

Syllabus (revised)

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Day/Time/Room: 12:15-1:45 PM, Tuesdays and Thursdays, by Zoom
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Course Description and Objectives

The world is in the midst of figuring out how to transition to clean energy. While much attention is given to energy *technologies*, one essential element of a clean energy system is creating *business models and financing strategies* to carry out a system transformation. This course will explore the rapidly changing energy markets, discuss how policy and consumer choice are shaping new markets, and examine emerging financing strategies that are being developed and deployed to accelerate the pace of implementation.

The course has three intertwined learning objectives:

1. Develop an understanding of clean energy systems, finance, and economics
2. Examine and gain an appreciation for the interface between policy and markets and finance, and explore specific efforts to accelerate market transformation by policy and program innovation
3. Learn how to develop financial analysis tools and create business models that can rationalize clean energy investments

The course has three main elements. One is directed reading and active classroom discussion. Second, you will have quizzes, reflections, and in-class activities to push you to articulate and manipulate course concepts and topics. Third, you will build, from the ground up, a set of individualized pro formas and an accompanying narrative (your team project).

Course Material

All of the readings are here. Every reading is in the public domain, or available from inside the UO domain via the library's web site.

Course Policies and Procedures

Communication: I will send course announcements by e-mail and post them on Canvas, at least once per week. When you send e-mail, please put "MGMT 608 - CEF" in the subject heading; if you don't do that, I'm not responsible for seeing it or responding to it.

Absences: Please inform me *ahead of time* (or as soon as possible after the fact) if you will be absent from a class. If you miss a class, you will miss the points for any in-class activities that day. I will make only rare exceptions.

Academic Integrity: I will not tolerate plagiarism or cheating. If you are found to be in violation of academic integrity rules, I will, without exception, pursue punishment to the fullest extent that University and LCB policies allow. Sadly, these issues have become a significant problem on this campus and other campuses; sometimes they occur in gray areas that are not obvious to the student. Please become familiar with the UO policies:

- **Ethics:** The Lundquist College of Business Code of Ethics must be followed at all times. It can be found at <http://lcb.uoregon.edu/welcome/procode.html>
- **Academic Misconduct:** <https://dos.uoregon.edu/academic-misconduct>.

Course Requirements

Grades will be based on the following individual and team assignments. You will receive a more detailed explanation of each written assignment in class and on Canvas.

Deliverable	Due Date	Percent
Contributions to class learning and discussion, and in-class activities	Ongoing	15%
Quizzes	Ongoing	15%
Reflections	Weekly (nearly)	20%
Project: Clean Energy Investment Financial Analysis	Draft outline by TBD Final version by March 16	Outline: 2% Week 10 discussion: 3% Final version: 25%
Take-home Final Exam (we'll figure out the due date together)	Exam week	20%

Contributions to class and in-class activities (15%)

You are expected to prepare for, attend, and actively participate in class. The quality of your learning is directly related to the quality of your preparation. I'll have fairly frequent in-class activities, sometimes with handouts and sometimes online submittals on Canvas. If you miss a class, you will miss the points for any in-class activities that day. I will make only rare exceptions.

I encourage you to bring a laptop, tablet, or phone to class, but please do not surf the web during class unless your purpose is tied to our discussion, and please silence phones during class. Violating these guidelines is disrespectful to the instructor and to your fellow students. In general, it is remarkably easy to detect when a student is idly surfing or texting rather than doing so to add to the class or taking notes on class discussions. So please...don't. Thank you.

Quizzes (15%)

You will have at-least-weekly quizzes to help you stay up with the material. The quizzes will be fairly superficial, but the point is to keep the material in your brains, not to help you think deeply about it (that's what reflections and class discussion are for). More info coming on Canvas.

Reflections (20%)

You will have close-to-weekly reflections to give you a chance to think more deeply about the material. They will be fairly short (350-400 words) and informal (no formatted references necessary), but they should be clearly and carefully written. Generally, you will choose the topic, but occasionally, I will give directions, so pay attention to the introductory text in each reflection. More guidance on Canvas.

Group Project: Clean Energy Investment Financial Analysis (30%)

Over the course of the quarter, you will assemble a set of financial pro formas (in Excel) and an accompanying report (in Word) to examine in detail several possible investments at the household scale. The purpose of the individual project is to demonstrate mastery of a narrow set of decisions by providing detailed financial analysis.

Format (for an individual): Written report, no more than 1500 words on no more than ten (10) pages (including graphs and charts from Excel embedded in the Word doc), brief in-class presentation and facilitated discussion. The Excel doc is a separate deliverable to accompany the Word doc in case I have questions. Key elements of the analysis:

- Clear summary of analysis and conclusions
- Description of the context of implementation
- Sensitivity analysis for major variables (energy prices, cost of carbon, financing options, etc.)

More information on content and format to follow. If you have an idea, check it out with me. In general, if you have a group, the total expectation will be calibrated to the person-power available.

[Click here for a list of project descriptions.](#)

Final Exam (20%)

Please do not forget course material after we have discussed it. You're still responsible for that material – at least into mid-March. Format: 24- or 48-hour take-home final, reasonable word count (~2,000), with modest expectations of polish. More information on content and format to follow.

For now and the future: Resources out there

There's a lot of clean energy information out there. The web is a great big place to forage for research, but sometimes too big, so here are some high-quality starting points (and you'll see all of these on the syllabus in some form or another).

