

Energy Policy in a Carbon Constrained World – Fall 2023
Syllabus – August 21, 2023

This is a “living” syllabus; some elements may change, particularly as new governmental policies are enacted, and if we see potential for site visits to power plants or for guest lecturers. If changes occur, we will discuss them in class or post them on the Canvas web site for the course. **You are responsible for accepting your Canvas invitation and periodically reviewing the site for updates. You should also sign up to automatically receive all announcements to your VLS email.**

Class Times

Tuesday and Thursday
9:55 am – 11:10 am pm
Oakes 110

Contact Information

Professor: Mark James
831-1060
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Assistant: Will Fridlund
831-1151

Offices: Eaton House, Room 103

Office Hours: By appointment

Textbooks

1. Scott Hempling, Regulating Public Utility Performance 2nd Edition. Available at Barrister’s Bookstore.
2. Joseph Tomain, Energy Law in a Nutshell 4th Edition. On reserve in the library and available for free via e-book.

Course Description & Overview

The energy industry is both:

- i) a path to the quality of life that billions seek and
- ii) our world’s most significant source of pollution.

Put another way, if you care about energy, environmental problems are the most important constraint now faced by energy industries; and if you care about the environment, the energy sector is the most important influence you must face. This course examines the key issues in American energy policy (with some reference to its global context), and searches for ways to resolve, or at least ease, the strains that such policy puts upon environmental sustainability.

Course Expectations:

Grading

Grading will be based on a 60–100-point score, converted to a letter grade. This score will be based on these elements: mid-term memo (25%); Problems and Solutions assignment (15%); take-home final examination (50%) and a professionalism and class performance grade (10%). Grading will be anonymous only on the final exam.

Grading of Professionalism and Class Performance

We will discuss what professionalism means in the first class. Your class performance grade will evaluate your knowledge of assigned materials and pre-class thought about their significance. In addition, participation that indicates an ability to learn from and encourage input from others will be valued highly. Comments that use an understanding of earlier readings to address later ones are particularly likely to make a favorable impression. Grading class performance is inherently subjective, but my conceptual model is very simple: how happy would an employer be to have had you as part of a taskforce that needed to resolve a hard, uncertain, and important problem?

To help me grade you on class performance, you **must** bring and display an easily readable tent-card with your full name upon it for each class. If you do not do this, your class-performance credit and your overall grade will suffer.

You should treat class like you would treat a job. First and foremost, treat everyone with respect. Come prepared to participate and if you are not prepared, notify the professor. Everyone receives two opt-out passes that they can use at any time during the course to avoid class participation responsibilities. Please tell me before the class starts if you would like to use a pass. Notify the professor if you must be late to or absent from class. Failure to notify me of an absence will result in a 0.5% deduction on the first occasion and 1.0% on each subsequent occasion.

Reading Questions

Reading questions will be made available for specific classes. The professor will distribute the reading questions through Canvas. It is expected that students will be able answer a reading question when called upon.

Written Projects: 15% of your grade will be based on the semester-long Problems and Solutions assignment, which is broken into five separate assignments. Twenty percent (25%) of your base grade in this course will be based on your take-home mid-term memo. The due date for the memo assignment will be set in the month of September.

A hard copy of your paper must be handed in at the start of the class on that day. A penalty will be assessed for late papers. If an emergency prevents you from meeting the deadline, you must notify me or the Registrar's office (tmjohnson@vermontlaw.edu) before the due date and time.

Final Examination: The final examination will count for 50% of the base grade. The final exam will be a take-home, multi-day exam with essay topics and short questions. It is likely to require you to consider several of the topics addressed during the course and may require you to focus on tensions and/or

synergies between and among the topics. In other words, if you have not kept up with the readings *throughout* the course, you will have a very difficult time doing well on the final examination.

Class Attendance and Participation: The course requires a great deal of reading upon demanding subjects; however, our class time will not be spent merely on going over each day's assigned material. Instead, I expect to spend most of our class time in discussions that compare different readings and that go beyond the texts themselves. That expectation is linked to the fact that this course is not just about learning an accepted body of knowledge; rather, it is about searching for better answers in areas where disagreements are persistent, among both experts and lay-folk.

Importantly, contributing to these discussions is not just a way for you to learn the underlying material; it is also a valuable skill that the course seeks to build – and grade.

If you must be absent due to serious illness or a family emergency, please notify the Registrar's Office (tmjohnson@vermontlaw.edu) which will notify all your professors. Absences resulting from religious observance, serious illness, and personal emergency will be excused if notice is given in advance or as early as possible, to the Professor or the Registrar. Absences for work, interviewing, exercise, or vacationing will not be excused even if prior notice is given. Students who are absent for more than 20% of classes will receive a F grade.

Covid and the Classroom: I expect all students to abide by VLGS policies and to adjust to any changes to VLGS policies. If we need to shift back to an online learning format, we will be using Microsoft Teams. If you have any questions about VLGS' Covid precautions, please contact me or VLGS' Covid coordinator.

Recording Lectures

Lectures may be recorded, as necessitated, using Microsoft Team and a link will be made available to the recorded lecture. Lectures will not be livestreamed. You may record the lecture on your own. My only request is to be informed that the lecture is being recorded.

Accommodations for Disabilities

If you have a disability and would like to request an accommodation, please review our Disability Policy at Vermont Law School academic accommodations at:

<https://www.vermontlaw.edu/community/students/academic-success/accommodations>.

On that webpage, there is also an on-line form you can complete and upload your supporting documentations. If you have questions, please make an appointment with the Vice Dean for Students. Please note that requests made within two weeks of a midterm, or a final examination may not be granted in time. Please make your request as soon as possible.

Plagiarism Policy

Students are cautioned to comply with the requirements of the Honor Code by avoiding plagiarism and other misconduct as provided in the student handbook. When in doubt about plagiarism, paraphrasing, quoting, or collaboration, consult the instructor. You all know not to plagiarize, but some of you may conceivably be confused as to what plagiarism means in this context. Of course, you all know that you

cannot quote another author without attribution. This includes web sites! Merely altering a few words does not permit you to omit quotation marks. In addition, it is also improper to paraphrase or borrow ideas from another, without attribution. If you got an idea from another author, cite that work. It is often appropriate to explain either in text or footnotes how your own argument differs from that previously made by others. You will find other articles' sources/footnotes to be a rich source of information. However, to the extent that you rely on another article's footnotes you must read all such sources yourself to make sure they really say what the other author said they said. It is never proper to cite a source you have not yourself read, unless you note that you are "citing Source A citing Source B." This should only be done rarely, when that second source is important but cannot be located. To the extent you use other authors' footnotes as starting points you will often find you need to update such footnotes, e.g., by citing to a more current statute or version of the book. If you have any questions regarding when cites are and are not needed, please ask me, or err on the side of citation. Plagiarism is an Honor Code violation that will result in an F in the course and a referral to the Vice Dean for Students for further action.

