



THE UNIVERSITY OF CHICAGO
THE HARRIS SCHOOL OF PUBLIC POLICY

PPHA 44340:
ENERGY AND ENVIRONMENTAL ECONOMICS III

Spring 2017: Mondays 3:00 – 5:50 pm

Instructor: Professor Koichiro Ito
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Office hours: Mondays 2:00-3:00pm

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Course Description: Optimal environmental regulation requires an analysis of the trade-offs between market and regulatory imperfections. Market allocations are inefficient in the presence of imperfections such as externalities, market power, and informational asymmetries. On the other hand, government intervention to mitigate these imperfections is not costless, and can even make market performance worse.

This course is the third course in the Ph.D. environmental and energy economics sequence at the University of Chicago. We focus on recent empirical analysis of the costs and benefits of environmental and energy policies, including an introduction to the relevant econometric methodologies such as randomized controlled trials, regression discontinuity design, bunching analysis, and structural estimation. Topics will include: energy demand and the energy efficiency gap, fuel economy and appliance efficiency standards, non-linear and real-time electricity pricing, wholesale electricity markets, renewable electricity policies, natural gas markets, retail gasoline markets, and technology innovations.

Prerequisites: PhD-level coursework on microeconomics and econometrics either at the Harris School, the economics department or Booth, Environmental and Energy Economics I (PPHA443201), and Environmental and Energy Economics II (PPHA44330). If you have not taken these courses, please obtain consent of the instructor to enroll.

Readings: Course readings are listed below. There is no textbook.

Audits: I welcome students who choose to audit the course. However, my class is a no-free-rider zone, so auditing students will be required to participate in class presentations and discussions as if they were taking the course for credit. Specifically, auditing students are required to read assigned papers (* and ** in the reading list) and participate in class discussions. Auditors may also be asked to present a paper in class. Auditors are exempt from turning in referee reports, problem sets, research summaries, and from taking the exam.

Seminars: All students interested in environmental and energy economics should attend the EPIC lunch seminar. This will be held on Tuesday between noon and 1PM in Saieh Hall. In addition, two web sites that will be of interest to students in environmental and energy economics are the EEE NBER Working Paper series (<http://www.nber.org/papersbyprog/EEE.html>) and the Energy Economics Exchange blog from UC Berkeley (<http://energyathaas.wordpress.com/>). For both of these sites, you can sign up for notifications of new papers and posts.

Weekly Class Format: The first goal of this course is to understand key issues in environmental and energy economics, comprehend important theoretical and empirical findings, and acquire available tools for conducting original research. Toward these ends, classes will involve lectures by the instructor, student presentations, and class discussion.

More specifically, our meetings will focus on pre-assigned papers. In most of the weeks, I structure the 3-hour class in the following way:

1. **Lecture:** In the first half of the class (1.5 hours), I summarize key issues for the topic covered for that week. I primarily use papers with * in the reading list. Students are asked to read these papers before coming to each class. I plan to actively ask questions about these papers and make the lecture much more like in-class discussions of these papers.
2. **Student Presentation and Discussion:** In the second half of the class (1.5 hours), two teams (each team consists of one or two students) present two papers with ** in the reading list. This will give you an opportunity to practice your presentation skill, which is actually quite important for your academic career (for both research and teaching).

The first team presents the first paper for 20 minutes and leads the class discussion for 20 minutes. Then, the second team does the same for the second paper. The presentation slides in PDF must be emailed to the TA **by 3 pm on Sunday**, a day before the presentation day. The presentation should include the following items:

- i. What is the research question?
- ii. Why is it interesting/important?
- iii. Brief data description
- iv. Estimation method (and a brief description of your model, if any, but not required)

- v. Results
 - vi. Contributions of the paper relative to previous studies (compare the paper to a few of the most key/relevant studies in the literature and explain why the paper provides novel contributions).
 - vii. Your questions and critiques for the paper to lead the class discussion
3. **Brief Referee Reports:** In the beginning of the class, all students will submit a brief referee report for the two assigned papers with **. I will provide a guideline in the first class.

Research Paper: The second goal of this course is to help students to start conducting original research in this field. Remember that your goal in the PhD program is to produce original research. Understanding someone else's research is useful but not a goal for your grad school.