- Greentech Media (www.greentechmedia.com)
- Rocky Mountain Institute (www.rmi.org)
- GreenBiz (www.greenbiz.com)
- CleanEdge (cleanedge.com)
- Guidehouse Insights (guidehouseinsights.com) (formerly Navigant Research)
- Utility Dive (<https://www.utilitydive.com>)
- National Renewable Energy Laboratory (www.nrel.gov)
- Energy News Network (energynews.us).

I also subscribe to and highly recommend the e-mail digests from Energy News Network.

Weekly Topics

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Weekly Details: Topics, Learning Objectives, and Readings

What appears below is my attempt to capture everything we will do. It may change (a bit) along the way, so please stay tuned and ask questions.

Week 1 (January 4-8) – Foundations: Science, Economics, and Policy

We will look briefly at a few aspects of the essential backdrop of the energy space: the global climate crisis, global economic pressures for growth in energy consumption, key technological trends, and major policy responses. We'll focus on the U.S., especially on the evolution of energy consumption and production, but we will also look globally. We will introduce the concept of levelized cost of energy (LCOE).

Learning objectives for Week 1 (questions to ask yourself and generate answers to):

- What is the state of the energy system in the U.S.?
- What are the major trends in energy? Did I already know them? Are they captured in mainstream discourse?
- What is LCOE, and what are its strengths and limitations?
- What is the connection between energy and the climate crisis?
- What evidence is there of global and national policy consensus on energy issues and the climate crisis?

For Tuesday

- Bloomberg New Energy Finance (2020). *2020 Sustainable Energy in America Factbook*. [Download here](#) (free registration required). Read p. 1-12, 16, 21-22, 28-29.
- Lazard (2020). *Lazard's Levelized Cost of Energy Analysis Version 14.0*. Browse [the release page here](#) and download [the PDF](#). Read slides 1-2 and 14.
- [Visualizing US Energy Use in One Massive Chart](#), Visual Capitalist

For Thursday

- [The Top 11 Clean Energy Developments of 2020](#), Rocky Mountain Institute (2020)
- [LCOE and its Limitations - Energy For Growth](#), Energy For Growth.
- World Bank (2020). [State and Trends of Carbon Pricing 2020](#) Washington, DC: World Bank. Read p. 1 and 6-8. Note the tone of the Executive Summary. (You'll read more of this document later.)
- [UN secretary general urges all countries to declare climate emergencies](#), Guardian
- "U.S. electric system is made up of interconnections and balancing authorities," EIA www.eia.gov/todayinenergy/detail.php?id=27152 (just one page)
- David Roberts (2013). [Utilities for dummies: How they work and why that needs to change](#), Grist.

Please note that you aren't expected to read every page of Bloomberg, Lazard, and the World Bank *State and Trends* right away, but I will assign more pages later. These are resources for you to draw upon. Keep them close by during the term.

Terms for the week: LCOE, utility scale, distributed generation, net zero, nameplate capacity, energy vs. power, load, generation, load profile, kWh, IOU

OPTIONAL:

- [World urgently needs to quicken steps to reduce global warming - IMF](#), International Monetary Fund
- [Seven Challenges Report](#), Rocky Mountain Institute (2019). Read the summary of the 'seven challenges' on that page (but no need to download and read the report).
- [Part V: Building the Low-Carbon Future](#), Robert J. Klee, Clean Energy Finance Forum
- [Can The Energy Industry Rise To The Challenge Of Climate Change?](#), Wood Mackenzie
- [Navigating the Path to the Low Carbon Future](#), ICF (2018)
- [Renewable Electricity Futures Study](#), NREL
- David Roberts, "[Why do 'experts' always lowball clean-energy projections?](#)," Grist
- [Crossing the Valley of Death, Solutions to the next Generation Clean Energy Project Financing Gap](#), Clean Energy Group, 21 June 2010.

- If you would like a background reading with the basics of climate science, I suggest this one: [Climate Change: Evidence and Causes](#), National Academy of Sciences and The Royal Society (2014).
- This California Air Resources Board (ARB) webinar describes the current science and the emerging policy framework: “Carbon Neutrality in the California Context,” January 23, 2019, [site](#) and [slides](#)

Week 2 (January 11-15) – The Utility Business Model and Challenges To It

How do utilities work?

Most of the electricity and natural gas in the U.S. market flows through private-sector entities that are regulated at the state level. The nature of this regulation and the traditional business model associated with it are fundamental starting points for understanding where we are now. Current forces – technological change and policy imperatives – represent a threat to the very existence of these business models.

Learning objectives for Week 2 (questions to ask yourself and generate answers to):

- What is the basic structure of the regulated utility business model? What are the incentives built into it?
- How do changes in policy priorities and technology erode or obviate the regulatory compact?
- What is the *utility death spiral*?
- What are the roles of the different moving parts – utilities, regulators, stakeholders, technology – in transitioning to a low-carbon electricity system?

