

Climate Change and the Future of Energy

DRAFT – NOVEMBER 13, 2017

Spring 2018

Professor Dan Esty

YID3202D

Tue/Fri 2:30 – 3:50pm

This course will examine the scientific, economic, legal, political, institutional, and historic underpinnings of climate change and the related policy challenge of developing the energy system needed to support a prosperous and sustainable modern society. Particular attention will be given to analyzing the existing framework of treaties, law, regulations, and policy -- and the incentives they create related to the build-up of greenhouse gas emissions in the atmosphere.

The course will center on a set of critical questions including: What would a 21st century policy framework designed to deliver a sustainable energy future and a successful response to climate change look like? Does the 2015 Paris Climate Change Agreement provide the right foundation for action? How should issues of equity – within countries and across nations – be addressed? How might incentives be structured to engage the business community in climate change problem solving and clean energy innovation?

Class sessions will be highly interactive – and each student will work on a team project that will explore some dimension of Singapore’s possible energy future. The readings required are extensive commensurate with the sweeping coverage of the course and include several books and a number of articles, studies, and reports that will be available on the Canvas website. Students are expected to come to each class prepared to engage in a thoughtful dialogue around critical questions – provided in italics for each class session in the syllabus below.

There are no prerequisites for this course.

Intensive week: All students enrolled in the course must participate in the “intensive” final week of class (February 26 – March 1) from 9:30 am to 4:00 pm each day. During this time, the student case teams will prepare their final presentations – and the class will undertake a series of site visits that highlight the range of energy options for the 21st century.

Grades will be based on three factors:

20% Class participation (including attendance, preparation for class, and contributions to class discussions)

20% Short written analysis assignments (two 2-page “policy memos” over the course of the semester – each 10%)

60% Final projects done in teams of 4 students – presented as a 20-slide PowerPoint deck.

Policy memo topics are provided in the syllabus for each class session. These memos should answer the question posed for that class – in the form of a memo to a decisionmaker. Although short, these memos require focused analysis, tight writing careful arguments, and citations as appropriate (endnotes can be on a third page). The essays must be submitted in Word format using 12-point type and single-spaced with double-spacing between paragraphs. The essays should be e-mailed to Professor Esty (daniel.esty@yale.edu), by midnight the night before the class for which the memo topic corresponds. The first policy essay should be completed by January 30. The second must be completed by February 20.

Each student team will be required to present its “case strategy” – presenting a pathway to the energy future for Singapore – on the final day of class (March 1).

Course Outline:

UNIT ONE

BACKGROUND

| | |
|----------------------|------------------------------------|
| January 16 – Class 1 | Climate Change and Energy Overview |
| January 19 – Class 2 | Energy Trends and Policy History |
| January 23 – Class 3 | Climate Change Science and Policy |
| January 26 – Class 4 | Global Response to Climate Change |

UNIT TWO

PATHWAYS FORWARD

| | |
|------------------------|---|
| January 30 – Class 5 | Energy Efficiency |
| February 2 – Class 6 | Natural Gas: Bridge to Sustainability or “Edge of the World” |
| February 6 – Class 7 | Renewable Energy: Options, Costs, and Benefits |
| February 9 – Class 8 | Nuclear Power |
| February 13 – Class 9 | Fossil Fuel’s Future: Carbon Capture and Sequestration, Geo-Engineering, Adaptation, and Resilience |
| February 16 – Class 10 | Clean Energy Finance and Innovation |
| February 23 – Class 11 | Private Sector Role in Delivering Solutions |
| February 26 – Class 12 | Global Sustainability: Toward a Smart Energy Future |

Course Schedule:

UNIT ONE **BACKGROUND**

January 16 **Climate Change and Energy Overview**

Why does energy matter?

Why does climate change matter?

Required Readings: Barbara Freese, COAL: A HUMAN HISTORY (chapters 1-3).

Kerry Emanuel, WHAT WE KNOW ABOUT CLIMATE CHANGE (pp. 3-93).

Daniel Yergin, THE QUEST (Introduction, Prologue, pp. 25-26, 28-29, 35-36, chapters 11-12).

