IGA-411 Syllabus
The Energy-Climate Challenge

(updated 08-30-17)

John Holdren and Henry Lee
Fall 2017
M/W, 2:45-4:00, 1 Brattle, Room 401
Review: Fridays at 1:15-2:30 Weil Town Hall

The greatest challenge at the intersection of science, technology, and public policy in the 21st century has arisen because society is getting 80 percent of the massive quantities of energy it needs using fuels and technologies that are disrupting global climate and the array of environmental goods and services that depend on it. This course will examine the character and magnitude of this challenge and the policy choices germane to meeting it, introducing and applying relevant concepts from environmental science, energy-technology assessment, policy design, and domestic and global politics.

This syllabus provides an outline of the classes and the required and optional readings. The course is divided into five sections: 1. An introduction to the energy–climate challenge; 2. Tools for understanding energy systems; 3. Technical options for a lower carbon energy mix; 4. Policies for a lower carbon future; and 5. Student presentations.

Requirements and Grading

Requirements include two take home assignments (30%) plus a group presentation (20%) and a 20-25 page paper on a topic to be selected from a list provided by the instructors (50%). The take-home assignments will be given out on Wednesdays and will be due at 2:30pm on the Wednesday of the following week. Due date for the term paper is noon on Friday, December 15.
Penalties for lateness:

- If by midnight on the due date, 10% off the assignment grade
- If by noon the next day, 20% off
- If by noon the following Monday, 50% off
- If past noon the following Monday, no credit

(In the real world of policy, being late often equates to irrelevance!)

An Important Reminder About Citing Sources: Students must be familiar with and observe Harvard Kennedy School protocols regarding the citation of sources. In short: Any sentences or paragraphs taken verbatim from the writing of or interviews with any other person or persons, or from your own writing produced for another purpose, must be placed in quotation marks and its source must be identified with a footnote or endnote that includes the usual bibliographic information: author's name, title of article or chapter, venue (book, journal, magazine, website, report, thesis, term paper, private letter), date, and page numbers if applicable. The inclusion – in assignments, exams, or term papers – of material taken verbatim from other work without the use of quotation marks and citations is regarded, as a matter of School and University policy, as a serious violation of academic and professional standards and can lead to a failing grade in the course, failure to graduate, and even expulsion from the University. Changing the wording of a sentence or passage slightly does not evade the requirement for citation (nor reduce the chance of detection). And, it must be emphasized, material taken from websites is not exempt from the requirement for citation.

NOTE: Students who have taken IGA-410 "Energy Policy: Technologies, Systems, and Markets" may not also take IGA-411 for credit.

The following book is on reserve at the HKS library or available online:

- Nordhaus, William. The Climate Casino: Risk, Uncertainty, and Economics for a Warming World. Yale University Press, 2015 (Hollis Link here).

Teaching Team

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Professor Henry Lee, Belfer 302, 617-495-1350, Henry_Lee@hks.harvard.edu
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Course Schedule

Class # Day Date Topic

Readings are designate **R** = REQUIRED or **O** = OPTIONAL. Assignments to be read before the indicated class where possible, but after is far better than not at all)

0 Aug 28 Shopping Day

Unit I: Introduction to Energy-Climate Issues and Challenges

1 W Aug 30 Introduction to the course; essence of the energy-climate challenge (HL + JH)
Overview of the substantive coverage and arrangements for the course. Introduction to the character of the challenge(s) in energy technology and policy, global climate change, and (especially) the energy-climate intersection.

Reading

- R: John P. Holdren, "The energy innovation imperative", *Innovations*, Spring 2006, pp 3-23. http://www.mitpressjournals.org/doi/pdf/10.1162/itgg.2006.1.2.3

- O: "Energy Challenges", Chapter I in Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities, U.S. Department of Energy, September 2015: pp 11-22 https://energy.gov/sites/prod/files/2017/03/f34/quadrennial-technology-review-2015_1.pdf

2 **F Sep 01 Energy magnitudes, patterns of supply & use, projections (JH + HL)**
Units of measurement of energy and power. Magnitudes of principal energy flows in nature and society. Sources of energy supply and patterns of energy end-use in the United States, other major countries, and the world as whole. Mainstream projections of future patterns of energy supply and use.