For Tuesday

Overview of the utility business model:

- (from last week) David Roberts, [Utilities for dummies: How they work and why that needs to change](#), Grist.
- [Easing the Transition to a More Distributed Electricity System](#), IREC. Through p. 12 (The Regulatory Compact).
- Bloomberg New Energy Finance 2020 *FACTBOOK: Sustainable Energy in America*, p. 33-34.
- [Reforming the Energy Vision: Transforming NY Utility Regulation](#), Jim Kennerly
- Example of an IOU’s service area: [PSE | Corporate Information and Facts](#)
- Examples of how IOUs (could) work: [How refinancing could help retire Colorado coal plants sooner](#), Energy News Network

Threats and Opportunities:

With the status quo understood, we will explore what threatens to replace the traditional utility business model, as well as potential resolutions to this tension.

- Grid defection and load defection
 - o RMI (2014). [The Economics Of Grid Defection: When And Where Distributed Solar Generation Plus Storage Competes With Traditional Utility Service](#). Read the executive summary (p. 6-9).
 - o Mandel, James, and Mark Dyson and Todd Zeranski, “Why We Still Need To Discuss Grid Defection,” (2017). [rmi.org/news/still-need-discuss-grid-defection/](#)

For Thursday

Threats and Opportunities, continued:

- Understand the so-called “duck curve” that is resulting from the massive rapid deployment of solar in California:
 - o Duck curve, Wikipedia, https://en.wikipedia.org/wiki/Duck_curve
 - o What the duck curve tells us about managing a green grid,” California Independent System Operator (CAISO) www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf
- Example of a utility and PUC decision making involving renewables and gas:
 - o [PGE plans 150 MWa renewables, 4 MW storage, finds wind cheaper than gas to meet future capacity](#), Utility Dive (2019)
- Example of a utility in transition, and a PUC’s involvement
 - o [A coal-powered giant bets on wind. Will it work?](#), Energy News Network
- Read these two short pieces for rationale and tone:
 - o [“In Conservative Indiana, Utility Chooses Renewables Over Gas As It Retires Coal Early.”](#) Forbes

- [Two Midwest utility execs explain why they're betting on renewables](#), Yale Climate Connections
- Solar and net metering
 - [California NEM 2.0 in 2020: What You Need to Know](#), Solar Reviews
 - [The 'small miracle' that may lead to California's net metering successor](#), Utility Dive
 - [The search for the next net metering policy takes center stage in California](#), Utility Dive
 - [Net metering talks break down in Arizona](#), Utility Dive

We'll do some exercises with this LCOE tool from UT-Austin: calculators.energy.utexas.edu/lcoe_map/#/county/tech

Terms for the week: IOU, grid defection, load defection, decoupling, regulatory compact, utility death spiral

OPTIONAL:

- This webinar will feel out of order, but I want you to experience this integration early, and we'll return to it later: [Stacking Value with VPPs in Today's Digital Power Grid](#), Guidehouse (just the first 17-18 minutes)
- [Californians are paying billions for power they don't need](#), Los Angeles Times
- [The Economics of Load Defection](#), RMI (2015)
- [The Minimum Bill: A First Step to Fair Utility Rates in a Distributed Energy Age](#), Jim Kennerly

Week 3 (January 18-22) – Solar Business Models

Introduction to solar energy and solar business models

Installed solar power will likely grow by an order of magnitude (or two) over the next generation. While it represents colossal promise, it also poses challenges for the existing business model and financing status quo. I will give some introduction to solar in class, and then we will dive into these more technical topics. We will also have a couple of short readings that combine the utility business model topic with solar.

Learning objectives for Week 3 (questions to ask yourself and generate answers to):

- What is the basic structure of the regulated utility business model? What are the incentives built into it?
- How do changes in policy priorities and technology erode or obviate the regulatory compact?
- What is the *utility death spiral*?
- What are the roles of the different moving parts – utilities, regulators, stakeholders, technology – in transitioning to a low-carbon electricity system?

For Tuesday

- Solar background
 - Read the two short solar sections of Bloomberg (*4.1 Solar (PV, CSP)* and *5.1 Small-scale solar*) and p. 3, 14-19 of Lazard.
 - “Solar 101: From Net Metering To Power Purchase Agreements, We Explain The What’s What Of The Solar Industry,” CB Insights, <https://www.cbinsights.com/research/solar-explainer/>
- Changes to net metering, or “net energy metering” (NEM)
 - “California net metering: everything you need to know about NEM 2.0,” Energy Sage, news.energysage.com/net-metering-2-0-in-california-everything-you-need-to-know/
- PPAs (brief background pages – very brief)
 - Power purchase agreements, en.wikipedia.org/wiki/Power_purchase_agreement (surprisingly good)
 - [Understanding commercial solar financing options: power purchase agreement \(PPA\)](#) - SunPower
 - Solar Lease & PPA Providers - sfenvironment.org/solar-ppa-and-lease-providers

For Thursday:

- Business models, deal structures, cost structures
 - *Solar Financing Structures: Partnership Flip, Sale-Leaseback and Lease Pass-Through* <https://drive.google.com/open?id=0B3PGeVjBt38CbGNGUXRQWkNfYVE>. Focus on introductory material and partnership-flip deal structure only.