Energy Policy Learning Outcomes

By the end of this course, you should understand and be able to apply the following concepts:

1. The relationship between energy production and consumption and the environment.
2. The drivers between major changes in American energy policy.
3. Policies and laws affecting major sources of conventional and renewable energy
4. The historical roots of utility regulation and how they affect current regulatory regimes.
5. The boundary between federal and state jurisdiction in energy regulation.
6. The obligations and duties of a public utility commission.
7. The changing relationship between electricity, transportation, and thermal uses of energy.
8. The role of beneficial electrification in the transition to a low-carbon economy.
9. Options for and obstacles to developing a pathway to a low-carbon energy system and the future course of a national energy policy.

Class Schedule and Learning Materials

Class 1 – Introduction to Energy Policy in a Carbon Constrained World – The Challenge

In our first class, we will discuss the big questions and themes of the course. Like, why are we here? What do we want to accomplish over the next 28 classes? What do you want to take away from Energy Policy in a Carbon Constrained World? We will spend the first part of the class going over the syllabus, the course goals, getting to know each other, and discussing student and professor expectations. The second half of the class will focus on how we will evaluate energy problems and create energy solutions.

Learning Materials

Class 1 – The Challenge

1. Carbon Brief, *In-depth Q&A: The IPCC's sixth assessment on how to tackle climate change*, April 5, 2022, <https://www.carbonbrief.org/in-depth-qa-the-ipccs-sixth-assessment-on-how-to-tackle-climate-change/>. Read the following sections (why can be accessed via hyperlinks at top of reading) and be ready to answer reading questions posted in Canvas.
 - a. What is the Working Group III report?
 - b. How have global emissions been changing?
 - c. How do current policies and pledges compare to scenarios assessed by the IPCC?
 - d. What would it take to limit warming to 1.5 or 2C?
 - e. How can shifting peoples' demand for products and services cut emissions?
 - f. How must global energy systems change to limit warming?
 - g. What needs to happen to the transport sector to cut CO₂?
 - h. How can industry be decarbonized?
 - i. What climate policies are being implemented and are they working?
 - j. How much innovation and new technology is needed to hit climate goals?
2. Sandia National Laboratory and ourenergypolicy.org, *The Goals of Energy Policy: Professional Perspectives on Energy Security, Economics, and the Environment* (2012) <https://www.ourenergypolicy.org/wp-content/uploads/2012/09/The-Goals-of-Energy-Policy-Sandia-and-OurEnergyPolicy.org.pdf>. Read pages 1-4.
3. Sovacool, Brown, and Valentine, *Fact and Fiction in Global Energy Policy: 15 Contentious Questions*. Read pages 345-352.
4. [Recommended] IPCC, *Working Group III Technical Summary* (2022). Read the following pages (sections are in parentheses).
 - a. TS-2 to TS-13 (TS. 2 The changed global context, signs of progress and continuing 1 challenges and TS. 3 Emission trends and drivers)
 - b. TS-52 to TS-60 (TS. 5 Mitigation responses in sectors and systems and TS. 5.1 Energy)

Class 2 – The Energy Transition

In this class, we will look at the overall structure of the course and our guiding theme, how to transition to a low-carbon economy equitably and quickly.

Learning Materials

1. Amory Lovins, *Energy Strategy: The Road Not Taken?* *Foreign Affairs* (October 1976, reprinted in *Friends of the Earth's Man Apart*, Volume 6, November 1977). (15 pages)

2. Project Drawdown, *The Drawdown Review: Climate Solutions for a New Decade* (March 2020). (Read pages 4-7 and 16-25) As you read, think critically about the size and scope of the challenge and the timelines for making the necessary changes.
3. Leah Stokes and Hanna Breetz, *Politics in the U.S. energy transition, Case studies of solar, wind, biofuels and electric vehicles policy*, Energy Policy 113 (2018) 76-86.
4. Evergreen Action, *The Climate Impact of the Inflation Reduction Act*, August 2022. Skim and be ready to discuss how the structure of this bill fits in with the theories of change presented in the other readings.
5. [Suggested] Evergreen Action, *Everything You Need to Know About Implementing the IRA's Most Important Programs*, June 26, 2023, <https://www.evergreenaction.com/blog/implementing-the-inflation-reduction-acts-most-important-programs>. Read to learn about how passage of the IRA is only the first step to realizing the potential change contained in the law.
6. [Supplemental] Volts Podcast, *The Inflation Reduction Act: everything in one place (with transcripts)* October 17, 2022. A gathering place for five different podcasts examining the Inflation Reduction Act, its potential, its purposes, and its undefined elements.

Class 3 - Energy Basics

In this class, we will get familiar with different energy terms. Energy law and policy has a unique jargon that combines legal terms, engineering concepts, and economics. To fully engage in the energy field, you will need to build your base knowledge and this class will provide a start to that process.

Learning Materials

1. Enphase Energy, *What is a kilowatt hour? Understanding home energy use*, YouTube, January 23, 2019 <https://www.youtube.com/watch/zRYESRObKqA>.
2. University of Chicago, Center for Robust Decision-making on Climate and Energy Policy, *U.S. Energy History Visualization*, <https://us-sankey.rcc.uchicago.edu/>.
3. Energy Information Administration, *Electricity explained: Electricity in the United States*, July 15, 2022, <https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php>.
4. Energy Information Administration, *Annual Energy Outlook 2023*. Read pages 4-21 and 33-34. Be ready to answer reading questions.
5. [Supplemental] Energy Information Administration, *Annual Energy Outlook 2023 with projections to 2050*, March 16, 2023, Read slides 7-20.
6. Lawrence Livermore National Laboratory, *Estimated U.S. Energy Consumption in 2021: 97.3 Quads*, <https://flowcharts.llnl.gov/commodities/energy>. Select the United States and 2021 to get to the Sankey diagram.

Class 4 - Electrify Everything

This class discusses the opportunities and challenges in reducing fossil fuel usage through electrification. The one source of energy that we know how to generate with little to no GHG emissions is electricity. Switching from fossil fuels to electricity is the best option for transitioning to a net-zero system. However, electrification will require a two- to four-fold increase in the amount of electricity that we currently generate and that brings challenges in making sure that our systems continue to function as they were designed.

