Energy

Harvard Business School
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Course Abstract

This course is about one of the largest industries in the world: energy. Not only will we cover energy sectors that have traditionally supplied economies across the globe, but we will also cover the energy transition needed to reduce climate change and its impacts. It will examine the economic, regulatory, and social contexts that provide the dynamic backdrop for how both new entrants and incumbent firms can navigate and drive the energy transition. How does the energy economy work, and how fast can it change? How are entrepreneurial start-ups disrupting the energy economy? How are corporations across sectors navigating and potentially driving the energy transition—or not? How are new policies being enacted worldwide impacting billion-dollar decisions? And how are different local communities responding, given the benefits and costs of enormous changes in the energy mix?

Energy tackles all of these questions and more.

Educational Objectives

This class is for students with a wide variety of interests seeking a better understanding of the role of energy in business and society. It will examine the energy transition in a time of surging global energy demand and the era of climate change. The course aims to drive an understanding of energy from both the supply and demand sides. It will unlock smarter perspectives in other domains, such as finance, real estate, and technology, that all rely on energy. Students will learn about new technologies and choices impacting financing, development, and deployment. Students will appreciate the interplay between market, regulatory, and societal influences on firm opportunities and choices.

Organization of the Course

Energy will meet in 14 sessions divided into three parts. The first section provides background to the energy ecosystem and relevant institutions such as the electrical grid. The second examines a set of energy sectors that supply energy. The final section shifts to the demand side. The highly interactive course will utilize cases, visitors on the front lines of the future energy economy, and a local field trip.

Grading structure

Student paper 40%

Drawing on their interests and backgrounds, students write a paper (2000 words) that identifies and analyzes a relevant business, regulatory, or related opportunity in the energy space. This might come from an existing company or sector grappling with a current challenge. Or it might be a new opportunity where there does not yet exist established organizations. Please see the assignment for additional details.

Participation 50%

Students will actively participate in class in constructive and respectful ways.

Lesson critique *(10%; non-graded (completed or not); 1 page single-spaced excluding references)*

What substantive 'angles' or 'perspectives' would you have developed more deeply if you were facilitating learning? Were there angles left out that the instructor could help better pull out next time? Were there angles that were well developed--and why? Was there any background information or context that would have been helpful? Were there any contemporary or future-looking perspectives to incorporate? It is due two weeks after the last day of class via Canvas but submitted anytime earlier.

Use of Generative AI. Students can explore the use of generative artificial intelligence (GAI) tools such as ChatGPT, but as noted in the paper assessment prompt, this cannot be used to write your paper submission. Any facts and perspectives from Generative AI are likely to be shallow for the purposes of that assignment. Any such use must be appropriately acknowledged and cited. It is also each student's responsibility to assess the quality, validity, and applicability of any GAI output that is submitted. Violations of this policy will be considered academic misconduct. Different courses at HBS are likely to specify different requirements on using GAI, and it is each student's responsibility to abide by them for each course.

Acknowledgments: The design of this class has benefitted from conversations with numerous people, beginning with Lynn Schenk and Mike Toffel. Conversations with a number of current and former MBA students and student clubs were instrumental. Bharat Anand, Willis Emmons, Robin Greenwood, Deb Spar, Jim Matheson, Secretary Ernie Moniz, Jim Stock, Gunnar

Trumbull and Peter Tufano were also enormously helpful. Jesse Jenkins, Dan Schrag and David Keith provided valuable materials and/or feedback.

Background/Pre-Class Assignments and Materials

Science Corner

What topics would you like to have a 'tutorial' in?

The Energy space is vast. What topics would you love to have a tutorial in? It could be on some science and engineering topics, policy, economics, etc..

Once you post, you can see the posts of other students. Feel free to like their posts or respond to them if you know of some resources that might help.

I'll take this discussion and try to summarize it and see what we can find/develop (though possibly not by the end of this short course!).

Energy and Earth Systems

Earth's radiation budget
https://player.vimeo.com/video/403845003 (Dan Schrag)
Physics of Planetary Energy Balance
https://player.vimeo.com/video/403845908 (Dan Schrag)

Units and Prices

When people talk about amounts of energy, as well as prices, we are in a world where we have to be mindful of units of measurement.

