

BE/EAS 527: Energy Markets and Energy Policy
Fall 2019
Dana 1028
MW 4:00 p.m. – 5:30 p.m.

Professor Thomas P. Lyon
Office Hours (Ross 6366): Monday 1:30 – 3:00 p.m. or by appointment

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INTRODUCTION

Energy is the lifeblood of industrial economies, and also a key factor in environmental and national security problems. Because of the extensive externalities associated with energy use, and the uneven distribution of energy resources around the globe, balancing the benefits and costs of energy use is one of the major challenges facing humanity. This balancing act involves blending markets and public policy in such a way as to align the incentives of businesses and individuals with the greater good of people and the planet. But do our energy institutions really accomplish this goal? And can they cope with the massive increase in energy use expected in developing countries over the next two decades?

In most developed countries, the marketplace plays the predominant role in determining what energy sources are used, and how. But government policy plays an extremely important role, as well---governments at the local, state, regional, national, and international levels all mold aspects of energy policy. In addition, non-governmental organizations (NGOs) of all sorts affect our energy choices, either by influencing government policy or influencing corporate behavior directly. In developing countries, government often controls most supplies of non-renewable energy resources, as well as the development of the infrastructure needed to exploit energy resources.

We will focus on three key dimensions of energy:

1. **Commodity markets** for energy, including oil, gas, coal, and electricity. Since one of the key management challenges associated with commodity markets is price volatility, we will pay special attention to the role of spot and futures markets. We will also explore the implications of market power in commodity markets, e.g. the role of OPEC in the oil market.
2. **Transmission and distribution infrastructure** for energy, including oil and natural gas pipelines, and the electric grid. Because these systems involve networks with highly specialized investments, we will pay special attention to the role of long-term contracts, vertical integration and regulation in shaping investments in energy infrastructure.
3. **Externalities and Public Goods**, including air pollution and climate change. Energy is highly regulated in all countries, because of the vast range of

environmental impacts it produces, from acid rain to mercury poisoning to global warming. Energy R&D is also highly subsidized by government because it produces benefits for society broadly.

Each of these dimensions creates challenges that lead to government intervention in markets. Concerns about market power and volatility in energy markets lead to calls for regulation, price controls and policies of energy independence. The magnitude of infrastructure investments and the market power they create lead to regulation of energy infrastructure. The environmental impacts of energy use mean that it is heavily regulated to control these impacts.

The goal of this course is to give you a solid grasp of the environmental and social impacts of, and the institutions that govern, energy use, so that you can play a more effective role in shaping future policy or business decisions. We will begin with basic scientific and technological facts regarding the major uses for and sources of energy. We will then study energy markets (including spot and futures markets), and what they are capable of accomplishing; we will also study the ways energy markets may fail. This will lead into an overview of the role of government in influencing energy decisions. We will begin with a high-level perspective, then work with a series of case studies that examine in depth what government has accomplished in the area of energy policy, and the types of issues facing business managers in the energy industries.

Because politics is so important in the energy industries, we will encounter many situations where profit-seeking and social welfare may come into conflict. Although this is not an ethics course, it will certainly provide numerous cases that you can use to sharpen your own ethical thinking.

Prerequisites: Economic reasoning will be used throughout the course, and many readings will take an economic perspective. We will not be doing any complicated economic analysis, but it will be helpful if you have at least been exposed to intermediate economics, have some recollection of what “market failure” means, and are willing and able to read articles that present econometric analysis of data.

READINGS

There will be several case studies used in class, which can be purchased through the Study.net coursesite, which in turn can be accessed via Canvas.

All of the other readings for this course can be found on the web or on the course Canvas site.

STRUCTURE OF THE COURSE

My intention is that this course be interactive, with substantial student input, and based on dialogue rather than a strict lecture format. Students are expected to master the

content of the readings, to make constructive contributions to class discussions, to make occasional presentations, and to perform adequately or better on the midterm examination.

The course is divided into two halves, separated by midterm break.

The first half develops basic concepts of energy supply and demand, energy markets, and energy policy. This section builds the analytical toolbox you need to participate meaningfully in discussions of energy policy and institutions. It will be more lecture oriented than the second half, and less oriented toward current policy issues.

The second half explores in detail a series of energy issues and policies. This section is designed to equip you with a critical perspective regarding what can be accomplished by energy markets and various types of government policy. My intention is to inoculate you against the utopian claims that are often made by well-meaning and/or self-interested players in the energy arena. This section will consider a variety of current energy challenges and policies for a sustainable energy future, using the tools developed earlier in the semester.

ASSIGNMENTS AND GRADING

Your course grade is based on five components:

Oil and electricity games	20%
In-class Performance	15%
Midterm Exam	30%
Final Project	35%

Some of this will be work done in a team of 4-5 students with whom you will work over the course of the semester.

Games

We will play two extended simulation games that are designed to give you a better feel for the operation of energy markets. The first involves the OPEC cartel, and the second involves bidding into deregulated electricity markets.

OPEC Game

For two weeks in the first half of the semester, we will play the OPEC game. In this game, you will be assigned to play the role of one of the OPEC countries, which differ in their oil reserves, their production capacity, and their costs of producing oil. Working as a team with other students, you will make a series of decisions about the quantity of oil to put on the global oil market. You will have the opportunity to negotiate cooperative production agreements with other OPEC members, but there is no way to enforce those agreements except through market interactions. In addition to OPEC, there are other producers around the world that do not participate in any production agreements. The

objective of the game is for you to develop a deeper understanding of the dynamics of rivalry in situations like this where incentives for cooperation and incentives for competition conflict with one another.

The Electricity Strategy Game (ESG)

For most of the second half of the semester, we will play the ESG. The ESG is designed to replicate the exciting and lucrative world of strategic trading in deregulated electricity markets. Players utilize generation portfolios to compete in a sequence of daily electricity spot markets. Spot market conditions will vary from hour to hour and day to day. Players must develop strategies to deploy their assets over this sequence of spot markets while accounting for the cost structure of their portfolio, varying levels of hourly demand, and the strategies of other players. In this game, your team will play the role of one of the electricity generators selling into California's deregulated wholesale market for electricity. You will begin by bidding for generation portfolios. You will then use the portfolio you purchase to sell power into the California Power Exchange. This involves a much complex decision process than was involved in the OPEC game, and will give you a very good feeling for how deregulated electricity markets actually work.