Learning Materials

1. David Roberts, Vox, *The key to tackling climate change: electrify everything*, October 27, 2017, <https://www.vox.com/2016/9/19/12938086/electrify-everything>.
2. Nadja Popovich and Brad Plumer, NY Times, *How electrification became a major tool for fighting climate change*, April 14, 2023, <https://www.nytimes.com/interactive/2023/04/14/climate/electric-car-heater-everything.html>.
3. Saul Griffith, *Rewiring America: A Field Manual for the Climate Fight*, July 29, 2020, https://static1.squarespace.com/static/5e540e7fb9d1816038da0314/t/5f21edad94f7832d9b1a31bf/1596059082636/Rewiring_America_Field_Manual.pdf. Read pages 44-69
4. Nelson Sepulveda et al (2018) Joule, *The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation*, [https://www.cell.com/joule/pdf/S2542-4351\(18\)30386-6.pdf](https://www.cell.com/joule/pdf/S2542-4351(18)30386-6.pdf). Read Introduction and Discussion. Skim Methodology but focus on understanding and being able to explain Figures 1, 2, and 3.

Class 5 - At What Price? Costing Out the Energy Transition

Every energy decision comes with a price tag. In this class, we will unpack some of the most common metrics for evaluating energy projects and explore their strengths and weaknesses.

Learning Materials

1. Energy Information Administration, *Today in Energy, EIA uses two simplified metrics to show future power plants' relative economics*, March 29, 2018, <https://www.eia.gov/todayinenergy/detail.php?id=35552>.
2. Lazard, *LCOE+*, 15.0, April 2023, <https://www.lazard.com/research-insights/levelized-cost-of-energyplus/>. Download report and watch video (1 min 45 sec). Read pages 1-13. Students will be assigned specific slides to discuss in class.
3. Energy Information Administration, *Levelized Costs of New Generation Resources in the Annual Energy Outlook 2023*, March 2023, https://www.eia.gov/outlooks/aeo/electricity_generation/pdf/AEO2023_LCOE_report.pdf. Read 6-13. Be ready to discuss LCOE versus LACE.
4. Rethinking Energy, *The Great Stranding: How Inaccurate Mainstream LCOE Estimates are Creating a Trillion-Dollar Bubble in Conventional Energy Assets*, February 2021, <https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/604a545fe0dbf3775ee6329b/1615484151178/Rethinking-Energy-LCOE.pdf>. Read pages 6-14, 20-23.
5. [Supplemental] James Loewen, Utility Dive, *LCOE is not the metric you think it is*, May 28, 2020, <https://www.utilitydive.com/news/lcoe-is-not-the-metric-you-think-it-is/578360/>.

Class 6 - Energy Justice

In this class, we will explore the growing interest in incorporating environmental and energy justice into the energy transition. We will look at the broad definitions of environmental and energy justice and how those definitions can be turned into actions.

Learning Materials

1. The White House, *Executive Order 14008, Executive Order on Tackling the Climate Crisis at Home and Abroad*, <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/>. Read Sections 219-223. Skim remainder of the Order.
2. Initiative for Energy Justice, *The Energy Justice Workbook* (2019) <https://iejusa.org/workbook/>. Read pages 8-23.
3. California Public Utilities Commission, *Environmental and Social Justice Action Plan 2.0* (2022) <https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/news-and-outreach/documents/news-office/key-issues/esj/esj-action-plan-v2jw.pdf>. Read pages 8-12, 14 - 17 (understand the diagram and skim the examples). See Reading Questions for assignment.
4. California Public Utilities Commission, *Environmental and Social Justice Action Plan, 2021 Update Workshop*, February 3 & 4, <http://www.adminmonitor.com/ca/cpuc/workshop/20210203/>.
 - a. Suggested – Watch 201:00 to 2:11:00. This section reviews and discusses CPUC procedures and how they can incorporate ESJ principles. Time permitting, we will be using this video in an issue spotting exercise.
5. [Supplemental] Julia Eagles, Institute for Market Transformation, *In Pursuit of Equitable Clean Energy: The Power of Coalitions for Utility Regulatory Transformation*, March 30, 2021, <https://www.imt.org/news/in-pursuit-of-equitable-clean-energy-the-power-of-coalitions-for-utility-regulatory-transformation/>.
6. [Supplemental] [California Public Utilities Commission, Environmental and Social Justice Action Plan V2](https://www.cpuc.ca.gov/ESJactionplan/), <https://www.cpuc.ca.gov/ESJactionplan/>. This webpage provides an overview of the ESJ Plan and access to webinars where feedback was provided on draft versions of the updates.

Class 7 – How to Pass an Energy Law in Vermont – Guest Lecture, State Senator Becca White

Senator White will discuss her work to pass Vermont’s Affordable Heating Act in the last legislative session.

Note: This lecture will occur on September 12th regardless of where we are in the syllabus.

Learning Materials

1. Vermont Affordable Heat Act (2023)
2. Vermont Natural Resources Council, *The Affordable Heat Act – S.5*, <https://vnrc.org/climate-action/affordableheatact/>.
3. Vermont Natural Resources Council, *Affordable Heat Act vs Clean Heat Standard*, <https://vnrc.org/climate-action/affordable-heat-act-vs-clean-heat-standard/>.

Class 8 - Constitutional Law - Federal-State Relationship

This class will explore key constitutional provisions that define how energy is regulated in the United States.

Learning Materials

1. Scott Hempling, *Regulating Public Utility Performance: The Law of Market Structure, Pricing and Jurisdiction*, 2nd edition (2021). Read Chapter 12, pages 407-450.
2. *Public Utilities Commission of Rhode Island v. Attleboro Steam & Electric Co.*, 273 U.S. 83 (1927).

Class 9 - Regulation of Environmental Impacts of Energy Consumption

In this class, we investigate the environmental and health impacts of fossil fuel usage and how those impacts are regulated.

