**ENVIRON 640K & PUBPOL 585K**

# Climate Change Economics and Policy

昆山杜克大学
DUKE KUNSHAN UNIVERSITY

## Spring 2018

**Dates / course meeting time**: Tuesdays, Thursdays 8:30-9:45
**Academic credit**: 3 credits
**Course format**: Lecture

## Instructor's Information

Instructor: Billy Pizer
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Website: https://sanford.duke.edu/people/faculty/pizer-billy

Billy Pizer holds joint appointments as professor in the Sanford School of Public Policy and as a faculty fellow in the Nicholas Institute for Environmental Policy Solutions. His current research examines how public policies to promote clean energy can effectively leverage private sector investments, how environmental regulation and climate policy can affect production costs and competitiveness, and how the design of market-based environmental policies can be improved. From 2008 until 2011, he was Deputy Assistant Secretary for Environment and Energy at the U.S. Department of the Treasury, overseeing Treasury's role in the domestic and international environment and energy agenda of the United States. Prior to that, he was a researcher at Resources for the Future for more than a decade. He has written more than two dozen peer-reviewed publications, books, and articles, and holds a Ph.D. and Master's degree in economics from Harvard University and Bachelor's degree in physics from the University of North Carolina at Chapel Hill.

## What is this course about?

Global climate change is thought by many to be the most significant environmental challenge of the 21st century. Unchecked, the continued accumulation of greenhouse gases (GHGs, such as carbon dioxide and methane) over this century is projected to eventually warm the planet by about 3 to 8 °C (6 to 14 °F), with associated impacts on the environment, economy, and society. Because the emissions of greenhouse gases result from virtually every kind of economic activity -- driving a car, heating a home, operating a steel mill, raising pigs -- any policy aimed at reducing emissions will have significant and broad-based impacts on the economy.

Several economic facets of the climate change problem illustrate in part why it has been so difficult to mount a successful effort to address it:

- The climate is a global public good. GHGs mix globally, so the impacts in the United States are affected equally by emissions within and beyond its borders. This international nature of the problem raises international governance difficulties related to national sovereignty, international coordination, free-riding tendencies, and equity concerns.
- Energy consumption is central to economic growth, development, and poverty alleviation. Yet, over 80% of global energy consumption is currently derived from fossil fuels. Emissions of carbon

dioxide and methane associated with fossil fuel extraction and use are therefore ubiquitous in the global economy. There are thousands of sectors and millions of sources to confront.

- The relevant timeframe is very long. Current estimates suggest that one ton of carbon dioxide emitted into the atmosphere today will cause a relatively constant amount of warming for the next millennium. Thus decisions today affect climate change for a very long time. Issues related to intergenerational equity and long-term discounting arise.
- Yet the timeframe for making decisions is short. Energy producing and consuming technologies often involve large, long-lived capital investment. Unlike electronic devices or software that gets updated or replaced within years or even months, power plants built today might be replaced after three to ten decades, locking in significant volumes of future emissions.
- Key uncertainties are large and persistent.
    - Our estimate of the amount of climate change that arises from a given amount of cumulative emissions remains as uncertain today as it was two decades ago: Doubling carbon dioxide in the atmosphere will likely lead to something like 3° C of warming, ± 1.5° C, but with considerable uncertainty about the "tail risk" of low probability, extreme outcomes. Note that current carbon dioxide levels are about 40% above pre-industrialization.
    - The impacts of climate change are not well understood and are often difficult to value. There is no ``experiment'' where the world experiences climate change, versus when it does not. Studies of weather variation, or comparison of outcomes in hotter versus cooler regions offer the best insights. Economic valuation of these impacts requires valuing coastal inundation, storm damage, mortality, and ecosystem damage, among other amenities, both in developed as well as developing countries.
    - As noted above, impacts from today's choices occur in the future. Valuation of these future impacts require population, economic growth, and technology projections over long timeframes. There is considerable uncertainty about such projections.
    - Uncertain technological developments could make drastic and perhaps cheaper emission reductions possible in the future, or not.
- Distributional impacts could be large. There could be substantial distributional implications at household, industry, and regional levels from climate change impacts and mitigation policies. As noted above, the long time frame also implies distributional effects across generations.
- There is limited experience with policy instruments to control greenhouse gas emissions. This is an area of very active policy development at the national, state, and international levels. Economic analysis of various policy proposals is also active, both at the level of theory and empirical application.

This course will explore the economic characteristics of the climate change problem, assess national and international policy design and current implementation issues, and survey the economic tools necessary to evaluate climate change policies. The course will be discussion-oriented and will require a high degree of participation by students in the classroom.

This course satisfies one of the elective requirements for the iMEP.

## What background knowledge do I need before taking this course?

Prerequisites: One semester of microeconomics (PPS 810 or equivalent) and statistics (PPS 812 or equivalent).

## What will I learn in this course?

The objectives of the course are:
(1) to identify and analyze the economic drivers of climate change and project them into the future;

(2) to identify and measure the costs and benefits of mitigation and how to simulate costs and benefits in a numerical model;
(3) to apply economics principles to carbon pricing policies and key design questions;
(4) to define the current landscape of domestic and international policy planning and implementation.

## How will I know if I have met the objectives of this course?

There will be four assignments. All will be done in groups that will be created within 24 hours after the first class based on responses to a short questionnaire distributed at the end of the first class. The first two assignments have a significant quantitative element. The first is statistical in nature; the second makes use of an Excel-based simulation model. I would suggest each student attempt these assignments on their own before getting together to decide on a group submission.

The last two assignments are small qualitative projects focusing on (a) domestic policy and (b) other policy topics.

Each assignment will include a self- and peer-review component, where students are asked to evaluate their own contributions as well of those of other group members.

Additional details follow; more will be provided when the tasks are assigned.

**Emission Projections and Measuring Effort**
You will use historic data to construct emission forecasts for the U.S. and China using alternative models. These forecasts will be completed in two separate steps.

