Energy and Resources Group (ERG) & Goldman School of Public Policy

ER 100 / 200 and Pub Pol C184 / C284
Energy and Society

Professor **Duncan Callaway**
318 Barrows Hall
Energy and Resources Group
Email: dcal@berkeley.edu
Office Hours: Wednesdays mornings in 318 Barrows Hall – schedule times via:
http://www.wejoinin.com/sheets/ngzvg

Lectures ER100 (cc # 24980) & ER200 (cc #25022)
Lectures Pub Pol C184 (cc #29178) & Pub Pol C284 (cc # 29121)
Tues & Thurs, 2:00 – 3:30 PM, 105 Stanley

Section	Day/time	Rm. No.	ER100 CC#	ER200 CC#	PP184 CC#	PP284 CC#
101	T 11-12	3113 Etcheverry	24981	25023	29179	29122
102	W 4-5	103 Moffit Library	24982	25024	29180	29123
103	W 2-3	3113 Etcheverry	24983	25025	29181	29124
104	W 4-5	107 Genetics & Plant Bio	24984	25026	29182	29115
105	M 12-1	3109 Etcheverry	24985	25027	29183	29116
106	M 1-2	289 Corry	24986	25028	29184	29117

Course website:https://bcourses.berkeley.edu/courses/1454367

Among the questions we will address in this course are:
- ***In what ways has fossil-fuel use defined the 20th Century? What about the 21st?***
- ***What role is there for renewable energy and energy efficiency today and in the future?***
- ***What is the role of nuclear power in our present and future energy mix?***
- ***Could fuel cells or the hydrogen economy cause a revolution in the automotive industry?***
- ***Is the U. S. ready to acknowledge and address global warming?***
- ***How are energy issues different in developing nations from those in the 'North'?***
- ***What tools do you need to address these questions from an interdisciplinary perspective?***

Interested in these questions? Then Energy and Society is for you.

Each of these questions about the use and impacts of energy systems requires an interdisciplinary understanding that explores the scientific, technical, economic, social, political, and environmental opportunities and impacts of our energy system.

In this course, you will develop an understanding—and a technically and socially deep working knowledge—of our energy technologies, policies, and options. This will include analysis of the different opportunities and impacts of energy systems that exist within and between groups defined by national, regional, household, ethnic, and gender distinctions. Analysis of the range of current and future energy choices will be stressed, as well as the role of energy in determining local environmental conditions and the global climate.

ER200/GSPP284 are graduate versions of ER100/GSPP184, and their lectures and sections are held in common. ER200/GSPP284 includes additional material, with added analytic tools and problems on both the problem sets and the examinations. *Grading for the undergraduate and graduate courses are separate*. Undergraduates must enroll in ER100/GSPP184, and graduate students must enroll in ER200/GSPP284.

Course Goals

This course is designed to provide you with the methods, tools and perspectives to understand, critique, and ultimately influence the management of technical, economic, and policy choices regarding the options for energy generation and use. We will focus equally on the technical, socioeconomic, political, and environmental impacts of energy.

We will examine the full 'life cycle', or 'cradle to grave to cradle again' of energy, from the stage of raw materials, or inputs, to generation, conversion, distribution, consumption, recycling, waste, impacts, and ethnic, racial, gender, and economic inequities. This work is inherently interdisciplinary, and will involve a fascinating but extensive effort to understand, critique, and integrate tools and perspectives from anthropology, cultural and ethnic studies, economics, engineering, physics, politics, sociology, and who knows what else.

The challenge of this integration is not simply one of learning and applying methods from very diverse disciplines, but more importantly is one of understanding how and when different types of analysis, disciplinary and political perspectives, and "voices" are heard, unheard, ignored, or discredited. Energy is a fundamental societal resource, the control of which reflects and shapes interactions both within society and between humans and the natural environment.

Coverage

Over the semester we will take a roughly chronological tour of the major fuel types used in human civilization. From there we will begin a broad-ranging analysis of the energy resource, combustion or conversion processes, application, waste, economic, social, political, cultural, and environmental impacts and options associated with these fuels and with the changing mix of fuels used within and across societies around the globe.

