Syllabus (Ver.1)
Environment and Resources (ENVRES)

ENVRES 260: Implementing & Financing a Decarbonized Economy
Spring Quarter 2022

Course Sessions:  Tuesdays  5:00 to 6:00 pm PT (1 hour)
                 Thursdays  5:00 to 7:00 pm PT (2 hours)
Commencing  Tuesday March 29, 2022
Ending   Tuesday May 31, 2022

Location:  Room 108, Shriram Building (Science and Engineering Quad)

Instructors:  Jeffrey D. Brown  Adjunct Professor  jdb79@stanford.edu
               David B. Rogers  Adjunct Professor  dbrogers@stanford.edu

Teaching Assistant:  Greg Zegas  MBA/MS Environment Candidate  gzegas@stanford.edu

Eligible Students:  Graduate students only. Based upon prior years’ experience, the Instructors anticipate that there will be a healthy mix of students from Earth, Engineering, GSB, Law and H&S.

Enrollment Process:  Solely by application and approval by Instructors. The application form is available at this link. In every past year, the course has been significantly oversubscribed, so interested students should be sure to apply timely.

Office Hours:  Standing office hours before class. And by appointment.

Course Description:

Overview

This is an ambitious course. Most persons who become skilled in the discipline taught by this course do so over many years and surely not over the duration of one academic quarter. The course material and its highly interdisciplinary nature bring about the challenges of this course, not some desire on the part of the Instructors to create artificial challenges.
The Instructors have between them over a half century and ++$100B worth of hands-on experience developing, financing, acquiring or selling a wide range of projects both in the US and outside the US. The goal of this course is to impart to the students some of the skills, analytical methods and knowledge that sponsors of projects need to have in order to develop and finance successful low-carbon projects that typically would be financed using non-recourse project financing.

What is meant by “non-recourse project financing”? Or, to shorthand it, “project finance”? Project finance means raising money for a special purpose company (called the “project company”) on a “stand alone” or “non-recourse” basis for the purpose of constructing a “project” (infrastructure asset, power plant, industrial facility, etc.). In other words, there is no independent balance sheet or creditworthy party guarantying the performance of the project company nor the repayment of the project company’s indebtedness. Rather, the repayment of the project company’s indebtedness and the distribution of equity returns to its owners will come out of the cash flows from the operation of the project.

How does a newly-formed shell entity called the project company raise millions or billions of dollars for a project that does not yet exist when no one with a credit-worthy balance sheet is prepared to give any assurances about the overall performance of the project company nor the repayment of the project company’s indebtedness? Well, as much as that description may sound like a very heavy lift, that type of transaction happens every week. Getting such a transaction completed is not magic, but it does require special skills. The US and global markets have developed an art or science (depending on one’s point of view) about how to craft a project that can be project financed. That is what this course intends to (at least begin to) teach.

And there is no small irony in recognizing that the financing tools that enabled a carbon-based economy will also be useful—and essential—to financing a decarbonized economy.

What makes project finance a subject worthy of study?

The transition of the global economy—not just in electricity or even all energy, but across all sectors—to low-carbon systems presents a challenge and a timeframe without precedent in human history. The amount of up-front capital needed in the coming decades to implement the transition to a low-carbon economy will be in the many tens of trillions of dollars. That capital will come from many sources and will be deployed through a variety of financing techniques. Without doubt, project finance will be a large and critical component of that capital and, in effect, will be essential to the successful transition of the global economy to low-carbon systems.

The importance of the cost of capital to fund a project, as distinct from the amount capital to fund a project, is very often underappreciated. When considering any plan or program to address either carbon emissions reductions or carbon removal:

- If it won’t scale, it won’t matter
- If it won’t be economic (as in providing reasonable returns to providers of debt and equity capital for the risks taken), it won’t scale
- If it involves a significant up-front capital investment to produce benefits over many years and cannot attract low-cost capital, it won’t be economic.
As a well-proven and long-standing technique for properly assessing and pricing risks for projects, project financing often offers a path to low-cost capital (at least compared to alternatives) for many types of projects. And sometimes, project finance is the path to obtaining capital at any cost.

