W100 Energy and Society
Summer 2020*

Four (4) semester credits

Sign up at: http://erg.berkeley.edu/academics/sustainability

No prerequisites – fully online (*watch lectures on your own schedule*)

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 begin with those tools, it truly balances as we progress and spend more and more lectures, readings, 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.

Instructor Information & Communication

Course Instructor

Daniel M. Kammen

Graduate Student Instructors (GSIs)

Isa Ferrall, lead GSI

Jess Carney

While the instructor will interact with the whole class and will oversee all activities and grading, as well as being available to resolve any issues that may arise, the lead GSI will be your main point of contact. The lead GSI is responsible for assisting you directly with your questions about assignments and course requirements, as outlined in the Assignments and Calendar. The lead GSI will also facilitate ongoing discussion and interaction with you on major topics in each module.

Discussion Sections and Office Hours

Your Graduate Student Instructor (GSI) will be facilitating online discussion sections, which will review important material from the lectures and assist you in working through the practice problems contained in the section notes.

In addition to discussion sections, the course instructor and GSIs will offer virtual office hours, which will be student-led questions and answers, when you can communicate synchronously (in real time). While these meetings are optional they can be valuable for discussion, answering questions, and reviewing for exams.

The appropriate Zoom links for discussion sections and office hours will be available in the course website on bCourses.

Course Mail

You can also contact your GSI and the course instructor via email. Make sure to check the Course Mail for messages from the instructor. You can access course email within the Learning Management System by clicking on the Inbox link or choose to have your course mail forwarded to your personal email account or your cell phone.

Question & Answer Forum

Please use this forum to post questions about the course material, assignments, the learning management system or online homework. The instructor/GSIs will monitor this forum**,** but you should also feel free to post answers to help other students. This helps to create a general FAQ so that all students in the course may benefit from the exchange.

Course Materials and Technical Requirements

Required Materials

In addition to required readings and extra materials made available on bCourses, there are two texts for this 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.*

You are free to purchase your textbooks from any vendor. Please be sure to thoroughly review the return policies before making a purchasing decision as UC Berkeley does not reimburse students for course materials in the event of a textbook change or an unexpected cancellation or rescheduled course section.

Technical Requirements

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.

Technical Support

If you are having technical difficulties, please reach out to tech support immediately to resolve the issues and notify your GSI of the situation. 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."**

Learning Activities

VERY IMPORTANT

You won't be able to access your course material until you read and make your pledge to Academic Integrity (in bCourses).

You are expected to fully participate in all the course activities described here.

1. Read web-based announcements and postings during the course
2. Read the assigned materials
3. Watch and listen to the lecture presentations
4. Complete problem sets
5. Complete the midterm quiz and final exam
6. [Optional, but highly suggested] Participate in Discussion Sections

Assignments

There will be six problem sets (40% of grade), a short mid-term check in quiz (10%), and a final exam (50%). Problem sets 1 & 2 will be self-graded for students to gauge their own progress, and problem sets 3 – 6 will be graded for credit. The problem sets will be assigned each week except the mid-term and the final week.

Weekly Topics

Table 1: 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 check-in, 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 a 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):

Table 2: Problem Sets

Problem Set #	Coverage
1	Short warm-up problems; unit analysis; getting comfortable with the units of energy analysis. [self graded]
2	Energy use at household and national scales; basic thermodynamics; combustion. [self graded]
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.

Grading and Course Policies

Your final course grade will be calculated as follows:

Table 3: Final Grade Percentages

Category	Percentage of Grade
Problem Sets	40%
Midterm Quiz	10%
Final Exam	50%

It is important to note that not all components are graded online and included in the online course grade book. Because of this, the online course grade book may not display your overall course grade at any given time or your final grade. It should simply be used to assess your performance on the components that are included within it: the written assignments and midterm exam. Your final letter grade will be mailed to you by the registrar's office.

Course Policies

Promptness

Homework assignments and discussion forum postings all have specific final due dates and times. You will not receive full credit if assignments are submitted after the indicated due date and time.

Further, each online activity must be submitted through the course website by the due date. Students who wait until the final hours prior to a submission deadline risk having problems with their ISP, hardware, software, or various other site access difficulties. Therefore, it is advisable to submit assignments and tests through the course website early. Students should plan accordingly and get into the habit of checking the course website several times each week, and submitting and posting early.

Honor Code

The student community at UC Berkeley has adopted the following Honor Code: "As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others." The expectation is that you will adhere to this code.

Collaboration and Independence

Reviewing lecture and reading materials and studying for exams can be enjoyable and enriching things to do with fellow students. This is recommended. However, unless otherwise instructed, homework assignments and the online exam are to be completed independently and materials submitted as homework should be the result of one's own independent work.

Cheating

A good lifetime strategy is always to act in such a way that no one would ever imagine that you would even consider cheating. Anyone caught cheating on a quiz or exam in this course will receive a failing grade in the course and will also be reported to the University Center for Student Conduct. The expectation is that you will be honest in the taking of exams.

Plagiarism

To copy text or ideas from another source without appropriate reference is plagiarism and will result in a failing grade for your assignment and usually further disciplinary action. For additional information on plagiarism and how to avoid it, explore the resources linked below:

UC Berkeley Library Citation Page, Plagiarism Section

GSI Guide for Preventing Plagiarism

Academic Integrity and Ethics

Cheating on exams and plagiarism are two common examples of dishonest, unethical behavior. Honesty and integrity are of great importance in all facets of life. They help to build a sense of self-confidence, and are key to building trust within relationships, whether personal or professional. There is no tolerance for dishonesty in the academic world, for it undermines what we are dedicated to doing - furthering knowledge for the benefit of humanity.

Incomplete Course Grade

Students who have substantially completed the course but for serious extenuating circumstances, are unable to complete the final exam, may request an Incomplete grade. This request must be submitted in writing or by email to the GSI and course instructor. You must provide verifiable documentation for the seriousness of the extenuating circumstances. According to the policy of the college, Incomplete grades must be made up within the first three weeks of the next semester.

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 in bCourses."

End of Course Evaluation

Before your course ends, please take a few minutes to participate in the course evaluation to share your opinions about the course. The evaluation does not request any personal information, and your responses will remain strictly confidential. A link to the evaluation (in the left-hand navigation menu) will be made available via bCourses. You will also be emailed a link to the course evaluation.

Course Outline

You'll find complete instructions for your assignments within the course modules.

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]

Liu, et al., (2020) “COVID-19 causes record decline in global CO2 emissions,“ *Nature Communications*, https://arxiv.org/abs/2004.13614

Week 2 – Combustion

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

Readings:

Rubin, Edward (2001) *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, Introduction and Chapters 1 & 2, 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)
4. Learning Curves

Readings:

Rubin, Edward (2001) *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, Richard (1999) *Power Loss*, Chapters 3 & 4, 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, Richard (1999) *Power Loss*, Chapter 10, pages 169 – 188.

Rubin, Edward (2001) *Introduction to Engineering & the Environment, pages*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, Edward (2001) *Introduction to Engineering & the Environment*, 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", Chapter 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, Edward (2001) *Introduction to Engineering & the Environment*, pages 217 - 220.

Cohen, D. and Kammen, D. (2020) "Climate crisis will deepen the pandemic. A green stimulus plan can tackle both" *The Guardian*, April 20. https://www.theguardian.com/commentisfree/2020/apr/20/climate-crisis-will-deepen-the-pandemic-a-green-stimulus-plan-can-tackle-both

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, Edward (2001) *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