Johan Rockström, *A Safe Operating Space for Humans*, 476 Nature 282

Optional Readings: Barbara Freese, COAL: A HUMAN HISTORY (skim chapters 5-9).

January 19 **Energy Trends and Policy History**

What sources of energy are most prevalent today?

How has the pattern of energy consumption changed over time?

What are the “planetary boundaries” of the Earth as a system?

What do we know about climate change? What don't we know?

Is there a global energy policy? Which nations have coherent national energy policies?

Required Readings: Sustainability Data Packet.

Al Gore, “An Inconvenient Truth” (Summary)

(http://www.ontheissues.org/Archive/Inconvenient_Truth_Al_Gore.htm) or watch Al Gore “Ted Talk: New Thinking on the Climate Crisis” (www.ted.com/talk/al_gore_on_averting_climate_crisis).

Daniel Yergin, *Hydrocarbon Man*, in THE PRIZE: THE EPIC QUEST FOR OIL, MONEY & POWER 523-542 (1990).

Amory Lovins, REINVENTING FIRE (TED talk: “A 40-year plan for energy”) (available at:

www.ted.com/talks/amory_lovins_a_50_year_plan_for_energy).

Stephen Pacala & Robert Socolow, “*Stabilization Wedges: Solving the Climate Problem for the Next Fifty years with Current Technologies*,” Science (13 August 2004) at

http://classes.atmos.colostate.edu/at760/Lectures_files/PacalaStabilizationWedges.pdf.

Gus Speth, THE BRIDGE AT THE EDGE OF THE WORLD (pp. 67- 88; skim pp. 17-66).

Yale Center for Environmental Law and Policy, 2014 Environmental Performance Index Summary for Policymakers.

Optional Readings

Katherine Michonski and Michael A. Levi, “Harnessing International Institutions to Address Climate Change,” CFR (2010), at

<http://www.cfr.org/climate-change/harnessing-international-institutions-address-climate-change/p21609>.

National Geographic, “Stabilization Wedges Guide”

http://ngm.nationalgeographic.com/2007/10/carbon-crisis/img/stabilization_wedges.pdf.

Sir Nicholas Stern, “Stern Review on the Economics of Climate Change,” at

[http://webarchive.nationalarchives.gov.uk/http://www.hm-](http://webarchive.nationalarchives.gov.uk/http://www.hm-treasury.gov.uk/sternreview_index.htm)

[treasury.gov.uk/sternreview_index.htm](http://webarchive.nationalarchives.gov.uk/http://www.hm-treasury.gov.uk/sternreview_index.htm) (read Executive Summary).

POLICY MEMO (1): Should energy policy focus on harnessing cheap energy as the key to economic competitiveness? If so, how? If not, why not?

January 23

Climate Change: Science and Policy

Why has climate change become such a big issue?

What policy initiatives have been developed to reduce greenhouse gas (GHG) emissions?

Why is climate change such a difficult policy problem?

- Readings: Garrett Hardin, *The Tragedy of the Commons*, 162 *SCIENCE* 1243-48 (1968).
- Intergovernmental Panel on Climate Change, *Summary for Policymakers*, in FIFTH ASSESSMENT REPORT, CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS 4-29 (2013).
- Jeffrey Sachs, *Planetary Boundaries*, in THE AGE OF SUSTAINABLE DEVELOPMENT 181–217 (2013).
- Robert N. Stavins, “Cap-and-Trade or a Carbon Tax?,” *The Environmental Forum*, p. 16 (January/February 2008).
- Optional Readings: President Obama’s Blueprint for a Clean and Secure Energy Future (March 2013)(available at: www.whitehouse.gov/the-press-office/2013/03/15/fact-sheet-president-obama-s-blueprint-clean-and-secure-energy-future).
- Gernot Wagner and Martin Weitzman, CLIMATE SHOCK: THE ECONOMIC CONSEQUENCES OF A HOTTER PLANET (Preface, chapters 1-3).
- POLICY MEMO: Is climate change a problem for [pick a country]? If so, why? If not, why not?

January 26

Global Response to Climate Change

What are the elements of the international climate change regime?