- o SolarCity slide deck on partnership-flip investment model:
https://drive.google.com/file/d/1JL_r5xB6AdrJUhTSoGdFE7u2WnGlZiJG/view?usp=sharing

Terms for the week: Balance of system, cost of acquisition, Investment Tax Credit (ITC), tax equity investor

OPTIONAL:

- NREL's page on Renewable Energy Finance, financere.nrel.gov/
- For a sense of how assets have evolved in the residential market, check out this Energy Gang podcast interview with [Sungage Financial](#) CEO Sara Ross. The accompanying Greentech Media article is here: [Solar Loans: Should PV Be More Like Car Sales or Cable Television Services?](#)
- [Solar Technology Got Cheaper and Better in the 2010s. Now What?](#), GTM

Week 4 (January 25-29) – More on solar business models, regulatory models, and streams of value

As we dig in deeper on solar, we will revisit the World Bank and Lazard reading, consider the community solar opportunity coming in Oregon, and look at a few other aspects of the market. We'll also look at a few different business models and the history of one big player.

Learning objectives for Week 4 (questions to ask yourself and generate answers to):

- What can we learn from NextEra's example? How is it a story of the regulatory compact and how is it something completely different? How did (and does) policy matter for the renewables market?
- What is the promise of *community solar* and how should we feel about that promise, given what we see in Lazard?
- What are the various business models for solar?

For Tuesday

These two bits are essential macro-context. The story of NextEra is much of the story of the renewables market in the U.S., and the earliest big example of change inside the regulatory compact. The World Bank update summarizes one of the big levers of policy action globally:

- "How a Florida Utility Became the Global King of Green Power," WSJ story on NextEra (PDF on Canvas)
- [same reading as from Week 2] World Bank (2020). *State and Trends of Carbon Pricing 2020*. Washington, DC: World Bank. Note the tone of the Executive Summary.
- Community Solar in Oregon and Minnesota and...elsewhere:
 - o "[Why Minnesota's Community Solar Program Is The Best](#)," by John Farrell of ISLR, in CleanTechnica
 - o [Oregon's community solar program](#) – read this site for the basic structure of the program.
 - o [Community-Scale Solar Is on the Fast Track to Grid Parity](#), RMI
- *U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018*, NREL, www.nrel.gov/docs/fy19osti/72399.pdf. Read p. vi-x (most of the executive summary).

For Thursday

It is worth considering a few companies that have blazed some trails in this space:

- Wunder Capital – www.wundercapital.com
 - o Read all of the page content under the menu items Invest and Financing.
 - o *2018 Year in Review*, Wunder Capital, assets.wundercapital.com/2018-year-in-review.pdf
- LevelTen – [Can this online startup change how companies buy renewable power?](#), Energy News Network (2019)
- Arcadia - [Decoding the New Energy Customer](#) GTM (The Interchange), also [on Apple Podcasts](#)

Consider briefly these open questions for solar – and in particular, note how these pieces relate to the pricing of an asset:

- "[Is the Utility-Scale Solar Industry in a Finance Bubble?](#)," GTM
- "[Key to Those Record-Low Solar Bids? Rosy Merchant Income Assumptions](#)," GTM

Finally, there's a particular policy angle here that goes by the name of RVoS – the *resource value of solar*. Check out this short piece to see the components of RVoS as Minnesota has defined it:

- [What goes into calculating Minnesota's groundbreaking 'value of solar' rate?](#), U.S. Energy News

OPTIONAL:

- [Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant](#), NREL (2017).
- [Arcadia Raises \\$30M to Expand Community Solar, Home Energy Platform](#), GTM
- [Solar-Plus-Storage Beats Combined-Cycle Gas in Jordan and Morocco](#), GTM
- Jim Kennerly and Kathryn Wright, [Executive Summary - Regulatory & Rate Design Pathways To Deeper Solar PV Cost Reductions](#). [Full document here](#).
- [Overgeneration from Solar Energy in California: A Field Guide to the Duck Chart](#), NREL

Week 5 (February 1-5) – Energy Efficiency, Demand Flexibility, Energy Storage, and VPPs

We have clear overarching policy goals of increasing our energy efficiency economy-wide and accommodating the growth of renewable sources of electricity. This week's readings together explore the opportunity of energy efficiency, some business models for making it happen, and the relationship to storage.

Learning objectives for Week 5 (questions to ask yourself and generate answers to):

- What is the scale of the opportunity in energy efficiency? And what do we mean by *energy efficiency* exactly?
- How can demand become more flexible? With what technologies? Across what timeframes?
- What is the state of energy storage? What are its roles? And at what scale and across what timeframes?
- How can storage, distributed generation, flexibility, and IT magic be combined to create pockets of flexibility that serve a private purpose and a broader purpose for the electric grid as a whole?

For Tuesday

To kick off this entire section, read this article before (and I suggest also after) all of the other readings this week:

- ['Not your grandma's DER': Distributed resources modernize, prove value to grid](#), Utility Dive

Read this background on energy efficiency and some related policies:

- BNEF 2020 Sustainable Energy Factbook (excerpts from the long section on energy efficiency and “demand response” – it's fine to browse these at a brisk pace): numbered pages: 108-110 on state and city policy, 111-112 on Energy Star, 133 on LEDs, 115-117 on energy efficiency spending by utilities and in various sectors.
- [Rollback of light bulb standards would cost consumers billions — \\$100 per household each year](#), ACEEE

Specifically, we'll consider demand flexibility:

- [The Economics of Demand Flexibility](#), RMI (2015). Read only this short blog post. (Full report [here](#).)
- [CTA-2045 Water Heater Demonstration Final Report](#), Bonneville Power Administration. Read i-iv, Figure 2, Figure 3, and Table 8.
- [The Impact of 'Plant Factories' on the Electric Grid](#), The Interchange (GTM podcast). Just listen to the snippet starting at 1:30 and going to about 20 minutes in.