Your team's performance in the two games will comprise 20% of your final grade.

In-class Performance. The Michigan learning experience transforms students by developing the ability to think rigorously, work collaboratively, and lead effectively. The classroom and course work are the foundational components of the Ross learning and growth process. Classroom activities are central to each student's experience – an experience they share with their classmates and faculty to develop each student's knowledge and personal growth and that of the student body as whole. Due to the importance of this shared experience, students should attend all classes, arrive on time, stay in class throughout and be prepared to contribute to the learning process for all. The expected level of engagement goes far beyond mere physical presence in class. Rather, students should come to each class having read all material, prepared all assignments, and ready to share their insights, thoughts and intellectual struggles with their classmates. Students should remain engaged and attentive throughout class, both for their own learning and in respect to the rest of the Ross community. Violations of these expectations will be reflected by reductions of the class participation grade as well as other penalties the faculty may view as appropriate.

Your attendance and individual contributions will constitute 15% of your grade.

Midterm Exam. **The midterm exam will cover the first half of the course.** This material forms the basic toolkit we will use in the rest of the class for thinking about energy markets and politics. **The midterm will be held Wednesday, October 16, from 4:00 p.m. – 5:30 p.m. in Dana 1028.** (This will count for 30% of your grade.)

Final Project: You will work in teams on a topic you select in consultation with me. A team should have no more than 5 members. Your paper should **be at most 15 pages**

(Double spaced; font size 12; one-inch margins) of text, with no more than 10 additional pages of exhibits. A title page does not count towards the page requirement. My evaluation of your work will be based primarily on the analysis in the main body of the paper.

- **October 9: 1-page topic proposal is due. Please be prepared to briefly describe your proposal to the class.**
- **December 11 before class: Final paper is due (The paper will count for 25% of your final grade).**
- **December 11 in class: Poster Session presenting your findings (This will count for 10% of your overall grade.)**

Some of you may not be familiar with the process of making a research poster. I will post a Powerpoint template in Canvas you can use to make your poster, and will arrange with SEAS to allow you to print one copy of your poster on the large printer there.

There is no final exam.

Useful Websites

American Council for an Energy-Efficient Economy <http://www.aceee.org/>

U.S. Energy Information Administration <http://www.eia.doe.gov/>

The Energy Foundation <http://www.ef.org/home.cfm>

International Energy Agency <http://www.iea.org/>

Resources for the Future www.rff.org

Pierre Desrochers' Energy and Society Class, with lots of "free market" pop readings:
<http://geog.utm.utoronto.ca/desrochers/ggr333a.htm>

Accommodations for Student Disabilities

The University of Michigan is committed to providing equal opportunity for participation in all programs, services and activities. Students wishing to receive testing accommodations must register with the University of Michigan [Services for Students with Disabilities \(SSD\)](#) office as soon as possible. Students must then submit their Verified Individualized Services and Accommodations (VISA) form online as early as possible, **but no later than two weeks prior to the first test or quiz for which accommodations are requested.** Accommodations arrangements are not guaranteed for students who submit their VISA form with less than two weeks' notice.

Requests must be sent using the [Ross Accommodations Request Form](#) and must include a scanned or photographed copy of the VISA form. This form only needs to be submitted once during your academic career with Ross unless your accommodations eligibility expires.

In rare cases, the need for an accommodation arises after the two week deadline has passed (example: a broken wrist). In these cases, students should still contact SSD and the Ross Accommodations Coordinator. However, due to logistical constraints, we cannot guarantee that an accommodation can be made after the two week deadline has passed.

Questions can be directed to the Ross Accommodations Coordinator at RossAccommodationsCoordinator@umich.edu.

Tentative Overview of Daily Topics

Items highlighted in bold are required reading for the class; the others are supplemental. NOTE: Some changes in readings and scheduling may occur---check Canvas.

Section 1: Overview of Energy Issues and Institutions

1. Wed., September 4: The Transition to Sustainable Energy

- Steven Chu and Arun Majumdar. "Opportunities and challenges for a sustainable energy future." *nature* 488.7411 (2012): 294-303.
- Jeffrey Chow, Raymond J. Kopp, and Paul R. Portney, "Energy Resources and Global Development," *Science*, 28 November 2003, 302: 1528-1531.
<http://www.sciencemag.org/cgi/content/full/302/5650/1528> Also see the excellent supplemental materials available at
<http://www.sciencemag.org/cgi/data/302/5650/1528/DC1/1>
- WEA, Overview, pp. 1-26
- Boulding, Kenneth. "Earth as a Spaceship,"
[http://www.eoearth.org/article/The_Economics_of_the_Coming_Spaceship_Earth_\(historical\)](http://www.eoearth.org/article/The_Economics_of_the_Coming_Spaceship_Earth_(historical))

2. Mon., September 9: Future Scenarios for Exhaustible and Renewable Energy

- **"Shell Energy Scenarios to 2050"** <http://www.shell.com/energy-and-innovation/the-energy-future/scenarios.html> In particular, read
 - **New Lens Scenarios.** <https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/new-lenses-on-the-future.html>
 - **A Better Life with a Healthy Planet.** <http://www.shell.com/energy-and-innovation/the-energy-future/scenarios/a-better-life-with-a-healthy-planet.html>
 - **Sky Scenario,** <https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenario-sky.html>
- International Energy Outlook 2018, US Energy Information Administration, <https://www.eia.gov/outlooks/ieo/>
- World Energy Outlook 2017, International Energy Agency, overview presentation, <https://www.iea.org/media/publications/weo/WEO2017launchpresentationprint.pdf>
- Wachtmeister, Henrik, Petter Henke, and Mikael Höök. "Oil projections in retrospect: Revisions, accuracy and current uncertainty." *Applied Energy* 220 (2018): 138-153.
- BP Energy Outlook to 2040, <https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html>
- United Nations Environment Program, *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*, 2011.