Learning Materials

1. Jody Freeman, *The Uncomfortable Convergence of Energy and Environmental Law*, Harvard Environmental Law Review Volume 41 (2017). Read pages 340-365. Focus on the historical division of the how energy and energy impacts are regulated.
2. https://static1.squarespace.com/static/5a1f1ec0017db2ba229768a1/t/5d1be0abf8ff4d0001f1b989/1562108076253/Freeman_final.pdf.
3. Environmental Protection Agency, *Particulate Matter (PM) Pollution*, <https://www.epa.gov/pm-pollution>. Read *Particulate Matter Basics*. Skim other sections as desired.
4. David Roberts, Vox, *Air pollution is much worse than we thought*, August 12, 2020, <https://www.vox.com/energy-and-environment/2020/8/12/21361498/climate-change-air-pollution-us-india-china-deaths>.
5. Oliver Milman, The Guardian, *'Invisible killer': fossil fuels caused 8.7m deaths globally in 2018, research finds*, February 9, 2021, <https://www.theguardian.com/environment/2021/feb/09/fossil-fuels-pollution-deaths-research>.
6. MIT News, *Study: Shutting down nuclear power could increase air pollution*, April 10, 2023 <https://news.mit.edu/2023/study-shutting-down-nuclear-power-could-increase-air-pollution-0410>. (This is an example of an article that could be used in your mid-term memo assignment)
7. [Supplemental] Valerie Cleland, NRDC, *Offshore Drilling: A threat to Public Health & Climate Justice*, August 3, 2023, <https://www.nrdc.org/bio/valerie-cleland/offshore-drilling-threat-public-health-climate-justice>.

Class 10 - Natural Gas

Natural gas has displaced coal as the largest fossil fuel resources in electricity generation. The lower emissions of natural gas plants reduced electricity sector's GHG emissions and the low prices of fracked natural gas reduced customer bills. In this class, we will explore the regulatory regime for natural gas, the role of fracking in unlocking vast reserves of natural gas, and if natural gas is a bridge fuel to a clean energy system.

Learning Materials

1. Joseph Tomain, Energy Law in a Nutshell 4th edition, *Natural Gas* (2022). Read pages 269-280; 306-314. Skim these pages to get a background on the history of the natural gas sector and emerging issues.
2. Inside Energy, YouTube, *Why Fracking, and Why Now?* December 22, 2017, <https://www.youtube.com/watch?v=7bbnoESSR7I&t>.
3. Nicholas Kusnetz, Inside Climate News, *Is Natural Gas Really Helping the U.S. Cut Emissions?* January 30, 2020, <https://insideclimatenews.org/news/30012020/natural-gas-methane-carbon-emissions/>
4. Hiroki Tabuchi, NY Times, *Leaks Can Make Natural Gas as Bad for the Climate as Coal, a Study Says*, July 19, 2023, <https://www.nytimes.com/2023/07/13/climate/natural-gas-leaks-coal-climate-change.html>.
5. Magdalena M. Klemun and Jessika E. Trancik, *Timelines for mitigating the methane impacts of using natural gas for carbon dioxide abatement*, Environmental Research Letters 14 124609 (2019), <https://iopscience.iop.org/article/10.1088/1748-9326/ab2577/pdf>. Read Sections 1, 3, and 4.
6. Climate & Clean Air Coalition, *Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions* (2021). Read the Executive Summary.
7. [Supplemental] Inside Energy, YouTube, *Water Use in Hydraulic Fracturing*, December 22, 2017, <https://www.youtube.com/watch?v=DZY9kJzrF-E&t>.
8. [Supplemental] Inside Energy, YouTube, *Drilling: A High Stakes Game*, December 22, 2017, <https://www.youtube.com/watch?v=iE1tkNFyqgl>.

Class 11 - The Rise or Fall of Nuclear

Nuclear power is a controversial topic. Is it a clean energy resource that is needed for the energy transition or is it an expensive relic that should be moved out to make space for newer and cheaper resources? Do the risks of nuclear power outweigh the benefits of its low carbon electricity? In this class, we will explore the role of existing nuclear in the energy transition.

Learning Materials

1. Union of Concerned Scientists, *The Nuclear Dilemma: Declining Profits, Plant Closures, and the Threat of Rising Carbon Emissions – Executive Summary* (2018) <https://www.ucsusa.org/sites/default/files/attach/2018/11/Nuclear-Power-Dilemma-executive-summary.pdf>.
2. Energy Information Administration, *U.S. nuclear electricity generation continues to decline as more reactors retire*, April 8, 2022, <https://www.eia.gov/todayinenergy/detail.php?id=51978#:~:text=Three%20more%20reactors%20with%20a,2024%20and%20one%20in%202025.>
3. NARUC, *Nuclear Energy as a Keystone Clean Energy Resource: The Potential Role of Nuclear Energy to Advance the Decarbonization of the U.S. Electric Grid and Beyond*, August 2022. Read pages 14-20.

4. Department of Energy, Office of Nuclear Energy, *Inflation Reduction Act Keeps Momentum Building for Nuclear Power*, September 8, 2022, <https://www.energy.gov/ne/articles/inflation-reduction-act-keeps-momentum-building-nuclear-power>.
5. Peter Bradford, *How to close the US nuclear industry: do nothing*. 63(2) Journal of the Atomic Scientists (2013) Read page 12-21. <https://www.tandfonline.com/doi/full/10.1177/0096340213477996?scroll=top&needAccess=true>.
6. [Supplemental] Department of Energy, Office of Nuclear Energy, *3 Ways Nuclear is More Flexible Than You Might Think*, June 23, 2020, <https://www.energy.gov/ne/articles/3-ways-nuclear-more-flexible-you-might-think>.
7. [Supplemental] Michigan.gov, *Gov. Whitmer Announces Plan with Holtec to Reopen Palisades Plant, Protect 600 Jobs, Shore up Clean, Reliable Energy Production in Michigan*, September 9, 2022, <https://www.michigan.gov/whitmer/news/press-releases/2022/09/09/whitmer-announces-plan-with-holtec-to-reopen-palisades-plant>.

Class 12 - Hydro

Hydropower is the first renewable resource. A power source that has been tapped to produce electricity since the 1800s. In this class, we examine the rise of hydropower and how it shaped our modern electricity regulatory system and what the future holds for this technology.