With this motivation, I ask you to work on the following items:

1. **Summary of Preliminary Findings (deadline 3 pm on 4/24):** Email a summary of the preliminary findings of your project in PDF to TA and me. The summary should include texts (max 3 pages) along with a reference list, tables, and figures. It should contain the following six sections:
 - viii. What is the research question?
 - ix. Why is it interesting/important?
 - x. Data description
 - xi. Estimation method (and a brief description of your model, if any, but not required)
 - xii. Preliminary results
 - xiii. Contributions of your paper relative to previous studies (compare your paper to a few of the most key/relevant studies in the literature and explain why your study provides novel contributions).
2. **Meetings with TA and me (the week of 4/24):** Schedule a meeting with me (half an hour) and a meeting with the TA (half an hour) to get feedback for your preliminary findings.
3. **Final Presentation (deadline: 3 pm on 5/21, the day before the presentation day):** Email TA and me your slides in PDF. Your presentation will be 10 minutes with no interruptions followed by 5-minute Q&A. Your presentation needs to cover the six items described in "summary of preliminary findings."
4. **Final Paper (deadline: 3 pm on 5/29):** Email TA and me your final paper in PDF. This should include texts (max 4 pages) along with a reference list, tables, and figures. Your paper needs to cover the six items described in "summary of preliminary findings."

Problem Sets: There will be two short problem sets. The questions in the problem sets can be answered by the good understanding of your readings and class discussions. These are meant to be practice questions for your final exam. You are encouraged to work with other students, but please submit your own answer to the TA.

Final Exam (Take-Home): The questions in the final exam can be answered by the good understanding of your readings and class discussions. It will be open-book, but you are prohibited to talk to other students to complete the exam.

Grading: The course grades will break out as follows:

Referee reports, presentation, and class discussion: 20%

Two problem sets: 20%

Research proposal (mid-term proposal, final proposal & presentation): 30%

Final exam: 30%

How is each assignment graded: Final research paper and final exam will be graded with numerical scores. Other assignments are graded based on check (default), check+ (exceptional), and check- (require more efforts).

Policy for Late Assignments: Please meet the deadline. Each assignment that missed its deadline will create a 5-point deduction per day from your final course grade, with no exception.

No electric device policy: I ask you not to use electric devices in class, including laptops, and phones. Please seek permission from the instructor if you need to use an electric device for a special reason (e.g. a medical reason).

Course Schedule:

	Date	Topic	Format	Assignment due
1	3/27	Introduction to the Course and Energy Markets	Lecture	
2		Electricity Markets: Supply	Lecture	
3	4/3	Electricity Markets: Supply	Lecture	Referee report
4		Electricity Markets: Supply	Presentation & discussion	
5	4/10	Electricity Markets: Demand	Lecture	Referee report
6		Electricity Markets: Demand	Presentation & discussion	
7	4/17	Oil and Gasoline Markets	Lecture	Referee report
8		Oil and Gasoline Markets	Presentation & discussion	
9	4/24	Automobile Markets	Lecture	Preliminary Research Results & Referee report
10		Automobile Markets	Presentation & discussion	
11	5/1	Renewable Energy Markets	Lecture	Problem set 1 & Referee report
12		Renewable Energy Markets	Presentation & discussion	
13	5/8	Emission Markets/R&D and Innovation	Lecture	Referee report
14		Emission Markets/R&D and Innovation	Presentation & discussion	
15	5/15	Energy and Environmental Markets in Developing Countries	Lecture	Problem set 2 & Referee report
16		Energy and Environmental Markets in Developing Countries	Presentation & discussion	
17	5/22	Further topics in Environmental and Energy Economics (if time permitted)	Lecture	Presentation slides for research presentation
18		Student Presentation of Preliminary Research Results	Research presentation	
	5/29	No class – Holiday		Final research paper
	TBA	Final exam (take-home)		Final exam

Reading list: The asterisk (*) identifies required readings, and the double-asterisk (**) identifies readings for referee reports and student presentations. All papers with * and ** are required readings for the course, problem sets, and final exam.

1. Introduction to Energy Markets: Market Power, Regulation and Deregulation

Borenstein Severin, James Bushnell, and Steven Stoft. "The Competitive Effects of Transmission Capacity in a Deregulated Electricity Industry." *Rand Journal of Economics*, Vol 31, No. 2, Summer 2000.

*Borenstein, Severin. 2002. "The Trouble with Electricity Markets: Understanding California's Restructuring Disaster," *Journal of Economic Perspectives*, 16(Winter).