<http://www.unep.org/greeneconomy/greeneconomyreport/tabid/29846/default.aspx>
[x](#)

- World Business Council for Sustainable Development, *Vision 2050: The New Agenda for Business*, 2011, <http://www.wbcsd.org/vision2050.aspx>.
- World Energy Assessment, Chapter 9, “Energy Scenarios,” pp. 333-343 and Annexes A-C, pp. 456-466 http://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_energy/world_energy_assessmentenergyandthechallengeofsustainability.html
- InterAcademy Council, “Lighting the Way: Toward a Sustainable Energy Future,” A study funded by Brazil and China, and led by a team of 15 scientists including DOE Secretary and Nobel Laureate Steven Chu. <http://www.interacademycouncil.net/?id=12161>.
- National Science Foundation, “Building a Sustainable Energy Future,” http://www.nsf.gov/nsb/publications/2009/comments_se_report.pdf
- International Energy Agency, “Toward a Sustainable Energy Future,” <http://www.iea.org/textbase/nppdf/free/2000/future2001.pdf>
- Department of Energy, “A Sustainable Energy Future: The Essential Role of Nuclear Energy,” http://www.ne.doe.gov/pdffiles/rpt_sustainableenergyfuture_aug2008.pdf

3. Wed., September 11: An Introduction to Institutions

- **Elinor Ostrom, “Understanding the Diversity of Structured Human Interactions,” Chapter 1 in *Understanding Institutional Diversity*, Princeton, NJ: Princeton University Press, 2005.**
- **Ronald H. Coase, “The Institutional Structure of Production,” Nobel Prize Lecture, 1991, Chapter 1 in *Essays on Economics and Economists*, Chicago, IL: University of Chicago Press, 1994.** <http://nobelprize.org/economics/laureates/1991/coase-lecture.html>
- **Oliver E. Williamson, “Transaction Cost Economics: How it Works, Where it is Headed.”**

Section 2: Energy Markets

4. Mon., Sept. 16: Competitive Markets and the Role of Prices: The Global Oil Market

- **Robert Pindyck and Daniel Rubinfeld, *Microeconomics*, Fourth Edition, Upper Saddle River, NJ: Prentice Hall, Ch. 9, “The Analysis of Competitive Markets”**
- **Robert Solow, “The Economics of Resources and the Resources of Economics,” *American Economic Review*, May, 1974, 64: 1-14.**
- Lutz Kilian, “Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market,” *The American Economic Review*, Vol. 99, No. 3 (Jun., 2009), pp. 1053-1069.
- Stephen Martin, “Petroleum,” in Walter Adams and James Brock, *The Structure of American Industry*, Tenth Edition.

- “Petroleum Industry Analysis Brief,” <http://www.eia.doe.gov/emeu/mecs/iab/petroleum/>
- Robert Pindyck and Daniel Rubinfeld, *Microeconomics*, Fourth Edition, Upper Saddle River, NJ: Prentice Hall, Ch. 2, “The Basics of Supply and Demand”
- “Hubbert Peak Theory,” http://en.wikipedia.org/wiki/Hubbert_peak
- Conan Crum, “The Economics of Peak Oil,” University of Texas at Austin Working Paper, 2008.
- Kenneth Deffeyes, *Beyond Oil: The View from Hubbert’s Peak*, Farrar, Strous and Giroux, 2005. Professor Deffeyes, perhaps the best-known proponent of the “peak oil” notion, argues we passed the peak of world oil consumption on December 16, 2005, <http://www.princeton.edu/hubbert/current-events-06-02.html>.
- Friedrich Hayek, “The Use of Knowledge in Society,” *American Economic Review*, 1945, 35: 519-530.

5. Wed., Sept. 18: Market Power in Energy Markets

- **W. Kip Viscusi, John M. Vernon, and Joseph E. Harrington, Jr., “Oligopoly, Collusion and Antitrust,” Chapter 5 of *Economics of Regulation and Antitrust*, Cambridge, MA: The MIT Press, 1998. (You can skip over the sections on Product Differentiation, pp. 109-112, and on Antitrust Law, pp. 122-132.)**
- **James M. Griffin and Weiwen Xiong, “The Incentive to Cheat: An Empirical Analysis of OPEC,” *Journal of Law and Economics*, Vol. 40, No. 2. (Oct., 1997), pp. 289-316.**
- Stephen, P.A. and G. Hillard Huntington, 2017. “OPEC and World Oil Security,” *Energy Policy*, 108: 512-523.
- Lutz Kilian, “Exogenous Oil Supply Shocks: How Big Are They and How Much Do They Matter for the U.S. Economy?,” *Review of Economics and Statistics* 2008, 90:2, 216-240.
- James M. Griffin, “OPEC Behavior: A Test of Alternative Hypotheses,” *The American Economic Review*, Vol. 75, No. 5. (Dec., 1985), pp. 954-963.
- Frank A. Wolak, 2003, “Measuring Unilateral Market Power in Wholesale Electricity Markets: The California Market, 1998-2000,” *The American Economic Review*, 93(2): 425-430.
- Borenstein, Severin, James Bushnell and Frank Wolak, “Measuring Market Inefficiencies in California’s Restructured Wholesale Electricity Market,” *American Economic Review*, 2002, 92: 1376-1405.
- Wolfram, Catherine. “Measuring Duopoly Power in the British Electricity Spot Market,” *American Economic Review*, 1999, 89: 805-826.
- Federal Energy Regulatory Commission, “Manipulations of Published Natural Gas Indices,” Chapter III in Price Manipulation in Western Markets, Docket PA02-2-000.