Assignments
There will be seven problem sets and a policy memo (in total 30% of the grade), a mid-term examination (25%), and a final exam (35%). Participation in sections counts for 10%.

Problem sets are distributed every other Tuesday, and due back, in class, the Thursday of the following week. You may also turn the assignment in at the box located in the hallway outside the ERG office (310 Barrows) **BEFORE 5pm Thursday**. Late assignments will be penalized 20% if turned in by 5pm on Monday, or 50% if turned in by 5pm on the following Thursday. No credit will be given for assignments turned in more than one week late.

You will get the most out of the problem sets if you make an initial effort to work through all of the problems on your own. After attempting to solve the problems on your own, you may then work with other students to discuss different approaches. It is vital that you do your own work. It is a violation of the Code of Student Conduct to copy answers from anyone.

As part of your participation in the course, you are encouraged to use the bCourses discussion board to make comments and/or ask questions related to the readings or lectures. We will also post the answers to questions about the problem sets on bCourses, so be sure to check bCourses regularly.

Required Texts (available at the campus store on Bancroft)

Hirsh, Richard (2000) *Power Loss: The Origins of Deregulation and Restructuring in the American Electric Utility System* (MIT Press: Cambridge, MA).
Rubin, Edward S. (2001) *Introduction to Engineering & the Environment* (McGraw Hill: New York, NY).

Web-based readings: A number of readings, both *required and supplemental*, are available on-line. In order to download some of these, you will need to use an on-campus computer or set up your home computer or laptop with the campus proxy service. For instructions, see:
http://www.lib.berkeley.edu/using-the-libraries/connect-off-campus
Readings are also available at the course website and on the course bCourses site.

Required Reading **assignments should be completed before the lecture for which they are assigned. While I recognize that this is not always possible, you need to try; the material in lecture *does not simply review the readings*; *we use it as a basis for exploration of the course material and ideas.***

Optional Field Trips

There will be one or two field trips during the semester. Each will be 3 - 6 hours (including travel time), and all will generally be Friday mornings. The list will depend on availability, but will likely include:

- The Pittsburgh Energy 'Park', a 2200 MW fossil-fuel power plant (gas and oil);
- The High Winds wind farm in Solano (near Sacramento);
- Moscone Center in San Francisco, site of the 675 kW solar photovoltaic array and a set of energy efficiency projects.

Graduate Student Instructors and Office Hours

	Kenji Shiraishi	**Christopher Hyun**	**Brett Webster**
Office:	399 Barrows	399 Barrows	399 Barrows
Hours:	F 2-4	M 9-11	M 2-4
Email:	kenjis@berkeley.edu	chrish@berkeley.edu	bwebster@berkeley.edu

The best way to reach us is by email or by coming to the office hours.

Section meetings begin in Week 2 (i.e. starting 8/29). Be sure to sign up for a section on-line.

Lecture Notes
Lecture notes (.pdf files) will be available for each lecture, and will be posted on the course website immediately before the lecture, so that you can review all of the graphs and diagrams right in front of you and take notes during lecture.

