

# ENVIRONMENTAL & ENERGY ECONOMICS AND POLICY

## BEPP/OIDD 263

*Spring Semester 2019, Tu/Th 12:00-1:20PM, JMHH 245*

*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.*

Professor Arthur van Benthem  
Office Hours: Tuesdays 4:35-5:35PM, SHDH 1354  
Phone: 215-898-3013  
Email: arthurv@wharton.upenn.edu

Teaching Assistant: Felipe Flores-Golfin and John Tiernan  
Office Hours: to be announced.  
Email: felipef@wharton.upenn.edu, jtiernan@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. There is special emphasis on the economics and finance of renewable energy, including an introduction to energy storage. 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 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.** An introductory microeconomics course (ECON1, or another course approved by the instructor) will be sufficient in most cases; BEPP 250 or an equivalent intermediate microeconomics course is recommended.

**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 scheduled guest lectures (exact number to be determined). These lectures will be joint with the MBA course *Energy Markets and Policy* (BEPP/OIDD 763) and will take place in JMHH 355 from 3:00-4:20PM. These lectures will be videotaped if you have a scheduling conflict, but you need to notify me and demonstrate the conflict at the beginning of the semester. Previous students have greatly enjoyed these lectures, but high turnout is necessary to keep this tradition alive. The content of the guest lectures is fair game for questions on assignments and exams.

**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. Contact Beth Moskat in BEPP ([emoskat@wharton.upenn.edu](mailto:emoskat@wharton.upenn.edu)) 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 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, laptops, tablets or other electronics.

**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 17): Course Introduction & Energy Overview**

International Energy Agency, 2018. *World Energy Outlook*, Executive Summary ([link](#)).

### **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”.

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

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

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

(\*) L. Cook and B. Olson, “Hurricanes Stir up Profits for Refiners”, *Wall Street Journal*, 9/17/17 ([link](#)).

### **Lecture 3 (Jan 24): 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 ([link](#)).

(\*) 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 29): 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 ([link](#)).

(\*) 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; [link](#)).

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

D. Fitzpatrick, R. Smith and R. Tracy. “J.P. Morgan Staring at Record Fine over Energy”, *Wall Street Journal*, 7/17/13 ([link](#)).

## **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).

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

### **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!*)

(\* R. Rowling and J. Blas, “Oil Traders Empty Key Crude Storage Hub”, *Bloomberg*, 9/20/17 ([link](#)).

T. DiChristopher, “Citi Forecasts Oil Goes Nowhere in 2019 as OPEC Cuts and US Pumps More”, *CNBC*, 12/10/18 ([link](#)).

### **Lecture 7 (Feb 7): 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 ([link](#)).

(\* A. Scurria, “Venezuela Strikes Deal to Save Citgo from Seizure”, *Wall Street Journal*, 11/25/2018 ([link](#)).

## 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).

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

“The Latest Report on Global Warming Makes Grim Reading”, *The Economist*, 10/11/18 ([link](#)).

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).

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

(\* L. Taschini, S. Dietz and N. Hicks, “Carbon Tax v Cap-and-Trade: Which is Better?”, *The Guardian*, 1/31/13 ([link](#)).

## 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.

(\*) 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 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.

(\*) L. Friedman, “Trump’s Plan for Coal Emissions: Let Coal States Regulate Them”, *New York Times*, 8/17/18 ([link](#)).

“California Shows How States Can Lead on Climate Change”, *New York Times*, 7/24/17 ([link](#)).

Note: this lecture will be held outside the regular class time (3-4:20PM; JMHH 355).

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

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

(\*) 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 ([link](#)).

(\*) R. Morison and J. Hodges, “Carbon Reaches 10-Year High, Pushing up European Power Prices”, *Bloomberg*, 8/23/18 ([link](#)).

(\*) K. Bradsher and L. Friedman, “China Unveils an Ambitious Plan to Curb Climate Change Emissions”, *New York Times*, 12/19/17 ([link](#)).

--- **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).

(\* B. Plumer, “Climate Negotiators Reach an Overtime Deal to Keep Paris Pact Alive”, *New York Times*, 12/15/18 ([link](#)).

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

C. Davenport et al., “Inside the Paris Climate Deal”, *New York Times*, 12/12/15 ([link](#)).

## 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.

(\* S. Borenstein, 2012. “The Private and Public Economics of Renewable Electricity Generation”, *Journal of Economic Perspectives* 26(1): pp. 67-92 ([link](#)). (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 ([link](#)).

D. Callaway, M. Fowle, 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 ([link](#)). (Note: this article is more technical.)

## 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.

Note: *this lecture will be held outside the regular class time (3-4:20PM; JMHH 355).*

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

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

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

(\* 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 ([link](#)).

(\* J. Brady, “Solar Firms Plan to Return to Nevada after New Law Restores Incentives”, *NPR*, 6/7/17 ([link](#)).

D. Cardwell, “Bonds Backed by Solar Power Payments Get Nod”, *New York Times*, 11/14/13 ([link](#)).

## Lecture 20 (Apr 2): **Renewable Energy Project Finance (1)**

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

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

Note: *this lecture will be held outside the regular class time (3-4:20PM; JMHH 355).*

## Lecture 21 (Apr 4): **Renewable Energy Policy**

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

(\* J. Deign, “More 'Subsidy-Free' Offshore Wind Emerges in Europe”, *Greentech Media*, 4/5/18 ([link](#)).



(\* N. Groom, “Billions in U.S. Solar Projects Shelved after Trump Panel Tariff”, *Reuters*, 6/7/18 ([link](#)).

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

## Lecture 22 (Apr 9): **Renewable Energy Project Finance (2)**

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

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

Note: this lecture will be held outside the regular class time (3-4:20PM; JMHH 355).

## **TOPICS: ENERGY EFFICIENCY AND TRANSPORTATION**

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

### Lecture 24 (Apr 16): **Energy Efficiency: Puzzle and Policies**

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

(\* D. Owen, “The Efficiency Dilemma”, *The New Yorker*, 12/20/10 ([link](#)).

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

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

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

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

*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 ([link](#)).

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

(\*) 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](#)).

(\*) A. Bento et al., 2018. “Flawed Analyses of U.S. Auto Fuel Economy Standards”, *Science* 362(6419), pp. 1119-1121 ([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](#)).

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