6. Mon., Sept. 23: Energy Investments: Transaction Costs, Contracts, and Vertical Integration in Oil, Gas and Electricity
- **Paul Joskow, “Vertical Integration and Long-Term Contracts: The Case of Coal-Burning Electric Generation Plants,” *Journal of Law, Economics and Organization*, 1985, 1: 33-79.**
 - **Keith Crocker and Scott Masten, “Pretia ex Machina? Prices and Process in Long-term Contracts,” *Journal of Law and Economics*, 1991, 34: 69-99.**
 - **Gary D. Libecap and Steven N. Wiggins, “Contractual Responses to the Common Pool: Prorating of Crude Oil Production,” *The American Economic Review*, Vol. 74, No. 1. (Mar., 1984), pp. 87-98.**
 - Keith J. Crocker and Scott E. Masten, “Regulation and Administered Contracts Revisited: Lessons from Transaction-Cost Economics for Public Utility Regulation,” *Journal of Regulatory Economics*, 1996, 9: 5-40.
 - Kaserman, David L. and John W. Mayo, “The Measurement of Vertical Economies and the Efficient Structure of the Electric Utility Industry,” *Journal of Industrial Economics*, 1991, 39: 483-502.
 - Oliver E. Williamson, “Transaction Cost Economics: How it Works, Where it is Headed,” *De Economist*, 1998.
7. Wed., Sept. 25: Managing Volatility: Spot Markets, Contracts, Futures Markets
- **“Equilibrium in Futures Markets,” chapter 4 from lecture notes on Futures Markets by Darrell Duffie.**
 - **New York Mercantile Exchange, “A Guide to Energy Hedging,” http://www.futuresfacts.com/images/edu_pdf/quick_guides/energyhedge.pdf**
 - **New York Mercantile Exchange, “Risk Management with Natural Gas Futures and Options.” https://www.rjobrien.com/documents/shared/energy/risk_management_with_natural_gas_futures_and_options_small.pdf**
 - Emile J. Brinkmann and Ramon Rabinovitch, “Regional Limitations on the Hedging Effectiveness of Natural Gas Futures,” *The Energy Journal*, 1995, 16: 113-124.
 - Severin Borenstein and Ryan Kellogg, “The Incidence of an Oil Glut: Who Benefits from Cheap Crude Oil in the Midwest?,” NBER Working Paper No. 18127, June 2012.
 - Michael J. Doane and Daniel F. Spulber, “Open Access and the Evolution of the U.S. Spot Market for Natural Gas,” *Journal of Law and Economics*, 1994, 37: 477-517.
 - Thomas P. Lyon and Steven C. Hackett, “Bottlenecks and Governance Structures: Open Access and Long-term Contracting in Natural Gas,” *Journal of Law Economics and Organization*, 1993, 9: 380-398.
 - Robert S. Pindyck (2001), “The Dynamics of Spot and Futures Markets: A Primer,” *The Energy Journal*, 22 (1), 1-29.
 - Thomas E. Copeland and Philip T. Keenan, “How Much is Flexibility Worth?,” *The McKinsey Quarterly*, 1998, #2.

- Thomas E. Copeland and Philip T. Keenan, “Making Real Options Real,” *The McKinsey Quarterly*, 1998, #3.
- David Berry, “Renewable Energy as a Natural Gas Price Hedge: The Case of Wind,” *Energy Policy*, 2005, 33: 799-807.
- Benjamin Israel and Jay Sonnenberg, “Wind Hedges Add Security, Introduce Risk,” North American Windpower, May 2008.
- New York State Energy Research and Development Authority, “Using Wind Power to Hedge Volatile Electricity Prices for Commercial and Industrial Customers in New York,” Executive Summary, May 14, 2003.
- Wright, Brian D., and Jeffrey C. Williams. "The economic role of commodity storage." *The Economic Journal* 92, no. 367 (1982): 596-614.

8. Mon., Sept. 30: Market Failure, Government Failure and the Theory of the Second Best

- **Robert Bradley, “A Free Market Energy Vision,”**
<http://www.masterresource.org/2010/07/a-free-market-energy-vision/>
- **David Anthoff and Robert Hahn, “Government Failure and Market Failure: On the Inefficiency of Environmental and Energy Policy,”** *Oxford Review of Economic Policy*, Volume 26, Number 2, 2010, pp.197–224.
- **“Trump Calls for Coal, Nuclear Power Plant Bailout,”**
<https://www.politico.com/story/2018/06/01/donald-trump-rick-perry-coal-plants-617112>
- **“Compete or Suckle? Should Troubled Nuclear Power Plants be Subsidized?”** <https://theconversation.com/compete-or-suckle-should-troubled-nuclear-reactors-be-subsidized-62069>
- Arthur A. Goldsmith, “Market Failure and Government Failure,” Chapter 3 in *Business, Government, Society: The Global Political Economy*, Chicago: Irwin, 1996.
- “Legal Theory Lexicon: The Second Best,”
<http://legaltheorylexicon.blogspot.com/2003/11/legal-theory-lexicon-011-second.html>
- Gary D. Libecap and Steven N. Wiggins, “The Influence of Private Contractual Failure on Regulation: The Case of Oil Field Unitization,” *The Journal of Political Economy*, Vol. 93, No. 4. (Aug., 1985), pp. 690-714.
- Stephen Breyer, “Typical Justifications for Regulation,” Chapter 1 in *Regulation and Its Reform*, Cambridge, MA: Harvard University Press, 1982.
- R. G. Lipsey and Kelvin Lancaster, “The General Theory of Second Best,” *The Review of Economic Studies*, Vol. 24, No. 1. (1956 - 1957), pp. 11-32.

Section 3: Government Involvement in Energy Markets

9. Wed., Oct. 2: Electricity Markets I

Guest: Henry J. Decker, Director, Business Planning & Development, DTE Energy

- **Borenstein, Severin, and James Bushnell. "The US electricity industry after 20 years of restructuring." *Annu. Rev. Econ.* 7.1 (2015): 437-463.**