Wk	Date	Lecturer	Lecture #/Topic
1	8-25	Callaway	1. How Energy Use Shapes Society & the Environment
2	8-30	Callaway	2. Energy Toolkit I: Units, Forecasts, and the Back-of-the-Envelope
	9-1	Kammen	3. Energy for 'the South' I: Energy Transitions and Development
3	9-6	Callaway	4. Energy Toolkit II: Fuels, Energy Content & Basics of Combustion
	9-8	Smith	5. Energy for 'the South' II: Biomass, Households, and Gender
4	9-13	Callaway	6. Energy Toolkit III: Energy Thermodynamics
	9-15	Callaway	7. Energy Toolkit IV: Thermodynamics of Modern Power Plants
5	9-20	Callaway	8. 'Hydrocarbon Man'
	9-22	Callaway	9. Evolution of the Modern Energy Economy
6	9-27	Kammen	10. Energy Toolkit V: Economic Analysis of Energy Systems
	9-29	Callaway	11. Electricity Grids: Managing the Network
7	10-4	Callaway	12. Energy Efficiency I: Devices
	10-6	Borgeson	13. Energy Efficiency II: Buildings and Larger Energy Systems
8	10-11	Horvath	14. Energy Toolkit VI: Life-Cycle and Cost-Benefit Analysis
	10-13	Callaway	15. Natural Gas, Fracking, and Carbon Capture and Storage
9	10-18	GSIs	Mid-term review
	10-20	**You!**	**Midterm Exam, In class**
10	10-25	Peterson	16. Nuclear Energy I: Physics and Engineering – Fission/Fusion
	10-27	Budnitz	17. Nuclear Energy II: Waste, Risk & Economics
11	11-1	Callaway	18. Energy and Environmental Justice
	11-3	Callaway	19. Renewable Energy I: Solar Energy
12	11-8	Callaway	20. Renewable Energy II: Wind, Geothermal & Hydropower
	11-10	Gur	21. Renewable Energy III: Electrochemistry - H_2 Batteries and Fuel Cells
13	11-15	Scown	22. Renewable Energy IV: Industrial Bioenergy & Land Use
	11-17	Callaway	23. International Energy Policy
14	11-22	Callaway	24. Climate Change I: Energy and Climate
	11-24		**HOLIDAY THANKSGIVING**
15	11-29	Shaheen	25. Transportation Systems and Policy
	12-1	Callaway	26. Climate Change II: Energy Policy

Final Exam Group: 5: TUESDAY, DECEMBER 13, 2016 8-11 AM

Problem Set #	Assigned	Due	Coverage
1	**8/30**	**9/8**	L 1-2: Short warm-up problems; analysis of utility bills; making unit analysis your friend, and getting comfortable with the myriad of energy units. These problems may be unfamiliar in style for many of you; if necessary use the GSI's and study groups to 'get into the swing' of these calculations/estimates. You must, however, do your own work.
2	**9/13**	**9/22**	L 3-6
3	**9/27**	**10/6**	L 7-10
4	**10/6***	**10/13**	L11-13: [Shorter problem set]
5	**10/25**	**11/3**	L14-16
6	**11/8**	**11/17**	L17-20
7	**11/22**	**12/1**	L21-24

*** Note: non-standard assignment dates (mid-term & thanksgiving). No late assignments accepted for PS #4 so that we can return to you graded problem sets prior to the exam.**

Problem sets are posted on the web, not physically distributed in class**.**

Do not leave problem sets for the final few days. They are not hard if started early; they can be an unpleasant experience if left for the night before they are due …

Problem sets are due in class or can be turned in to the problem set drop-off box outside of the Energy and Resources Group, 310 Barrows Hall. Problem sets are late after 5:00 PM.

Problem sets cannot be turned in electronically or by fax.

You should be familiar with the readings listed for each lecture date when the lecture occurs—they will be referenced under the assumption that you have read them already. Readings listed for **ER200/PP284** *are required for graduate students. Readings listed as* **Supplemental** *will (perhaps obviously) supplement your understanding of the course material, but are not required to successfully complete the course.*

Week 1 – Introduction to Energy Systems and Society

Lecture 1 (8/25) – Energy and Society: How Energy Use Shapes Society & the Environment:

Recommendation: Try getting into the habit of looking for energy articles in newspapers and begin to get a feel for how ubiquitous and far-reaching energy issues are in society. In addition, check the opinion ("OpEd") and editorial pages of your favorite newspapers. As your last assignment of the course, you will be writing a 'policy memo' that in most cases can and should be submitted as an Op Ed yourself

Yergin, D. (1991) The Prize: The Epic Quest for Oil, Money, and Power (Simon & Schuster: New York).
Pages 11 – 16. [Yergin_1991.pdf]

Plus, read a selection – you decide how many -- of these energy-related op-eds or others you look up (a good habit).