Reading

- R: US Energy Information Administration, Monthly Energy Review July 2017: pp iii-viii, pp 1-19 (focus on graphics, simply note what's covered in tables) https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

- R: US EIA, Annual Energy Outlook 2017: pp 2-24 https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf

- R: BP Statistical Review of World Energy 2017: pp 1-10 https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

- R: BP Energy Outlook 2017: pp 1-8 http://www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2017/bp-energy-outlook-2017.pdf

3 **W Sep 06 Resource & environmental issues around energy (JH)**
Estimates of reserves and ultimately recoverable resources of nonrenewable fuels. Natural flows and harvestable fractions of renewable energy sources. Nonfuel resource requirements of energy systems. Introduction to impacts of energy systems on human health and Earth systems.

Reading

- R (skim): John P. Holdren and Kirk R. Smith, "Energy, environment, and health", Chapter 3 in *World Energy Assessment: Energy and the Challenge of Sustainability*, 2001: pp 61-110. http://www.undp.org/content/dam/aplaws/publication/en/publications/environment-energy/www-ee-library/sustainable-energy/world-energy-assessment-energy-and-the-challenge-of-sustainability/World%20Energy%20Assessment-2000.pdf

F Sep 08 Review Class
Reviews magnitudes and patterns of supply and use projections

4 **M Sep 11 Causes, dynamics, & impacts of climate change – Part 1 (JH)**
The machinery of Earth's climate. Natural and human influences on global climate. What we know about the history of climate over the millennia and since the Industrial Revolution—and how we know it.

Readings

- R: National Academy of Sciences and Royal Society of London, *Climate Change Evidence and Causes*, 2014: pp B1-B8, pp 5-14
  http://dels.nas.edu/resources/static-assets/exec-office-other/climate-change-full.pdf
- O: U.S. Global Change Research Program (USGCRP), *Climate Science Special Report* (Fifth Order Draft), 28 June 2017: pp 4-16.
  https://assets.documentcloud.org/documents/3920195/Final-Draft-of-the-Climate-Science-Special-Report.pdf

5 W Sep 13 Causes, dynamics, & impacts of climate change – Part 2 (JH)
Impacts of climate change to date on society and ecosystems. Scenarios of future climate change and its impacts.

Readings

- R: National Academy of Sciences and Royal Society of London, *Climate Change Evidence and Causes*, 2014: pp 17-15 (R)
  http://dels.nas.edu/resources/static-assets/exec-office-other/climate-change-full.pdf

- O: U.S. Global Change Research Program (USGCRP), *Climate Science Special Report*(Fifth Order Draft), 28 June 2017: pp 17-37.
  https://assets.documentcloud.org/documents/3920195/Final-Draft-of-the-Climate-Science-Special-Report.pdf

Unit II: Tools for Understanding Energy Systems

6 M Sep 18 Why Economics Matters (HL)
Will review demands on capital and labor, patterns of energy use, elasticity, tariff setting, and trade impacts; introduction to market failures (excessive concentration of market power, lack of information, externalities, public goods, and inequality). This class aims to familiarize students with the basic economic concepts that we will use to assess the effectiveness of energy policies to mitigate ghg emissions in subsequent classes.

Readings

- R: Global Energy Assessment – Towards a Sustainable Future – Cambridge University Press, 2012, ch. 6.1-6.5, p. 389-407, http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/GEA_Chapter6_economy_lowres.pdf

- R: Tol, Richard S J. 2009. "The Economic Effects of Climate Change." Journal of Economic Perspectives, 23(2): 29-51. http://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.23.2.29

7 W Sep 20 Cost Comparison Methodologies and Finance (HL)
To mitigate GHG emissions, countries will have to embrace new energy options, particularly those in the electricity sector. This class will present students with methodologies for evaluating and comparing the costs of

energy projects. It will provide the analytical methods for comparing different electricity generation options and sets the stage for the classes on electricity options that follow.

Reading

- R: William D. Nordhaus. The Climate Casino: Risk, Uncertainty, and Economics for a Warming World. Yale University Press. October 2013. Chapter 16: Discounting and the Value of Time.

- R: Robert S. Pindyck, Microeconomics [7th edition], Upper Saddle River: Prentice Hall, 2009. "Investment, Time, and Capital Markets," pp. 573-577.

- R: Congressional Budget Office, "The Economics of Climate Change: A Primer," US Congress, Washington, DC. April 2003, pp. 23-34.

- O: Edith Stokey and Richard Zeckhauser, A Primer for Policy Analysis, Norton, Chapter 10, pp. 159-176.