- Paul L. Joskow, “Markets for Power in the United States: An Interim Assessment,” *The Energy Journal*, v. 27, no. 1, 2006.
- Matthew Barmack, Edward Kahn, and Susan Tierney. “A cost-benefit assessment of wholesale electricity restructuring and competition in New England,” *Journal of Regulatory Economics* (2007) 31:151–184.
- Hausman, Catherine. "Corporate incentives and nuclear safety." *American Economic Journal: Economic Policy* 6.3 (2014): 178-206.
- Linares, Pedro, and Adela Conchado. "The economics of new nuclear power plants in liberalized electricity markets." *Energy Economics* 40 (2013): S119-S125.
- John Kwoka, “Restructuring the U.S. Electric Power Sector: A Review of Recent Studies,” *Review of Industrial Organization*, 2008, 32: 165-196.
- Seth Blumsack, Jay Apt, and Lester Lave. 2006. “Lessons from the Failure of U.S. Electricity Restructuring,” *The Electricity Journal*, 19(2): 15-32.
- Jerry Taylor and Peter van Doren, “Rethinking Electricity Restructuring,” Cato Institute Policy Analysis No. 530, 2004.
- Steven Stoft, *Power System Economics: Designing Markets for Electricity*, Wiley-IEEE Press, 2002.
- Timothy J. Brennan, Karen L. Palmer, and Salvador A. Martinez, “State and Federal Roles,” Chapter 12 in *Alternating Currents: Electricity Markets and Public Policy*, Washington, DC: RFF Press, 2002.
- Paul Joskow, “Restructuring, Competition and Regulatory Reform in the U.S. Electricity Sector,” *Journal of Economic Perspectives*, 1997, 11: 119-138.
- William Hogan, “Electricity Market Restructuring: Reform of Reforms,” *Journal of Regulatory Economics*, January 2002, pp. 103-132.
- R. W. Bacon and J. Besant-Jones, “Global Electric Power Reform, Privatization, and Liberalization of the Electric Power Industry in Developing Countries,” *Annual Review of Energy and Environment*, 2001, 26: 331-359.
<http://arjournals.annualreviews.org/doi/pdf/10.1146/annurev.energy.26.1.331?cookieSet=1>
- David Newbery, “Reforming the Electricity Supply Industry,” Chapter 6 in *Privatization, Restructuring, and Regulation of Network Utilities*, Cambridge, MA: The MIT Press, 1999.
- David M. Newbery, 1998, “Competition, Contracts, and Entry in the Electricity Spot Market,” *The RAND Journal of Economics*, Vol. 29, No. 4 (Winter, 1998), pp. 726-749.
- Frank A. Wolak, 2003, “Measuring Unilateral Market Power in Wholesale Electricity Markets: The California Market, 1998-2000,” *The American Economic Review*, 93(2): 425-430.
- Ali Hortaçsu and Steven L. Puller. 2008. “Understanding Strategic Bidding in Multi-Unit Auctions: A Case Study of the Texas Electricity Spot Market,” *The RAND Journal of Economics*, Vol. 39, No. 1 (Spring, 2008), pp. 86-114.
- THE CALIFORNIA DEBACLE

- Borenstein, Severin. “The Trouble with Electricity Markets: Understanding California’s Restructuring Disaster,” *Journal of Economic Perspectives*, 2002, 16: 191-211.
- Paul Joskow, “California’s Electricity Crisis,” NBER Working Paper W8442.
- Timothy J. Brennan, Karen L. Palmer, and Salvador A. Martinez, “The California Experience,” Chapter 5 in *Alternating Currents: Electricity Markets and Public Policy*, Washington, DC: RFF Press, 2002.

10. Mon., Oct. 7: Natural monopoly and regulation, govt. ownership, and antitrust

- **W. Kip Viscusi, John M. Vernon, and Joseph E. Harrington, Jr., “Natural Monopoly Regulation,” Chapter 12 of *Economics of Regulation and Antitrust*, Cambridge, MA: The MIT Press, 1998.**
- John E. Kwoka, Jr., “Governance Alternatives and Pricing in the U.S. Electric Power Industry,” *Journal of Law, Economics and Organization*, 2002, 18: 278-294.
- Paul L. Joskow, “Inflation and Environmental Concern: Structural Change in the Process of Public Utility Regulation,” *Journal of Law and Economics*, 1974, 17: 291-327.
- Jarrell, Gregg A. 1978. “The Demand for State Regulation of the Electric Utility Industry,” *Journal of Law and Economics*, 21, pp. 269-295.
- Priest, George L. 1993. “The Origins of Utility Regulation and the ‘Theories of Regulation’ Debate.” *Journal of Law and Economics*, 36, pp. 289-323.
- Emmons, William M. III. 1993. “Franklin D. Roosevelt, Electric Utilities, and the Power of Competition,” *The Journal of Economic History*, 53: 880-907.
- Lyon, Thomas P., and Nathan Wilson. "Capture or contract? The early years of electric utility regulation." *Journal of Regulatory Economics* 42.3 (2012): 225-241.

11. Wed., Oct. 9: Environmental externalities

(Paper topic proposals due)

- **WEA, Chapter 3, “Energy, the Environment, and Health”**
- **Landrigan PJ, Fuller R, Acosta NJ, Adeyi O, Arnold R, Baldé AB, Bertollini R, Bose-O’Reilly S, Boufford JI, Breyse PN, Chiles T. “The Lancet Commission on pollution and health.” *The Lancet*. 2017 Oct 19.**
- **“Cost of New EPA Coal Rules: Up to 1,400 Deaths a Year,”**
<https://www.nytimes.com/2018/08/21/climate/epa-coal-pollution-deaths.html>
- **“EPA Analysis of its Own New Climate Proposal: Thousands will Die,”**
<https://www.vox.com/2018/8/21/17763916/epa-clean-power-plan-affordable-clean-energy>
- Holland, Stephen P., Erin T. Mansur, Nicholas Z. Muller, and Andrew J. Yates. "Are there environmental benefits from driving electric vehicles? The importance of local factors." *American Economic Review* 106, no. 12 (2016): 3700-3729.

- Rhodes, Joshua D., Carey King, Gürcan Gulen, Sheila M. Olmstead, James S. Dyer, Robert E. Hebner, Fred C. Beach, Thomas F. Edgar, and Michael E. Webber. "A Geographically Resolved Method To Estimate Levelized Power Plant Costs With Environmental Externalities." *Energy Policy* 102 (2017): 491-499.
- Fowlie, Meredith. "Emissions trading, electricity restructuring, and investment in pollution abatement." *American Economic Review* 100.3 (2010): 837-69.
- Joseph E. Aldy, Alan J. Krupnick, Richard G. Newell, Ian W. H. Parry, and William A. Pizer, "Designing Climate Mitigation Policy," *Journal of Economic Literature*, 2010, 48:4, 903–934.
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12. Mon., Oct. 14: Public Goods, Energy R&D and Information Problems

- **Robert M. Margolis and Daniel M. Kammen, “Underinvestment: The Energy Technology and R&D Policy Challenge,”** *Science*, July 1999, 285: 690-692.
- **David Popp, “R&D Subsidies and Climate Change: Is There a Free Lunch?,”** *Climatic Change* (2006) 77: 311–341.
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- Edward A. Parson and Jennie C. Stephens, “Reducing Automobile Emissions: Strategy and Technology,” Working Paper for chapter in book *Feasible*

Improvements: Technological uncertainty and strategic behavior in environmental regulation

- Karen Palmer; Wallace E. Oates; Paul R. Portney, "Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm?," *The Journal of Economic Perspectives*, Vol. 9, No. 4. (Autumn, 1995), pp. 119-132.