What policy tools have been deployed to address climate change globally? How have they worked over the past two decades?

What is new in the 2015 Paris Change Agreement?

- Required Readings: IPCC. 2014. Fifth Climate Change Assessment Report : Synthesis Report at http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf (read Summary for Policymakers).

“Paris City Hall Declaration: A decisive contribution to COP21.”

“Adapt, Curb, Engage: 21 Solutions to Protect Our Shared Planet,” Cities4Climate.

RMI. The Paris Agreement: 10 Key Takeaways For the Global Energy Landscape
http://blog.rmi.org/blog_2015_12_18_the_paris_agreement_10_key_takeaways.

Optional Readings: William Nordhaus, CLIMATE CASINO (2013) (pp. 3-66).

Decision of the Parties to the 2015 Paris Conference of the Parties (COP21).

Daniel Esty, *Bottom-Up Climate Fix*, N.Y. TIMES (Sept. 21, 2014),
<http://www.nytimes.com/2014/09/22/opinion/bottom-up-climate-fix.html>

Dan Bodansky, Enormous Challenges, Enormous Rewards: 10 Precepts for U.S. Climate Policy, (2009) at http://www.rff.org/RFF/Documents/RFF-Resources-171_10PreceptsforClimatePolicy.pdf.

Jennifer Duggan, “China makes carbon pledge ahead of Paris climate change summit,” *The Guardian*. June 30, 2015.

POLICY MEMO: Did the 2015 Paris Climate Change Agreement change the trajectory of the global response to build-up of greenhouse gas emissions? If so, how? If not, why not?

UNIT TWO **PATHWAYS FORWARD**

January 30 **Energy Efficiency**

Why is energy efficiency often a policy priority?

What programs have been used to promote energy efficiency? What has worked?

Required Readings: Amory Lovins, “Energy Strategy: The Road Not Taken?” FOREIGN AFFAIRS (October 1976).

Michael B. Gerrard, “Introduction and Overview,” in Michael B. Gerrard, ed., THE LAW OF CLEAN ENERGY: EFFICIENCY AND RENEWABLES (2011).

Optional Reading: WRI. Bottom Line on Public Private Tools for Energy Efficiency Finance
<http://www.wri.org/publication/bottom-line-public-private-finance-tools-energy-efficiency>.

POLICY MEMO: How might policymakers expand energy efficiency efforts?

February 2 **Natural Gas: Bridge to Sustainability or to “the Edge of the World”**

What are the recent trends with regard to natural gas?

What is shale gas? What is fracking? Is it safe? Is it sustainable?

Required Readings: *The Natural Gas Revolution (Ch. 16)*, in Daniel Yergin, *The Quest: Energy, Security, and the Remaking of the Modern World* (2012).

CSIS. Prospects for Shale Gas in Asia.

http://csis.org/files/publication/120824_Nakano_ProspectsShaleGas_Web.pdf

MIT. (2011). *The Future of Natural Gas*.

<http://mitei.mit.edu/publications/reports-studies/future-natural-gas>.

Mason Inman, “Natural Gas: The Fracking Fallacy,” 516 *Nature* 7529, December 3, 2014.

Optional Reading: MIT. (2007) *The Future of Coal*. <http://web.mit.edu/coal/>

POLICY MEMO: Is the shale gas boom a help or a hindrance to progress on climate change? What approach should policymakers take in dealing with shale gas?

February 6 **Renewable Energy: Options, Costs, and Benefits**

Which alternative energy source offers the most promise: Wind? Solar? Geothermal? Biomass? Fuel cells? Biofuels?

How do we decide what renewable power options to pursue? How should we decide?

Is technology development the key to progress toward a clean energy future? How should we promote innovation?

