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)**


**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](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 several field trips during the semester. Each will be 3 - 6 hours (including travel time), and all will 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);
- California Windfarm
- FlexLab, LBL
- SunSet Solar (San Francisco)

Graduate Student Instructors and Office Hours

<table>
<thead>
<tr>
<th></th>
<th>John Romankiewicz</th>
<th>Fernando Castro-Alvarez</th>
<th>Jessie Knapstein</th>
<th>Julia Sznai</th>
<th>Kenji Shiraiishi</th>
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<tbody>
<tr>
<td>Office:</td>
<td>399 Barrows</td>
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<tr>
<td>Hours:</td>
<td>Tues 9-11am</td>
<td>Mon 4-6pm</td>
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<td>Mon 9-11am</td>
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<tr>
<td>Email:</td>
<td><a href="mailto:sustainablejohn@gmail.com">sustainablejohn@gmail.com</a></td>
<td><a href="mailto:fcastroa@berkeley.edu">fcastroa@berkeley.edu</a></td>
<td><a href="mailto:jessie.l.knapstein@gmail.com">jessie.l.knapstein@gmail.com</a></td>
<td><a href="mailto:jszinai@berkeley.edu">jszinai@berkeley.edu</a></td>
<td><a href="mailto:kenjis@berkeley.edu">kenjis@berkeley.edu</a></td>
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Reach us by email or by coming to the office hours.

Section meetings begin in Week 2 (i.e. starting 9/1). 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 generally a week before the lecture. You should download the files and bring them to lecture so that you have all of the graphs and diagrams right in front of you.
<table>
<thead>
<tr>
<th>Wk</th>
<th>Date</th>
<th>Lecturer</th>
<th>Lecture #/Topic</th>
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<tbody>
<tr>
<td>1</td>
<td>8-27</td>
<td>Kammen</td>
<td>1. How Energy Use Shapes Society &amp; the Environment</td>
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<tr>
<td>3</td>
<td>9-8</td>
<td>Kammen</td>
<td>4. Energy for ‘the South’ I: Energy Transitions and Development</td>
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<td>9-10</td>
<td>Kammen</td>
<td>5. Energy for ‘the South’ II: Biomass, Households, and Gender</td>
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<td>4</td>
<td>9-15</td>
<td>Kammen</td>
<td>6. Energy Toolkit III: Energy Thermodynamics</td>
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<td>9-22</td>
<td>Kammen</td>
<td>7. Energy Toolkit IV: Thermodynamics of Modern Power Plants</td>
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<td>9-24</td>
<td>Kammen</td>
<td>8. ‘Hydrocarbon Man’</td>
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<td>10-1</td>
<td>Horvath</td>
<td>10. Energy Toolkit V: Economic Analysis of Energy Systems</td>
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<td>6</td>
<td>10-6</td>
<td>Kammen</td>
<td>11. Energy Efficiency I: Devices</td>
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<td></td>
<td>10-15</td>
<td>Kammen</td>
<td>14. Electricity Grids: Managing the Network</td>
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<td>8</td>
<td>10-20</td>
<td>GSIs</td>
<td>15. Natural Gas, Fracking, and Carbon Capture and Storage</td>
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<td>10-22</td>
<td>You!</td>
<td>Mid-term review</td>
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<td><strong>Midterm Exam, In class</strong></td>
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<td></td>
<td>10-29</td>
<td>Budnitz</td>
<td>17. Nuclear Energy II: Waste, Risk &amp; Economics</td>
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<tr>
<td>11</td>
<td>11-3</td>
<td>Kammen</td>
<td>18. Energy and Environmental Justice / Designing Policy Memos</td>
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<tr>
<td>13</td>
<td>11-17</td>
<td>Kammen</td>
<td>22. Renewable Energy IV: Industrial Bioenergy &amp; Land Use</td>
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<td>14</td>
<td>11-24</td>
<td>Kammen</td>
<td>24. Transportation systems and policies</td>
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<td>11-26</td>
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<td><strong>HOLIDAY THANKSGIVING</strong></td>
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<tr>
<td>15</td>
<td>12-1</td>
<td>Kammen</td>
<td>25. Climate Change I: Energy and Climate</td>
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<td>12-3</td>
<td>Kammen</td>
<td>26. Climate Change II: Energy Policy</td>
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<tr>
<td>Problem Set #</td>
<td>Assigned</td>
<td>Due</td>
<td>Coverage</td>
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<tr>
<td>1</td>
<td>9/1</td>
<td>9/10</td>
<td>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.</td>
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<tr>
<td>2</td>
<td>9/15</td>
<td>9/24</td>
<td>Energy use at household and national scales; basic thermodynamics; combustion.</td>
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<tr>
<td>3</td>
<td>9/29</td>
<td>10/8</td>
<td>Thermodynamics of energy systems, combustion of various fuels; comparisons of energy conversion efficiencies, emissions, financial analysis of power plants. Energy economics.</td>
</tr>
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<td>4</td>
<td>10/8*</td>
<td>10/15</td>
<td>Life-cycle analysis; learning curves; energy efficiency, evolution of the modern energy system. [Shorter problem set]</td>
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<tr>
<td>5</td>
<td>10/27</td>
<td>11/5</td>
<td>Environmental justice; energy efficiency and conservation; the grid; nuclear energy.</td>
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<tr>
<td>6</td>
<td>11/10</td>
<td>11/19</td>
<td>Nuclear energy and waste, renewable energy systems, fuel cells and hydrogen.</td>
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<tr>
<td>7</td>
<td>11/24</td>
<td>12/3</td>
<td>Biomass energy, transportation, energy and climate, and climate policy.</td>
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</tbody>
</table>

* 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 on 10/21, 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 (8/27) – 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.