*Borenstein, Severin, James Bushnell, and Frank Wolak. 2002. "Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market," *American Economic Review*, 92(5): 1376-1405.

Joskow, Paul L. 1973. "Pricing Decisions of Regulated Firms: A Behavioral Approach." *Bell Journal of Economics* 4(1): 118-140.

* Joskow, Paul L. 1997. "Restructuring, Competition and Regulatory Reform in the U.S. Electricity Sector." *Journal of Economic Perspectives* 11: 119-138.

Joskow, Paul L. and Nancy L. Rose. 1989. "The Effects of Economic Regulation." In *Handbook of Industrial Organization*, North Holland.

Rose, Nancy L. 1987. "Labor Rent-Sharing & Regulation: Evidence from the Trucking Industry," *Journal of Political Economy*, 95 (December): 1146-1178.

Sweeny, J. L. (2002). *The California electricity crisis*. Hoover Institution Press.

Wolfram, Catherine. 1999. "Measuring Duopoly Power in the British Electricity Spot Market." *American Economic Review*, 89(4): 805-826.

2. Electricity Markets: Supply

Bohn, R.E., Caramanis, M.C., and Schweppe, F.C., (1984) "Optimal Price Electrical Networks Over Space and Time," *Rand Journal of Economics*, volume 15, pp. 360-376.

* Bushnell, James, Erin Mansur and Celeste Saravia. 2008. "Vertical Arrangements, Market Structure, and Competition: An Analysis of Restructured U.S. Electricity Markets," *American Economic Review*, 98(1): 237-266.

** Referee report due 4/3: Cicala, Steve. “When Does Regulation Distort Costs? Lessons From Fuel Procurement in U.S. Electricity Generation.” *American Economic Review*, 105(1): 411-44. [Student presentation by: TBD](#)

Davis, Lucas W. and Catherine D. Wolfram. 2012. “Deregulation, Consolidation and Efficiency: Evidence from U.S. Nuclear Power,” *American Economic Journal: Applied Economics*, 2012, 4(4), 194-225

Fabrizio, Kira R., Nancy L. Rose, and Catherine D. Wolfram. 2007. “Do Markets Reduce Costs? Assessing the Impact of Regulatory Restructuring on U.S. Electric Generation Efficiency.” *American Economic Review*, 97(4), 1250-1277.

** Referee report due 4/3: Hortacsu, A. and Puller, S. L. (2008). “Understanding Strategic Bidding in Multi-Unit Auctions: A Case Study of the Texas Electricity Spot Market.” *The RAND Journal of Economics*, 39(1):86-114. [Student presentation by: TBD](#)

* Ito, Koichiro and Mar Reguant. Sequential Markets, Market Power, and Arbitrage. *American Economic Review*, 106(7):1921–1957, July 2016.

* McRae, Shaun and Frank A. Wolak, "How Do Firms Exercise Unilateral Market Power? Evidence from a Bid-Based Wholesale Electricity Market," EUI Working Papers 2009/36, (2009).

Reguant, Mar. “Complementary bidding mechanisms and startup costs in electricity markets,” *Review of Economic Studies*, vol. 81, pp. 1708–1742, June 2014.

Wolak, F. A. (2000). An Empirical Analysis of the Impact of Hedge Contracts on Bidding Behavior in a Competitive Electricity Market. *International Economic Journal*, 14(2):1-39.

Wolak, F. A. (2003). Identification and Estimation of Cost Functions Using Observed Bid Data: An Application to Competitive Electricity Markets, chapter 4, pages 133-169. Cambridge University Press.

Wolak, F. A. (2007). Quantifying the Supply-Side Benefits from Forward Contracting in Wholesale Electricity Markets. *Journal of Applied Econometrics*, 22:1179-1209.

3. Electricity Markets: Demand

** Referee report due 4/10: Allcott, Hunt and Dmitry Taubinsky. 2015. "Evaluating Behaviorally Motivated Policy: Experimental Evidence from the Lightbulb Market." *American Economic Review*, 105(8): 2501-38. [Student presentation by: TBD](#)

Borenstein, S. and Holland, S. (2005). On the Efficiency of Competitive Electricity Markets with

Time-Invariant Retail Prices. *The RAND Journal of Economics*, 36(3):469-493.