Having completed the forecasts, as a third and final step, you will write a brief memo assessing various forecasts using them to assess the ambition of each country's 2015 mitigation pledge. The memo can be up to 1,500 words (plus tables and figures).

**Simulation Analysis**
You will use an Excel-based integration model to examine the costs and benefits of various climate change goals. This will be completed in two steps.

In the first step you will write a short memo answering two questions: (1) How different is a 2 degree goal from the target that maximizes net benefits? (2) How does that difference change in response to key uncertainties?

In the second step you will write a short memo examining whether price or quantity targets have higher expected welfare when costs are uncertain.

Both memos can be up to 1,500 words (plus tables and figures).

**Qualitative Projects: Domestic Policy Analysis / Other Topics**
Your group will research (a) the domestic policy landscape of a key jurisdiction, and (b) a topic of group interest not sufficiently covered in class. Both projects will involve separate <4,000 reports and 20 minute oral presentations.

## How can I prepare for the class sessions to be successful?

The course will be discussion-oriented and will require a high-degree of participation by students in the classroom. Class participation is not optional. Students are expected to prepare for class by completing the assigned reading prior to the class for which they are listed, and to participate in class sessions. Please read

the newspaper (e.g., New York Times, Washington Post, Wall Street Journal), and track EENews services such as ClimateWire, EnergyWire, and E&E Daily (while at Duke, you can sign up for a free subscription at www.eenews.net). Each class will begin with a short discussion of news and you may be asked to discuss items of interest since the previous class.

In general, I will randomly call on people to answer questions.

Laptops are allowed in class for note taking and to review readings or quickly look up topics. They are not for checking email and other personal business.

## What required texts, materials, and equipment will I need?

Readings will include journal articles and book chapters drawn from the academic literature, policy-oriented publications, and government reports. Readings will be available on the internet or via Sakai. Assigned readings may be revised up until one week before class, so please check the syllabus regularly.

## What optional texts or resources might be helpful?

Useful websites:

Resources for the Future (RFF): http://www.rff.org/Focus_Areas/Pages/Energy_and_Climate.aspx

Energy Information Administration (EIA): http://www.eia.doe.gov/environment

Center for Climate and Energy Solutions (formerly Pew Center on Global Climate Change):
http://www.pewclimate.org

U.S. Environmental Protection Agency: http://www.epa.gov/climatechange/
Proposed Rule for Existing Power Plants:
http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule

Intergovernmental Panel on Climate Change: http://www.ipcc.ch/
UNFCCC portal for submissions related to the Durbin process
http://unfccc.int/bodies/awg/items/7398.php (on or before ADP 2.5, June 2014)
http://goo.gl/vzLJIm (post ADP 2.5)

## How will my grade be determined?

| Assignment | Date Assigned | Date Due | Percentage |
|---|---|---|---|
| Emission Projection | January 12 | January 23 for step 1<br>January 30 for step 2<br>February 6 for step 3 | 25 |

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| Simulation Analysis | February 7 | February 20 for step 1<br><br>February 27 for step 2 | 25 |
| Domestic Policy Analysis | February 28 | March 28 or 30 | 20 |
| International Negotiation | February 28 | April 4 or 6 | 20 |
| Class Participation | | | 10 |
| Total | | | 100 |

Your number grade will be translated into a letter grade of A, A-, B+, B, B-, or C+.
A+: 97-100 A: 93-96 A-: 90-92
B+: 87-89 B: 83-86 B-: 80-82
C+: 70-79

All assignments are due at 9am on the day indicated. Late assignments will be marked down one-third of a letter grade for each day (or part thereof) late for the first three days. Assignments that are still incomplete after five days will receive no credit unless prior arrangements are made. If you are ill or have a family emergency that prevents you from being able to complete the assignment on time, please contact the instructor by email prior to the class in which the assignment is due.

## What are the course policies?

Laptops are allowed in class for note taking and to review readings or quickly look up topics. They are not for checking email and other personal business.

All assignments are due at 9am on the day indicated. Late assignments will be marked down one-third of a letter grade for each day (or part thereof) late for the first three days. Assignments that are still incomplete after five days will receive no credit unless prior arrangements are made. If you are ill or have a family emergency that prevents you from being able to complete the assignment on time, please contact the instructor by email prior to the class in which the assignment is due.

**ACADEMIC INTEGRITY:**
Each student is bound by the academic honesty standard of the Duke Kunshan University. Its Community Standard states: "Duke Kunshan University is a community composed of individuals of diverse cultures and backgrounds. We are dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Members of this community commit to reflecting upon and upholding these principles in all academic and non-academic endeavors, and to protecting and promoting a culture of integrity and trust."

## What campus resources can help me during this course?

The instructor will need telepresence and, ideally, an RA to help manage the class on the DKU side.

## What is the expected course schedule?

**Week 1**

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| **Date** | Th 1/11 |
| **Class topic/unit name** | Costs and Benefits of Climate Change Mitigation |
| **Pre-class work for students** | **Background Reading on Climate Change Science**<br><br>Tol, Richard (2014) Climate Economics. Chapter 1.<br><br>Klein, Grady and Yoram Bauman (2014). Cartoon Introduction to Climate Change. Chapters 1-7.<br><br>IPCC (2014). Climate Change 2014: Synthesis Report. Summary for Policymakers. Pages 1-16.<br><br>Allegre (2012). No Need to Panic About Global Warming. The Wall Street Journal. January 27.<br><br>Nordhaus (2012). Why the Global Warming Skeptics Are Wrong. The New York Review of Books. March 22.<br><br>**Course Introduction and Overview**<br><br>*Goulder, Lawrence and William A. Pizer (2008). The economics of climate change. In The New Palgrave Dictionary of Economics 2nd edition. Hampshire, UK: Palgrave Macmillan.<br><br>*Nordhaus (2013). DICE 2013R: Introduction and User's Manual. Sections I and II (pages 3-6).<br><br>*Congressional Budget Office (CBO) (2003). The economics of climate change. Chapter 3 in The Economics of Climate Change: A Primer. Washington, DC: CBO. pp 1-4 required.<br><br>Lazarus, Richard (2009). Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future. Cornell Law Review 94(5). Especially pp 1153-1187.<br><br>IPCC (2004). 16 Years of Scientific Assessment in Support of the Climate Convention. Geneva: IPCC Secretariat. |
| **Planned in-class activities** | Questions for discussion:<br><br>(1) What is climate change economics? What topics does it include? |