And we'll glance at the policy environment (for EE and other things):

- Database of State Incentives for Renewables & Efficiency (DSIRE), [DSIRE: Database of State Incentives for Renewables & Efficiency](#). Browse the site for a bit, and in particular, look under [Detailed Summary Maps](#), and see the maps of Renewable Portfolio Standards, Net Metering, and Energy Efficiency Resource Standards.

For Thursday

Now we add storage, and then look at configurations and variations emerging in the marketplace. Each of these three articles is short, and you can read for just the main points:

- [US storage deployments shatter record in Q3, with 7.5 GW projected by 2025: WoodMac](#), Utility Dive
- [Solar-Plus-Storage Beats Combined-Cycle Gas in Jordan and Morocco](#), GTM (January 2019)
- [New York Approves 316MW Battery Plant for Peak Power, First of Its Kind in Region](#), GTM (October 2018) (optional: this piece mentions a similar [project in California in 2018 at Moss Landing](#), notably covered in its regulatory compact context here: [PG&E's Record-Breaking Battery Proposal Wins Approval From Regulators](#))

As a moment of integration, we will look at this idea of virtual power plants (VPPs). This looks like a messy deluge of articles, but read the first two closely, and then just skim the others and *note the date, the system scale, and journalistic tone* in each. Also pay attention to the specific services that each system will provide:

- [Thousands of California homes to be linked for 550 MW virtual power plant, North America's largest](#), Utility Dive
- [Sunrun Wins Big in New England Capacity Auction With Home Solar and Batteries](#), GTM

And the ones to skim:

- [Enbala to Enable World's Biggest Residential Solar-Plus-Storage Virtual Power Plant](#), GTM (December 2018)
- [Rocky Mountain Power to operate largest US residential battery demand response project](#), Utility Dive (August 2019)
- [Sunrun Lands Another Big Virtual Power Plant Deal, This Time in Hawaii](#), GTM (September 2019)

We close this week with two articles that raise different issues related to storage, flexibility, and (by extension) efficiency:

- [The 5 Most Promising Long-Duration Storage Technologies Left Standing](#), GTM (2020)
- [Minnesota study finds it cheaper to curtail solar than to add storage](#), Utility Dive

OPTIONAL:

- [Energy Storage: Drivers and Pitfalls](#), webinar by ICF (2018)
- [Two Birds, One Water Heater: How Shifted Energy and Hawaiian Electric are Helping Hawaii Meet its Clean Energy Goals](#)
- [Behavioral Efficiency Not Forgone in the Ultimate Energy Cloud Platform](#), Guidehouse webinar (2019)
- [Energy Efficiency Impact Report](#), ACEEE
- [Report: Batteries Will Not Be the Future of Grid Balancing in Germany](#), GTM
- [Utility-Scale Energy Storage Will Enable a Renewable Grid](#), Scientific American
- Webinar: Monetizing Distributed Energy Resources through Demand Response Markets, Navigant www.navigantresearch.com/webinars/monetizing-distributed-energy-resources-through-demand-response-markets
- [Flow Batteries Struggle in 2019 as Lithium-Ion Marches On](#), GTM
- For fun, take a moment to find what's wrong in this bad reporting example: [Report: Utility-Scale Energy Storage Expected to Grow 35% by 2028](#), Environmental Leader
- [Evaluating the Slow Adoption of Energy Efficient Investments: Are Renters Less Likely to Have Energy Efficient Appliances?](#)
- [Valuing Energy Efficiency and Distributed Energy Resources in the Built Environment](#), NREL

Week 6 (February 8-12) – Monetizing Carbon

Learning objectives for Week 6 (questions to ask yourself and generate answers to):

- What are the voluntary and compliance markets for carbon? Where do these markets exist? How do they relate to carbon pricing policies more broadly?
- What are the types of projects that generate monetizable carbon benefits?
- What price ranges exist? How do they matter?
- How do these voluntary and compliance markets (that have been around for a while) relate to recent efforts to pursue *carbon capture* as extreme voluntary action?

For Tuesday

First, we have to get a handle on what it means to create and recognize carbon credits in some form.

- Bite-sized intro: [What Makes a Quality Carbon Offset | How to Make It Work](#), TerraPass
- A few related resources (from two credible organizations, GHG Management Institute and Stockholm Environment Institute) that put flesh on the bones:
 - A similar intro: [High-Quality Offsets](#)
 - The linchpin criterion that you must fully grasp: [Additionality](#)

Next, it's helpful to wrap our brains around a leading organization in this space, the Climate Action Reserve. Get a feel for CAR's overall shape and purpose, how it thinks about developing protocols, the protocols it has developed, and the project types that have dominated real projects and emissions reductions:

- [Criteria for Protocol Development - Climate Action Reserve](#)

This all makes more sense if you look at one business that does offsets for a living. Read/watch all of these pieces on Native Energy:

- [Understand NativeEnergy's Help Build Carbon Offsets](#)
- [NativeEnergy - Carbon Offset Providers | Programs & Projects for Emission Reduction](#)
- [Help BuildTM Carbon Offsets](#)

For Thursday

There are several striking corporate efforts unfolding in this space. Stripe, the payments processing firm, has set bold goals and made waves

- Stripe
 - [A Start-Up's Unusual Plan to Suck Carbon Out of the Sky](#), The Atlantic
- Microsoft
 - Quick overviews: [Could Microsoft's climate crisis 'moonshot' plan really work?](#), The Guardian; and [Microsoft will invest \\$1 billion into carbon reduction and removal technologies](#), Technology Review
 - Official statement: [Microsoft will be carbon negative by 2030 - The Official Microsoft Blog](#), Microsoft

We consider the voluntary markets – in large part because they are the springboard for lots of future compliance market activity, but also because they relate to the compliance markets over time.