This video overviews some basics of energy pricing:

https://youtu.be/8jk7s4ZMLMQ (David Keith)

These slides go over different energy units, and give examples from daily life: Unit slides

Physics of Energy

Energy obeys the law! (thermodynamic laws). These slides give a high level overview: Slides (Jesse Jenkins)

The tomb on this topic is *The Physics of Energy*, Robert Jaffe and Washington Taylor. It is pretty technical/mathematical but very thorough.
https://www.amazon.com/Physics-Energy-Robert-L-Jaffe/dp/1107016657

These are notes from the MIT course that the book is based on,
https://ocw.mit.edu/courses/8-21-the-physics-of-energy-fall-2009/pages/lecture-notes/

Energy Power and its Production

What is the relationship between energy, power and work? Slides (Jesse Jenkins)

Steam!!! Making the world go round (how steam turbines work) Slides (Jesse Jenkins)

Gas turbines Slides (Jesse Jenkins)

Class Sessions

Energy Background and Institutions

Day 1: Size and scope of the energy industry. Big Oil versus Big Automotive strategy

No case. Background materials.

Breaking apart the energy economy (David Keith)

https://www.youtube.com/watch?v=OywMnCoJdSU

History of Energy System (David Keith)

https://youtu.be/L_2EbwxgBhA

Class focus: Background information on energy production, distribution, and consumption. Discussion of recent strategy trends by oil majors versus the automotive industry.

Optional supplemental materials:

- US Electricity Markets 101 (https://www.rff.org/publications/explainers/us-electricity-markets-101/)

- Competitive Electricity Markets: A Wholesale Primer, Bill Hogan, Harvard HKS, https://scholar.harvard.edu/whogan/files/empr1298.pdf

Background video resources
Breaking apart the energy economy (David Keith)

https://www.youtube.com/watch?v=OywMnCoJdSU
History of Energy System (David Keith)
https://youtu.be/L_2EbwxgBhA

Day 2: Industrial policy and project financing

Class Design: What is the role of government in energy industry innovation? Are earlier examples of US industrial policy in energy successes or failures? Will the new (US) industrial policy for the energy sector be any different? How are energy projects financed and what are the unique challenges that these types of projects face? How will the global–and geopolitical—nature of the energy sector impact businesses?

Case: Shaping the Future of Solar Power: Climate Change, Industrial Policy, and Free Trade. (https://hbsp.harvard.edu/tu/1fdc407c)

Pre-class question 1: In the Solyndra case, who were the US proponents of restrictions on Chinese solar panel imports? Who were the opponents?

Pre-class question 2: Is it ok for the US government to break international free trade treaty commitments to build up new energy industries that will have low(er) environmental impacts? Yes/No and explain in 2-3 sentences why. "It depends" is a reasonable response, but let's have everyone take a hard position.

Pre-class question 3: What is a project financing component (as defined in the Esty et al. reading) that you think will be especially relevant for energy sectors? In 2-3 sentences, explain why.

Required supplemental materials:

An Overview of Project Finance and Infrastructure Finance (214083); Yes, I know this is a bit long!

Optional supplemental materials

Financing U.S. Decarbonization: A Conversation with Jigar Shah (director of the Loan Programs Office in the US Department of Energy)
(https://www.youtube.com/live/6YNNc2IPmEo?feature=share

Impact of IRA, IIJA, CHIPS, and Energy Act of 2020 on Clean Technologies, BCG,
(https://breakthroughenergy.org/wp-content/uploads/2023/05/Crosstech-Cleantech-Policy-Impact-Assessment.pdf

Inflation Reduction Act (IRA) Summary: Energy and Climate Provisions
(https://bipartisanpolicy.org/blog/inflation-reduction-act-summary-energy-climate-provisions/

Uncertain Futures, chapter 2, Alex Gazmararian and Dustin Tingley, www.uncertainfuturesbook.com; Access via Harvard Library or purchase

The New Economics of Industrial Policy. Juhász R, Lane N, Rodrik D. 2023. (https://drodrik.scholar.harvard.edu/sites/scholar.harvard.edu/files/dani-rodrik/files/the_new_economics_of_ip_080123.pdf