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| | (2) What are some current issues in climate change policy?<br><br>(3) How can economics help inform policies?<br><br>(4) Why log data? |
| **Assignments due** | Assignment #1: Empirical analysis of carbon dioxide data |

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| **Date** | F 1/12 |
| **Class topic/unit name** | Extra time on manipulating data |
| **Pre-class work for students** | |
| **Planned in-class activities** | |
| **Assignments due** | |

**Week 2**

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| **Date** | T 1/16 |
| **Class topic/unit name** | What drives carbon dioxide emissions, and how do we model it? |
| **Pre-class work for students** | *Darmstadter, J. (2003). The energy-CO2 connection: A review of trends and challenges. Chapter 1 of Climate Change Economics and Policy: An RFF Anthology. Washington: RFF.<br><br>*Nordhaus (2013). DICE 2013R: Introduction and User's Manual. Sections III.B (pages 8-15).<br><br>*United States Government (2014). U.S.-China Joint Announcement on Climate Change. https://www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change.<br><br>*Francsen, Taryn, Mengpin Ge, and Thomas Damassa (2014). The China-US Climate Agreement: By the Numbers. http://www.wri.org/blog/2014/11/numbers-china-us-climate-agreement. |

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| | Tol, Richard. Climate Economics (2014). Chapter 2.<br><br>Lutter, Randall (2000). Developing Countries' Greenhouse Gas Emissiosn: Uncertainty and Implications for Participation in the Kyoto Protocol. Energy Journal 4(21). Pp. 93-120. Read Sections 3-6.<br><br>Gillingham, Kenneth, William D. Nordhaus, David Anthoff, Geoffrey Blanford, Valentina Bosetti, Peter Christensen, Haewon McJeon, John Reilly, Paul Sztorc (2015). Modeling Uncertainty in Climate Change: A Multi-Model Comparison. NBER Working Paper 21637.<br><br>IEA (2014). World Energy Outlook 2014.<br><br>IPCC (2000). Emission Scenarios: Summary for Policymakers. Geneva: IPCC.<br><br>Interagency Working Group on Social Cost of Carbon, United States Government (2010). Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis. Section III.E on socio-economic assumptions.<br><br>Parson, E. et al (2007). Global Change Scenarios: Their Development and Use. Sub-report 2.1B of Synthesis and Assessment Product 2.1 by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Department of Energy, Office of Biological &Environmental Research, Washington. Executive Summary required.<br><br>Hall, D.S. (2007). Greenhouse gas emissions and the fossil fuel supply chain in the United States. Issue Brief 1 in Assessing U.S. Climate Policy Options. Washington: RFF.<br><br>Clarke, L., J. et al (2007). Reference Scenarios. Chapter 3 of Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations. Sub-report 2.1A of Synthesis and Assessment Product 2.1 by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Department of Energy, Office of Biological &Environmental Research, Washington.<br><br>Van Vuuren, D.P et al. (2011) The representative concentration pathways: an overview. Climate Change 109.<br><br>Moss, R.H. et al. (2010). The next generation of scenarios for climate change research and assessment. Nature 463 (pp. 747-756).<br><br>Nordhaus and Boyer (1999). Roll the Dice Again, Chapter 3. Section 3. |
| **Planned in-class activities** | Questions for discussion:<br><br>(1) What drives emissions and how do we forecast them?<br><br>(2) How well can we forecast emissions?<br><br>(3) What is a "baseline" forecast? |

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| **Assignments due** | |

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| **Date** | W 1/17 |
| **Class topic/unit name** | Lab session on Stata |
| **Pre-class work for students** | |
| **Planned in-class activities** | |
| **Assignments due** | |

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| **Date** | Th 1/18 |
| **Class topic/unit name** | Impacts of climate change: What is the role of benefit-cost analysis in climate change policy versus other policy goals? |
| **Pre-class work for students** | *Clark, D. (2011). What's the target for solving climate change? The Guardian. http://www.guardian.co.uk/environment/2011/nov/14/climate-change-targets<br><br>*IPCC (1996). Applicability of techniques of cost-benefit analysis to climate change. Chapter 5 in Climate Change 1995: Economic and Social Dimensions of Climate Change. Contribution of Working Group III to the Second Assessment of the IPCC. Cambridge: Cambridge University Press. (read the summary).<br><br>*Portney, P.R. (1998). Applicability of cost-benefit analysis to climate change: In Nordhaus, ed., Economics and Policy Issues in Climate Change. Washington: RFF. pp. 111-127. (required 117-121)<br><br>*Harvey, Chelsea. (2017). Scientists have a new way to calculate what global warming costs. Trump's team isn't going to like it. Washington Post. https://www.washingtonpost.com/news/energy-environment/wp/2017/01/12/scientists-have-a-new-way-to-calculate-what-global-warming-costs-trumps-team-isnt-going-to-like-it/?utm_term=.6ddacf02136d |