- [State of the Voluntary Carbon Markets 2020](#). Read the page, and then download the *The Only Constant is Change* (the second installment) and read p. 1-3, 6-10, and 13-15.

Optional:

- [German Ministry for the Environment supports Gold Standard to frame transition of voluntary carbon market in line with Paris Ag](#), Gold Standard

Week 7 (February 15-19) – Transportation: Electrification and Low-Carbon Fuels

A few clean energy themes are manifesting in the transportation realm, and we focus on two: electrification and the implications for the grid; and the policy instruments for low-carbon transportation energy, especially in California.

Learning objectives for Week 7 (questions to ask yourself and generate answers to):

- What is the economic case for transportation electrification? How does it look different from different business, technical, geographic, and policy perspectives?

For Tuesday

I think it's helpful to start with the BNEF section on transportation (p. 120-130). Then consider the breadth of the value chain implications in this piece:

- In the Bloomberg/BNEF section on Sustainable Transportation, read p. 123-126 and 129.
- [Will EV Adoption Become California's Next Economic Engine?](#), Governing
- [Electric Cars Are Better for the Planet – and Often Your Budget, Too](#), NY Times

With those starting points in hand, let's consider these integrating examples:

- [Amplify Wants to Make EV Fleet Charging Super Simple](#), GTM
- [Electric Vehicles as Distributed Energy Resources](#), RMI (2017). Read through p. 9 (just the executive summary – short, lots of pictures)
- [Charging Ahead with EV Analytics](#), Navigant/Guidehouse whitepaper for SAS and Intel, 2019

[GM plans to be carbon neutral by 2040, aspires to end tailpipe emissions by 2035](#), Reuters (2021)

[GM Will Sell Only Zero-Emission Vehicles by 2035](#), New York Times (2021)

For Thursday

Read these two short articles to see how tech plus clean energy will combine for immense economic and environmental benefit. (If you're interested in transportation, you will want to read the underlying reports in full.)

- [Can autonomous vehicles help cities address their climate goals? Only if they start planning now](#), ACEEE
- [BP Forecast: Shared, Autonomous EVs Will Help Drive to Peak Oil Before 2040](#), Julia Pyper in GTM (2018)

Next, you must grasp the structure and dynamics of California's LCFS and the Oregon Clean Fuels Program:

- [The Low Carbon Fuel Standard](#), UC Davis. Read p. 7-10,
- One-minute summary, juxtaposed with cap-and-trade: [Carbon Pricing and Low-Carbon Fuel Programs](#), Union of Concerned Scientists (2017).
 - Look at how credit prices have evolved in California and (more recently) Oregon:
 - California LCFS: California ARB's Monthly LCFS Credit Transfer Activity Reports, www.arb.ca.gov/fuels/lcfs/credit/lrtmonthlycreditreports.htm (from www.arb.ca.gov/fuels/lcfs/credit/lrtcreditreports.htm)
 - Monthly LCFS Credit Transfer Activity Reports, CARB – and click on one of the recent months for some \$/ton examples: www.arb.ca.gov/fuels/lcfs/credit/lrtmonthlycreditreports.htm
 - Oregon CFS credit prices: <https://www.oregon.gov/deq/aq/programs/Pages/Clean-Fuels-Data.aspx>

OPTIONAL:

- "Overview of ARB Emissions Trading Program," CARB www.arb.ca.gov/newsrel/2011/cap_trade_overview.pdf
- [Policy context map](#), C2ES
- Oregon CFS home page (www.oregon.gov/deq/aq/programs/Pages/Clean-Fuels.aspx) and Overview of the Clean Fuels Program (www.oregon.gov/deq/FilterDocs/cfpoverview.pdf) – just a web page and a two-pager.
- [2018 California Renewables Portfolio Standard Annual Report](#), November 2018, California Public Utilities Commission, read p. 1-4.
- [Electric buses are coming, and they're going to help fix 4 big urban problems](#), Vox
- [Status and Trends in the U.S. Voluntary Green Power Market \(2016 Data\)](#), NREL
- [California extends cap-and-trade program – what it will look like post 2020](#), webinar (2017)
- [California's Low Carbon Fuel Standard: Evaluation of the Potential to Meet and Exceed the Standards](#), Promotum, February 2, 2015. Through p. 8.
- *Review of Existing Offset Protocols Against WCI Offset Criteria*, Det Norske Veritas
- "The global status and trends of Payments for Ecosystem Services," Salzman et al (2018) www.nature.com/articles/s41893-018-0033-0
- RECs, SRECs, and RPS rules
 - What Is a Renewable Energy Certificate?, www.youtube.com/watch?v=opJMrzNauFQ
 - EPA, Renewable Portfolio Standards, www.epa.gov/greenpower/us-renewable-electricity-market
 - "RECs: Making Green Power Possible," EPA (www.youtube.com/watch?v=_12VYXms6-c).
 - "SREC Markets," www.srectrade.com/srec_markets/introduction

Terms: RECs, RINs, LCFS, carbon offsets, carbon credits, carbon allowances; additionality, leakage.