Borenstein, S (2012) "The Redistributive Impact of Non-Linear Electricity Pricing", forthcoming in *American Economic Journal: Economic Policy*.

Duflo, Esther & Glennerster, Rachel & Kremer, Michael, 2008. "Using Randomization in Development Economics Research: A Toolkit," *Handbook of Development Economics*

Greenstone, Michael & Gayer, Ted, 2009. "Quasi-experimental and experimental approaches to environmental economics," *Journal of Environmental Economics and Management*, Elsevier, vol. 57(1), pages 21-44, January.

* Holland, S. P. and Mansur, E. T. (2008). Is Real-Time Pricing Green? The Environmental Impacts of Electricity Demand Variance. *The Review of Economics and Statistics*, 90(3):550-561.

** Referee report due 4/10: Holland, Stephen P, Erin T. Mansur, Nicholas Z. Muller and Andrew J. Yates. 2016. "Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors." *American Economic Review*, 106(12): 3700-3729. [Student presentation by: TBD](#)

* Ito, Koichiro. 2014. "Do Consumers Respond to Marginal or Average Price? Evidence from Nonlinear Electricity Pricing." *American Economic Review*, 104(2): 537-63.

* Ito, Koichiro. 2015. "Asymmetric Incentives in Subsidies: Evidence from a Large-Scale Electricity Rebate Program." *American Economic Journal: Economic Policy*, 7(3): 209-237.

Kahn, Matthew and Erin Mansur. "Do Local Energy Prices and Regulation Affect the Geographic Concentration of Employment? A Border Pairs Approach". Working Paper. 2011. http://www.dartmouth.edu/~mansur/papers/kahn_mansur_manufacturing.pdf

Reiss, P. and White, M. (2005). Household Electricity Demand, Revisited. *Review of Economic Studies*, 72(3):853-883.

Reiss, Peter and Matthew W. White, 2008. "What changes energy consumption? Prices and public pressures," *RAND Journal of Economics*, RAND Corporation, vol. 39(3), pages 636-663.

Wolak, F. A. (2006). Residential Customer Response to Real-Time Pricing: The Anaheim Critical-Peak Pricing Experiment.

* Wolak, F. A. (2010). An Experimental Comparison of Critical Peak and Hourly Pricing: The PowerCentsDC Program. Working paper available at Professor Wolak's website.

4. Oil and Gasoline Markets

Anderson, Soren T., Ryan Kellogg, and James M. Sallee, "What Do Consumers Believe About Future Gasoline Prices?" working paper (2010).

* Auffhammer, M., & Kellogg, R. (2011). "Clearing the air? The effects of gasoline content regulation on air quality." *American Economic Review*, 101(6), 2687-2722.

* Borenstein, S., Cameron, C., and Gilbert, R. (1997) "Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes?" *Quarterly Journal of Economics*, vol.112, 305-339.

Borenstein, S. and Shepard, A, (1996) "Dynamic Pricing in Retail Gasoline Markets," *RAND Journal of Economics*, vol. 27, No. 3, 429-451.

Borenstein, S. and Shepard, A, (1996) "Sticky prices, inventories, and market power in wholesale gasoline markets," *RAND Journal of Economics*, vol. 33, No. 1, 116-139.

Borenstein, S., Bushnell J. and Lewis, M. (2005), "Market Power in California's Gasoline Market, CSEM Working Paper No. 132 (available at <http://www.ucei.berkeley.edu/PDF/csemwp132.pdf>)

Cuddington, J.T. and Moss, D.L. (2001) "Technological Change, Depletion, and the U.S. Petroleum Industry," *American Economic Review*, 1135-1148 (cuddington_and_moss.pdf)

Griffin, J.M. and Xiong, W. (1997) "The Incentive to Cheat: An Empirical Analysis of OPEC," *Journal of Law and Economics*, 40(2), 289-316.

Hamilton, J. (2008) "Understanding Crude Oil Prices," Department of Economics, UC-San Diego. (understand_oil.pdf).

* Hastings, Justine, "Vertical Relationships and Competition in Retail Gasoline Markets: Empirical Evidence from Contract Changes in Southern California." *American Economic Review*, March 2004.

Hastings, Justine and Jesse Shapiro, "Wholesale Price Discrimination and regulation: Implications for Retail Gasoline Prices." Working Paper. April (2008).

Hastings, Justine and Jesse Shapiro, "Mental Accounting and Consumer Choice: Evidence from Commodity Price Shocks." Working Paper. April (2011).

