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/](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


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”.


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

Topics: market power; deregulation.

(*) Pre-recorded video: Market Power


Lecture 4 (Feb 2): **Market Power in Electricity Markets (2)**

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


(*) 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).


**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).


Lecture 6 (Feb 9): **Oil and Natural Gas Extraction and Pricing (2)**

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


Lecture 7 (Feb 11): **Upstream Investment under Uncertainty**

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


**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).


Lecture 9 (Feb 18): **Externatilities 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).

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).


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.


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.


(*) M. Carr, “Carbon Pollution Costs Are Likely to Rise Again in Europe”, *Bloomberg*, 2/6/20 (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. Mundy, “India’s Renewable Rush Puts Coal on the Back Burner”, *Financial Times*, 1/1/19 ([link](#)).


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

*Topsics*: 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.


(*) Lecture notes on renewable energy finance and policy, pp. 3-15 (on Canvas).


*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](#)).


(*) 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](#)).

**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.


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


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.


(*) 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 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).


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).


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