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| | Stern, Nicholas (2013). The Structure of Economic Modeling of the Potential Impacts of Climate Change: Grafting Gross Underestimation of Risk onto Already Narrow Science Models. Journal of Economic Literature 51(3).<br><br>Shogren, J.F. and Michael Toman (2001). How much climate change is too much? An economics perspective. Chapter 4 in Climate Change Economics and Policy: An RFF Anthology.<br><br>Heinzerling, L. (2010).Why care about the polar bear?: economic analysis of natural resources law and policy. The Evolution of Natural Resources Law and Policy. 53-76.<br><br>Friedman, T.L. (2009). Going Cheney on climate. The New York Times. http://www.nytimes.com/2009/12/09/opinion/09friedman.html |
| **Planned in-class activities** | Questions<br><br>(1) How should we answer the fundamental question of "how much" mitigation to pursue?<br><br>(2) What are the challenges to current CBA of climate change?<br><br>(3) How does CBA fit into the scheme of climate change policy choices? |
| **Assignments due** | Assignment #1 part I due at 9am M 1/22 |

***Week 3***

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| **Date** | T 1/23 |
| **Class topic/unit name** | More on modeling the natural trajectory of carbon dioxide emissions:<br><br>The Environmental Kousnetz Curve (EKC). |
| **Pre-class work for students** | *Levinson, Arik (2008). Environmental Kuznets Curve. In The New Palgrave Dictionary of Economics 2nd edition. Hampshire, UK: Palgrave Macmillan.<br><br>*Holtz-Eakin, D. and T. Seldon (1995). Stoking the fires? CO2 emissions and economic growth. Journal of Public Economics 57(1):85-101. (mainly, 85-92).<br><br>Schmalensee, Richard, Thomas M. Stoker, and Ruth A. Judson (1998). World carbon dioxide emissions: 1950–2050. Review of Economics and Statistics 80(1): 15-27.<br><br>Stern, David (2004). The rise and fall of the environmental Kuznets curve. World Development 32(8). pp 1419-1439.<br><br>Dinda, Soumyananda (2004). Environmental Kuznets Curve Hypothesis: A Survey. Ecological Economics 49. Pp 431-455. |

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| | Brock, WA and MS Taylor (2005). Economic Growth and the Environment: A Review of Theory and Empirics. In Aghion and Durlauf, eds, Handbook of Economic Growth. |
| **Planned in-class activities** | Questions<br><br>(1) What is the EKC?<br><br>(2) What is the evidence with regard to carbon dioxide?<br><br>(3) What is the implication for policy?<br><br>(4) Is it a good model? |
| **Assignments due** | |

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| **Date** | Th 1/25 |
| **Class topic/unit name** | The Paris Agreement: What are we getting? |
| **Pre-class work for students** | *UNFCCC (2004). "The First Ten Years." p. 12-17.<br><br>*Climate Group (2011). UNFCCC Timeline<br><br>*C2ES (2016). Outcomes of the UN Climate Change Conference in Paris.<br><br>*Aldy et al. (2016). Economic tools to promote transparency and comparability in the Paris Agreement. Nature Climate Change.<br><br>Aldy, J. and R. Stavins (2008). Climate Policy Architectures for the Post-Kyoto World. Environment.*<br><br>Sunstein, Cass (2007). "Of Montreal and Kyoto: A tale of two protocols," Harvard Environmental Law Review 31, pp. 1-29.<br><br>UNFCCC (2011). Establishment of an Ad Hoc Working Group on the Durban Platform for Enhanced Action. Draft decision -/CP.17. Geneva: UNFCCC.<br><br><Durban paper by Rajamani><br><br>Diringer (2013). A patchwork of emission cuts. Nature.<br><br>C2ES (2014). Outcomes of the U.N. Climate Change Conference in Lima.<br><br>Levi, Michael (2011). A Misplaced Climate Celebration In Durban. http://blogs.cfr.org/levi/2011/12/11/a-misplaced-climate-celebration-in-durban/<br><br>Houser, Trevor (2011). Dissecting Durban. http://rhgroup.net/notes/dissecting-durban |

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| | Council on Foreign Relations (2007). Confronting Climate Change: A Strategy for U.S. Foreign Policy. Washington: CFR. Executive summary required. |
| **Planned in-class activities** | Questions:<br><br>(1) What is the UNFCCC and how did it get started?<br><br>(2) What are "differentiated responsibilities"?<br><br>(3) What does the Paris Agreement require and how does it differ from the UNFCCC?<br><br>(4) Why does comparability of effort matter, and what is its role in the Paris Agreement? |
| **Assignments due** | Assignment #1 part II due at 9am M 1/29 |

***Week 4***

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| **Date** | T 1/30 |
| **Class topic/unit name** | Introduction to mitigation cost |
| **Pre-class work for students** | *Per-Anders Enkvist, Tomas Nauclér, and Jerker Rosander (2007). A cost curve for greenhouse gas reduction. McKinsey Quarterly.<br><br>*Weyant and Hill (1999). Introduction and Overview. Kyoto Protocol Special Issue of Energy Journal. Pp xix-xxii.<br><br>*Ross, M (2007). Documentation of the Applied Dynamic Analysis of the Global Economy (ADAGE) Model. Pp 19-28.<br><br>McKinsey & Company (2010). Impact of the financial crisis on carbon economics. Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve.<br><br>Weyant, J.P. (2000). An introduction to the economics of climate change policy. Report prepared for the Pew Center on Global Climate Change. Arlington. Section III, pp. 8-29.<br><br>IPCC (2014). Climate Change 2014: Mitigation of Climate Change. Section 6.3.6.1-6.3.6.2. Also look at Table 6.2, 6.3, Figure 6.7, 6.15.<br><br>IPCC (2014). Technical Summary in: Climate Change 2014: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Section 3.1. |

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| | Clarke. L.J. et al (2009). International climate policy architectures: Overview of the EMF 22 international scenarios. Energy Economics 31. pp S64-S81.<br><br>Clarke, L., J. et al (2007). Technical Summary. Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations. Sub-report 2.1A of Synthesis and Assessment Product 2.1 by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Department of Energy, Office of Biological &Environmental Research, Washington. |
| **Planned in-class activities** | Questions:<br><br>(1) How are the McKinsey cost curves constructed?<br><br>(2) How does this compare to the various approaches to modeling emissions and emission mitigation described by Weyant and Hill?<br><br>(3) How would you classify the ADAGE model? Where are all the different points emissions and/or emission mitigation can occur? |
| **Assignments due** | |

