(*) I. Galiana and C. Green, 2009. “Let the Global Technology Race Begin”, *Nature* 426(3): pp. 570-571.

(*) W. Nordhaus, 2009. “Designing a Friendly Space for Technological Change to Slow Global Warming”, Snowmass Conference on Technologies to Combat Global Warming, pp.1-8. **Skip Section IV!**

(*) A. Swanson, “To Protect U.S. Solar Manufacturing, Trade Body Recommends Limits on Imports”, *New York Times*, 10/31/17.

VALUING THE ENVIRONMENT

Lecture 23 (Apr 5): **Market Valuation**

Topics: philosophical issues; use vs. non-use value; travel cost method; hedonic pricing; cost-benefit analysis; value of a statistical life.

(*) KO Chapter 3: “The Benefits and Costs of Environmental Protection”.

(*) Lecture notes on the travel cost method (on Canvas).

E. Goodstein, 2010. *Economics and the Environment*, 6th edition, Wiley, Chapter 8: Measuring the Benefits of Environmental Protection.

Lecture 24 (Apr 10): **Non-Market Valuation**

Topics: contingent valuation.

(*) P. Portney, 1994. “The Contingent Valuation Debate: Why Economists Should Care”, *Journal of Economic Perspectives* 8(4): 3-17.

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.

(*) R. Tracy, “Final Rules Set On Car Mileage”, *Wall Street Journal*, 8/28/12.

(*) M. Spector, “Trump Heads to Detroit as EPA Reviews Fuel-Economy Targets”, *Wall Street Journal*, 3/14/17.

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

(*) 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).

Lecture 27 (Apr 19): **Unintended Policy Consequences & 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.

B. Carlson, “Big in China: License-Plate Marriages”, *The Atlantic*, October 2017.

“Day Without a Daft Idea”, *The Economist*, 7/16/14.

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

Note: the exam will be held outside the regular class time (6-8PM, JMHH 360). 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 360