Financing Innovation: Evidence from R&D Grants, Sabrina T. Howell, American Economic Review, (https://www.aeaweb.org/articles?id=10.1257/aer.20150808

Innovation and Entrepreneurship in the Energy Sector, David Popp, Jacquelyn Pless, Ivan Haščič and Nick Johnstone, (https://www.nber.org/system/files/working_papers/w27145/w27145.pdf)

Energy Supply

Day 3: Natural Gas (methane+)

Class design: What is the future of "natural gas"? Will it be a viable bridge fuel? Will it form the basis for other energy sources, such as hydrogen and ammonia (and are these viable fuel forms)? How will the industry deal with leaks in extraction and transportation that create substantial global warming pollution?

Case: Woodside - Betting on the Future of Gas (https://hbsp.harvard.edu/tu/55dc4f02)

Pre-class question 1: Do you agree with the projections that LNG demand will grow over the next 15-20 years? Why/Why not?

Pre-class question 2: Should Woodside continue to develop gas resources (such as Browse) and rely on offsets such as tree planting to lower the carbon content of delivered LNG?

Pre-class question 3: Should Woodside move to selling hydrogen made from gas as the energy source and CCS, or instead move all the way to making and selling green hydrogen?

Required supplemental materials

Browse: The Rise of Responsibly Sourced Gas, CMEGroup, (https://www.cmegroup.com/articles/whitepapers/the-rise-of-responsibly-sourced-gas.html

Browse: Hydrogen market primer, Charles River Associates, (https://www.marakon.com/media/1859/210722-cra-marakon-hydrogen-market-primer.pdf

Optional supplemental materials:

How an international agreement on methane emissions can pave the way for enhanced global cooperation on climate change, Kimberly Claussing and Catherine Wolfram,

https://www.piie.com/publications/policy-briefs/how-international-agreement-methane-emissions-can-pave-way-enhanced

Certified Disaster: How Project Canary and Gas Certification are Misleading Markets & Governments, EarthWorks, https://earthworks.org/wp-content/uploads/2023/04/certified_disaster_report_FINAL_04_14_2023.pdf

Japan Says It Can Make Coal Cleaner. Critics Say Its Plan Is 'Almost Impossible, New York Times, https://www.nytimes.com/2023/07/22/world/asia/japan-coal-renewable-energy-ammonia.html

Background Video Resources:
Exxon on the LNG value chain
https://www.youtube.com/watch?v=rjlRTFyennU
The chemistry of steam methane reformation (hydrogen from methane)
https://www.youtube.com/watch?v=LoFB3JjfGNs
"Undecided" episode on hydrogen challenges
https://www.youtube.com/watch?v=GbcXfbRvvrA
Well capping
https://www.youtube.com/watch?v=iAf2k9b0drY

Day 4: New Nuclear

Class design: What role does nuclear energy play in the current energy economy? What problems do new technologies like small modular reactors (SMR's) solve, and which do they not? What is their optimal place within the energy ecosystem? What do they rely on? Is the permitting process too stringent or too lenient? What time scales are we looking at for their deployment, and are they fast enough given energy transition needs and advances in other technologies? What are the challenges behind commercializing SMR's that are similar or dissimilar to traditional nuclear energy? How does growing investment in fusion technologies disrupt or complement SMR's?

Pre-class question 1: What is something about the NuScale SMR **design** that you find interesting and/or having significant potential?

Pre-class question 2: What is something that nuclear systems like NuScale produce besides electricity that could be useful for other business applications?

Case: NuScale: Commercializing the First Small Modular Reactor in the World, https://hbsp.harvard.edu/tu/8e69e6af

Optional Supplemental Materials

(strongly encouraged) The Pathway to Advanced Nuclear Commercial Liftoff, US Department of Energy, (https://liftoff.energy.gov/advanced-nuclear/)

The end of Oppenheimer's energy dream, https://iai.tv/articles/the-end-of-oppenheimers-energy-dream-auid-2549?_auid=2020

Nuclear Power in a Clean Energy System, International Energy Agency, https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system

America aims for nuclear-power renaissance, The Economist, (https://www.economist.com/united-states/2023/06/25/america-aims-for-nuclear-power-renaissance

OpenAI's Sam Altman Is Taking a Nuclear-Energy Startup Public, WSJ, (https://www.wsj.com/articles/sam-altman-backed-nuclear-startup-is-going-public-through-altmans-spac-cf1ae712 (Nuclear behind the meter!)