Wed., Oct. 16: MIDTERM EXAM

Oct. 21-25: ROSS MIDTERM BREAK, NO CLASS!

Section 4: Policies for a Sustainable Energy Future

Note: Schedule may be rearranged somewhat to accommodate outside speakers' availability.

13. Mon., October 28: Electricity Markets II: The Grid

- **Joskow, Paul, and Jean Tirole. "Merchant transmission investment." *The Journal of industrial economics* 53.2 (2005): 233-264.**
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- Paul Joskow, "Transmission Policy in the United States," *Utilities Policy*, 2005, 13: 95-115.
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- Borenstein, Severin. "The long-run efficiency of real-time electricity pricing." *The Energy Journal* (2005): 93-116.
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- FERC Order 1000A, <http://www.ferc.gov/whats-new/comm-meet/2012/051712/E-1.pdf>
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- US Department of Energy, "The Smart Grid: An Introduction"
- Hunt Alcott, "Real-Time Pricing and Electricity Markets," Harvard University Working paper.
- Richard Green, "Electricity Transmission Pricing: How Much Does it Cost to Get it Wrong?," MIT Working Paper, 2004.
- Stephen Holland and Erin Mansur, "Is Real-Time Pricing Green?: The Environmental Impacts of Electricity Demand Variance," *Review of Economics and Statistics*, August 2008, 90: 550-561.
- Nathaniel Greene and Roel Hammerschlag, "Small and Clean is Beautiful: Exploring the Emissions of Distributed Generation and Pollution Prevention Policies," *The Electricity Journal*, June 2000, 13: 50-60.
- Lucy Butler and Karsten Neuhoff, "Comparison of Feed in Tariff, Quota and Auction Mechanisms to Support Wind Power Development," Cambridge University Working Paper, 2006.
- S. Jacobsson and V. Lauber, The politics and policy of energy system transformation-explaining the German diffusion of renewable energy technology, *Energy Policy* 34 (2006) (3), pp. 256–276.

14. Wed., October 30: Promoting Renewables for Electricity Production

GUEST: Monica Schewbs

- **Carolyn Fischer and Richard Newell, “Environmental and Technology Policies for Climate Mitigation,” *Journal of Environmental Economics and Management*, 2008, 55: 142-162.**
- **Ben Ho, “The Conservative Case for Solar Power Subsidies,” *New York Times*, 2016, <https://www.nytimes.com/2016/01/05/opinion/the-conservative-case-for-solar-subsidies.html?smprod=nytcore-iphone&smid=nytcore-iphone-share&r=0>**
- Karen Palmer and Dallas Burtraw, “Cost-Effectiveness of Renewable Electricity Policies,” *Energy Economics*, 27: 873-894, 2005.
- “What Can We Learn From Germany’s Solar Power Experience?,” <https://www.greentechmedia.com/articles/read/what-can-we-learn-from-germanys-solar-experience#gs.QfDd00k>
- Richard Martin, “Germany Runs Up Against the Limits of Renewables,” MIT Technology Review, <https://www.technologyreview.com/s/601514/germany-runs-up-against-the-limits-of-renewables/>
- Stanley Reed, “Germany’s Shift to Renewable Power Stalls, Despite Huge Investments,” <https://www.nytimes.com/2017/10/07/business/energy-environment/german-renewable-energy.html>
- National Renewable Energy Laboratory, *Renewable Electricity Futures Study Volume 1: Exploration of High-Penetration Renewable Electricity Futures*, Hand, M.M.; Baldwin, S.; DeMeo, E.; Reilly, J.M.; Mai, T.; Arent, D.; Porro, G.; Meshek, M.; Sandor, D. eds. 4 vols. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/re_futures/
- Mark Bernstein, Jay Griffin, and Robert Lempert, *Impacts on US Energy Expenditures of Increasing Renewable Energy Use*, RAND Institute, 2006.
- Thomas P. Lyon and Haitao Yin, 2010, “Why Do States Adopt Renewable Portfolio Standards?: An Empirical Investigation,” *The Energy Journal*, 31: 131-155.
- Nicholas Powers and Haitao Yin, 2010, “Do State Renewable Portfolio Standards Promote In-State Renewable Generation?,” *Energy Policy* 38: 1140–1149.

15. Mon., November 4: Challenges of Distributed Energy Resources

- **Guest: Brandon Hofmeister, Executive Director of Policy, Research and Public Affairs, Consumers Energy Company**
- ***Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business*, Edison Electric Institute, January 2013.**
- Baker, Erin, Meredith Fowlie, Derek Lemoine, and Stanley S. Reynolds. "The Economics of Solar Electricity." *Annu. Rev. Resour. Econ.* 5, no. 1 (2013): 387-426.
- Reichelstein, Stefan, and Michael Yorston. "The prospects for cost competitive solar PV power." *Energy Policy* 55 (2013): 117-127.
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- Ryan Wiser and Changgui Dong. “The Impact of City-level Permitting Processes on Residential Photovoltaic Installation Prices and Development Times: An Empirical Analysis of Solar Systems in California Cities,” Environmental Energy Technologies Division, LBNL, April 2013.
- Gregory S. Nemet. 2006. “Beyond the learning curve: factors influencing cost reductions in photovoltaics,” *Energy Policy*, 34: 3218–3232.