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| **Date** | Th 2/1 |
| **Class topic/unit name** | How mitigation cost models are used |
| **Pre-class work for students** | *EPA (2014). Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants. Pages ES1-9.<br><br>*Aldy, J.E. (2007). Assessing the costs of regulatory proposals for reducing U.S. greenhouse gas emissions. Issue Brief 3 in Assessing U.S. Climate Policy Options. Washington: RFF.<br><br>*Wigley, Richels and Edmonds (1996). Economic and environmental choices in the stabilization of atmospheric CO2 concentrations. Nature.<br><br>Newell, R.G. and D. Hall (2007). U.S. mitigation in the context of global stabilization. Issue Brief 2 in Assessing U.S. Climate Policy Options. Washington: RFF. <EMF-22 instead><br><br>McKinsey & Company (2009). Pathways to a Low-Carbon Economy. Version 2 of the Global Greenhouse Gas Abatement Cost Curve.<br><br>EIA (2013). Electricity Market Module. |

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| | EIA (2010). Energy Market and Economic Impacts of the American Power Act of 2010. Washington: EIA.<br><br>EPA (2009). EPA Analysis of the American Clean Energy and Security Act of 2009 H.R. 2454 in the 111th Congress. Washington: EPA. |
| **Planned in-class activities** | Questions for discussion:<br><br>(1) How are cost models used in the RIA?<br><br>(2) How would you contrast this with the use of models in the Aldy Issue Brief?<br><br>(3) Mitigation cost models are lurking in the background of the Wigley, Richels, and Edmonds paper. What are they using those models to argue?<br><br>(4) What would be some important differences among the kinds of models used in the aforementioned articles? |
| **Assignments due** | Assignment #1 part III due at 9am M 2/6 |

***Week 5***

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| **Date** | T 2/6 |
| **Class topic/unit name** | If benefit-cost, how do we monetize mitigation benefits? |
| **Pre-class work for students** | *Tol, Richard S.J. (2009). The Economics Effects of Climate Change, Journal of Economic Perspecitves 23(2). P 29-51.<br><br>*National Research Council (2010). "Climate change," Chapter 5 of Hidden Costs of Energy. Pp 294-308.<br><br>*Interagency Working Group on Social Cost of Carbon, United States Government (2013). Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis. Executive Summary.<br><br>Rose, Steven, Delavane Turner, Geoffrey Blanchard, John Bistline, Francisco de la Chesnaye, Tom Watson (2014). Understanding the Social Cost of Carbon: A Technical Assessment. Executive Summary. Palo Alto: Electric Power Research Institute.<br><br>Tol, R.S.J. (2005). The marginal damage of carbon dioxide emissions: An assessment of the uncertainties. Energy Policy 33: 2064-2074.<br><br>Tol, R.S.J., S. Fankhauser, R.g. Richels, and J.B. Smith (2000). How much damage will climate change do? Recent estimates. World Economics 1(4): 179-206. |

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| | IPCC (1996). The social costs of climate change: Greenhouse damages and the benefits of control. Chapter 6 in Climate Change 1995: Economic and Social Dimensions of Climate Change. Contribution of Working Group III to the Second Assessment of the IPCC. Cambridge: Cambridge University Press. Pp 179-209 (section on regional/country-level impacts can be skimmed).<br><br>Smith, J.B. (2004). A Synthesis of Potential Climate Impacts on the U.S. Washington: Pew Center on Global Climate Change. Executive summary required.<br><br>Tol, R.S.J. (2007). The social cost of carbon: Trends, outliers and catastrophes. Working paper, Economic and Social Research Institute, Dublin. |
| **Planned in-class activities** | |
| **Assignments due** | Assignment #2: Simulation analysis with DICE |

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| **Date** | Th 2/8 |
| **Class topic/unit name** | More details on benefit modeling |
| **Pre-class work for students** | *Nordhaus and Boyer (1999). "Impacts of Climate Change", Chapter 4 of Roll the DICE Again: Economic Models of Global Warming.<br><br>*Moore, F.C. and Delavane Diaz (2015). Temperature impacts on economic growth warrant stringent mitigation policy. Nature Climate Change 2481.<br><br>*Pizer, W. et al (2014). Using and improving the social cost of carbon. Science 346(6214). Pp 1189-1190.<br><br>Interagency Working Group on Social Cost of Carbon, United States Government (2010). Appendix 15a. Social cost of carbon for regulatory impact analysis under executive order 12866. Washington. Section 15.A.4.<br><br>Dell, Melissa, Benjamin Jones, and Benjamin Olken (2012). Temperature Shocks and Economic Growth: Evidence from the Last Half Century. American Economic Journal: Macroeconomics 4(3). Pp 66-95.<br><br>EPA Slides (2013).<br><br>Nordhaus (2010). Economic aspects of global warming in a post-Copenhagen environment. PNAS 107(26). Pp 11721-11726. |

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| | Deschênes, Olivier, and Michael Greenstone. 2011. "Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the US." American Economic Journal: Applied Economics, 3(4): 152–85. |
| **Planned in-class activities** | |
| **Assignments due** | |

