W100 - Energy and Society

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 take a very interdisciplinary and integrative approach to 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 the ethnic, racial, gender, and economic inequities found in those stages. 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, and sociology. The course may feel, initially, like more 'STEM' focused (science, technology, engineering & mathematics), but while we largely being with those tools, it truly balances our as we progress and spend more and more lecture, reading, and section time on social and policy issues, environmental and social justice, and on behavior.

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 six problem sets (30% of grade), a mid-term examination (35%), and a final exam (35%). The problem sets will be each week except the mid-term and the final week.

Weekly topics:

Week	Module	Topic
1	The basics	1. Introduction – Course overview and goals 2. Unit analysis and forecasting 3. Back of the envelope
2	Combustion	4. Combustion 5. Energy and international development 6. Household energy, gender and health
3	Energy systems	7. Thermodynamics 8. Utility-scale power plants 9. The US utility industry (part I)
4	Energy economics	10. Energy economics 11. Life-cycle and cost-benefit analysis 12. The US utility industry (part II) [**Mid-term exam, no problem set this week**]
5	Efficiency	13. Energy efficiency 14. Buildings 15. Energy innovation
6	Large-scale energy	16. Nuclear power 17. The grid 18. Fracking and the new rise of natural gas
7	The rise of renewables	19. Environmental justice 20. Solar power 21. Wind power
8	Energy, land and climate	22. Bioenergy and hydrogen 23. Transportation 24. Climate change and energy **[Final exam, no problem set this week]**

The online lectures are supported by set of weekly 'Section Notes' that provide added worked and unworked problems, exercises, and links to additional material. These are reference material to aid you in coming to the online sections prepared, and to assist you in studying the material.

Problem Sets (each week except for the mid-term and the final week):

Problem Set #	Coverage
1	Short warm-up problems; unit analysis; getting comfortable with the units of energy analysis.
2	Energy use at household and national scales; basic thermodynamics; combustion.
3	Thermodynamics of energy systems, combustion of various fuels; comparisons of energy conversion efficiencies, emissions, financial analysis of power plants. Energy economics.
4	Life-cycle analysis; learning curves; energy efficiency, evolution of the modern energy system.
5	Environmental justice; energy efficiency and conservation; the grid; nuclear energy.
6	Nuclear energy and waste, renewable energy systems, transportation, climate policy.

There are two texts for the course:

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

Rubin, Edward S. (2001) *Introduction to Engineering & the Environment* (McGraw Hill: New York, NY).

We will use these two books extensively. While all required sections of these two books are available in the readings you can download, we also recommend you order them to have a permanent copy, because, you know, *books* are *cool.*

Technical Requirements and Support
This course is built on a Learning Management system (LMS) called Canvas and you will need to meet these computer specifications to participate within this online platform.

If you are having technical difficulties please alert one of the GSIs immediately. However, understand that neither the GSIs, nor the professor can assist you with technical problems. You must call or email tech support and make sure you resolve any issues immediately.

In your course, click on the "Help" button on the bottom left of the global navigation menu. Be sure to document (save emails and transaction numbers) for all interactions with tech support. **Extensions and late submissions will not be accepted due to "technical difficulties."**

Students with Disabilities
If you require course accommodations due to a physical, emotional, or learning disability, contact UC Berkeley's Disabled Students' Program (DSP). Notify the instructor and GSI through course email of the accommodations you would like to use.

UC Berkeley is committed to providing robust educational experiences for all learners. With this goal in mind, we have activated the ALLY tool for this course. You will now be able to download content in a format that best fits your learning preference. PDF, HTML, EPUB, and MP3 are now available for most content items. For more information visit the alternative formats link or watch the video entitled, "Ally First Steps Guide."

Week 1 – The Basics

1. **Introduction – Course overview and goals**
2. **Unit analysis and forecasting**
3. **Back of the envelope calculations**

Recommendation: Get in 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. In this course, we will read as much as we do calculations, so these are great ways to see how to think about different topics.

These are a selection of examples to get you started:

Jeffrey Ball and Dan Reicher (2017) "Making solar big enough to matter" (3/21/2017)
https://www.nytimes.com/2017/03/21/opinion/making-solar-big-enough-to-matter.html?mcubz=1

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

Paul Krugman *(2017) "Trump's energy, low and dirty*" (5/29/2017)
https://www.nytimes.com/2017/05/29/opinion/trump-g-7-summit-energy.html?mcubz=1

Scott Wiener and Daniel M. Kammen *(2019) "For US cities, housing policy is climate policy"* (3/25/2019)
https://www.nytimes.com/2019/03/25/opinion/california-home-prices-climate.html

Readings:

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

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

Week 2 – Combustion

1. **Combustion**
2. **International Development**
3. **Gender and Household Energy**

Readings:

Rubin, *Introduction to Engineering & the Environment,* Chapter 5, pages 162 – 175.

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

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

Sovacool, B. (2014) "Energy studies need social science," *Nature*, **511**, 529 – 530.