Take Home 1 handed out – due on September 27 at 2:30

F Sep 22 Review Class
Reviews economic and cost methodologies

8 M Sep 25 Engineering analysis: fuel cycles, efficiencies, carbon intensities (JH)

9 W Sep 27 Engineering analysis: electricity systems (JH)

Readings

(R) "Modernizing the Electricity Grid", Chapter III in *Quadrennial Energy Review*, U.S. Department of Energy and Executive Office of the President of the United States, 2015: pp 3-1 to 3-5. https://www.energy.gov/sites/prod/files/2015/08/f25/QER%20Chapter%20III%20Electricity%20April%202015.pdf

F Sep 29 Review Class
Reviews engineering analysis, fuel cycle efficiencies, electricity systems

Unit III: Technologies for the Energy-Climate Challenge

10 M Oct 02 Introduction to climate-change mitigation & adaptation (JH)

11 W Oct 04 Energy-end-use efficiency: Buildings, Industry, Transportation (HL)
The potential to reduce energy use and improve energy efficiency are vast. This class will introduce students to some of the opportunities and challenges to improve energy productivity in the building, industrial and transportation sectors.

Reading

- R: Lucas Davis. New CAFE Standards: The Good, the Bad, and the Ugly (Energy Institute of HAAS Business School, January 2016). https://energyathaas.wordpress.com/2016/01/25/new-cafe-standards-the-good-the-bad-and-the-ugly/

- R: Soren Anderson, Ian Perry et.al. Automobile Fuel Economy Standards: Impacts, Efficiency and Alternatives--Review of Economics and Policy, winter 2011, p. 89-108. http://reep.oxfordjournals.org/content/early/2011/06/18/reep.req021.short

- R: National Academies of Sciences, Engineering, and Medicine. The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies, Washington, DC, 2016. Chapter 4: The Role of Energy Efficiency in Increasingly Clean Electricity, p. 87-114. https://www.nap.edu/read/21712/chapter/6

M Oct 09 HOLIDAY: COLUMBUS DAY

12 W Oct 11 Renewable electricity technologies (HL)

This class provides an overview of key renewable technologies, including wind, solar, biomass and geothermal energy.

Reading

- R: MIT, The Future of Solar Energy, May, 2015. Executive Summary and p. 19-42, http://energy.mit.edu/publication/future-solar-energy/

- R: David J.C. Mackey, Sustainable Energy – Without the Hot Air, UIT Cambridge, 2009:
  pp. 22-28: http://www.inference.phy.cam.ac.uk/withouthotair/c2/page_22.shtml
  pp. 38-49: http://www.inference.phy.cam.ac.uk/withouthotair/c6/page_38.shtml
  pp. 50: http://www.inference.phy.cam.ac.uk/withouthotair/c7/page_50.shtml
  pp. 81-87: http://www.inference.phy.cam.ac.uk/withouthotair/c14/page_81.shtm l
  pp. 88: http://www.inference.phy.cam.ac.uk/withouthotair/c15/page_88.shtml
  pp. 186-201: http://www.inference.phy.cam.ac.uk/withouthotair/c26/page_186.shtml

- R: John Decicco, Why Pushing Alternate Fuels Makes for Bad Public Policy, Environment 360, 22 Aug 2013, http://e360.yale.edu/feature/why_pushing_alternate_fuels__makes_for_bad_public_policy/2682/

- R: Video: Komp, Richard: How do solar panels work? TedEd: 5 minute video: https://www.youtube.com/watch?v=xKxrkht7CpY

F Oct 13 Review Class
Reviews renewables, energy efficiencies

13 M Oct 16 Nuclear electricity technologies (JH)

14 W Oct 18 Carbon capture & sequestration for fossil-fuel technologies (Dan Schrag)

15 M Oct 23 Biofuels & biological carbon sequestration (JH)

16 W Oct 25 Geoengineering approaches & air capture of CO2 (David Keith)

Take Home 2 handed out – due on Nov 1 at 2:30

F Oct 27 Review Class
Reviews nuclear, CCS, biological sequestration, and Take Home 2

Unit IV: Energy-Climate Policy, Case Studies, and Projects

17 M Oct 30 Policy for electricity, renewables, and carbon emissions (HL)
This class will introduce students to the challenges of integrating intermittent renewable energy options into the grid. It will discuss curtailment and pricing alternatives and distributed vs. central power systems.