Read these 'classic' energy op eds:

Tim Flannery – *The New York Times* "A 'Third Way' to Fight Climate Change"
http://www.nytimes.com/2015/07/24/opinion/a-third-way-to-fight-climate-change.html
July 23, 2015

Ralph Cavanagh (2013) "How we learned not to guzzle" (9/12/13)
http://www.nytimes.com/2013/09/13/opinion/how-we-learned-not-to-guzzle.html?_r=0

Ban Ki-Moon (2012) "Powering sustainable energy for all" (1/11/12)
http://www.nytimes.com/2012/01/12/opinion/powering-sustainable-energy-for-all.html

Kirk Smith (2014) "In praise of power" (8/8/14)
http://www.sciencemag.org/content/345/6197/603.full.pdf?sid=1593517d-66d6-47b9-a8dc-3419985a8a3b

Doerr, J. and Immlet, J. (2009) "Falling behind on green tech", *The Washington Post* (8/3/09)
http://www.washingtonpost.com/wp-dyn/content/article/2009/08/02/AR2009080201563.html

For a feed of (hopefully) interesting energy news, see Twitter: @dan_kammen

Week 2 – Methods in Energy Analysis and Energy and Development

Lecture 2 (8/30) – Energy Toolkit I: Units, Forecasts, and the Back-of-the-Envelope:

Rubin, *EE*, *Rates of Technology Adoption*, Pages 669 – 677.

Lovins, Amory (1976) "Energy Strategy: The Road Not Taken", *Foreign Affairs*, **55(1):** 65–96. [Lovins_1976.pdf]

ER200 & Pub Pol 284:
A nice commentary on the Lovins paper from *The New York Times:*
http://www.nytimes.com/2008/10/07/science/07tier.html?_r=1&8dpc&oref=slogin

Supplemental:
Toolkit 1 (a review and refresher) – optional/reference for those who have done these sorts of problems before.
A bit more than back of the envelope, applied to scaling-up technologies:
http://www.gigatonthrowdown.org/

Lecture 3 (9/1) – Energy for 'the South' I: Energy Transitions and Development:

Goldemberg, J. (1996) *Energy, Environment, and Development* (Earthscan: London, UK), 11 – 37. [Goldemberg_1996.pdf]

Jacobson, A. and D.M. Kammen. (2005). "Science and Engineering Research that Values the Planet." *The Bridge*. **35**(4): pp. 11-17. [Jacobson_2005.pdf]

ER200/PP284:
Alstone, P., Gershenson, D. and Kammen, D. M. (2015) "Decentralized energy systems for clean electricity access", *Nature Climate Change*, **5**, 305 – 314.

Week 3 – Methods in Energy Analysis and Energy and Development

Lecture 4 (9/6) – Energy Toolkit II: Fuels, Energy Content, and Basics of Combustion:

Rubin, *EE*, Chapter 1, pages 3 – 17.

Masters, G. (1991) *Introduction to Environmental Engineering and Science* (Prentice Hall: NJ), pages 39–47. [Masters_1991_Enviro_Chemistry.pdf]

Supplemental: Toolkit 2 (resource material)

Lecture 5 (9/8) – Energy for 'the South' II: Biomass, Households, and Gender:

Smith KR, Frumkin H, Balakrishnan K, Butler CD, Chafe Z, Fairlie I, Kinney P, Kjellstrom T, Mauzerall DL, McKone TE, McMichael AJ, Schneider M, (2013) Energy and human health, *Ann Rev of Public Health* 34: 159-188

Smith KR, (2014) In Praise of Power, *Science*, 345: 603

Smith KR, (2015) Changing paradigms in clean cooking, *EcoHealth* 12, 196–199

ER200 & Pub Pol 284:
Smith KR, Bruce N, Balakrishnan K, Adair-Rohani H, Balmes J, Chafe Z, Dherani M, Hosgood HD, Mehta S, Pope D, Rehfuess E, and others in the HAP CRA Expert Group (2014), Millions dead: how do we know and what does it mean? Methods used in the Comparative Risk Assessment of Household Air Pollution, *Ann Rev of Public Health*, 35: 185-206.

For those with historical interests

Kammen, D. M. and Dove, M. R. (1997) The virtues of mundane science, *Environmen*t, 39(6): 10–15, 38–41.

Kammen, D. M. (1995) Cookstoves for the developing world, *Scientific American*, 273, 72 - 75.