Project development precedes project finance

As much as the techniques of project finance are important to understand, most of this course does not focus on project finance. The hard part of project finance is not so much the finance part, but rather having a project that is worthy of being financed. Accordingly, most of our time is spent on what it takes to craft a viable project and, importantly, with emphasis on what analytical tools are necessary to determine whether a project is viable.

How does this course intersect with the transition to a decarbonized economy?

There are so many interesting and different ways to explore the transition to a decarbonized economy. Accordingly, the Instructors wish to be clear about what this course is and is not about.

There are many programs or proposals—whether within NGOs, academia or governments—for the decarbonization of the economy. Examples include: the US Green New Deal, the EC’s European Green Deal, Project Drawdown, the Evergreen Action Plan, Governor Inslee’s 100% Clean Energy for America Plan or his Climate Mission Agenda, Bill Gates’ climate plan and, of course, the climate elements of the Biden administration’s (currently stalled) Build Back Better legislation. And what of these programs?

• A great course in the discipline of energy and engineering economic systems might unpack (as in study, compare and critique) these various programs or proposals in terms of how best (at least on paper) to transition to a decarbonized economy (e.g., emphasize or de-emphasize solar, onshore wind, offshore wind, storage, hydropower, geothermal, nuclear, energy efficiency, EVs, hydrogen, etc.).

• A great course in public policy might unpack the programs or proposals in terms of what mechanisms they propose to implement policy (e.g., what mix of carbon pricing, regulatory mandates, loan guaranties, tax credits, grants, etc.).

• A great course in political science might unpack the programs or proposals in terms of how they might fare in Congress.

• A great course in law might examine the extent to which the administration can effect changes via regulation in the absence of cooperation from Congress or study the tensions between the federal government and the states in their respective jurisdictions and roles as relevant to decarbonization policies.

But unpacking these various high-level programs or proposals—whether from perspectives of energy and engineering economic systems, public policy, political science or law—is not what this course is about. For sure, this course will touch on many of those topics, but its emphasis will be elsewhere. For lack of a better analogy, think of those rather worthy topics as the “macroeconomics” of decarbonization.

Instead, to continue the analogy, think of this course as the “microeconomics” of decarbonization. The contrast between the two is rather sharp. Here below to illustrate the point is just one example: the critical issue of developing new high-voltage electric transmission lines:
On the “macroeconomics” level (i.e., not this course), the programs or proposals described above will talk about the critical need for significant additional transmission line infrastructure to be built to get large-scale renewable power moved from production locations (windy, sunny or hot geothermal areas) to locations where the “load” is, the challenges of building new lines and some policy changes that would help enable the needed transmission infrastructure to be built. The more detailed of such programs or proposals described above might even talk about how many million megawatt miles of transmission need to be built and/or depict some of the origin and destination locations in general terms. They might also name some identified projects that should get built (but not really dive into what it would take for those projects to get built).

On the “microeconomics” level (i.e., this course), by contrast, the focus would be on a particular project. Specifically, to study the development of new high-voltage electric transmission lines, this course would examine whether some specific proposed transmission line could get built. How would the developer get it get permitted? What permitting agencies (state and federal) would be involved? What issues does the primary route present? What alternative routes need to be studied? What environmental studies need to be undertaken? What endangered species are anywhere along the routes? Who are all of the potential stakeholders and constituencies? What environmental justice issues does the project present? How would the developer acquire rights of way given that the developer (typically) will not have condemnation authority? Should the developer try to partner with WAPA (a federal agency) to get some condemnation authority? What would be the downsides of doing so? What agreements will be needed with independent transmission system operators or regional transmission organizations? Will the line be AC or DC? If it is AC, will it have excess line losses? If it is DC, how will the inability to tie into the line along the route (i.e., only at each end) affect the “buy-in” (or opposition) by the affected communities? How many years is the lead time for procurement of major equipment? How backed up are the very limited number of eligible transmission equipment suppliers? How, well ahead of the project being ready for financing overall, does the developer finance the 8-figure equipment deposit that is needed to lock down a manufacturing slot? Who can challenge the project, whether people along the route, environmental groups or others? What would be the points of vulnerability (whether legal, practical or political)? What will it take (in time, money, evidentiary showings and/or politics) to overcome the challenges? How long will appeals take? Do the financing and commencement of construction need to wait for appeals to play out? If so, can the developer still meet whatever commitment(s) it made as to when the line would be built and energized? Who would the users of the line be? Do the users of the line even yet exist or are the users some yet-to-be-built set of renewable energy projects? If so, how real are the prospects that those projects will get built and built timely? And even if real, how does one solve that not-so-uncommon chicken-and-egg problem of separate projects being mutually dependent?  