Learning Materials

1. Caitlin McDermott-Murphy, *How Will Hydropower Bolster a Renewable Energy World?* June 7, 2022, <https://www.nrel.gov/news/program/2022/how-will-hydropower-bolster-a-renewable-energy-world.html>
2. Department of Energy, *Biden-Harris Administration Launches \$28 Million Program to Advance Hydropower for Clean Energy*, August 19, 2022, <https://www.energy.gov/articles/biden-harris-administration-launches-28-million-program-advance-hydropower-clean-energy>.
3. Department of Energy, *Hydropower Basics*, <https://www.energy.gov/eere/water/hydropower-basics>. Read the text and watch the YouTube video embedded in the page.
4. FERC, *Hydropower Primer* (2017), <https://www.ferc.gov/sites/default/files/2020-04/HydropowerPrimer.pdf>. Read pages 1-3, 8-16. Skim 4-7. Make a list of different environmental considerations assessed during hydropower licensing process.
5. FERC, *Applications for New Licenses (Relicenses)*, <https://www.ferc.gov/licensing/applications-new-licenses-relicenses>.
6. FERC, *Licensing Processes*, <https://www.ferc.gov/industries-data/hydropower/licensing/licensing-processes>.
7. FERC, *Exemptions from Licensing*, <https://www.ferc.gov/licensing/exemptions-licensing>.
8. [Supplemental] Department of Energy, *U.S. Hydropower Market Report, January 2021*, Read Section 2.2 (pages 50-52).
9. Department of Energy, *Pumped Storage Hydropower*, <https://www.energy.gov/eere/water/pumped-storage-hydropower>.
10. Department of Energy, *WPTO Studies Find Big Opportunities to Expand Pumped Storage Hydropower*, June 13, 2022, <https://www.energy.gov/eere/water/articles/wpto-studies-find-big-opportunities-expand-pumped-storage-hydropower>.

11. FERC, *Docket No. RM19-6-000; Order No. 858, Hydroelectric Licensing Regulations Under the America's Water Infrastructure Act of 2018*, April 18, 2019, <https://cms.ferc.gov/sites/default/files/whats-new/comm-meet/2019/041819/H-1.pdf>. Skim pages 66-77. We will be using this resource for an in-class assignment.
12. [Supplemental] David Victor, *Pumped Energy Storage: Vital to California's Renewable Energy Future*, May 21, 2019. Read pages 1-7.
13. [Supplemental] Miranda Wilson, E&E News EnergyWire, *Pumped storage is having a moment. Will it shift renewables?* April 15, 2022, <https://www.eenews.net/articles/pumped-storage-is-having-a-moment-will-it-shift-renewables/>. (Every VLGS student has free access to E&E News through an institutional subscription. Read for background purposes.)
14. [Supplemental] American Rivers et al, *Summary of Federal Power Act Amendments Package*, April 2022. This resource addresses efforts to increase consultation with affected parties including states and Indian tribes.
15. [Supplemental] FERC, *Pumped Storage Projects*, <https://www.ferc.gov/licensing/pumped-storage-projects>. This is a regularly updated list of the status of different applications for licenses to construct pumped storage projects.
16. [Supplemental] Department of Energy, *Study Finds Hydropower Provides Reliable Electricity Even During Historic Droughts*, September 20, 2022, <https://www.energy.gov/eere/water/articles/study-finds-hydropower-provides-reliable-electricity-even-during-historic>.
17. [Supplemental] FERC, *Hydropower: Commission's Responsibilities*, <https://www.ferc.gov/industries-data/hydropower>.
18. [Supplemental] FERC, *Hydropower and FERC, Read the Story*, <https://ferc-oep.maps.arcgis.com/apps/MapSeries/index.html?appid=447e5523f6bc4a759c5667791d5af074>
Review all the pages.
19. [Supplemental] Department of Energy, *Closed-Loop Pumped Storage Hydropower Resource Assessment for the United States, Final Report on HydroWIREs Project D1: Improving Hydropower and PSH Representations in Capacity Expansion Models*, May 2022. Read the Executive Summary and Section 4.1 for more background on the study cited in the article presented above.

Classes 13 and 14 - Wind and Solar

The path to a clean energy system will be built upon our most plentiful renewable resources, wind and solar. There was a time when wind and solar were more expensive than conventional fossil fuel resources. Technology and manufacturing improvements combined with government incentives have dramatically cut the costs of installing wind and solar generation. As wind and solar generation increases, so do concerns about how to balance the intermittent nature of their generation with the need to maintain grid stability. Over two class, we will explore some of the incentive mechanisms supporting renewable energy; the challenges and benefits of integrating variable energy resources onto the grid; and the next big renewable resource – offshore wind.

Learning Materials

Renewable Energy

1. Energy Information Administration, *Renewable energy explained – Portfolio standards*, November 30, 2022, <https://www.eia.gov/energyexplained/renewable-sources/portfolio-standards.php>. Skim this reading.
2. Energy Information Administration, *Five states updated or adopted new clean energy standards in 2021*, February 1, 2022, <https://www.eia.gov/todayinenergy/detail.php?id=51118>. Know the difference between an RPS and CES.
3. NREL, *The Challenge of the Last Few Percent: Quantifying the Costs and Emissions Benefits of a 100% Renewable Energy U.S. Electricity System*, June 16, 2021, <https://www.nrel.gov/news/program/2021/the-challenge-of-the-last-few-percent-quantifying-the-costs-and-emissions-benefits-of-100-renewables.html>.
4. NREL, *What We Know – and Do Not Know – About Achieving a National-Scale 100% Renewable Electric Grid: NREL and DOE Experts Offer Fresh Perspective on Technical and Economic Challenges, Call for Collaborative Solutions to Decarbonization*, May 19, 2021, <https://www.nrel.gov/news/features/2021/what-we-know-and-dont-know-about-achieving-a-national-scale-100-renewable-electric-grid.html>.

Offshore Wind

5. Kassia Micek, S&P Global, *US offshore wind investments more than triple in 2022, IRA to boost alternative uses*, February 21, 2023 <https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/022123-us-offshore-wind-investments-more-the-tripled-in-2022-ira-to-boost-alternative-uses>.
6. Elizabeth C. Crouse et al., K&L Gates LLP, *Offshore Wind Handbook 2022*, April 2022, https://marketingstorageragrs.blob.core.windows.net/webfiles/2022_Offshore_Wind_Handbook.pdf. Read pages 15-21 and CZMA section on page 23. (Laws and Regulations Shaping Offshore Wind Development). Make a list of key players involved in the process of leasing and in approving project development plans.
7. Center for American Progress, *The Road to 30 Gigawatts: Key Actions to Scale an Offshore Wind Industry in the United States*, March 14, 2022, <https://www.americanprogress.org/article/the-road-to-30-gigawatts-key-actions-to-scale-an-offshore-wind-industry-in-the-united-states/>. Read full document, note the different jurisdiction authority of various levels of government.
8. Department of Interior, Bureau of Ocean Energy Management, *Final Sale Notice (FSN) for Commercial Leasing for Wind Power Development on the Outer Continental Shelf in the Gulf of Mexico (GOMW-1)* Federal Register, Volume 88, No. 139, July 21, 2023. Read 47177-9. Identify conflict management provisions (what conditions have been inserted to avoid or reduce future problems. Compare against CAP reading).
9. [Supplemental] Department of Energy, *Offshore Wind Market Report: 2022 Edition*, August 2022, https://www.energy.gov/sites/default/files/2022-08/offshore_wind_market_report_2022.pdf. Read pages vi-vii, x-xi, and 21-33.
10. [Supplemental] America Clean Power, *Offshore Wind Market Report*, May 2023 https://cleanpower.org/wp-content/uploads/2023/05/ACP_Offshore_Wind_Market_Report_2023_PUBLIC.pdf.