Crewe, E. (1997) *The silent traditions of developing cooks*, Discourses of Development, RD Grillo and RL Stirttat, eds. (Berg: Oxford, UK), 59-81

Smith KR,(2002) In Praise of Petroleum? *Science* 298: 1847.

Supplemental

Bailis, Ezzati, Kammen, (2005) Mortality and Greenhouse Gas Impacts of Biomass and Petroleum Energy Futures in Africa, *Science*, 308 (5718): p. 98-103.

Week 4 – Thermodynamics of Energy

Lecture 6 (9/13) – Energy Toolkit III: Energy Thermodynamics:

Masters, G. (1991) *Introduction to Environmental Engineering and Science* (Prentice Hall: NJ), pages 15 – 29. [Masters_1991_Energy.pdf]

Lecture 7 (9/15) – Energy Toolkit IV: Thermodynamics of Modern Power Plants:

Rubin, *EE*, Sections 5.1 - 5.6.3 (except 5.2.2 & 5.2.3); Pages 162 – 175, 179 – 215

Masters, G. (1991) *Introduction to Environmental Engineering and Science* (Prentice Hall: NJ), pages 327–339. [Masters_1991_Air_Pollution.pdf]

ER200 & Pub Pol 284:
Dirty Coal, Clean Future, *The Atlantic Monthly* (November 2010)
http://www.theatlantic.com/magazine/archive/2010/12/dirty-coal-clean-future/8307/

Supplemental: Beér, J. M. (2000) "Combustion technology developments in power generation in response to environmental challenges", *Progress in Energy and Combustion Science*, **26**, 301 – 327. [Beer_2000.pdf] [An advanced treatment of state-of-the-art fossil-fuel power plant design issues and opportunities].

Week 5 – 'Hydrocarbon man'

Lecture 8 (9/20) – Hydrocarbon Man:

Friedman, Thomas L. (2006) "The First Law of Petropolitics", *Foreign Policy*, **154:** (28 – 36). [Friedman_2006.pdf]

Farrell, Alex E., and Brandt, Adam R. (2006) "Risks of the oil transition," *Environmental Research Letters,* **1**, October 30. [Farrell_2006_Risks.pdf]

ER200/PP284 (Supplemental for ER100/Pub Pol 184)

Nef, John U. (1977) "An early energy crisis and its consequences", *Scientific American*, November, pages 140 – 151. [Nef_1977.pdf]

Lecture 9 (9/22) – Evolution of the Modern Energy Economy:

Hirsh, Richard (1999) *Power Loss* (MIT University Press: Cambridge, MA) Section I, Pages 1 - 88.

Week 6 – Energy Economics and Electricity Grids

Lecture 10 (9/27) – Energy Toolkit V: Economic Analysis of Energy Systems:

Rubin, *EE*, Chapter 13, Pages 545 – 577

ER200/PP284:
Arrow, K. *et al.*, (2013) "Determining the benefits and costs for future generations," *Science*, **341**, 349 – 350. [Arrow_2013.pdf]

Lecture 11 (9/29) – Electricity Grids: Managing the Network:

Masters, G. (2004) "Transmission and Distribution," in *Renewable and Efficient Power Systems* (Wiley InterScience: New York), pages 145 – 151. [Masters_2004_TD.pdf]

von Meier, Alexandra (2006), "Reliability" and "Security," in *Electric Power Systems: a conceptual introduction* (John Wiley & Sons: New Jersey), pp. 229–234. [von_Meier_2006.pdf]

ER200/PP284: Fairley, P. (2004) "The unruly power grid", *IEEE Spectrum*, 13 August, 5 pages. [Fairley_2004.pdf]

Reference: Glossary of electricity terms. [Electricity_Glossary.pdf]

Week 7 – Energy Efficiency (I & II)

Lecture 12 (10/4) – Energy Efficiency I: Devices:

Rubin, *EE*, Chapter 7, and Section 13.8 of Chapter 13, Pages 281 – 314, 577 – 583.

Hirsh, Richard (1999) *Power Loss* (MIT University Press: Cambridge, MA), pages 90 – 117.