Week 8 (February 22-26) – New Paths for Change: California, Corporates, and Consumers

We look this week at three vehicles for renewable energy choice and investment. First, policy efforts in the great state of California bring together all of the threads of the course, so we will take a week to examine the combined suite of policies in California, including AB 32, the Low Carbon Fuel Standard (LCFS) that we looked at last week, and the Renewable Portfolio Standard (RPS). Since environmental policy that starts in California often ends up in other states' policy efforts or even federal policy, we can perhaps get a glimpse of the future.

Second, and distinct from California's other efforts, we consider community choice aggregation (CCA), a way for geographic blocks of consumers to drive demand for renewables.

Third, we look at corporate efforts to source renewables. We hear from Microsoft and Google as they do this, often with innovative relationships with utilities. I've saved this delicious podcast for the final third of the course because it draws on just about every theme in the course so far. In addition to the podcast, we briefly consider the RE100 effort and the newer Renewable Energy Buyers Association (REBA), and a couple of quick case studies.

For Tuesday

- California – and these items are all short:
 - Materials on AB 32 from Cal EPA, EDF, and C2ES:
 - [6 successes from California and Quebec's third year of cap and trade](#), EDF
 - [Climate Change 101: Cap and Trade](#), C2ES, read through p. 4 (through cost containment)
 - [AB 32 Cap-and-Trade Auction Frequently Asked Questions](#), EDF
 - [Summary of Auction Results](#), California-Quebec auctions. Just look at the trajectory of current auction and advance auction prices.
- California RPS (plus material on RECs in class) and parallel policies
 - California Renewables Portfolio Standard, www.cpuc.ca.gov/renewables/ (just read that page)
- Community Choice Aggregation:
 - [Community Choice Aggregation](#), Wikipedia
 - [Community Choice Aggregation](#), NYSEERDA
 - [Learn what Community Choice Aggregation is](#), Pacific Gas & Electric
 - [What you need to know about Clean Power Alliance, SoCal's newest electric company](#), LA Times

For Thursday

- Corporates
 - RE100 (there100.org). [Going Beyond: A guide to integrating renewable electricity into your supply chain](#) (2017), through p. 4, then skim, then read p. 9-10, and then browse the titles of all Reports & Briefings at the full site (there100.org/reports-briefings).
 - Renewable Energy Buyers Alliance (REBA), <https://rebuyers.org>.
 - Read the About page, the one-page introduction, and Appendix B in this case study: <https://rebuyers.org/wp-content/uploads/2019/11/reba-aggregation-case-study.pdf>
 - Listen to this podcast: "Google and Microsoft Are Shaping Energy Markets," Greentech Media, short article [here](#) and also on [The Interchange \(podcast\)](#)
 - Proxy Generation PPAs, https://orrick.blob.core.windows.net/orrick-cdn/Proxy_Generation_PPAs.pdf. Read all of the document (10 pages, but dense).
 - Note what's different about this story, i.e., where the new roles are, how this is consistent with or challenges existing business models, and who led the effort: [How an organic dairy's quest for clean energy spread solar across Wisconsin](#),
 - [The Future of Small-Scale Aggregation Deals: New Frameworks and Developments from the Renewable Energy Markets Conference](#), Clean Energy Finance Forum

OPTIONAL:

- Additional examples of corporates:
 - Skim these examples: [Starbucks](#), [Google](#), [Facebook](#), [Target and Walmart](#), [Walmart \(in GreenBiz\)](#)
 - Wood MacKenzie, *Corporates usher in new wave of US wind and solar growth*, www.woodmac.com/our-expertise/focus/Power--Renewables/corporates-usher-in-new-wave-of-u.s.-wind-and-solar-growth/
 - Google - https://www.eenews.net/assets/2018/07/16/document_cw_01.pdf
- On mandatory rooftop PV in California:
 - [It's Official. All New California Homes Must Incorporate Solar](#), Greentech Media
 - [California will require solar panels on all new homes. That's not necessarily a good thing](#), David Roberts in Vox

- [Consumer choice has suddenly revolutionized the electricity business in California. But utilities are striking back](#), Los Angeles Times
- [The Basics of Transacting in Offsets Under AB 32](#), Reed Smith
- [Google's Carbon Offsets: Collaboration and Due Diligence](#), Google (White Paper)

Terms for this week: AB32, RPS, CPUC, CARB, CCA.

Week 9 (March 1-5) – Integrated systems and transactions: CHP, microgrids, and blockchain

There is a huge amount of change and investment happening at the so-called grid edge, and there are too many technologies, business models, and financing tools for us to do a comprehensive survey. However, I will give you a sampling of what's out there, with slightly deeper dives on (1) blockchain and (2) CHP and microgrids (from a particular perspective).