** Referee report due 4/17: Hastings, Justine, and Jesse Shapiro, "Fungibility and Consumer

Choice: Evidence from Commodity Price Shocks,” *The Quarterly Journal of Economics*, vol. 128, pp. 1449–1498, Nov. 2013. [Student presentation by: TBD](#)

Houde, J. F. (2012). “Spatial differentiation and vertical mergers in retail markets for gasoline”. *American Economic Review*, 102(5), 2147-2182.

Hughes, Jonathan E., Christopher R. Knittel, and Daniel Sperling, “Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand,” *Energy Journal* 29 (2008).

Kellogg, Ryan, "Learning by Drilling: Inter-Firm Learning and Relationship Persistence in the Texas Oilpatch," *Quarterly Journal of Economics* 126 (Nov., 2011), 1961-2004.

** Referee report due 4/17: Kellogg, Ryan. 2014. "The Effect of Uncertainty on Investment: Evidence from Texas Oil Drilling," *American Economic Review*, 104(6): 1698-1734.
[Student presentation by: TBD](#)

Lewis, M., (2004) “Asymmetric Price Adjustment and Consumer Search: An Examination of the Retail Gasoline Market, May 2004 (available at http://economics.sbs.ohio-state.edu/mlewis/APACS_9_1_04.pdf)

Lewis, Matthew and Howard P. Marvel, "When Do Consumers Search?," *Journal of Industrial Economics*, 59 (3), September 2011: 457-483.

Lewis, Matthew and Michael Noel, "The Speed of Gasoline Price Response in Markets with and without Edgeworth Cycles," *Review of Economics and Statistics*, 93 (2), May 2011: 672-682.

5. Automobile Markets

Allcott, Hunt and Nathan Wozny, “Gasoline Prices, Fuel Economy, and the Energy Paradox,” working paper (2010).

Anderson, Michael and Max Auffhammer, “Pounds that Kill: The External Costs of Vehicle Weight”, NBER Working Paper 17170

* Anderson, Soren T. and James M. Sallee, “Using Loopholes to Reveal the Marginal Cost of Regulation: The Case of Fuel Economy Standards,” *American Economic Review*, forthcoming (2011).

** Referee report due 4/24: Bento, Antonio M., Lawrence H. Goulder, Mark R. Jacobsen, and Roger H. von Haefen, “Distributional and Efficiency Impacts of Increased US Gasoline Taxes,” *American Economic Review* 99 (2009), 667-699. [Student presentation by: TBD](#)

Berry, Steven, James Levinsohn, and Ariel Pakes, "Automobile Prices in Market Equilibrium," *Econometrica* 63 (1995), 841-890.

Busse, Meghan R., Christopher R. Knittel, and Florian Zettelmeyer, "Pain at the Pump: The Differential Effect of Gasoline Prices on New and Used Automobile Markets," NBER working paper 15590 (2009).

Davis, Lucas W. and Matthew E. Kahn, "International Trade in Used Vehicles: The Environmental Consequences of NAFTA," working paper (2010).

Goldberg, Pinelopi Koujianou, "The Effects of the Corporate Average Fuel Efficiency Standards in the US," *Journal of Industrial Economics* 46 (Mar., 1998), 1-33.

Holland, Hughes and Knittel. 2009. "Greenhouse Gas Reductions under Low Carbon Fuel Standards?," *The American Economic Journal: Economic Policy*, 1(1), February 2009, pp. 106--146.

* Ito Koichiro and J. M. Sallee, "The Economics of Attribute-Based Regulation: Theory and Evidence from Fuel-Economy Standards," NBER Working Paper, vol. 20500, 2014.

Jacobsen, M. R. (2013). "Evaluating US Fuel Economy Standards in a Model with Producer and Household Heterogeneity." *American Economic Journal: Economic Policy*, 5(2): 148-87.

** Referee report due 4/24: Jacobsen, Mark R and Arthur A. van Benthem. 2015. "Vehicle Scrappage and Gasoline Policy." *American Economic Review*, 105(3): 1312-38. [Student presentation by: TBD](#)

Knittel, C. R. (2011). "Automobiles on Steroids: Product Attribute Trade-Offs and Technological Progress in the Automobile Sector." *American Economic Review*, 101(7): 3368-99.

