**Climate Change and the Energy Transition**

Geoffrey Heal

Fall Semester 2021, B term

Office hours: by appointment.

**Overview.**

About 80% of the greenhouse gases (primarily carbon dioxide and methane) that drive climate change are emitted as a result of the use of fossil fuels (coal, oil and gas). Minimizing climate change will therefore require that societies move away from fossil fuels in most of their applications, the most important of which are electricity generation, transportation and heating. This transition from fossil fuels to alternatives such as renewable energy and nuclear power poses substantial challenges and also offers once-in-a-lifetime opportunities to the business world. These challenges and opportunities are the topic of this class.

**Schedule of classes:**

1. **Climate change overview**
   1. The drivers of climate change
   2. The Paris Agreement
   3. Implications of 1.5 – 2C target: is it attainable?
   4. Carbon budgets and carbon offsests

Readings 1, 2

1. **Consequences of climate change**
   1. Sea level rise
   2. Storms
   3. Agriculture
   4. Temperature
   5. Oceans
   6. Health

Readings 2, 5, 7, 9, 10

1. **Current energy scene** 
   1. The economics of coal, oil and gas

Reading 3

1. **Current energy scene**
   1. Oil and gas (continued)
   2. Nuclear and others: economics and safety
2. **Economics of Renewable Energy**
   1. Solar
   2. Wind

Readings: 8, 12

1. **Energy storage: Batteries and Hydrogen**

Reading 13, 17, 19

1. **Utility Business Model**
   1. Adapting to distributed generation and storage
   2. Adapting to intermittency
2. **Energy Transition – power generation**
   1. How much investment is needed in capacity, storage and grid expansion?
   2. What are the savings from moving to renewable energy?

Reading 4, 16,

1. **Energy Transition – transportation**

Reading 14, 15, 16

1. **Energy Transition – heating**
   1. New York City’s Local Law 97
   2. Outside speaker Donnel Baird of BlocPower

Reading 18

1. **Carbon capture and storage**
   1. CCS and direct air capture – economics and technology
   2. The role of negative emissions in attaining the Paris targets
   3. Outside speaker Julio Friedman of Columbia Center on Global Energy Policy

Reading 11

1. **What are companies doing about the energy transition?**

Many companies have pledged to go “carbon neutral” by mid-century: what does this mean, how will they do this, and why are they doing this? Some plan to use carbon offsets, some carbon capture and storage and some plan changes to their input and output mixes. We will examine case studies of corporate emission reductions, and discuss whether these pledges are important from the perspective of overall emissions. Do they contribute to the attainment of the 2015 Paris targets? (Cases will be available by the start of the course.)

Reading 20

Reading

Overall background reading item 1 below

1. Geoffrey Heal, *Endangered Economies: How the Neglect of Nature Threatens Our Prosperity*, Chapters 1 to 5
2. IPCC, *Special Report on Warming of 1.5C* <https://www.ipcc.ch/sr15/chapter/spm/>
3. David MacKay, *Sustainable Energy – Without Hot Air* Chapters 1 & 2. <https://www.withouthotair.com/download.html>
4. Geoffrey Heal, *The Cost of a Carbon-Free Electricity System in the US,* NBER Working Paper, <https://www.nber.org/papers/w26084>
5. Solomon Hsiang, Michael Greenstone, et al., *American Climate Prospectus: Economic Risks in the United States*. <https://rhg.com/research/american-climate-prospectus-economic-risks-in-the-united-states/>
6. Sandia National Laboratory, *Assessing the Near-Term Risk of Climate Uncertainty*, <https://cfwebprod.sandia.gov/cfdocs/CompResearch/docs/Climate_Risk_Assessment.pdf>
7. Geoffrey Heal and Marco Tedesco. *Rising Oceans: Economics and Science*
8. Bruce Usher. *Renewable Energy: A Primer for the Twenty-First Century.*
9. Gernot Wagner and Martin Weitzman (2015). *Climate Shock: The Economic Consequences of a Hotter Planet.* Princeton University Press
10. Michael Oppenheimer and Richard Alley, *How Hight Will Sea Level Rise?* Science, 16 December 2016, Vol 354 Issue 6318 Pages 1375-6
11. Julio Friedman. *Examining the Development and Deployment of Large-Scale Carbon Dioxide Management Technologies*, <https://www.energypolicy.columbia.edu/research/testimony/examining-development-and-deployment-large-scale-carbon-dioxide-management-technologies>
12. Geoffrey Heal and Bruce Usher, *Ørsted’s Offshore Wind Farms*, Columbia Case Works 210304
13. Geoffrey Heal and Bruce Usher, *ELP Greenport Solar*, Columbia Case Works 210305
14. Geoffrey Heal and Bruce Usher, *Architects of the Future? Tesla, Energy, Transportation and the Climate*. Columbia Case Works 170306
15. EVVolumes.com *Global Plug-In Vehicle Sales Reached 3.2m in 2020*
16. Simon Sharpe and Timothy Lenton. *Upscaling tipping cascades to meet climate goals: plausible grounds for hope*. Climate Policy, DOI: [10.1080/14693062.2020.1870097](https://doi.org/10.1080/14693062.2020.1870097)
17. International Energy Agency, *The Future of Hydrogen: Seizing today’s opportunities*. <https://webstore.iea.org/download/direct/2803>
18. Noah Kauffman, David Sandalow, Clothilde deSchio and Jake Higdon. *Decarbonizing space heating with air source heat pumps*. Center on Global Energy Policy, Columbia. <https://www.energypolicy.columbia.edu/research/report/decarbonizing-space-heating-air-source-heat-pumps>
19. [Hydrogen – its role in the UK economy. Nigel Brandon. On youTube at](https://www.youtube.com/watch?v=Z_1ekMoVBVI) <https://www.youtube.com/watch?v=Z_1ekMoVBVI>
20. [Microsoft carbon removal – Lessons from an early corporate purchase](https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE4MDlc)

All of the above will be on Canvas, and additional reading will also be available on Canvas.

**Assessment.**

There are three elements to the assessment: **the first two are to be completed individually and the third in groups of not more than three**. All three items are due by December 15th, 2021. Each item is worth 30% of the final grade and class participation counts for 10%.

1. Item 4 on the reading [Geoffrey Heal, *The Cost of a Carbon-Free Electricity System in the US,* NBER Working Paper] list calculates the cost of replacing fossil fuel electricity generators with renewable energy sources. Using the spreadsheet discussed in class, investigate the sensitivity of the results to
   1. The cost of energy storage
   2. The amount of storage capacity needed
   3. The extent to which the high-voltage grid will need to be extended.
2. In item 13 on the reading list [*ELP Greenport Solar*], how would you incorporate energy storage into ELP Greenport Solar’s financial model?
3. Write a paper of **not more than 4 pages single spaced** about **either** the decarbonization of space heating **or** role that hydrogen might play in a carbon-free economy.