11. [Supplemental] International Energy Agency, *Wind Electricity* (2019), <https://www.iea.org/reports/wind-electricity>. This resource provides a global overview of the wind industry and progress towards a net-zero electricity system.
12. [Supplemental] American Clean Energy Association, *Wind Power Facts*, <https://cleanpower.org/facts/wind-power/>.

Distributed Solar

13. David Roberts, Vox, *Solar power's greatest challenge was discovered 10 years ago. It looks like a duck.*, August 29, 2018, <https://www.vox.com/energy-and-environment/2018/3/20/17128478/solar-duck-curve-nrel-researcher>.
14. David Roberts, Volts, *Rooftop solar and home batteries make a clean grid vastly more affordable*, May 28, 2021, <https://www.volts.wtf/p/rooftop-solar-and-home-batteries>.
15. [Supplemental] Vibrant Clean Energy, *Why Local Solar For All Costs Less: A New Roadmap for the Lowest Cost Grid – Technical Report* (2012), https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_TR_Final.pdf.

Class 15 - Geothermal and Biomass

Renewable energy skeptics often point to the variable nature of wind and solar as the reason why a clean energy system is either unfeasible or too expensive. Some renewable energy proponents point to geothermal and biomass as two resources that can provide on-demand renewable electricity that will balance out the intermittency of wind and solar. In this class, we will investigate the potential of geothermal and biomass in the energy transition and the pitfalls of each resource.

Learning Materials

1. Ethan Howland, Utility Dive, *Fervo Energy see 'breakthrough' in enhanced geothermal technology, opening path for firm, clean power*, July 21, 2023, <https://www.utilitydive.com/news/fervo-energy-enhanced-geothermal-system-google/688620/>.
2. Department of Energy, *Geovision: Harnessing the Heat Beneath Our Feet* (2019), <https://www.energy.gov/sites/default/files/2019/06/f63/GeoVision-full-report-opt.pdf>. Here are the reading instructions for this report.
 - a. Read Executive Summary
 - b. Skim Sections 1.1 and 1.2
 - c. Read Section 1.3
 - d. Skim Section 2.1
 - e. Read Section 2.2.1
 - f. Read Section 2.3 (all parts of Section 2.3)
 - g. Read Section 2.4, 2.4.1, and 2.4.3.1.
3. Department of Energy, Geothermal Technologies Office, *Enhanced Geothermal Shot*, <https://www.energy.gov/eere/geothermal/enhanced-geothermal-shot>.
4. Department of Energy, *Enhanced Geothermal Shot™: Unlocking the Power of Geothermal Energy*, <https://www.energy.gov/sites/default/files/2022-09/EERE-ES-Enhancing-Geothermal-508-v2.pdf>.

5. Department of Energy, Geothermal Technologies Office, *Fervo Energy Sets the Stage for Accelerating Geothermal Deployment with Successful Well Test*, July 20, 2023, <https://www.energy.gov/eere/geothermal/articles/fervo-energy-sets-stage-accelerating-geothermal-deployment-successful-well>.
6. [Supplemental] Erik Olson, The Breakthrough Institute, *It's Time to Take Geothermal Energy Seriously*, September 10, 2020, <https://thebreakthrough.org/issues/energy/take-geothermal-seriously>.
7. [Supplemental] Volts, *The extraordinary potential value of enhanced geothermal power*, September 30, 2022, <https://www.volts.wtf/p/the-extraordinary-potential-value#details>.
8. [Supplemental] Wilson Ricks et al., *The value of in-reservoir energy storage for flexible dispatch of geothermal power*, Applied Energy, Volume 313, May 1, 2022, <https://www.sciencedirect.com/science/article/abs/pii/S0306261922002537#:~:text=We%20find%20that%20operational%20flexibility%20and%20in-reservoir%20energy,to%20conventional%20baseload%20plants%20operating%20under%20identical%20conditions>
9. Saul Elbein, Vox, *Europe's renewable energy policy is built on burning American trees*, March 4, 2019, <https://www.vox.com/science-and-health/2019/3/4/18216045/renewable-energy-wood-pellets-biomass>.
10. John Sterman et al., *Does replacing coal with wood lower CO₂ emissions? Dynamic lifecycle analysis of wood bioenergy*, Environmental Research Letters 13 015007 (2018), <https://iopscience.iop.org/article/10.1088/1748-9326/aaa512/pdf>. Read Sections 1, 3, and 4.

Classes 16-18 - Public Utility Commission – History, Ratemaking, and Planning

State public utility commissions will be key players in determining the pace and scale of the energy transition. In this series of lectures, we will explore the historic origins of the utility commission, how regulatory principles espoused in the 18th century still affect public utility regulation today, the ratemaking authority of utility commissions, and how utility commissions can plan for a low-carbon grid.

Class 16 - History of Public Utility Regulation

In this class, we investigate why utility commissions were created and what it means to regulate in the “public interest.”

Learning Materials

1. Richard F. Hirsh, *Power Loss: The Origins of Deregulation and Restructuring in the American Electric Utility System* (2001). Read Chapter 1, Creation of the Utility Consensus (22 pages) and Chapter 2, Utility Managers Gain Dominance (22 pages).
2. *The Proprietors of Charles River Bridge v. The Proprietors of the Warren Bridge*, 36 U.S. 420 (1837).
3. *Munn v. Illinois* 94 U.S. 113 (1877).

Class 17 - Ratemaking

In this class, we explore the ratemaking authority of public utility commissions and how commissions determine the rates that appear on your utility bills.

Learning Materials

1. Jim Lazar et al., Regulatory Assistance Project, *Electricity Regulation in the United States*, 2nd edition (2016). Read pages 25-35.
2. Scott Hempling, *Regulating Public Utility Performance: The Law of Market Structure, Pricing and Jurisdiction* (2021). Read Chapter 6, Sections A-D. For Section 6C, you only need to know the different categories of imprudence.