* Knittel, Christopher R., "Reducing Petroleum Consumption from Transportation," forthcoming *Journal of Economic Perspectives*.

Langer, Ashely and Nathan Miller, "Automakers' Short-Run Responses to Changing Gasoline Prices and the Implications for Energy Policy," working paper (2009).

Li, Shanjun, Christopher Timmins, and Roger H. von Haefen, "How Do Gasoline Prices Affect Fleet Fuel Economy?" *American Economic Journal: Economic Policy* 1 (2009), 113-137.

Sallee, James M., "The Surprising Incidence of Tax Credits for the Toyota Prius," *American Economic Journal: Economic Policy*, forthcoming (2011).

6. Renewable Energy Markets

Bollinger, Bryan and Kenneth Gillingham. "Peer Effects in the Diffusion of Solar Photovoltaic Panels." *Marketing Science* (2012), 31(6): 900-912

Borenstein, Severin. 2008. "The market value and cost of solar photovoltaic electricity production." Center for the Study of Energy Markets Working Paper

* Borenstein, Severin. 2012. "The Private and Public Economics of Renewable Energy." *Journal of Economic Perspectives*.

Callaway, Duncan and Meredith Fowle. 2009. "Greenhouse Gas Emissions Reductions from Wind Energy: Location, Location, Location?" <http://nature.berkeley.edu/~fowle/papers.html>.

Callaway, Duncan S. 2009. "Tapping the energy storage potential in electric loads to deliver load following and regulation, with application to wind energy." *Energy Conversion and Management*, 50(5):1389---1400.

Cory, Karlynn and Paul Schwabe. 2009. "Wind Levelized Cost of Energy: A Comparison of Technical and Financing Input Variables." National Renewable Energy Laboratory Technical Report NREL/TP---6A2--- 46671. <http://www.nrel.gov/docs/fy10osti/46671.pdf>.

* Cullen, Joseph. 2013. "Measuring the Environmental Benefits of Wind-Generated Electricity." *American Economic Journal: Economic Policy*, 5(4): 107-33.

Energy Information Administration. 2011. "Levelized Costs in the Annual Energy Outlook 2011." http://205.254.135.24/oiaf/aeo/electricity_generation.html

** Referee report due 5/1: Gowrisankaran, Gautam, Stanley S. Reynolds, and Mario Samano, "Intermittency and the Value of Renewable Energy," *Journal of Political Economy* 124, no. 4 (August 2016): 1187-1234. [Student presentation by: TBD](#)

Hughes, Jonathan and Molly Podolefsky. "Getting Green with Solar Subsidies: Evidence from the California Solar Initiative." *Journal of the Association of Environmental and Resource Economists*, 2(2), June 2015.

Intergovernmental Panel on Climate Change Working Group III. 2011. *Special Report on Renewable Energy Sources and Climate Change Mitigation*. <http://srren.ipcc-wg3.de/>

* Joskow, Paul. 2011. "Comparing the Costs of Intermittent and Dispatchable Electricity Generation Technologies." *American Economic Review*

National Renewable Energy Laboratory. 2010. "Windpowering America: Estimates of Windy Land Area and Wind Energy Potential, by State, for areas \geq 30% Capacity Factor at 80m."

http://www.windpoweringamerica.gov/docs/wind_potential_80m_30percent.xlsx.

* Novan, Kevin. 2015. "Valuing the Wind: Renewable Energy Policies and Air Pollution Avoided." *American Economic Journal: Economic Policy*, 7(3): 291-326.

** Referee report due 5/1: Pless, Jacquelyn and Arthur A. van Benthem. 2017. "The Surprising Pass-Through of Solar Subsidies." NBER Working Paper #23260. [Student presentation by: TBD](#)

Schmalensee, Richard. Forthcoming. "Evaluating Policies to Increase the Generation of Electricity from Renewable Energy." *Review of Environmental Economics and Policy*.

Wiser, Ryan, Galen Barbose, Carla Peterman, and Naim Darghouth. 2009. "Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998 - 2008." Lawrence Berkeley National Laboratory Paper LBNL---2674E. <http://eetd.lbl.gov/ea/emp/reports/lbnl---2674e.pdf>

7. Emission Markets/R&D and Innovation

1) Emissions Markets

Bushnell, J., H. Chong and E. Mansur, "Profiting from Regulation: An Event Study of the EU Carbon Market," *American Economic Journal: Economic Policy*, forthcoming.