Extra material:

If you want to dig deeper and join the debate, here are two views of cookstoves

Morrison, Sarah (2018) "Undercooked: An Expensive Push to Save Lives and Protect the Planet Falls Short". *ProPublica* https://www.propublica.org/article/cookstoves-push-to-protect-the-planet-falls-short

Goodman, Peter (2018) Toxic Smoke Is Africa's Quiet Killer. An Entrepreneur Says His Fix Can Make a Fortune, *The New York Times*, December 6 https://www.nytimes.com/2018/12/06/business/rwanda-charcoal-pellet-stoves-.html

Week 3 – Energy Systems

1. Thermodynamics
2. Utility-scale power plants
3. The US utility industry (part I)

Readings:

Rubin, Edward (2001) *Introduction to Engineering & the Environment,* Chapter 5, pages 183 – 212.

Hirsh, Richard (1999) *Power Loss*, Section I, Pages 1 - 54.

Extra material:

David Roberts (2017) "By 2020, every Chinese coal plant will be more efficient than every US coal plant" (5/16/2017) https://www.vox.com/energy-and-environment/2017/5/15/15634538/china-coal-cleaner

Week 4 – Energy economics

1. **Energy economics**
2. **Life-cycle and cost-benefit analysis**
3. **The US utility industry (part II)**

Readings:

Rubin, *Introduction to Engineering & the Environment,* Chapter 13, pages 545 – 583

Friedman, Thomas L. (2006) “The First Law of Petropolitics,” *Foreign Policy*, **154:** (28 – 36).

Hirsh, *Power Loss* (MIT University Press: Cambridge, MA) Section I, Pages 55 - 88.

Edenhofer, O. (2015) “King Coal and the queen of subsidies,” *Science*, 1286 – 1287.
http://science.sciencemag.org/content/sci/349/6254/1286.full.pdf

Extra material:

A guide to the costs of energy, which is updated regularly and provides great background on the calculational methods is:
https://energy.utexas.edu/policy/fce

W. Pizer, M. Adler, Anthoff, D.J. Aldy, M. Cropper, K. Gillingham, M. Greenstone, B. Murray, R. Newell, R. Richels, A. Rowell, S. Waldhoff and J. Wiener, “Using and improving the social cost of carbon,” *Science*, 2014, 346(6214): 1189-1190.

Week 5 – Energy Efficiency

1. **Energy efficiency**
2. **Buildings**
3. **Energy innovation**

Readings:

Hirsh, *Power Loss* (MIT University Press: Cambridge, MA), Chapter 10, Pages 169 – 188.

Rubin, *Introduction to Engineering & the Environment,* 109 – 111*,* 190 – 196, 207 – 212, 257 – 275.

Week 6 – Large-scale energy

1. **Nuclear power**
2. **The grid**
3. **Fracking and the new rise of natural gas**

Readings:

Lester, Richard K. "A Roadmap for U.S. Nuclear Energy Innovation," *Issues in Science and Technology* 32, no. 2 (Winter 2016). http://issues.org/32-2/a-roadmap-for-u-s-nuclear-energy-innovation/

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

Martin, R. (2016) "Fail-safe nuclear power," *MIT Technology Review* *https://www.technologyreview.com/s/602051/fail-safe-nuclear-power/*

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

Brandt, A.R., 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

Extra material:

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

Week 7 – The Rise of Renewables

1. **Environmental justice**
2. **Solar power**
3. **Wind power**

Readings:

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

Bullard, Robert (2000) *Dumping in Dixie: Race, Class, And Environmental Quality* (Routledge: New York), chapter 2 (Race, Class, and the Politics of Place).

Haegel, N, *et al.* (2017) "Terawatt-scale photovoltaics: Trajectories and challenges", *Science*, **356**, Issue 6334, pp. 141-143. DOI: 10.1126/science.aal1288

Rubin, *Introduction to Engineering & the Environment,* 217 - 220.

Extra material:

Sunter, Deborah, Castellanos, Sergio, and Daniel M Kammen (2019) "Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity," *Nature Sustainability*, **2**, 71 – 76.

Week 8 – Energy, land and climate

1. **Bioenergy and hydrogen**
2. **Transportation**
3. **Climate change and energy**

Readings:

Rubin, *Introduction to Engineering & the Environment* Pages 97 – 114 (some advanced examples in here, too).

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.

Intergovernmental Panel on Climate Change: Global Warming of 1.5° C, *Summary for Policymakers*, https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/

Figueres, C., *et al.* (2017) "Three years to safeguard our climate," *Nature*, **546**, 593 – 595. doi:10.1038/546593a. https://rael.berkeley.edu/wp-content/uploads/2017/06/Figueres-ThreeYearstoSafeguardOurPlanet-Nature-2017_full.pdf

Steffen, W. *et al. (2015) "*Planetary boundaries: Guiding human development on a changing planet" *S*cience, **347**, Issue 6223. DOI: 10.1126/science.1259855.

United State Department of Energy, *Bioenergy and Hydrogen Basics: https://www.energy.gov/eere/bioenergy/bioenergy-basics*

Extra material:

Christopher M. Jones, Stephen M. Wheeler, and Daniel M. Kammen (2018) "Carbon Footprint Planning: Quantifying Local and State Mitigation Opportunities for 700 California Cities", *Urban Planning*, **3 (2)**, 35 - 51.

Kittner, N., Lill, F. and Kammen, D. M. (2017) "Energy storage deployment and innovation for the clean energy transition" *Nature Energy*, **2**, DOI: 10.1038/nenergy.2017.125. https://rael.berkeley.edu/wp-content/uploads/2017/07/Kittner-Lill-Kammen-NatureEnergy-Storage-Innovation-2017.pdf