

# ENVIRONMENTAL & ENERGY ECONOMICS AND POLICY

## BEPP/OIDD 263

*Spring Semester 2020, Tu/Th 12:00-1:20 p.m., JMHH 270*

*Note: Due to potential guest speaker schedule changes, this syllabus may be updated during the semester. I will also update readings up to the first class session. Please check Canvas for the latest version.*

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**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. These lectures will be joint with the MBA course *Energy Markets and Policy* (BEPP/OIDD 763) and will take place in JMHH 360 from 3:00-4:20 p.m. 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 in all 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: <https://catalog.upenn.edu/pennbook/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 Studies majors from the Earth & Environmental Science department, and in the university-wide minors in Environmental Studies and 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 16): Course Introduction & Energy Overview**

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

### **Lecture 2 (Jan 21): 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 23): 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 28): 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 30): 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 4): 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 6): 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](#)).

## **ENERGY AND ENVIRONMENTAL POLICY**

### **Lecture 8 (Feb 11): 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](#)).

### **Lecture 9 (Feb 13): 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.

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

Z. Colman and E. Wolff, “Why Greens Are Turning Away from a Carbon Tax”, *Politico*, 12/9/18 ([link](#)).

### **Lecture 10 (Feb 18): Cap-and-Trade & OPEC Group Meetings**

*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 20): **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 25): **U.S. and Global Policy Developments & International Environmental Agreements**

*Topics:* U.S. climate change policy; global carbon trading developments; emissions leakage; international climate agreements; Kyoto Protocol; Paris Accord; free-riding; carbon offsets.

(\*) 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](#)).

(\*) 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](#)).

## **THE ECONOMICS AND FINANCE OF RENEWABLE ENERGY**

### Lecture 13 (Feb 27): **The Economics of Renewable Energy**

*Topics:* levelized cost of electricity; environmental benefits of renewables; energy storage basics.

(\*) 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.)

(\*) S. Mundy, “India’s Renewable Rush Puts Coal on the Back Burner”, *Financial Times*, 1/1/19 ([link](#)).

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 ([link](#)). (Note: this article is more technical.)

#### Lecture 14 (Mar 3): **Energy Policy and the Media**

**Guest speaker:** Juliet Eilperin, Energy and Environment Reporter, The Washington Post

*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 (3-4:20 p.m.; JMHH 360).

#### Lecture 15 (Mar 5): **OPEC Game Debriefing**

--- SPRING BREAK ---

#### Lecture 16 (Mar 17): **Introduction to the Electricity Strategy Game & Renewable Energy Finance (1)**

*Topics:* electricity strategy game; intro to renewable energy finance.

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

#### Lecture 17 (Mar 19): **Energy Storage**

**Guest speaker:** Judy Chang, Principal, The Brattle Group

*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 (3-4:20 p.m.; JMHH 360).

## Lecture 18 (Mar 24): **Electricity Strategy Game Auction & Renewable Energy Finance (2)**

*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 energy finance and policy (on Canvas).

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

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

## Lecture 19 (Mar 26): **Renewable Energy Policy (1)**

*Topics*: PACE; net metering; feed-in tariffs; tenders.

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

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

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

## Lecture 20 (Mar 31): **Renewable Energy Policy (2)**

*Topics*: import tariffs; green subsidy vs. carbon tax; waterbed effect.

(\* 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 21 (Apr 2): **Renewable Energy Policy (3)**

**Guest speaker:** Anne Hoskins, Chief Policy Officer, Sunrun

*Topics:* market for residential solar, solar energy policy, regulatory risk, case study: net metering in Nevada

Note: this lecture will be held outside the regular class time (3-4:20 p.m.; JMHH 360).

Lecture 22 (Apr 7): **Renewable Energy Project Finance**

**Guest speaker:** Gianluca Signorelli, VP, Head of Project Finance and M&A Execution, U.S. SB Energy (SoftBank)

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

Note: this lecture will be held outside the regular class time (3-4:20 p.m.; JMHH 360).

Lecture 23 (Apr 9): **Electricity Strategy Game Debriefing**

Lecture 24 (Apr 14): **Clean Energy Entrepreneurship**

**Guest speaker:** Pier LaFarge, Co-Founder and CEO, Sparkfund

*Topics:* energy efficiency business models; economic and behavioral incentives for energy savings; government regulations for energy efficiency.

Note: this lecture will be held outside the regular class time (3-4:20 p.m.; JMHH 360).

**TOPIC: TRANSPORTATION POLICY**

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 21): **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 23): **Unintended Consequences of Transport 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 28): **Exam**

*Note: the exam will be held outside the regular class time (6-8 p.m.; location to be announced). Class will not meet during the regular hours from 12:00-1:20 p.m.*

## **PRELIMINARY DUE DATES**

### **Assignment dates**

Assignment 1: posted on February 6, due by February 20

Assignment 2: posted on February 27, due by March 19

Assignment 3: posted on April 9, due by April 23 (before class)

### **OPEC Game**

January 30 Introduction to the OPEC game in class  
February 5 Production quantities due by 10 p.m. for phase 1, period 1  
February 7 Production quantities due by 10 p.m. for phase 1, period 2  
February 11 Production quantities due by 10 p.m. for phase 2, period 1  
February 12 Production quantities due by 10 p.m. for phase 2, period 2  
February 14 Production quantities due by 10 p.m. for phase 2, period 3  
February 17 Production quantities due by 10 p.m. for phase 2, period 4  
February 18 OPEC group meetings in class  
February 20 Production quantities due by 10 p.m. for phase 3, period 1  
February 24 Production quantities due by 10 p.m. for phase 3, period 2  
February 25 Production quantities due by 10 p.m. for phase 3, period 3  
February 26 Production quantities due by 10 p.m. for phase 3, period 4  
March 5 OPEC strategy memo due before class  
March 5 OPEC game debriefing in class

### **Electricity Strategy Game**

March 17 Introduction to the Electricity Strategy Game in class  
March 21 Bids due for the ESG test run  
March 24 First ESG divestiture auction, in class  
March 25 ESG strategies due by 10 p.m. for year 1, day 1  
March 26 ESG strategies due by 10 p.m. for year 1, day 2  
March 27 ESG strategies due by 10 p.m. for year 1, day 3  
March 30 Sealed portfolio bids for year 2 due by 10 p.m.  
March 31 ESG strategies due by 10 p.m. for year 2, day 1  
April 1 ESG strategies due by 10 p.m. for year 2, day 2  
April 2 ESG strategies due by 10 p.m. for year 2, day 3  
April 9 ESG strategy memo due before class  
April 9 ESG debriefing in class

### **Exam**

Tuesday April 28, 6-8 p.m., location to be announced