ER200/PP284:
Attari, S. Z. DeKay, M. L. Davidson, C. I. and Bruine de Bruin, W. (2010) "Public perceptions of energy consumption and savings", *PNAS*, 2010. [Attari_2010.pdf]

Lecture 13 (10/6) – Energy Efficiency II: Buildings as Energy Systems

David B. Goldstein (2008) Extreme Efficiency: How Far Can We Go If We Really Need To? ACEEE Summer Study Paper. [Goldstein_2008.pdf]

And for a look at why it is so hard, ask Dilbert:
Adams, S. (2010) "How I (Almost) Saved the Earth", *The Wall Street Journal*, August 21:
http://online.wsj.com/article/SB10001424052748704868604575433620189923744.html

A. Nagourney, *et al. (2015)* "California drought tests history of endless growth," *The New York Times*
http://www.nytimes.com/2015/04/05/us/california-drought-tests-history-of-endless-growth.html?smid=tw-share&_r=0

Supplemental: American Physical Society Review and Recommendations for Energy Efficiency (2008) *Think Efficiency.* http://www.aps.org/energyefficiencyreport/
Chapter 3 (buildings, pages 52 – 85)

Week 8 – Life-cycle Analysis and Natural Gas/CCS

Lecture 14 (10/11) – Energy Toolkit VI: Life-cycle and Cost-Benefit Analysis:

Rubin, *EE*, Section 13.4, Life-cycle cost, 556 – 562.

ER200/PP284 [Supplemental for ER100/PP184]:

Jones, C. M. and Kammen, D. M. (2014) "Spatial distribution of U.S. carbon footprints reveals suburbanization offsets benefits of population density", *Environmental Science and Technology*, ***48*** **(2**), 895 – 902.

Lecture 15 (10/13) – Natural Gas, Fracking, and Carbon Capture and Storage

Brandt, A. *et.al.*, (2014) "Methane Leaks from North American Natural Gas Systems" *Science,* **343**(6172), 733-735.

Deborah Sontag And Robert Gebeloff (2014) The downside of the boom" The New York Times, 22 November, http://www.nytimes.com/interactive/2014/11/23/us/north-dakota-oil-boom-downside.html

Aisch, Gregor (2014) "What North Dakota Would Look Like if Its Oil Drilling Lines Were Above ground"*The New York Times*, November 25 http://www.nytimes.com/interactive/2014/11/24/upshot/nd-oil-well illustration.html?_r=0&abt=0002&abg=1

ER200 & Pub Pol 184

MIT CCS roadmap - http://web.mit.edu/coal/
Chapters 2 and 3 (pages 5 – 42)

Week 9 – Mid-Term Review & Exam

Class (10/18) – Midterm examination review

Your notes, lecture slides, section handouts, past problem sets and solutions, all previous readings.

Class (10/20) – Midterm examination

Your notes, lecture slides, section handouts, past problem sets and solutions, all previous readings.

Week 10 –Nuclear Power

Lecture 16 (10/25) – Nuclear Energy I: Physics and Engineering – Fission/Fusion:

Deutch and Lester, (2004) Making Technology Work, Ch. 7: Nuclear Power and Its Fuel Cycle, Cambridge Univ. Press, Cambridge, UK, p. 109-133. [Deutch_2004.pdf]

Moore, P. (2005) "Greenpeace founder makes the case for nuclear power", *Nuclear News*, June, p. 15. . [Moore_2005.pdf]

Supplemental: Excellent online material on reactor types and performance is available at http://www.nrc.gov/reactors/power.html
In particular, review 'About the NRC', 'Nuclear security', and read about the events (power production and management) at one of the featured reactors, such as Diablo Canyon (under nuclear reactors) that provides power to northern California)

Lecture 17 (10/27) – Nuclear Energy II: Waste, Risk & Economics:

Rubin, *EE*, pages 63-68, 175-178.