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:

July 23, 2015

Ralph Cavanagh (2013) “How we learned not to guzzle” (9/12/13)

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

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

Lecture 2 (9/1) – Energy Toolkit I: Units, Forecasts, and the Back-of-the-Envelope:

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

ER200 & Pub Pol 284:

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 (9/3) – Energy Toolkit II: Fuels, Energy Content, and Basics of Combustion:

Rubin, EE, Chapter 1, pages 3 – 17.


Supplemental: Toolkit 2 (resource material)
Week 3 – Energy and Development

Lecture 4 (9/8) – Energy for ‘the South’ I: Energy Transitions and Development:


ER200/PP284:

Lecture 5 (9/10) – Energy for ‘the South’ II: Biomass, Households, and Gender:


ER200/PP284


Note: this is a challenging reading.

Week 4 – Thermodynamics of Energy

**Lecture 6 (9/15) – Energy Toolkit III: Energy Thermodynamics:**


**Lecture 7 (9/17) – 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


**ER200 & Pub Pol 284:**

Week 5 – ‘Hydrocarbon man’

Lecture 8 (9/22) – Hydrocarbon Man:


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


Lecture 9 (9/24) – Evolution of the Modern Energy Economy:

Week 6 – Energy Economics and Life-Cycle Methods

Lecture 10 (9/29) – Energy Toolkit V: Economic Analysis of Energy Systems:

Rubin, EE, Chapter 13, Pages 545 – 577

ER200/PP284:

Lecture 10 (10/1) – 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]:
Week 7 – Energy Efficiency (I & II)

Lecture 12 (10/6) – Energy Efficiency I: Devices:

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


ER200/PP284:

Lecture 13 (10/8) – Energy Efficiency II: Buildings as Energy Systems


And for a look at why it is so hard, ask Dilbert:

Week 8 – Buildings as Energy Systems

Lecture 14 (10/13) – Electricity Grids: Managing the Network:


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

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


http://www.nytimes.com/interactive/2014/11/24/upshot/nd-oil-well-illustration.html?_r=0&abt=0002&abg=1

ER200 & Pub Pol 184
Chapters 2 and 3 (pages 5 – 42)
Week 9 – Mid-Term Review & Exam

**Class (10/20) – Midterm examination review**

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

**Class (10/22) – Midterm examination**

Your notes, lecture slides, section handouts, past problem sets and solutions, all previous readings.
Week 10 – Nuclear Power

Lecture 16 (10/27) – Nuclear Energy I: Physics and Engineering – Fission/Fusion:


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 (10/29) – Nuclear Energy II: Waste, Risk & Economics:

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


Week 11 – Energy and Environmental Justice & Renewables

Lecture 18 (11/3) – Energy and Environmental Justice:


"Climate Change, Consumerism and the Pope with Prof. Daniel Kammen and Governor Jennifer Granholm -- In The Living Room with Henry E. Brady -- UC Public Policy Channel"
http://www.uctv.tv/shows/29853

Islamic Call on Climate Change

ER200/PP284:

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

<table>
<thead>
<tr>
<th>Contents</th>
<th>URL</th>
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<tbody>
<tr>
<td>The EJ Information Page</td>
<td><a href="http://eelink.net/EJ/">http://eelink.net/EJ/</a></td>
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<tr>
<td>Climate Justice and People of Color</td>
<td><a href="http://www.ejrc.cau.edu/climatechgpoc.html">http://www.ejrc.cau.edu/climatechgpoc.html</a></td>
</tr>
<tr>
<td>Ken Saro-Wiwa and Shell Oil (Nigeria)</td>
<td><a href="http://uk.oneworld.net/guides/nigeria/development">http://uk.oneworld.net/guides/nigeria/development</a></td>
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<tr>
<td>EJ Case Studies</td>
<td><a href="http://www.umich.edu/%Esnre492/cases.html">http://www.umich.edu/%Esnre492/cases.html</a></td>
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<tr>
<td>Center for Science and Environment (India)</td>
<td><a href="http://www.cseindia.org/">http://www.cseindia.org/</a></td>
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Lecture 19 (11/5) – 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

ER200/PP284:
Week 12 – Renewable Energy II: Wind and Water Power


Hydropower reading TBD

Lecture 21 (11/12) – Renewable Energy III: Electrochemistry H₂ Batteries and Fuel Cells


ER200/PP284:

Week 13 – Energy and Sustainability Challenges

Lecture 21 (11/17) – Renewable Energy IV: Industrial Bioenergy and Land Use

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

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


Lecture 22 (11/19) – International Energy Policy


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

Week 14 – Transportation Systems

Lecture 23 (11/24) – Transportation systems and policy:


ER200 & Pub Pol 284:


Supplemental:


No Lecture on (11/26) – Academic Holiday.
**Week 15 – Energy and the Global Environment**

**Lecture 24 (12/1) – Climate Change I: Energy and Climate:**

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


**Lecture 25 (12/3) – Climate Change II: Energy Policy:**


**Supplemental:**

Online resource: C-ROAD