***Week 6***

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| **Date** | T 2/13 |
| **Class topic/unit name** | Discounting future generations (and intrageneration equity) |
| **Pre-class work for students** | *Arrow K., M. Cropper, C. Gollier, B. Groom, G. Heal, R. Newell, W. Nordhaus, R. Pindyck, W. Pizer, P. Portney, T. Sterner, R. S. J. Tol, M. Weitzman (2013). Determining Benefits and Costs for Future Generations. Science 341(6144). Pp 349-350.<br><br>*Newell, R.G. and W.A. Pizer (2001). Discounting the Benefits of Climate Change Mitigation: How Much Do Uncertain Rates Increase Valuations? Report prepared for the Pew Center on Global Climate Change. Arlington. pp 1-26 required.<br><br>*United States Environmental Protection Agency (2010). "Guidelines for Preparing for Economic Analyses." Chapter 6: Discounting Future Benefits and Costs.<br><br>IPCC (1996). Intergenerational equity and discounting. Chapter 4 in Climate Change 1995: Economic and Social Dimensions of Climate Change. Contribution of Working Group III to the Second Assessment of the IPCC. Cambridge: Cambridge University Press. pp 129-144.<br><br>"Discount Rates." Interagency Working Group on Social Cost of Carbon, United States Government. pp 18-24.<br><br>Nordhaus, W.D. (2007). A review of the Stern Review on the Economics of Climate Change. Journal of Economic Literautre 45: 686-702.<br><br>OMB (2003). Circular A-4. Regulatory Analysis (9/17/2003). pp 31-37. http://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/a-4.pdf.<br><br>Moore, M.A. et al (2004). "Just give me a number!" Practical values for the social discount rate. Journal of Policy Analysis and Management 23(4): 789-812. |

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| **Planned in-class activities** | Questions:<br><br>1. What are the different ways to explain the discount rate and/or come up with a number?<br><br>2. Why are taxes important?<br><br>3. Why does uncertainty matter? |
| **Assignments due** | |

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| **Date** | Th 2/15 |
| **Class topic/unit name** | Economics of catastrophic risk |
| **Pre-class work for students** | *Nordhaus, W.D. (2011). The Economics of Tail Events with an Application to Climate Change. Review of Environmental Economics and Statistics 5(2). pp 240-257<br><br>Nordhaus, William (2008). Question of balance: Economic Modelling of Global Warming pp 30-45 and 205-208.<br><br>Pindyck, R.S. (2011). Fat Tails, Thin Tails, and Climate Change Policy. Review of Environmental Economics and Statistics 5(2). pp 258-274<br><br>Weitzman, M.L. (2011). Fat-Tailed Uncertainty in the Economics of Catastrophic Climate Change. Review of Environmental Economics and Statistics 5(2). pp 275-292<br><br>IPCC (1996). Decision making frameworks for addressing climate change. Chapter 2 in Climate Change 1995: Economic and Social Dimensions of Climate Change. Contribution of Working Group III to the Second Assessment of the IPCC. Cambridge: Cambridge University Press.<br><br>CBO (2005). Uncertainty and analyizing climate change: Policy implications. Washington. |
| **Planned in-class activities** | |
| **Assignments due** | Assignment #3: Simulation analysis 2 with DICE<br><br>Assignment #2 part I due at 9am M 2/19 |

***Week 7***

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| **Date** | T 2/20 |

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| **Class topic/unit name** | Taxes and Cap & Trade |
| **Pre-class work for students** | *Gruber, J. Distinctions Between Price and Quantity Approaches to Addressing Externalities. Section 5.4 in Public Finance and Public Policy.<br><br>*Aldy, J.E. and W.A. Pizer (2009). Issues in Designing U.S. Climate Change Policy. Energy Journal 30(3). **read pages 179-191**<br><br>*Center for Climate and Energy Solutions (2013). Options and Considerations for a Federal Carbon Tax. Washington: C2ES. **read pages 1-6**<br><br>*Mooney and Eilpren (2017). Senior Republican statesmen propose replacing Obama's climate policies with a carbon tax. NYT February 8.<br><br>World Bank (2014). State and Trends of Carbon Pricing. Washington: World Bank. Executive Summary.<br><br>Summers, L. (2015). Let this be the year when we put a proper price on carbon. London: Financial Times. January 4.<br><br>Parry, I.W.H. and W.A. Pizer (2007). Emissions Trading versus CO2 Taxes versus Standards. Assessing U.S. Climate Policy Options. Washington: RFF.<br><br>Ellerman, A.D. and Paul Joskow (2008). The European Union's Emissions Trading System in perspective. Washington: Pew Center. pp 1-11 required; skim other sections.<br><br>Center for Climate and Energy Solutions (C2ES) (2011). Australia's Carbon Pricing Mechanism. Washington: C2ES.<br><br>Center for Climate and Energy Solutions (C2ES) (2011). Market Mechanisms: Understanding the Options. Washington: C2ES.<br><br>Holtz-Eakin, Douglas (2011). Beware Liberals Bearing Miracle Cures: Blinder's Case for a Carbon Tax. National Review Online. January 31.<br><br>Blinder, Alan (2011). The Carbon Tax Miracle Cure. Wall Street Journal. January 31.<br><br>D'Andrea Tyson, Laura (2013). The Myriad Benefits of a Carbon Tax. http://economix.blogs.nytimes.com/2013/06/28/the-myriad-benefits-of-a-carbon-tax/<br><br>Mankiw, N. Gregory (2013). A Carbon Tax That America Could Live With. http://www.nytimes.com/2013/09/01/business/a-carbon-tax-that-america-could-live-with.html<br><br>Waxman, Henry, Sherwood Boehlert, Edward J. Markey and Wayne Gilchrest (2012). Carbon emission policy could slash debt, improve environment. Washington Post. February 23. |

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| | Metcalf, Gilbert (2007). A proposal for a U.S. carbon tax swap. Washington: The Brooking Institution. |
| **Planned in-class activities** | |
| **Assignments due** | |