- Required Readings: RFF. Designing Renewable Energy Policies to Reduce Emissions
<http://www.rff.org/RFF/Documents/RFF-DP-12-54.pdf>.
- Richard Kauffman, “Obstacles to Renewable Energy and Energy Efficiency,”
From Silos to Systems: Issues in Clean Energy and Climate Change at
<http://environment.research.yale.edu/publication-series/5981>.
- Vinod Khosla, “Green Investing Strategies” at
<http://www.khoslaventures.com/presentations/GreenStrategy.pdf>.
- Optional Reading: Avicenne, “Present and Future Market Situation for Batteries,” at
<http://www.avicenne.com/v2/forms.asp?id=6&source=articles>.
- Greentech Media, “Why Solar Is, and Isn’t, Like the Chip Industry” at
<http://www.greentechmedia.com/articles/read/why-solar-is-and-isn't-like-the-chip-industry/>.
- MIT Technology Review, “Less May be More for Wind Turbines” at
<http://www.technologyreview.com/energy/23109/page1>.
- POLICY MEMO: What should policymakers do to promote clean energy technology development?

February 9

Nuclear Power

Why have a number of environmental advocates become pro-nuclear?

Are we on the verge of a nuclear renaissance? Does the Fukushima accident affect this prospect?

Required Readings: DANIEL YERGIN, THE QUEST (pp. 364-381).

Fred Bosselman, *The Ecological Advantages of Nuclear Power*, 15 N.Y.U. ENVTL. L.J. 1 (2007).

Optional Reading: Robert Bryce, Reactors Unplugged: Can the Decline of America’s Nuclear Sector be Stopped? *Manhattan Institute*. September 1, 2015.
<https://www.manhattan-institute.org/sites/default/files/R-RB-0915.pdf>

POLICY MEMO: What role should nuclear power play in climate change strategy?

February 13

Fossil Fuel Future: Carbon Capture and Sequestration, Geo-Engineering, Adaptation, and Resilience

Can forests sequester enough carbon to make a difference?

What can be done to protect forests? Who should do it? What is REDD?

Can carbon be “captured” as it goes up the smokestack after fossil fuel combustion?

Can we geoengineer our way out of a climate change crisis?

What role should resilience play in climate change policymaking?

Required Readings: Michael Gerrard on CCS, “Carbon Capture, Sequestration Raises Myriad Legal Issues”, NYLJ (May 23, 2008), http://apps.americanbar.org/abapubs/globalclimate/docs/Arnold-&-Porter-LLP_Carbon-Capture-Sequestration-Raises-Myriad-Legal-Issues_New-York-Law-Journal_052308.pdf.

WILLIAM NORDHAUS, CLIMATE CASINO, (chapter 13).

CBO, “Deforestation and Greenhouse Gases” (2012), (read the Executive Summary)

http://www.gcftaskforce.org/documents/CBO_deforestation_GHG.pdf.

David Victor, M. Granger Morgan, et al., *The Geoengineering Option: A Last Resort Against Global Warming?* Foreign Affairs (March/April 2009).

National Research Council, “Adapting to the Impacts of Climate Change” (2010) (summary).

Optional Reading: Mark Scott, “Companies struggle to make carbon capture viable,” *New York Times*. October 5, 2015.

Charlotte Streck, “Forests, Carbon Markets, and Avoided Deforestation: Legal Implications,” *Carbon & Climate Law Review*, pages 239-247 (March 2008).

Scott Barrett, “The incredible economics of geoengineering,” *Environmental and Resource Economics* 39:1 (2008) at 45-54.

Henry Fountain, “Panel Urges Research on Geoengineering as a Tool against Climate Change,” *New York Times*, February 10, 2015.

Ed King, “What does it mean to be climate resilient?” Climate Home, November 17, 2014. <http://www.climatechangenews.com/2014/11/10/what-does-it-mean-to-be-climate-resilient/>

POLICY MEMO: Should geo-engineering be part of a robust climate change policy program? How and why (or why not)?

February 16 **Clean Energy Finance and Innovation**

What policies best promote clean energy innovation? Who should drive the process?

Is finance for clean energy the key arena for innovation?

What is the Connecticut Green Bank? How does it work?

Why makes a “finance” approach to clean energy different from a “subsidy” policy framework?

Required Readings: CFR. Levi et al. Energy Innovation: Driving Technology Competition and Cooperation Among the United States, China, India, and Brazil
<http://www.cfr.org/innovation/energy-innovation/p23321>.

