

ENVIRONMENTAL & ENERGY ECONOMICS AND POLICY

BEPP/OIDD 263

Spring Semester 2021, Tu/Th 12:00-1:20 p.m., virtual via zoom

*Note: This syllabus may be continuously updated. Please check Canvas for the latest version.
Note that readings will be updated throughout the semester as policy developments occur.*

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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.

Course format. Most of the instruction will happen via live, synchronous sessions during the pre-announced class times. For some lectures, there will be pre-recorded videos and the synchronous class time will be shorter. In such cases, I will stay online for the entire duration of the lecture to answer questions in ‘extra office hours’.

Attendance and virtual expectations. Attendance is mandatory. Please email me in advance if you have a good reason not to attend a particular session. I encourage everyone to turn on video, with a virtual background if you wish. Asking questions is encouraged, either by interrupting me directly or via the hand button in zoom. I will not always be able to monitor the chat window, but will read it after the lecture to see if any lingering questions need to be addressed.

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 on Tu/Th from 3:00-4:20 p.m. These lectures will be recorded. Attendance is mandatory unless you have a conflict with another class and 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 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 online during a two-hour window on the last day of class (details to be announced later).

Practice questions. An extensive set of practice questions and solutions has been 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/>.

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

International Energy Agency, 2020. *World Energy Outlook*, Executive Summary ([link](#)).

Lecture 2 (Jan 26): **Market Efficiency and Scarcity Pricing**

Topics: market efficiency; scarcity pricing; electricity markets; refined products markets.

(*) Pre-recorded video: Market Efficiency

(*) 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](#)).

D. Winning and R. Elliott, “Pandemic Pushes Fuel Makers in Richer Countries to the Brink”, *Wall Street Journal*, 12/6/20 ([link](#)).

Lecture 3 (Jan 28): **Market Power in Electricity Markets (1)**

Topics: market power; deregulation.

(*) Pre-recorded video: Market Power

(*) 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 (Feb 2): **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 (Feb 4): **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. Dezember, “U.S. Glut in Natural-Gas Supply Goes Global”, *Wall Street Journal*, 8/27/19 ([link](#)).

J. Wallace, “U.S. Gas Exporters Eye Europe’s Surging Prices”, *Wall Street Journal*, 9/16/20 ([link](#)).

Lecture 6 (Feb 9): **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 (see Readings folder on Canvas). (*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](#)).

Lecture 7 (Feb 11): **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 Creditor Cleared to Resume Citgo Seizure Efforts”, *Wall Street Journal*, 9/30/19 ([link](#)).

ENERGY AND ENVIRONMENTAL POLICY

Lecture 8 (Feb 16): **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](#)).

United Nations Environment Programme, 2020. *Emissions Gap Report*, Executive Summary ([link](#)).

Lecture 9 (Feb 18): **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 23): **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 25): **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 (Mar 2): **U.S. and Global Policy Developments**

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](#)).

(*) M. Carr, “Carbon Pollution Costs Are Likely to Rise Again in Europe”, *Bloomberg*, 2/6/20 ([link](#)).

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

M. Martina and M. Xu, “China Expects First Trade in National Emissions Scheme in 2020”, *Reuters*, 3/30/19 ([link](#)).

S. Mufson, “Are Republicans Coming out of ‘the Closet’ on Climate Change?”, *The Washington Post*, 2/4/20 ([link](#)).

B. Geman, “House Democrats' Climate Bill Aims to Achieve Net-Zero Emissions by 2050”, *Axios*, 1/9/20 ([link](#)).

Lecture 13 (Mar 4): **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.

Note: this lecture will be held from 3-4:20 p.m., outside the regular class time.

Lecture 14 (Mar 9): **OPEC Game Debriefing**

--- SPRING BREAK ---

THE ECONOMICS AND FINANCE OF RENEWABLE ENERGY

Lecture 15 (Mar 16): **The Economics of Renewable Energy**

Topics: 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.)

(* 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 16 (Mar 18): **Introduction to the Electricity Strategy Game & Renewable Energy Finance (1)**

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

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

(* Lecture notes on renewable energy finance and policy, pp. 1-3 (on Canvas).

Lecture 17 (Mar 23): **Energy Storage**

Guest speaker: to be announced

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

Note: this lecture will be held from 3-4:20 p.m., outside the regular class time.

Lecture 18 (Mar 25): **Renewable Energy Finance (2) & Electricity Strategy Game Auction**

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, pp. 3-15 (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 (Apr 1): **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](#)).

J. Deign, “When Will European Offshore Wind See Negative Bids?”, *Greentech Media*, 11/18/19 ([link](#)).

Lecture 20 (Apr 6): **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, tax equity, capital structure, PPAs, hedging.

Note: this lecture will be held from 3-4:20 p.m., outside the regular class time.

Lecture 21 (Apr 8): **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 22 (Apr 13): **Financing Offshore Wind Investments**

Guest speaker: Peter Allen, Head of Finance, Offshore North America, Orsted

Topics: investing in wind energy, wind energy finance, wind energy contracts

Note: this lecture will be held from 3-4:20 p.m., outside the regular class time.

Lecture 23 (Apr 15): **Electricity Strategy Game Debriefing**

TOPIC: TRANSPORTATION POLICY

Lecture 24 (Apr 20): **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 ([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](#)).

(* C. Davenport, “Trump’s Path to Weaker Fuel Efficiency Rules May Lead to a Dead End”, *New York Times*, 2/13/20 ([link](#)).

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

Lecture 25 (Apr 22): **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 26 (Apr 27): **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 27 (Apr 29): **Exam**

Note: there will be a two-hour online exam through Canvas that you will be able to take during a time window that is yet to be determined. No live class session during the regular hours from noon-1:20 p.m.

DUE DATES

Assignment dates

Assignment 1: posted on February 11, due by February 25

Assignment 2: posted on March 4, due by March 22

Assignment 3: posted on April 8, due by April 22

OPEC Game

February 4 Introduction to the OPEC game in class
February 10 Production quantities due by 10 p.m. for phase 1, period 1
February 12 Production quantities due by 10 p.m. for phase 1, period 2
February 16 Production quantities due by 10 p.m. for phase 2, period 1
February 17 Production quantities due by 10 p.m. for phase 2, period 2
February 19 Production quantities due by 10 p.m. for phase 2, period 3
February 22 Production quantities due by 10 p.m. for phase 2, period 4
February 23 OPEC group meetings in class
February 25 Production quantities due by 10 p.m. for phase 3, period 1
March 1 Production quantities due by 10 p.m. for phase 3, period 2
March 2 Production quantities due by 10 p.m. for phase 3, period 3
March 3 Production quantities due by 10 p.m. for phase 3, period 4
March 9 OPEC strategy memo due before class
March 9 OPEC game debriefing in class

Electricity Strategy Game

March 18 Introduction to the Electricity Strategy Game in class
March 22 Bids due for the ESG test run
March 25 First ESG divestiture auction, in class
March 26 ESG strategies due by 10 p.m. for year 1, day 1
March 29 ESG strategies due by 10 p.m. for year 1, day 2
March 31 ESG strategies due by 10 p.m. for year 1, day 3
April 2 Sealed portfolio bids for year 2 due by 10 p.m.
April 5 ESG strategies due by 10 p.m. for year 2, day 1
April 6 ESG strategies due by 10 p.m. for year 2, day 2
April 7 ESG strategies due by 10 p.m. for year 2, day 3
April 15 ESG strategy memo due before class
April 15 ESG debriefing in class

Exam

Thursday April 29, online through Canvas