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| **Date** | Th 2/22 |
| **Class topic/unit name** | Emission allowance allocation, cost distribution, and revenue disposition |
| **Pre-class work for students** | *Stavins (2009). The Wonderful Politics of Cap-and-Trade: A Closer Look at Waxman-Markey. http://www.robertstavinsblog.org/2009/05/27/the-wonderful-politics-of-cap-and-trade-a-closer-look-at-waxman-markey/<br><br>*Blonz, Joshua, Dallas Burtraw, and Margaret A. Walls (2010). Climate Policy's Uncertain Outcomes for Households: The Role of Complex Allocation Schemes in Cap-and-Trade. BEJ Econ Analysis and Policy. **Examine and interpret figures 1 and 3**.<br><br>*David Roberts (2016). The left vs. a carbon tax. Vox. http://www.vox.com/2016/10/18/13012394/i-732-carbon-tax-washington<br><br>*Parry, I.W.H. (2001). Revenue recycling and the cost of reducing carbon emissions. Chapter 11 in: M.A. Toman, ed: Climate Change Economics and Policy: An RFF Anthology. Washington, RFF. **pages 119-124**<br><br>U.S.E.P.A. (2014). Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants. Section 3.7.7-3.7.10 (p. 3-36 to 3-43).<br><br>Blonz, Joshua, Dallas Burtraw, and Margaret A. Walls (2011). How do the costs of climate policy affect households? The distribution of impacts by age, income, and region. RFF DP 10-55. Washington, RFF. Sections 1-2 required.<br><br>Waxman and Markey (2009). Proposed Allowance Allocation. http://democrats.energycommerce.house.gov/Press_111/20090515/allowanceallocation.pdf<br><br>Kopp, R.J. (2007). Allowance allocation. Issue Brief 6 in Assessing U.S. Climate Policy Options. Washington: RFF. |

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| | Goulder, L.H. 2001. Confronting the adverse industry impacts of CO2 abatement policies: What does it cost? Chapter 12 in: M.A. Toman, ed: Climate Change Economics and Policy: An RFF Anthology. Washington, RFF.<br><br>Pizer, William A., Sanchirico, James N. and Batz, Michael B. 2009. Regional Patterns of U.S. Household Carbon Emissions. Climatic Change, September 2009. Available at SSRN: http://ssrn.com/abstract=1480408<br><br>National Commission on Energy Policy (2007). Allocating allowances in a greenhouse gas trading system. Washington: NCEP.<br><br>Blonz, Burtraw, Walls (2010). RFF DP 10-12-REV |
| **Planned in-class activities** | |
| **Assignments due** | Assignment #2 part II due at 9am M 2/26 |

***Week 8***

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|---|---|
| **Date** | T 2/27 |
| **Class topic/unit name** | Competitiveness impacts and approaches |
| **Pre-class work for students** | *Fischer, Carolyn and Alan Fox (2011). Comparing Policies to Combat Emissions Leakage. http://www.rff.org/rff/documents/rff-dp-09-02-rev.pdf<br><br>*Interagency Competitiveness Analysis Team. (2009). The effects of H.R. 2454 on international competitiveness and emission leakage in energy-intensive trade-exposed industries, from http://www.epa.gov/climatechange/economics/pdfs/InteragencyReport_Competitiveness-EmissionLeakage.pdf. Executive summary, Sections VI-VII.<br><br>*Stavins (2009). Worried About International Competitiveness? Another Look at the Waxman-Markey Cap-and-Trade Proposal. http://www.robertstavinsblog.org/2009/06/18/climate-cap-and-trade-and-international-competitiveness-another-look-under-the-hood-of-waxman-markey/<br><br>Morgenstern, R.D. et al. (2007). Competitiveness impacts of carbon dioxide pricing policies on manufacturing. Issue Brief 7 in Assessing U.S. Climate Policy Options. Washington: RFF. |

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| | Morgenstern, R.D. (2007). Addressing competitiveness concerns in the context of mandatory policy for reducing U.S. greenhouse gas emissions. Issue Brief 8 in Assessing U.S. Climate Policy Options. Washington: RFF.<br><br>Pauwelyn, Joost (2007). U.S. federal climate policy and competitiveness concerns: The limits and options of international trade law. Durham: Nicholas Institute for Environmental Policy Solutions. |
| **Planned in-class activities** | |
| **Assignments due** | Assignment #3 & 4: Domestic Policy and Other Topics |

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| **Date** | Th 3/1 |
| **Class topic/unit name** | TBD |
| **Pre-class work for students** | |
| **Planned in-class activities** | |
| **Assignments due** | |

***Week 9***

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|---|---|
| **Date** | T 3/6 |
| **Class topic/unit name** | Offsets and linking |
| **Pre-class work for students** | *Hall, D.S. (2007). Offsets: incentivizing reductions while managing uncertainty and ensuring integrity. Issue Brief 15 in Assessing U.S. Climate Policy Options. Washington: RFF.<br><br>*Ranson, Matthew and Robert Stavins (2015). Linkage of Greenhouse Gas Emissions Trading Systems: Learning from Experience. Climate Policy |

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| | *Mansell, Anthony (2016). What's ahead for carbon markets after COP21? http://www.ictsd.org/bridges-news/biores/news/what%E2%80%99s-ahead-for-carbon-markets-after-cop21.<br><br>Pizer, W. and A. Yates (2014). Terminating Links Between Emission Trading Programs. NBER Working Paper 20393. Pages 1-7 (introduction and history).<br><br>CCAP (2012). NAMAs and the Clean Development Mechanism (CDM): An Overview.<br><br>Vivid Economics (2013). The market impact of a CDM capacity fund<br><br>Richards, Kenneth and Krister Andersson (2001). The leaky sink: Persistent obstacles to a forest carbon sequestration program based on individual projects. Climate Policy 1:41-54.<br><br>Siikamäki, J. and J. Maher (2007). Climate change and U.S. agriculture. Issue Brief 13 in Assessing U.S. Climate Policy Options. Washington: RFF.<br><br>Trexler, Mark, et al (2006). A stastically-driven approach to offset-based GHG additionality determinations. Sustainable Development Law & Policy 6(2):30-40. |
| **Planned in-class activities** | |
| **Assignments due** | |