McKinsey on Sustainability & Resource Productivity, “Energy=Innovation: 10 Disruptive Technologies.”

Review the website of the CT Clean Energy Finance and Investment Authority (or “Green Bank”) (www.CTcleanenergy.com).

Hallie Kennan, *Working Paper: State Green Banks for Clean Energy*, ENERGY INNOVATION (Jan. 2014) (on YLS Inside).

Optional Reading: Gillingham, K. and J. Sweeney (2012) Barriers to Implementing Low Carbon Technologies. *Climate Change Economics*, 3(4).

Burtaw, Dallas. RFF. Technology Flexibility and Stringency for Greenhouse Gas Regulations <http://www.rff.org/RFF/Documents/RFF-DP-13-24.pdf>.

Jaffe, A., R. Newell and R. Stavins (2005) A tale of two market failures: technology and environmental policy. *Ecological Economics*, 54: 164-74.

Whitney Leonard, "Clean is the New Green: Clean Energy Finance and Deployment Through Green Banks, *Yale Law & Policy Review* (2014) 33:197-230.

Ken Berlin et al., *State Clean Energy Finance Banks: New Investment Facilities for Clean Energy Deployment*, Brookings Inst. (2012), <http://www.brookings.edu/~media/research/files/papers/2012/9/12%20state%20energy%20investment%20muro/12%20state%20energy%20investment%20muro.pdf>.

POLICY MEMO: What sort of financing mechanisms can best spur clean energy deployment?

February 23

Private Sector Role in Delivering Solutions

Has too much emphasis been put on government action as the key to climate change progress?

What can the private sector do to address climate change? What incentives are needed to promote action by the business community?

Will companies that develop climate change mitigation strategies achieve a "green to gold" breakthrough? Or will they suffer a competitive disadvantage?

Do we need to restructure the business model of utilities?

Required Readings: Daniel Esty and Andrew Winston, GREEN TO GOLD (paperback edition)(pp. 7-43).

"Carbon Copy," THE ECONOMIST 14 December 2013. Pg. 70.

Optional Reading: Assessing the Risk of Utility Investments in a Least-Cost-Planning Framework
http://nicholasinstitute.duke.edu/sites/default/files/publications/ni_wp_13-07.pdf

Heather Grady, "The Role of Private Sector Investment in Climate Change," *The Huffington Post*, September 19, 2014.

POLICY MEMO: Does private sector action offer a more promising avenue to climate change progress than government programs? How can we promote greater private sector action?

February 26 Global Sustainability: Toward a Smart Energy Future

How is the world's energy mix changing?

What impact will smart grids and microgrids have in the developed and developing world?

Required Readings: J.P. Morgan, "A Brave New World: Deep Decarbonization of Electricity Grids," *Eye on the Market*, October 19, 2015.

William D. Nordhaus, *Climate Clubs: Overcoming Free-Riding in International Climate Policy*, 105 AM. ECON. REV. 1339-41 (2015).

Jedediah Purdy, *AFTER NATURE* 11-50 (2015).

Jeffrey Sachs, *Sustainable Development Goals*, in *THE AGE OF SUSTAINABLE DEVELOPMENT*, 481-511 (2015).

Jeff St. John, "Utilities see Threat, Opportunity in Distributed Generation," *Greentech Media*, August 13, 2014.

US Department of Energy, "What is the Smart Grid"
<https://www.youtube.com/watch?v=JwRTpWZReJk>

Optional Readings: Danielle Spiegel-Feld and Katrina M. Wyman, "Power Progress," *US News*, October 14, 2015.

James Gustave Speth, *Off the Pedestal: Creating a New Vision of Economic Growth*, *YALE ENVIRONMENT* 360 (May 31, 2011),
http://e360.yale.edu/feature/off_the_pedestal_creating_a_new_vision_of_economic_growth/2409/.

Eric Niller, "Microgrids: Could Africa Become a Pioneer?" *Discovery News*, November 17, 2015.

Jeff St. John, "US Smart Grid Cybersecurity Spending to Reach \$7.25B by 2020," *Greentech Media*, April 17, 2013.