Reading

- R: National Academies of Sciences, Engineering, and Medicine. The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies, Washington, DC, 2016. Chapter 2: Assessment of Current Technologies for and Policies Supporting Increasingly Clean Electric Power Generation, p. 19-48. https://www.nap.edu/read/21712/chapter/4

18 W Nov 01 Policy case study 1: Feed In Tariffs—Gainesville Regional Utility (HL)
This class will look at the strengths and weaknesses of various policies to promote solar energy options—including feed-in tariffs and renewable portfolio standards.

Reading

- R: Leah Stokes and Henry Lee, Gainesville Regional Utilities' Feed-In Tariff, HKS Case 1963.0.

- R: MIT, The Future of Solar Energy, May, 2015. Executive Summary and p. 209-230, http://energy.mit.edu/publication/future-solar-energy/

- R: Renewable portfolio Standards by the National Renewable Energy Lab: http://www.nrel.gov/tech_deployment/state_local_governments/basics_portfolio_standards.html

- R: Glen Barbose Slides from the Lawrence Berkeley Lab, 2013: http://www.cesa.org/assets/2012-Files/RPS/RPS-SummitDec2012Barbose.pdf

F Nov 03 Review Class
Reviews economics and pricing of electricity

19 M Nov 06 Integrating Renewables into the Grid
Argentina has embarked on a new program to attract greater investment in renewable energy options. The case will introduce students to the challenges of integrating intermittent renewables into the national grid in a developing country (coming out of an economic crisis).

Reading

- HKS Case Study: Argentina and Renewables, in progress

- MIT Energy Initiative. Utility of the Future. Chapter 1. https://energy.mit.edu/wp-content/uploads/2016/12/Utility-of-the-Future-Full-Report.pdf

20 W Nov 08 Putting a Price on Carbon—British Columbia (HL)

This class will discuss domestic policy options to address climate change including carbon tax, cap and trade and compulsory regulation of power plants and other sources of greenhouse gas emissions.

Reading

- R: William D. Nordhaus. The Climate Casino: Risk, Uncertainty, and Economics for a Warming World. Yale University Press. October 2013. Chapter 20: Climate-Change Policies at the National Level.

- R: Pricing Carbon: The Birth of British Columbia's Carbon Tax Case, Anjani Datla and Henry Lee, HKS Case, 2015.

- R: Ian W.H. Parry and William A. Pizer, Emissions Trading versus CO2 Taxes versus Standards, RFF: Resources for the Future, http://www.rff.org/files/sharepoint/WorkImages/Download/CPF_7_IssueBrief_5.pdf

- O: Harvard Magazine, Time to Tax Carbon: Enhancing environmental quality and economic growth. September-October 2014. http://harvardmagazine.com/2014/09/time-to-tax-carbon

- O: Designing Climate Mitigation Policy. *Journal of Economic Literature* 48(4): 903-934, with Alan J. Krupnick, Richard G. Newell, Ian W.H. Parry, and William A. Pizer, 2010. http://www.nber.org/papers/w15022.pdf?new_window=1

21 M Nov 13 Policy case study 4: Climate Adaptation—Miami-Dade county (HL)

This class will look at key questions surrounding the role of government in designing adaptation programs using Miami Dade County in Florida as a case study.

Reading

- R: HKS Case Study: Miami-Dade County and Sea Rise, Kennedy School of Government, November 2016, Case no. 2084.0

- R: Jane C. S. Long and Jeffery Greenblatt. The 80% Solution: Radical Carbon Emission Cuts for California. ISSUES IN SCIENCE AND TECHNOLOGY. Spring, 2012. http://issues.org/28-3/long-3/

- R: Desiree, A. et al (n.d.) Planning for Climate Change: Adaptation, a Primer. Planning for Climate Change Studio UAP 5794/4354. http://www.sealevelrisevirginia.net/docs/CC_workgroups/Adapt_EnvPlanningStudio_PrimerCHD-1.pdf

22 W Nov 15 Energy-climate policy in in the Obama Administration (JH)

F Nov 17 Review Class (Henry Lee)
Reviews presentations and final papers

23 M Nov 20 China's low-carbon policies (Kelly Gallagher)

24 W Nov 22 Student Presentation (HL + JH)

25 M Nov 27 Student Presentation (HL + JH)

26 W Nov 29 Student Presentation (HL + JH)

Term paper due on Friday, December 15 at noon