Nuclear energy data, Our World in Data, https://ourworldindata.org/nuclear-energy

Background video resources:
Physics of nuclear energy
https://youtu.be/07rbp-3H_8o
Nuclear waste
https://youtu.be/_pG2wCnkQ_8
Introduction to "Levelized Costs"
https://youtu.be/mw90-DAqRzQ
Capital charge factors
https://youtu.be/Bq2C_Q0i1Yw
"Undecided" episode on fusion energy
https://youtu.be/_opQgKtIsEs
Levelized Costs for a GAS plant (think about the nuclear case)
https://youtu.be/XUECDPUKJU0

Day 5: Geothermal

Class design: What problems does geothermal energy solve, and what problems does it not? What is their optimal place in the energy ecosystem? What are the challenges behind the commercialization of a new energy technology unfamiliar to many? Will expertise from the oil and gas industry unlock new geothermal opportunities?

Pre-class question 1: What was the claimed advantage of injecting carbon dioxide rather than using water in the GreenFire geothermal process? And how did they plan to obtain carbon dioxide in the future?

Pre-class question 2: Beyond electricity production, what are other applicabilities (the 6th category Porter forgot) of GreenFire's technology mentioned in the case? Are there any you can think of?

Case: GreenFire Energy, 2020: Geothermal Innovation (https://hbsp.harvard.edu/tu/f06b15ae)

Required supplemental materials:

Backgrounder slides

Optional supplemental materials:

Enhanced Geothermal: A New Tool for Deep Decarbonization, Jesse Jenkins,

https://youtu.be/ynvD9shBBl8 **starting at 45:08**

Slides at
https://www.dropbox.com/s/009datvh94a0bip/Jenkins-2023-05-11%20-%20Geothermal%20EarthShot%20DOE.pdf?dl=0

Geothermal basics, Department of Energy,
(https://www.energy.gov/eere/geothermal/geothermal-basics)

Community-based geothermal energy production (Princeton University going geothermal neighborhood geothermal)

Eversource in Framingham

An Overview of Indonesia's Geothermal Sector, ASEAN,
(https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/

The value of in-reservoir energy storage for flexible dispatch of geothermal power. Ricks, W., Norbeck, J., & Jenkins, J. (2022). *Applied Energy*, *313*, 118807.

Geothermal May Beat Batteries for Energy Storage, Praci Patel, IEEE Spectrum,
https://spectrum.ieee.org/geothermal-energy

This geothermal startup showed its wells can be used like a giant underground battery, James Temple, MIT Technology Review,
https://www.technologyreview.com/2023/03/07/1069437/this-geothermal-startup-showed-its-wells-can-be-used-like-a-giant-underground-battery/

Day 6: Wind

Class Design: What could have happened differently in the Cape Wind case? What could the firm have done differently? What could the government and civil society have done differently? Are the lessons from this case ones that continue to be "re-learned"? What is exciting about wind as a renewable energy source right now and in the coming decade? What will be its core challenges? Can it complement other energy supply sources and technologies? Will it be disruptive of other industries, and how can this be handled?

Pre-class question 1: Vineyard Wind's Chief Commercial Officer will visit our class. Thinking about their role in an offshore wind company (i.e., he is the CCO) what is one question you might like to ask?

Case: Cape Wind; (https://hbsp.harvard.edu/tu/eb33c9e1

Class visitor: Vineyard Offshore Chief Commercial Officer, Ben Koffel.

Optional Supplemental Materials:

- (strongly encouraged!) US Electricity Markets 101 (https://www.rff.org/publications/explainers/us-electricity-markets-101/

Browse:
https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/how-to-succeed-in-the-expanding-global-offshore-wind-market

https://www.iea.org/energy-system/renewables/wind

Day 7: Class Field Trip to Harvard Energy Plants

Class visit to one of Harvard's energy sources, including the Harvard District Energy Facility and the Blackstone Steam Plant. All students are assigned to a visit date/location. No in-class meeting.