Blockchain. Let's start with a definition from [this GTM Research advertising page](#) – and no, the \$3000 report is not required:

Blockchain is an immutable distributed ledger that verifies and records peer-to-peer transactions without a central authority. It promises more efficient transactions with lower costs based on disintermediation of identity verification. While it has been around since 2009, 2017 marked a turning point in global recognition for its potential applications.

The first blockchain in energy transaction took place in April 2016 in Brooklyn, New York. Today, less than two years later, there are 122 organizations involved in blockchain technology and 40 deployed projects. Between Q2 2017 and Q1 2018, over \$300 million was invested in the blockchain in energy industry.

With that under our belts, let's check out a bundle of short pieces:

- These three provide helpful context:
 - [Blockchain: so much bigger than bitcoin...](#), The Guardian
 - [www.greentechmedia.com/articles/read/four-predictions-for-blockchain-in-energy-in-2018](#)
 - [www.greentechmedia.com/articles/read/worlds-top-energy-companies-look-to-blockchain#gs.BKuYasI](#)
- Please watch this half-hour video from a recent GTM conference: <https://www.greentechmedia.com/multimedia/view/blockchain-101-with-gtm>
- These two pieces on the blockchain-enabled Brooklyn microgrid nicely cue up a discussion of CHP and microgrids:
 - "Blockchain and Renewable Energy Are Utterly Disrupting Society as We Know It," Futurism.com, [futurism.com/blockchain-and-renewable-energy-are-utterly-disrupting-society-as-we-know-it/](#)
 - "Blockchain Is Helping to Build a New Kind of Energy Grid," Technology Review, [www.technologyreview.com/s/604227/blockchain-is-helping-to-build-a-new-kind-of-energy-grid/](#)
- eLab/RMI: (you must register to download the paper, but there is no cost) [New Business Models for the Distribution Edge](#), p. 1-10 and 19.
- [Combined Heat and Power and Clean Distributed Energy Policies](#), ACEEE

OPTIONAL

- [How blockchain can democratize green power](#), Srinivasan Keshav, January 2018, *The Conversation*
- [Real-World Use Cases for Blockchain in the Energy Sector: Grid+ and Power Ledger](#), Greentech Media
- [Beyond the Buzzwords: Making the Specific Case for Community Resilience Microgrids](#), ACEEE
- Webinar Replay – The Energy Cloud (webinar), Navigant. [www.navigantresearch.com/webinarvideos/webinar-replay-the-energy-cloud](#)
- The consulting firm ICF has produced a ton of research and policy work on CHP. These materials demonstrate the opportunities for CHP at the grid edge / in the energy cloud: on [supporting grid modernization](#), on [utility ownership of CHP](#), on [CHP as DG](#), on [CHP microgrids as resiliency](#)

Terms for this week: blockchain, CHP, grid edge, distribution edge

Week 10 (March 8-12) – Miscellaneous topics and group project discussions

I would be remiss if I didn't introduce these topics briefly, but we don't have space to cover them in detail. Also, this will be a good week for you to catch up or work on your project.

- Green building finance and benchmarking
- Natural gas prices, petroleum prices
- Biogas / anaerobic digesters
- Nuclear power
- PG&E and wildfire
- Ground-source geothermal heat pumps
- Climate Risk
- [This climate problem is bigger than cars and much harder to solve](#), David Roberts in Vox

All readings this week are optional:

- [Where Does the Natural Gas 'Bridge' End?](#), GTM
- ['Electrification of Everything' Would Spike US Electricity Use, but Lower Final Energy Consumption](#), GTM
- [Ameren, Xcel, Dominion, Duke among most at-risk from changing climate: Moody's](#), Utility Dive
- ["How A Climate Change Nonprofit Got Eversource Thinking About A Geothermal Future,"](#) WBUR/NPR
- Two NY Times articles on California, wildfires, and PG&E: [The Haves and Have-Nots of \(Electrical\) Power in California](#) and ["This Did Not Go Well": Inside PG&E's Blackout Control Room](#)
- [San Diego Gas & Electric Hits Snag in California Microgrids Rollout](#), GTM
- ["Fourteen Alleged Magical Properties That Coal and Nuclear Plants Don't Have and Shouldn't Be Paid Extra for Providing,"](#) Amory Lovins
- [Bill Gates in Search of Nuclear Nirvana](#), Scientific American
 - o And an update: "NuScale's Small Modular Nuclear Reactor Passes Biggest Hurdle Yet," www.forbes.com/sites/jamesconca/2018/05/15/nuscales-small-modular-nuclear-reactor-passes-biggest-hurdle-yet/#3d87289d5bb5
- [Financing the Energy Transition](#), interview by Joel Makower with Erin Robert of JPMorgan,
- [MIT researchers say nuclear fusion will feed the grid "in 15 years"](#), Technology Review
- plaNYC, building benchmarking program information (www.nyc.gov/html/gbee/html/plan/ll84_scores.shtml), and *New York City Local Law 84 Benchmarking Report, August 2012*, www.nyc.gov/html/gbee/downloads/pdf/nyc_ll84_benchmarking_report_2012.pdf

Review and discussion

We will prepare for the final, work through details of your pro formas, and do any other necessary catch-up. There will be a separate final exam review session, if desired (if so, it will probably be during the scheduled exam time).

Finished team projects are due Sunday, March 14, 2021, at 2 PM PST (noon).