Flynn, J. et al. (1997) "Overcoming Tunnel Vision: Redirecting the U.S. High-Level Nuclear waste program", *Environment*, **39** (3): 6–11, 25–30. . [Flynn_1997.pdf]

Hultman, N., Koomey, J. G, and Kammen, D. M. (2007) "What history can tell us about the costs of future nuclear power", *Environmental Science & Technology,* 41(7): 2088-2093. . [Hultman_2007.pdf]

The Nuclear Fuel Cycle Cost Calculator:
http://thebulletin.org/nuclear-fuel-cycle-cost-calculator

ER200/PP284: Peterson, P., W. Kastenberg, and M. Corradini. (2006). "Nuclear Waste and the Distant Future." *Issues in Science and Technology*. Summer: pp. 47-50. . [Peterson_2006.pdf]

Week 11 – Energy and Environmental Justice & Renewables

Lecture 18 (11/1) – Energy and Environmental Justice:

Pastor, Manuel, (2007) "Environmental Justice: Reflections from the United States", Ch. 14 in *Reclaiming Nature,* pp. 351–376. [Pastor_2007.pdf]

ER200/PP284:

O'Rourke, D. and Connolly, S. (2003) "Just oil? The distribution of environmental and social impacts of oil production and consumption," *Annual Reviews of Environment and Resources*, 28, 587-617. [Orourke_2003.pdf]

An Environmental Justice Resource: A sampling of EJ websites includes:

Contents	URL
The EJ Information Page	http://eelink.net/EJ/
Climate Justice and People of Color	http://www.ejrc.cau.edu/climatechgpoc.html
Ken Saro-Wiwa and Shell Oil (Nigeria)	http://uk.oneworld.net/guides/nigeria/development
EJ Case Studies	http://www.umich.edu/%7Esnre492/cases.html
Center for Science and Environment (India)	http://www.cseindia.org/
EPA Toxic Release Inventory	http://www.epa.gov/tri/ & http://www.scorecard.org/
EPA Environmental Justice Program	http://www.epa.gov/compliance/environmentaljustice/index.html & http://www.calepa.ca.gov/EnvJustice/

Lecture 19 (11/3) – Renewable Energy I: Solar and Wind Energy:

SunShot Vision Study: Read the Executive Summary; Chapter 4, Photovoltaics: Technology, Cost, and Performance; and ; chapter [Solar_Vision_Study_2010.pdf]
http://energy.gov/eere/sunshot/sunshot-vision-study

Masters, G. (2004) "Photovoltaic Materials and Electrical Characteristics." *Renewable and Efficient Power Systems* (Wiley InterScience: New York), pages 445 – 463. [Masters_2004_PV.pdf]

ER200/PP284:

Zheng, Cheng and Kammen, Daniel (2014) "An Innovation-Focused Roadmap for a Sustainable Global Photovoltaic Industry," *Energy Policy,* **67**, 159–169.

Week 12 – Renewable Energy II: Wind and Water Power

Lecture 20 (11/8) – Renewable Energy II: Wind, Hydropower and Geothermal Energy

Masters, G. (2004) "Wind Power Systems." *Renewable and Efficient Power Systems* (Wiley InterScience: New York), pages 307 – 354 (pages 335-347 are supplemental), 371 – 378. [Masters_2004_Wind.pdf]

Updated hydropower and geothermal readings needed

Lecture 21 (11/10) – Renewable Energy III: Electrochemistry H_2 Batteries and Fuel Cells

Masters, G. (2004) "Batteries" 9.5.3 9.5.6, pages 557- 568 *Renewable and Efficient Power Systems* (Wiley InterScience: New York)

Week 13 – Energy and Sustainability Challenges

Lecture 22 (11/15) – Renewable Energy IV: Industrial Bioenergy and Land Use

USDA - *Billion Ton Vision* (http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf) Replace

Rubin, *EE*, Chapter 3, Pages 83-123.

ER200/PP284: Farrell A. E., Plevin, R. J. Turner, B. T., Jones, A. D. O'Hare, M. and Kammen, D. M. (2006) "Ethanol can contribute to energy and environmental goals," Science, **311**, 506 – 508. [Farrell_2006_Ethanol.pdf]

Supplemental: Intergovernmental Panel on Climate Change, *Special Report on Renewable Energy Sources and Climate Change Mitigation,* http://srren.ipcc-wg3.de/, Chapter 2, "Bioenergy", 209-332.