Required reading:

US Electricity Markets 101 (https://www.rff.org/publications/explainers/us-electricity-markets-101/)

Explore ISO New England: https://www.iso-ne.com/

Required short videos:

District Cooling
https://www.youtube.com/watch?v=tEh16-NusuQ

District Heating:
https://www.youtube.com/watch?v=7BznKyEb0bc
Cogeneration
https://www.youtube.com/watch?v=B1MkfNqUxMM
Cogeneration at NYU
https://www.youtube.com/watch?v=MmGQ1GjCLLg

Background on facilities being visited:

https://www.energyandfacilities.harvard.edu/real-time-energy-production-demand

https://www.energyandfacilities.harvard.edu/utilities/allston-district-energy-facility

https://www.energyandfacilities.harvard.edu/utilities/steam

Day 8: Solar

Class Design: What are the economics of building and maintaining utility-scale solar? What are available risk mitigation strategies and what role do public-private partnerships play? What are the risks of accepting subsidies from governments? What are power purchasing agreements (PPA's), and how might they be best structured? How will countries like India be able to finance the massive changes necessary to meet decarbonization targets?

Pre-class question 1: What is viability gap funding?

Pre-class question 2: What was the role of International Financial Institutions (IFI's) in the Rewa project?

Case: Rewa Solar India: PPP Innovation Unleashed (https://hbsp.harvard.edu/tu/d54ce64a)

Background slides

from Prof. Tingley on India and energy.

Optional Supplemental Materials:

Short background videos on solar energy

IEA Solar PV Report, https://www.iea.org/energy-system/renewables/solar-pv

IEA Country Report: India, https://www.iea.org/countries/india

Inching closer: Who will pay for a decarbonized world? (Confronting Climate Change HBS conference),
https://www.hbs.edu/environment/climate-change/Pages/key-insights.aspx?item=toward-a-decarbonized-future

Uncertain Futures, chapter 2, Alex Gazmararian and Dustin Tingley, www.uncertainfuturesbook.com

How Solar Got Cheap, Gregory Nemet: https://www.howsolargotcheap.com/

Reimagining Net Metering: A Polycentric Model for Equitable Solar Adoption, Alex Gazmararian and Dustin Tingley, (https://scholar.harvard.edu/sites/scholar.harvard.edu/files/dtingley/files/polycentricenergyaccess.pdf)

India's quest to build the world's largest solar farms, New Yorker, https://www.newyorker.com/news/dept-of-energy/indias-quest-to-build-the-worlds-largest-solar-farms

India's solar power rollout is flagging, https://www.economist.com/asia/2023/02/23/indias-solar-power-rollout-is-flagging

ReNew Power: Leading the Energy Transition in India

TECNOSOL 2017: Bringing Solar Energy to Rural Communities in Nicaragua

Scaling Up Private Finance for Clean Energy in Emerging and Developing Economies, IEA, https://www.iea.org/reports/scaling-up-private-finance-for-clean-energy-in-emerging-and-developing-economies

Background resource videos:
Concentrated solar power
https://youtu.be/rO5rUqeCFY4
Solar photo-voltaic (PV)
https://youtu.be/0elhIcPVtKE
Template for solar farm costs: https://ratedpower.com/blog/solar-farm-costs/
Cost benchmarking:
https://youtu.be/rpHvaEza5ls

Day 9: Storage

Class design: What storage goals can and should state governments be making? What are the obstacles and opportunities? How will storage transform the way businesses think about energy production and usage? And what role will large infrastructural investments play in deploying energy storage? What are the technology and strategy challenges for large-scale storage, and how does this impact firm and government decision-making?

Pre-class question 1: On the day ahead wholesale market for energy, what determines the cost of energy? And how would quickly accessible storage change this cost?

Pre-class question 2: In your opinion, are smart meters (devices that let consumers track the price of electricity at any point in time) a complement, a substitute, or neither (ie., irrelevant) to battery storage for residential customers? Why?