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|---|---|
| **Date** | Th 3/8 |
| **Class topic/unit name** | Subsidized Finance |
| **Pre-class work for students** | *Newell, Richard (2007). Climate Technology Deployment Policy. Assessing U.S. Climate Policy Options. Washington: RFF. Pages 140-145 (on subsidies and limited liability).<br><br>*Metcalf, Gilbert (2009). Tax Policies for Low-Carbon Technologies. National Tax Journal 62(3). pp 519-533 (intro and conclusion).<br><br>*EIA (2015). Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013. Washington: EIA. Executive summary tables ES2, ES4, figure ES1.<br><br>*GCF (2015). 3 minute brief on the green climate fund.<br><br>Allaire M., and S. Brown (2012). U.S. Energy Subsidies: Effects on Energy Markets and Carbon Dioxide Emissions. |

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| | Aldy, JE (2013). A Preliminary Assessment of the American Recovery and Reinvestment Act's Clean Energy Package. Review of Environmental Economics and Policy.<br><br>Miller, Daniel (2014). What is the Coalition's direct action climate change policy? ABC News. http://www.abc.net.au/news/2013-12-20/coalition-climate-change-direct-action-policy-explained/5067188. Accessed February 17, 2015. |
| **Planned in-class activities** | |
| **Assignments due** | |

***Week 11: Spring Break***

***Week 11***

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|---|---|
| **Date** | T 3/20 |
| **Class topic/unit name** | Power Sector Policies |
| **Pre-class work for students** | *Palmer, K.L. and D. Burtraw (2007). The electricity sector and climate policy. Issue Brief 11 in Assessing U.S. Climate Policy Options. Washington: RFF.<br><br>*US EPA (2015). Fact Sheet: Overview of the Clean Power Plan<br><br>*Committee on Energy and Natural Resources, US Senate (2012). The Clean Energy Standard Act Of 2012, two-page summary.<br><br>Aldy, J.E. (2011). Promoting clean energy in the American power sector. Hamilton Project Discussion Paper 2011-04. Washington: Brookings.<br><br>US EPA (2014). Proposed Rule: Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units. Executive Summary p. 34832-34841.<br><br>Larsen et al (2014). Remaking American Power. CSIS<br><br>Aarons (2014). Carbon Pollution Standards for Existing Power Plants: Key Challenges. C2ES.<br><br>Fowlie et al (2014). An economic perspective on the EPA's Clean Power Plan. Science. |
| **Planned in-class activities** | |

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| **Assignments due** | |

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| **Date** | Th 3/22 |
| **Class topic/unit name** | Transportation Sector Policies |
| **Pre-class work for students** | *Kopp, R.J. (2007). Transport Policies to Reduce Emissions from the Light-Duty Vehicle Fleet. Issue Brief 12 in Assessing U.S. Climate Policy Options. Washington: RFF.<br><br>*C2ES (2017). Federal Vehicle Standards. https://www.c2es.org/federal/executive/vehicle-standards#timeline<br><br>*Lade and Lowell (2015). First 3 pages. |
| **Planned in-class activities** | |
| **Assignments due** | |

***Week 12***

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| **Date** | T 3/27 |
| **Class topic/unit name** | Adaptation / TBD |
| **Pre-class work for students** | *Bierbaum et al (2013). A comprehensive review of climate adaptation in the United States: more than before, but less than needed. Mitigation and Adaptation Strategies for Climate Change.<br><br>*World Bank (2010). "Reducing Human Vulnerability: Helping People Help Themselves" Chapter 2 in World Development Report: Development and Climate Change.<br><br>*Agrawala et al (2010). "Plan or React? Analysis of Adaptation Costs and Benefits Using Integrated Assessment Models", OECD Environment Working Papers, No. 23, OECD Publishing. http://dx.doi.org/10.1787/5km975m3d5hb-en Sections 1-3 |

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| | Shardul Agrawala and Samuel Fankhauser (2008). Economic Aspects of Adaptation to Climate Change: Costs, Benefits and Policy Instruments. Paris: OECD. Read executive summary.<br><br>de Bruin, K., R. Dellink and S. Agrawala (2009), "Economic Aspects of Adaptation to Climate Change: Integrated Assessment Modelling of Adaptation Costs and Benefits", OECD Environment Working Papers, No. 6, OECD Publishing. Read abstract and sections 1 & 2.<br><br>Cruce, Terri L. (2009). Adaptation Planning – What U.S. States and Localities are Doing. C2ES.<br><br>White House Council on Environmental Quality (2010). Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy. |
| **Planned in-class activities** | |
| **Assignments due** | |

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| **Date** | Th 3/29 |
| **Class topic/unit name** | Guest Talk<br><br>Brian Prest: TBD |
| **Pre-class work for students** | |
| **Planned in-class activities** | |
| **Assignments due** | |

***Week 13***

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| **Date** | T 4/3 |
| **Class topic/unit name** | Domestic Policies in Other Countries / Jurisdictions |

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| **Pre-class work for students** | |
| **Planned in-class activities** | |
| **Assignments due** | |

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| **Date** | Th 4/5 |
| **Class topic/unit name** | Guest Talk<br><br>Jonathan Wiener: Legal aspects of US federal climate change policy |
| **Pre-class work for students** | |
| **Planned in-class activities** | |
| **Assignments due** | |

***Week 14***

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|---|---|
| **Date** | T 4/10 |
| **Class topic/unit name** | Domestic Policies in Other Countries / Jurisdictions |
| **Pre-class work for students** | |
| **Planned in-class activities** | |
| **Assignments due** | |

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|---|---|
| **Date** | Th 4/12 |
| **Class topic/unit name** | Other topics |
| **Pre-class work for students** | |
| **Planned in-class activities** | |
| **Assignments due** | |

***Week 15***

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|---|---|
| **Date** | T 4/18 |
| **Class topic/unit name** | Other topics |
| **Pre-class work for students** | |
| **Planned in-class activities** | |
| **Assignments due** | |