Lecture 23 (11/17) – International Energy Policy

Intergovernmental Panel on Climate Change, *Special Report on Renewable Energy Sources and Climate Change Mitigation,* http://srren.ipcc-wg3.de/, Chapter 11, "Policy, Financing, and Implementation", 882 – 916 (all), 917 – 928 (**ER200).**

World Energy Council (2011) *Policies for the future, 2011 Assessment of country energy and climate policies.*

Skim the initial chapters after you review the energy policy metric (Chapter 1), and specifically read pages, 48 – 63.

http://www.worldenergy.org/documents/wec_2011_assessment_of_energy_and_climate_policies.pdf

Week 14 – Climate Change

Lecture 24 (11/22) – Climate Change I: Energy and Climate:

Rubin, *EE*, Chapter 12, Pages 470 – 537.

Hansen, J., Sato, M. and Ruedy, R. (2012) "Perception of climate change", *PNAS*, [Hansen_etal_2012.pdf]

Collins, William, et al. (2007) "The Physical Science Behind Climate Change." *Scientific American.* August, 297, pp 64–71. [Collins_2007.pdf] Need a replacement (IPCC?)

Supplemental: Emanuel, Kerry (2005), "Increasing destructiveness of tropical cyclones over the past 30 years." *Nature*, **436**: 686–688, August 4. [Emanuel_2005.pdf]

No Lecture on (11/24) – Academic Holiday.

Week 15 – Transportation, Energy and the Global Environment

Lecture 25 (11/29) – Transportation systems and policy:

Service, R. (2013) "Battle for the barrel", *Science*, **339,** 1374 – 1379.

Sager, J., Lemoine, D, Apte, J. and Kammen, D. M. (2011) "Reduce growth rate of light duty vehicle travel to meet 2050 global climate goals." *Environmental Research Letters*, **6**(2), 024018. [Sager_etal_2011.pdf]

ER200 & Pub Pol 284:

Jones, C. M. and Kammen, D. M. (2014) "Spatial distribution of U.S. carbon footprints reveals suburbanization offsets benefits of population density", *Environmental Science and Technology*, ***48*** **(2**), 895 – 902.

Supplemental:

Schewel, L., & Schipper, L. (2011). Fossil Freight: How Much Fossil Fuel Does It Take to Move Fossil Fuel?. In *Transportation Research Board 90th Annual Meeting* (No. 11-1281).

Bürer, Mary J., et al. (2004) "Location Efficiency as the Missing Piece of The Energy Puzzle: How Smart Growth Can Unlock Trillion Dollar Consumer Cost Savings." Natural Resources Defense Council and Sierra Club. [Burer_2004.pdf]

Lecture 26 (12/1) – Climate Change II: Energy Policy:

Pacala, S., and Socolow, R. (2004) "Stabilization wedges: solving the climate problem for the next fifty years with current technologies", *Science*, **305**, 968 – 971. [Pacala_2004.pdf]

Baer, P., et al. (2000). "Equity and Greenhouse Gas Responsibility." *Science* **289**(5488): 2287. [Baer_2000.pdf]

David J Frame and Cameron Hepburn (2010) "An issue of trust: state corruption, responsibility and greenhouse gas emissions", *Environ. Res. Lett.* 5 (2010), doi:10.1088/1748-9326/5/1/014004

Steffen, W. *et al. (2015) "*Planetary boundaries: Guiding human development on a changing planet" *S*cience, 347

Supplemental:

Online resource: C-ROAD
http://climateinteractive.wordpress.com/2008/09/19/pangaea-our-decision-maker-oriented-uclimate-simulator/

Sailor, W. C., Bodansky, D., Braun, C. Fetter, S. and van der Zwaan, R. (2000) "A nuclear solution to climate change", *Science*, **288** (5469), 1177–1178. [Sailor_2000.pdf]

Kammen, D.M. and Nemet, G.F. (2005). "Reversing the Incredible Shrinking Energy R&D Budget." *Issues in Science and Technology.* Fall: pp. 84-88.