Class 18 - Utility Commission and System Planning

To change our energy systems, we must change how we plan our energy systems. Energy system planning has always been driven by the lowest cost option. However, for many decades, not all costs were weighed in determining what was the lowest cost option. In this class, we look at how utilities and utility commissions are adapting planning criteria to value climate change.

Guest Lecture – TJ Poor, Director, Regulated Utility Planning Division, Vermont Public Service Department. This lecture will occur on November 7, 2023.

Learning Materials

1. Vermont Comprehensive Energy Plan (2022)
 - a. Read Chapters 1, 2, and 3.
2. Rachel Wilson and Bruce Biewald, Regulatory Assistance Project, *Best Practices in Electric Utility Integrated Resource Planning: Examples of State Regulations and Recent Utility Plans*, June 2013.
 - a. Read Pages 4-5, The Purpose and Use of Integrated Resource Planning.
 - b. Skim Pages 6-15, Examples of State Integrated Resource Planning Statutes and Regulations.
 - c. Read Pages 26-32, Recommendations for Prudent Integrated Resource Planning and Integrated Resource Plans.

Mid-term

Take-home memo assignment. To be scheduled.

Class 19 - Hydrogen

In this class, we will explore and investigate the use of hydrogen in the clean energy transition in accessing difficult to decarbonize sectors and providing long-term energy storage. We will examine the different uses of hydrogen, the concerns about the climate impacts of different production methods, and the obstacles and opportunities of hydrogen.

Learning Materials

1. Dan Esposito and Hadley Tallackson, Utility Dive, *The Inflation Reduction Act opens hydrogen economics with opportunities, pitfalls*, September 30, 2022, <https://www.utilitydive.com/news/the-ira-will-accelerate-electrolyzed-hydrogens-future-heres-what-that-me/632925/>.

2. Energy Information Administration, *Hydrogen explained: Production of hydrogen*, <https://www.eia.gov/energyexplained/hydrogen/production-of-hydrogen.php>.
3. RMI, *Clean Energy 101: The Colors of Hydrogen*, April 13, 2022, <https://rmi.org/clean-energy-101-hydrogen/>.
4. RMI, *Hydrogen Reality Check: We Need Hydrogen – But not for Everything*, June 27, 2022, <https://rmi.org/we-need-hydrogen-but-not-for-everything/>.
5. RMI, *Hydrogen Reality Check: All “Clean Hydrogen” Is Not Equally Clean*, October 4, 2022, <https://rmi.org/all-clean-hydrogen-is-not-equally-clean/>.
6. Dan Esposito, Eric Gimon, and Mike O’Boyle, Energy Innovation, *Smart Design of 45V Hydrogen Production Tax Credit Will Reduce Emissions and Grow the Industry*, April 2023, <https://energyinnovation.org/wp-content/uploads/2023/04/Smart-Design-Of-45V-Hydrogen-Production-Tax-Credit-Will-Reduce-Emissions-And-Grow-The-Industry.pdf>. Read Executive Summary (pages 1-6) and skim remainder of document as needed to understand three design principles.
7. [Supplemental] Kelly Nault, Harvard, John A. Paulson School of Engineering and Applied Sciences, *Clean Hydrogen: A long-awaited solution for hard-to-abate sectors, New research in Nature Energy models that value of clean hydrogen in decarbonizing heavy industries/heavy transport*, October 3, 2022, <https://www.seas.harvard.edu/news/2022/10/clean-hydrogen-long-awaited-solution-hard-abate-sectors>.
8. [Supplemental] America Hernandez, Politico, *EU goes big on hydrogen as gas crunch looms*, July 15, 2022, <https://www.politico.eu/article/industrial-hydrogen-state-aid-technology/>.
9. [Supplemental] European Commission, *A hydrogen strategy for a climate-neutral Europe*, July 8, 2020, <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0301&from=EN>. Read Sections 1 and 2.
10. [Supplemental] Emma Penrod, Utility Dive, *As momentum for hydrogen builds, electric utilities chart multiple paths forward*, August 18, 2021, <https://www.utilitydive.com/news/as-momentum-for-hydrogen-builds-electric-utilities-chart-multiple-paths-fo/603914/>.
11. [Supplemental] Science News, *Touted as clean, ‘blue’ hydrogen may be worse than gas, coal, researchers say*, August 12, 2021, <https://www.sciencedaily.com/releases/2021/08/210812161902.htm>.
12. [Supplemental] Carbon Brief, *In-depth Q&A: Does the world need hydrogen to solve climate change?* November 30, 2021, <https://www.carbonbrief.org/in-depth-ga-does-the-world-need-hydrogen-to-solve-climate-change>.

Class 20 - Battery Storage

Electricity must be generated when it is needed. This law of physics has guided the development and operation of our electricity grid since its inception. Efforts to store energy have been underway. In this class, we will explore the history of energy storage and the potential for energy storage to reshape how our electricity systems work.

Guest Lecturer – Kevin Jones, Director of the Institute for Energy and the Environment

Learning Materials

1. Jones et al., *The Electric Battery: Charging Forward to a Low-Carbon Future* (2017). Read Chapters 1 and 7.

Class 21 - Transmission

A bigger, stronger electrical grid is a necessity if we are to tap into the tremendous potential for renewable energy. Moving energy from where it is generated to where it is consumed will facilitate the energy transmission. Much of that transmission will be planned and constructed in RTOs. In this class, we investigate the proposals for building out transmission and why building transmission has proven to be a hurdle to developing renewable energy resources.

Learning Materials

1. David Roberts, Volts, *Transmission Week: Why We Need More Transmission*, January 25, 2021 <https://www.volts.wtf/p/transmission-week-why-we-need-more>. You have the option of reading or listening to the post.
2. Lucas W. Davis, Catherine Hausman, and Nancy L. Rose, *Transmission Impossible? Prospects for Decarbonizing the US Grid*, National Bureau of Economic Research, Working Paper 31337, June 2023. Read pages 1-23. Pick out obstacles and opportunities in transmission system expansion.
3. Dana Nuccitelli, Yale Climate Connections, *Permitting: America's next big climate conundrum*, October 11, 2022, <https://yaleclimateconnections.org/2022/10/permitting-americas-next-big-climate-conundrum/>.
4. Kristina Karlson, *Three Takeaways from the Roosevelt Institute's Permitting Reform Forum*, Roosevelt Institute, April 21, 2023, <https://rooseveltinstitute.org/2023/04/21/three-takeaways-from-the-roosevelt-institutes-permitting-reform-forum/>.
5. [Supplemental] David Roberts, Volts, *Transmission Week: How to Start Building More Big Power Lines*, January 27, 2021 <https://www.volts.wtf/p/transmission-week-how-to-start-building>.