16. Wed., November 6: Energy Efficiency: Commercial

- **Case: Equilibrium Capital Group (A): Investing in Energy Efficiency Companies**
- **Piet Eichholtz, Nils Kok and John M. Quigley. “Doing Well by Doing Good? Green Office Buildings,” *The American Economic Review*, Vol. 100, No. 5 (December 2010), pp. 2492-2509.**
- Piet Eichholtz, Nils Kok and John M. Quigley. 2013. “The Economics of Green Building,” *Review of Economics and Statistics*, 95: 50-63.
- Nils Kok, Marquise McGraw, and John M. Quigley. 2011. “The Diffusion of Energy Efficiency in Building,” *American Economic Review: Papers & Proceedings*, 101: 77–82.
- “The Greening of Walmart,” Environmental Defense Fund Solutions Newsletter, July 2010. <http://www.edf.org/article.cfm?contentID=11212>
- Kenneth Gillingham, Richard Newell, and Karen Palmer, “Energy Efficiency Policies: A Retrospective Examination,” *Annual Review of Environment and Resources*, 2006. 31:161–92.
<http://web.mit.edu/annakot/OldFiles/MacData/afs.cron/project/urban-sustainability/Old%20files%20from%20summer%202009/Ingrid/Urban%20Sustainability%20Initiative.Data/Energy%20Efficiency%20Policies%20A%20Retrospective%20Examination.pdf>
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- Hunt Alcott, “Social Norms and Energy Conservation,” MIT CEEPR Working Paper, 2009. <http://dspace.mit.edu/bitstream/handle/1721.1/51712/2009-014.pdf?sequence=1>
- Gilbert E. Metcalf and Donald Rosenthal, “The New View of Investment Decisions and Public Policy Analysis: An Application to Green Lights and Cold Refrigerators,” *Journal of Policy Analysis and Management*, 1995, 14: 517-531.
- Adam Jaffe, Richard Newell, and Robert Stavins, “Energy-Efficient Technologies and Climate Change Policies: Issues and Evidence,” Resources for the Future Discussion Paper, December 1999.
- James E. Smith and Robert F. Nau, “Valuing Risky Projects: Option Pricing Theory and Decision Analysis,” *Management Science*, 1995, 41: 795-816.
- William H. Golove and Joseph H. Eto, “Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency,” Lawrence Berkeley Laboratory, March 1996, <http://eetd.lbl.gov/ea/ems/reports/38059.pdf>

- Adam B. Jaffe and Robert N. Stavins, “The energy paradox and the diffusion of conservation technology,” *Resource and Energy Economics*, 1994, 16: 91-122.

17. Mon., November 11: Energy Efficiency---Residential

- **Case: “OPOWER: Increasing Energy Efficiency through Normative Influence (A),” (Harvard Business School 911-016)**
- Allcott, Hunt. "Social norms and energy conservation." *Journal of public Economics* 95.9-10 (2011): 1082-1095.
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- Dirk Brounen and Nils Kok. 2011. “On the economics of energy labels in the housing market,” *Journal of Environmental Economics and Management*, 62: 166–179.
- Davis, Lucas W. "Evaluating the slow adoption of energy efficient investments: are renters less likely to have energy efficient appliances?." *The design and implementation of US climate policy*. University of Chicago Press, 2011. 301-316.
- Ronald J. Sutherland, “The High Costs of Federal Energy Efficiency Standards for Residential Appliances,” Policy Analysis No. 504, Washington DC, The Cato Institute, December 23, 2003.
- Gilbert E. Metcalf and Kevin Hassett, “Measuring the Energy Savings from Home Improvement Investments: Evidence from Monthly Billing Data,” *Review of Economics and Statistics*, August 1999, pp. 516-528.

18. Wed., November 13: Driving the Future: Policy Options for Alternative Fuel Vehicles

- Today we will use a simulation developed by faculty at MIT to build experience with policies to encourage the development of alternative fuel vehicles. It can be found at <https://forio.com/app/mit/afv/> You are welcome to experiment with it individually before class so that you are familiar with its basic structure. During class, you will play the role of a particular stakeholder group designing a set of policies that work best for your interests.
- Keith, David R., Sergey Naumov, and John Sterman. "Driving the Future: A Management Flight Simulator of the US Automobile Market." *Simulation & Gaming* 48, no. 6 (2017): 735-769.

- *Transitions to Alternative Vehicles and Fuels*, Committee on Transitions to Alternative Vehicles and Fuels; Board on Energy and Environmental Systems; Division on Engineering and Physical Sciences; National Research Council, 2013.
- McCollum, David, and Christopher Yang. "Achieving deep reductions in US transport greenhouse gas emissions: Scenario analysis and policy implications." *Energy Policy* 37.12 (2009): 5580-5596.

19. Mon., November 18: Vehicle/Grid Integration

- **Guest: Alex Keros, GM Chief of Maven Smart Cities program**
- **McCollum, David, and Christopher Yang. "Achieving deep reductions in US transport greenhouse gas emissions: Scenario analysis and policy implications." *Energy Policy* 37.12 (2009): 5580-5596.**
- *Transitions to Alternative Vehicles and Fuels*, Committee on Transitions to Alternative Vehicles and Fuels; Board on Energy and Environmental Systems; Division on Engineering and Physical Sciences; National Research Council, 2013.
- Melaina, M., and K. Webster. "Role of fuel carbon intensity in achieving 2050 greenhouse gas reduction goals within the light-duty vehicle sector." *Environmental science & technology* 45.9 (2011): 3865-3871.
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- NCEP Report, section 1, "Enhancing Oil Security," pp. 1-18.
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- Ian Parry and Joel Darmstadter, "The Costs of US Oil Dependency," RFF Discussion Paper 03-59. <http://www.rff.org/Documents/RFF-DP-03-59.pdf>
- Keith Crane et al., "Imported Oil and National Security," RAND Corporation, 2009.

20. Wed., November 20: Policies for Sustainable Vehicles

- **Guest: Ellen Hughes-Cromwick, former VP Ford Motor Company**
- **Jody Freeman, "The Obama Administration's National Auto Policy: Lessons from the 'Car Deal'," *Harvard Environmental Law Journal*, 35: 343-374.**
- US EPA, "EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks"
- Catherine Wolfram, "The MPG Illusion," <http://blogs.berkeley.edu/2013/06/03/the-mpg-illusion/>
- Hunt Alcott, "The Welfare Effects of Misperceived Product Costs: Data and Calibrations from the Automobile Market," *American Economic Journal: Economic Policy* 2013, 5(3): 30-66
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- Paul Portney, Ian Parry, Howard Gruenspecht, and Winston Harrington, “The Economics of Fuel Economy Standards,” *Journal of Economic Perspectives*, 2003, 17: 203-217.
- Mian, Atif, and Amir Sufi. "The effects of fiscal stimulus: Evidence from the 2009 cash for clunkers program." *The Quarterly journal of economics* 127.3 (2012): 1107-1142.
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- A. Denny Ellerman, Henry D. Jacoby and Martin B. Zimmerman, “Bringing Auto Transportation into a CO2 Cap-and-Trade Regime,” Ross School of Business Working Paper.
- Holland, Stephen P., Jonathan E. Hughes, and Christopher R. Knittel. "Greenhouse gas reductions under low carbon fuel standards?." *American Economic Journal: Economic Policy* 1.1 (2009): 106-46.
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- Edward A. Parson and Jennie C. Stephens, “Reducing Automobile Emissions: Strategy and Technology,” Working Paper for chapter in book *Feasible Improvements: Technological uncertainty and strategic behavior in environmental regulation*