** Referee report due 5/8: Fabra, Natalia and Mar Reguant. 2014. "Pass-Through of Emissions Costs in Electricity Markets." *American Economic Review*, 104(9): 2872-99. [Student presentation by: TBD](#)

Fowlie, M. L. (2009). Incomplete Environmental Regulation, Imperfect Competition, and Emissions Leakage. *American Economic Journal: Economic Policy*, 1:72–112.

Fowlie, M. (2010). "Emissions Trading, Electricity Restructuring, and Investment in Pollution Abatement." *The American Economic Review*, 100:837–869.

* Fowlie, M., Holland, S. P., and Mansur, E. T., 2012. "What Do Emissions Markets Deliver and to Whom? Evidence from Southern California's NO_x Trading Program." *American Economic Review*, 102(2): 965–93.

Kolstad, J. T. and Wolak, F. A. (2008). Using Environmental Emissions Permit Prices to Raise Electricity Prices: Evidence from the California Electricity Market.

2) R&D and Innovation

Goulder, Lawrence H. and Stephen H. Schneider, 1999. "Induced technological change and the attractiveness of CO₂ abatement policies," *Resource and Energy Economics* 21 pp. 211--253.

Goulder, L.H., Mathai, K. (2000). “Optimal CO2 abatement in the presence of induced technological change”. *Journal of Environmental Economics and Management* 39, 1-38.

** Referee report due 5/8: Howell, Sabrina. “Financing Innovation: Evidence from R&D Grants.” Forthcoming. *American Economic Review*. [Student presentation by: TBD](#)

Jaffe, A.B., Palmer, K. (1997). “Environmental regulation and innovation: A panel data study”. *Review of Economics and Statistics* 79, 610-619.

Jaffe, A.B., Stavins, R.N. (1994). “The energy paradox and the diffusion of conservation technology”. *Resource and Energy Economics* 16, 91-122.

Jaffe, A.B., Stavins, R.N. (1995). “Dynamic incentives of environmental regulations: The effects of alternative policy instruments on technology diffusion”. *Journal of Environmental Economics and Management* 29, S43-S63.

Jaffe, A.B., Newell, R.G., Stavins, R.N. (2003). “Technological change and the environment”. In: Ma'ler, K.-G., Vincent, J. (Eds.), *Handbook of Environmental Economics*. Handbooks in Economics Series (Arrow, K.J., Intriligator, M.D., Series Eds.), vol. 1. North-Holland/Elsevier, Amsterdam, pp. 461-516.

Jaffe, A.B., Newell, R.G., Stavins, R.N. (2005). “A tale of two market failures: Technology and environmental policy”. *Ecological Economics* 54, 164-174.

Jaffe, A.B. (2011). “Technology Policy and Climate Change”. *The Next Round of Climate Economics & Policy Research* Washington, D.C. October 2728, 2011

Moser, Petra and Tom Nicholas. “Was Electricity a General Purpose Technology? Evidence from Historical Patent Citations”, *The American Economic Review, Papers and Proceedings*, May 2004, vol.94, no.2, pp.388-394

* Newell, R., Jaffe, A., Stavins, R. (1999). “The induced innovation hypothesis and energy-saving technological change”. *The Quarterly Journal of Economics* 114 (3), 941-975.

* Popp, D. (2002). “Induced innovation and energy prices”. *American Economic Review* 92 (1), 160-180.

* Popp, David, Richard Newell and Adam Jaffe, 2010. “Energy, the environment, and technological change,” in Hall, Bronwyn H. and Nathan Rosenberg, eds., *Handbook of the Economics of Innovation*, North Holland, <http://fds.duke.edu/db/attachment/1682>

Rose, N., Joskow, P. (1990). “The diffusion of new technologies: Evidence from the electric utility industry”. *Rand Journal of Economics* 21, 354-373.

8. Energy and Environmental Markets in Developing Countries

Allcott, Hunt, Allan Collard-Wexler, and Stephen D. O’Connell. 2016. “How Do Electricity Shortages Affect Industry? Evidence from India.” *American Economic Review*, 106(3): 587-624.

Burlig, Fiona, and Louis Preonas. “Out of the Darkness and Into the Light? Development Effects of Rural Electrification,” *Energy Institute at Haas Working Paper 268*. Available at: <https://ei.haas.berkeley.edu/research/papers/WP268.pdf>

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