Case: State of Charge: The Massachusetts Energy Storage Initiative

Class visitor: Tom Ferguson, Energy Storage Programs Manager, Renewable and Alternative Energy Division, Massachusetts Department of Energy Resources

Broader context

Optional supplemental materials:

Long duration energy storage, Department of Energy Liftoff report, https://liftoff.energy.gov/long-duration-energy-storage/

IEA, Grid Scale Storage, https://www.iea.org/energy-system/electricity/grid-scale-storage

IEA, Battery Trends, https://www.iea.org/reports/global-ev-outlook-2023/trends-in-batteries

IRENA Battery cost analysis (a bit dated, but very helpful breakouts of data), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Oct/IRENA_Electricity_Storage_Costs_2017.pdf

Monetizing Energy Storage: A Toolkit to Assess Future Cost and Value, Oliver Schmidt And Iain Staffell, Oxford University Press, open access at https://global.oup.com/academic/product/monetizing-energy-storage-9780192888174

EPRI Energy Storage Economics: https://storagewiki.epri.com/index.php/Energy_Storage_101/Economics#

Sepulveda, Nestor A., Jesse D. Jenkins, Aurora Edington, Dharik S. Mallapragada, and Richard K. Lester. "The design space for long-duration energy storage in decarbonized power systems." *Nature Energy* 6, no. 5 (2021): 506-516.

The value of in-reservoir energy storage for flexible dispatch of geothermal power. Ricks, W., Norbeck, J., & Jenkins, J. (2022). *Applied Energy*, *313*, 118807.

Geothermal May Beat Batteries for Energy Storage, Praci Patel, IEEE Spectrum, https://spectrum.ieee.org/geothermal-energy

This geothermal startup showed its wells can be used like a giant underground battery, James Temple, MIT Technology Review, https://www.technologyreview.com/2023/03/07/1069437/this-geothermal-startup-showed-its-wells-can-be-used-like-a-giant-underground-battery/

Background resource videos:

10 Grid facts (David Keith) (was suggested in an earlier module as well)
https://youtu.be/n_N_eyFFJes
Lazard's Levelized Cost of Storage analysis
Download Levelized Cost of Storage analysis
(starts on page 15)
Brief explainer for Levelized Cost of Storage (rather than LCO-Energy)
https://invinity.com/what-levelized-cost-of-storage-means-to-project-stakeholderss/
Salt for Batteries? (fyi, has an advertisement)
https://youtu.be/vm2hNNA4lvM
Consumer batteries
https://youtu.be/DzTlyM-IA-I

Day 10: Redesigning Energy at Harvard

The class session will discuss options for addressing Harvard's energy needs in the next decade in light of Harvard and local municipal goals, as well as recently passed regulations.

We will have a live case with visitors from Harvard's leadership in this space: Heather Henriksen (Chief Sustainability Officer) and Jaclyn Olsen (Director, Harvard's Office for Sustainability).

Pre-class question 1: What are one or two questions you would like to ask Harvard leadership about its plans and strategy for moving away from energy sources that generate carbon and related climate-changing emissions?

Required reading: 2023 Harvard Sustainability Plan

Background resource videos:

Decarbonizing Residential and Commercial Buildings,
https://player.vimeo.com/video/446614447

Energy Demand

Day 11: Transportation

Class Design: What is the competitive landscape of EVs and how are firms competing with each other, or even with themselves? What industries surrounding EVs will impact the viability of EV products? Will electrified transportation be accessible to poorer communities? How will the

rollout of the IRA and other government programs impact the EV competitive landscape, and what will be the impact of opposition to these programs? Are there interesting new Battery(as a service) models to consider, and where?

Pre-class question 1: Should Tesla focus on further scaling of its best-selling models or introducing new products into new segments? Do you believe Tesla can maintain its current position as additional automakers enter the market?