21. Mon., November 25: Hydraulic Fracturing of Shale

Guest Speaker: Daniel Raimi, author of The Fracking Debate

- **Readings: 6 short 2-page briefs on the Fracking Debate at**
<http://www.rff.org/research/publications/fracking-debate-risks-benefits-and-uncertainties-shale-revolution>
- Hausman, Catherine, and Ryan Kellogg. “Welfare and Distributional Implications of Shale Gas.” *Brookings Papers on Economic Activity* (2015): 71-125.
- Kilian, Lutz. “The impact of the shale oil revolution on US oil and gasoline prices.” *Review of Environmental Economics and Policy* 10.2 (2016): 185-205.
- Feyrer, James, Erin T. Mansur, and Bruce Sacerdote. “Geographic dispersion of economic shocks: Evidence from the fracking revolution.” *American Economic Review* 107.4 (2017): 1313-34.
- Hill, Elaine, and Lala Ma. “Shale gas development and drinking water quality.” *American Economic Review* 107.5 (2017): 522-25.

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- Robert W. Howarth, Renee Santoro, and Anthony Ingraffea. “Methane and the greenhouse-gas footprint of natural gas from shale formations,” *Climatic Change* (2011) 106:679–690.
- Lawrence M. Cathles III & Larry Brown & Milton Taam & Andrew Hunter, 2012, “A commentary on “The greenhouse-gas footprint of natural gas in shale formations” by R.W. Howarth, R. Santoro, and Anthony Ingraffea,” *Climatic Change*, 113: 525–535.
- Andrew Burnham, Jeongwoo Han, Corrie E. Clark, Michael Wang, Jennifer B. Dunn, and Ignasi Palou-Rivera. “Life-Cycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum,” *Environmental Science and Technology*, 2012, 46, 619–627.
- Sally Entekin, Michelle Evans-White, Brent Johnson, and Elisabeth Hagenbuch. “Rapid expansion of natural gas development poses a threat to surface waters,” *Frontiers in Ecology and the Environment* 9: 503–511
- Case: Range Resources: A Commitment to Transparency

Wed., Nov. 27: THANKSGIVING BREAK
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22. Mon., December 2: Carbon Policy and Coal

- **Özge İsligen and Stefan Reichelstein, “The Economics of Carbon Capture,” *The Economist’s Voice*, December 2009. Available at <http://ebookbrowse.com/gdoc.php?id=40616397&url=1126253a40d5c0d0dc67472283940dea>**

- Özge Islegen and Stefan Reichelstein, 2011, “Carbon Capture by Fossil Fuel Power Plants: An Economic Analysis,” *Management Science*, 57: 21–39.
- “The Trump Administration’s Latest Attempt to Prop Up Coal,” *The Economist*, <https://www.economist.com/united-states/2018/08/23/the-trump-administrations-latest-plan-to-prop-up-coal>
- “Trump Makes Coal Great Again—Overseas,” <https://foreignpolicy.com/2018/04/04/trump-makes-american-coal-great-again-overseas/>
- “Trump Gives Craziest Climate Speech Yet,” *New York Magazine*, <http://nymag.com/daily/intelligencer/2018/08/trump-gives-his-craziest-climate-speech-ever.html>
- “Trump’s Affordable Clean Energy Plan Won’t Save Coal,” <https://www.scientificamerican.com/article/trumps-affordable-clean-energy-plan-wont-save-coal/>
- “Trump-Appointed Regulators Reject Plan to Rescue Coal and Nuclear Plants,” https://www.washingtonpost.com/news/energy-environment/wp/2018/01/08/trump-appointed-regulators-reject-plan-to-rescue-coal-and-nuclear-plants/?noredirect=on&utm_term=.32935ab767cd
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- Meredith Fowlie, Lawrence Goulder, Matthew Kotchen, Severin Borenstein, James Bushnell, Lucas Davis, Michael Greenstone, Charles Kolstad, Christopher Knittel, Robert Stavins, Michael Wara, Frank Wolak, Catherine Wolfram, “An economic perspective on the EPA’s Clean Power Plan,” *Science* 14 Nov 2014: Vol. 346, Issue 6211, pp. 815-816.
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- Jia-Hai Yuan and Thomas P. Lyon. “Promoting Global CCS RDD&D by Stronger U.S.–China Collaboration,” *Renewable and Sustainable Energy Reviews*, 2012, 16: 6746-6769.
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- William A. Pizer, “Combining price and quantity controls to mitigate global climate change,” *Journal of Public Economics* 85 (2002) 409–434.
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- Ian W. H. Parry, Roberton C. Williams, III and Lawrence H. Goulder, “When Can Carbon Abatement Policies Increase Welfare? The Fundamental Role of Distorted Factor Markets,” *Journal of Environmental Economics and Management* 37, 52-84 (1999).
- Richard K. Morse, Varun Rai, and Gang He, “The Real Drivers of Carbon Capture and Storage in China and Implications for Climate Policy,” Working Paper #88, August 2009, Stanford Program on Energy and Sustainable Development.

23. Wed., December 4: International Climate Agreements & the Paris COP

- **Nordhaus, William. "Climate Clubs: Overcoming Free-riding in International Climate Policy." *American Economic Review* 105.4 (2015): 1339-70.**
- **Paris 2015: Getting a global agreement on climate change. Green Alliance.**
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- Hulme, Mike. "1.5 C and climate research after the Paris Agreement." *Nature Climate Change* 6, no. 3 (2016): 222.
 - Dimitrov, Radoslav S. "The Paris agreement on climate change: Behind closed doors." *Global Environmental Politics* 16, no. 3 (2016): 1-11.

24. Mon., December 9: Wrap Up and Prepare for Poster Session

25. Wed., December 11: Student Project Poster Session