Class 22 - Energy Efficiency, Low-Income Programs, and GHG Reductions

This class investigates the role of energy efficiency in a clean energy transition and its untapped potential to reduce electricity bills and GHG emissions and to serve energy-burdened low income communities.

Learning Materials

1. ACEEE, *Halfway There: Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050*, September 2019, <https://www.aceee.org/press/2019/09/energy-efficiency-can-slash>.
2. Katie Pyzyk, Smart Cities Dive, *67% of low-income households face high energy burden: ACEEE* (September 10, 2020) <https://www.smartcitiesdive.com/news/67-of-low-income-households-face-high-energy-burden-aceee/584961/>.
3. ACEEE, Press Release, *Report: Despite Progress, Low-Income Households Underserved by Utilities' Efficiency Programs*, November 18, 2022, <https://www.aceee.org/press-release/2022/11/report-despite-progress-low-income-households-underserved-utilities>.

4. Diana Morales and Steven Nadel, ACEEE, *Meeting the Challenge: A Review of Energy Efficiency Program Offerings for Low-Income Households* (2022). Read pages v-xi, 1-2, 33-41.
5. Environmental Defense Fund, *Low-Income Energy Efficiency: A Pathway to Clean, Affordable Energy for All* (2018) https://www.edf.org/sites/default/files/documents/liee_national_summary.pdf.
6. [Supplemental] ACEEE, *The Greatest Energy Story You Haven't Heard: How Investing in Energy Efficiency Changed the US Power Sector and Gave Us a Tool to Tackle Climate Change*, 2016 <https://www.aceee.org/sites/default/files/publications/researchreports/u1604.pdf>.
7. [Supplemental] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, *Weatherization Works!* (2019) <https://www.energy.gov/sites/prod/files/2019/07/f64/WAP-Fact-Sheet-2019.pdf>.
8. [Supplemental] Ariel Dreihobl et al, ACEEE, *How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burden across the United States* (2020) <https://www.aceee.org/sites/default/files/pdfs/u2006.pdf>. Read pages 1-6, 19-29.

Class 23 – Transportation Electrification

Transportation is going electric. In this class, we explore how the efforts to electrify transportation must address equity considerations.

Learning Materials

1. The White House, *FACT SHEET: President Biden Announces Steps to Drive American Leadership Forward on Clean Cars and Trucks*, August 5, 2021, <https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/fact-sheet-president-biden-announces-steps-to-drive-american-leadership-forward-on-clean-cars-and-trucks/>.
2. Carolyn Gramling, Science News, *There's good and bad news with California's electric vehicle program*, May 12, 2023, <https://www.sciencenews.org/article/california-electric-vehicle-program>.
3. Alessandra Carreon et al, RMI, *Increasing Equitable EV Access and Charging: A Path Forward for States*, October 2022. Read pages 6-17.
4. Peter Huether, ACEEE, *Electric Vehicle Supply Equipment (EVSE) with Equity in Mind*, April 2021, https://www.aceee.org/sites/default/files/pdfs/siting_evse_with_equity_final_3-30-21.pdf. Read pages 1-22, skim case studies. (Try to understand how a comprehensive planning program is constructed and what are its constituent elements)
5. [Supplemental] Citizens Utility Board, *EV for All: Electrifying Transportation in Low-Income Communities* (2021)
6. Discussion Focus – How do we plan to get out ahead of a problem? Chicken and egg situation – Building chargers before they are needed or waiting for need and potentially suppressing demand. Is the goal to electrify transportation or to integrate equity into transportation electrification?

Class 24 - Stranded Energy Assets

For much of this course, we have talked about adding new resources to the grid. That is an essential part of the energy transition. We have also learned about the long-lived nature of energy infrastructure. The deconstruction of historical systems is also an essential part of the energy transition and the focus of

this class. We must eliminate fossil fuel infrastructure faster than its planned retirement dates and that raises issues of cost, equity, and reliability planning.

Learning Materials

1. Mark Dwortzan, MIT News, *Stranded assets could exact steep costs on fossil energy producers and investors*, August 19, 2022, <https://news.mit.edu/2022/stranded-assets-could-exact-steep-costs-fossil-energy-producers-investors-0819>.
2. Matthew Taylor, The Guardian, *Loss of fossil fuel assets would not impoverish general public, study finds*, June 22, 2023, <https://www.theguardian.com/environment/2023/jun/22/fossil-fuel-assets-loss-study>.
3. G. Semeniuk et al., *Potential pension fund losses should not deter high-income countries from bold climate action*, Joule 7 1383, July 19, 2023, [https://www.cell.com/joule/pdf/S2542-4351\(23\)00220-9.pdf](https://www.cell.com/joule/pdf/S2542-4351(23)00220-9.pdf).
4. Tyler Fitch, Vote Solar, *New analysis: Unusable fossil fuels will cost Duke's Carolina customers \$4.8 billion*, January 26, 2021, <https://votesolar.org/new-analysis-unusable-fossil-fuels-will-cost-dukes-carolina-customers-4-8-billion/>.
5. Kavya Balaraman, Utility Dive, *Close to \$16B in gas investments could be stranded with a net-zero by 2050 timeline, report finds*, October 19, 2021, <https://www.utilitydive.com/news/close-to-16b-in-gas-investments-could-be-stranded-with-a-net-zero-by-2050/608510/>.

Class 27 - The Big Finish

In this class, we wrap up the course and discuss the obstacles and opportunities embedded in the energy transition.

Learning Materials

1. Emily Atkin, Heated Newsletter, *What Can I Do? Anything*, July 12, 2021.
2. Yuki Numata and Laurens Speelman, RMI, *The Energy Transition is A Technological Revolution – with a Deadline*, August 10, 2023, <https://rmi.org/the-energy-transition-is-a-technological-revolution-with-a-deadline>.
3. Hannah Ritchie, Vox, *We need the right kind of climate optimism*, March 21, 2023. <https://www.vox.com/the-highlight/23622511/climate-doomerism-optimism-progress-environmentalism>.
4. Jack Ewing et al., NY Times, *The Clean Energy Future Is A Battle for Hearts and Minds*, August 14, 2023, <https://www.nytimes.com/interactive/2023/08/12/climate/electric-car-politics-chevy-general-motors.html>.