Case: The New War of the Currents: The Race to Win the Electric Vehicle Market (https://hbsp.harvard.edu/tu/bee96295)

Background slides

Optional Supplemental Materials

The New Death Match Over EV Chargers, HeatMap, https://heatmap.news/electric-vehicles/ev-chargers-gas-stations-utilities

Rivian's quest...WSJ, https://www.wsj.com/business/autos/rivian-ev-truck-electric-vehicle-8e8dc124 (Provides a nice overview of challenges market entrants face)

Monthly Energy Review, Energy Information Agency, https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

Energy Use for Transportation, EIA, https://www.eia.gov/energyexplained/use-of-energy/transportation.php

Background resource videos:
From Prof. Dan Schrag
Liquid Fuels for Transportation
https://player.vimeo.com/video/437950408
Decarbonizing Heavy Transport
https://player.vimeo.com/video/437951410

Day 12: Transmission and Law

No case. Focus on how grids work, what business models operate on top of them, and what the challenges and opportunities will be in the future at the national and local level. We will also discuss the role of lawyers in the Energy sector. Carrie Jenks and Ari Pescoe from Harvard Law School will be joining!

Pre-class question 1: What do you see as the biggest barrier to building out more high-voltage transmission, and what might be done to overcome this barrier?

Required Materials

U.S. Electricity Grid & Markets, EPA, https://www.epa.gov/green-power-markets/us-electricity-grid-markets(a good overview)

FERC, Wholesale Electricity Markets, pages 35-39 of https://www.ferc.gov/sites/default/files/2020-06/energy-primer-2020.pdf

Ari Peskoe, Is the Utility Transmission Syndicate Forever? Energy Law Journal (2021), this is an excerpt.

Background slides

Optional Supplemental Materials

Digital innovation: Creating the utility of the future, Deloitte, (https://www2.deloitte.com/us/en/insights/industry/power-and-utilities/digital-transformation-utility-of-the-future.html

Electricity Regulation in the US: A Guide (Second Edition), Regulatory Assistance Project, (https://www.raponline.org/knowledge-center/electricity-regulation-in-the-us-a-guide-2/

Transmission Impossible? Prospects for Decarbonizing the US Grid, Journal of Economic Perspectives, 2023, Davis, Lucas W., Catherine Hausman, and Nancy L. Rose.

Background resource videos:
10 Grid facts (David Keith)
https://youtu.be/n_N_eyFFJes
Marginal costs and dispatch curves (David Keith)
https://youtu.be/xoq7H_MYS4Y
Why monopolies? (David Keith)
https://youtu.be/xKGURnpcDS
Distributed generation (and net-metering) (David Keith)
https://youtu.be/P5ibQNYIUF8
Grid synchronization
https://www.scientificamerican.com/article/how-ukraine-unplugged-from-russia-and-joined-europes-power-grid-with-unprecedented-speed/

Day 13: Student Projects

Class Design: Student paper day.

Students will discuss in small rotating groups their class project. Class session will close with report outs on what you learned from your peers. Chocolate provided.

Day 14: Energy Efficiency + Class Closing

Class Design: Why can there be low adoption rates of technologies that save money? What are the adoption barriers for consumers? How can firms take advantage of information asymmetries in a way that is good for their clients but also good for their business? How can firms more effectively sell “credence goods”? What is the role of regulatory or standard-setting instruments?

Pre-class question 1: How does Groom Energy create value for its customers? How does it capture value?

Pre-class question 2: Which segments should Groom Energy focus on for its future growth? Why?

Case: Groom Energy Solutions (https://hbsp.harvard.edu/tu/abaadf0a

Optional Supplemental Materials:

Browse https://www.iea.org/reports/energy-efficiency-2022

Generate Capital and McKinstry launch Viridis Initiative to accelerate the decarbonization of institutional buildings and facilities, (https://www.businesswire.com/news/home/20230615202390/en/Generate-Capital-and-McKinstry-launch-Viridis-Initiative-to-accelerate-the-decarbonization-of-institutional-buildings-and-facilities

There is an academic journal titled "Energy Efficiency", https://www.springer.com/journal/12053

Resources for the Future, Energy Efficiency 101, https://www.rff.org/publications/explainers/energy-efficiency-101/

Copenhagen Center for Energy Efficiency, Energy Efficiency Business Models, https://c2e2.unepccc.org/wp-content/uploads/sites/3/2021/01/business-models.pdf

Background resource videos:
The Science of Insulation, The International Association of Heat and Frost Insulators and Allied Work
https://youtu.be/f4R64FhGeis
Smart meters in Uzbekistan, Asian Development Bank
https://youtu.be/YMln_y7QJls