As just this one example illustrates, one need not be an expert in project development to see that there is quite a gulf between the aspirations of an adopted “macro” plan (“we ought to do X”) and its commercial

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1 The faster the energy transition (and in the domain of energy and industrial infrastructure the intended path is very fast), the more these sorts of chicken-and-egg problems will arise.
implementation on the ground (“actually get X done”).

2 No matter how impressive a “macro” program may be for the decarbonization of the economy, at the end of the day, the “macro” program only comes to fruition if the “micro” side gets real projects built. And a whole lot of them. Nothing will get built unless there is a vast team of people well skilled at sorting out everything needed to get projects done. As Grandpa would say, “There’s an awful lot of felt between the ball and the pocket.” This course seeks to put a small dent in the real shortage of human capital needed to effect the transition.

The high voltage transmission line illustration above is just an example. This same sharp contrast between the “macro” and the “micro” would apply to any category of low-carbon project studied in this course. This course will apply that same type of very granular “micro” analysis to whatever low-carbon projects are being examined, whether renewable energy, storage, direct air capture, carbon capture, cement decarbonization or otherwise.

Urgency of the problem and relevance of technology

The Biden administration’s nationally determined contribution (NDC) under Article 4 of the Paris Agreement sets an economy-wide (not just power sector) target of reducing 2030 net greenhouse gas emissions by 50-52 percent below 2005 levels. In the context of energy and industrial infrastructure development, 2030 is very soon—the equivalent in other contexts of “Tuesday in the week after next.”

Achieving 2030 climate goals cannot await new technologies being developed and becoming commercial. The vast majority of achieved greenhouse gas reductions by 2030 (or later) are going to come from projects that deploy technologies that are already commercial today.

But new climate technologies have a vital role to play, particularly in later years that permit time for maturation to the point of commercialization at scale. Stanford will be an important factor in the development of new climate technologies. And if past years are any indication, many students of the course will have an interest in deploying new climate technologies. As noted below, having familiarity with developing and financing projects of any sort will be useful background for the typically harder task of developing a project with a new technology. Hence, the focus of this course is on developing and financing projects generally with a balanced emphasis on new technologies.

Non-US projects

2 And, just to put a finer point on the contrast, the gulf focused on here is not what is takes to get a “macro” plan (1) fully figured out as among its advocates and advisors, (2) enabled by Congress with legislation enactments or budgetary appropriations or (3) adopted through administrative rulemaking processes and past inevitable legal challenges. While those are no small steps, they are not the gulf focused on here. Even with a “macro” plan fully resolved and instantly in place (with whatever requisite legislation, appropriations and regulations in hand), there is still a huge gulf between the “macro” and the “micro”.

3 Of course, there are many elements of any “macro” program that will not have this described dependence on the “micro” side (as in not requiring projects of the sort covered in this course), such as with light transportation policy (e.g., incentives for EVs and fuel economy standards for, or phase-outs of, ICE cars), energy efficiency steps (e.g., tightening standards for lighting, appliances or HVAC equipment) or certain agricultural policy changes (e.g., changing farming practices). But an enormous part (i.e., tens of trillions of dollars globally in the coming decades) of any “macro” program will have this dependency.
Studies and reports on climate impacts point out that a successful decarbonization of the US and EU countries would mean very little without a successful global decarbonization. The implementation of decarbonization steps throughout the world will require vast capital investment flows from wealthy economies to developing economies. Much of that capital investment will be in the form of cross-border project finance. Why? The next two decades of energy spending required in developing countries to achieve a low-carbon economy materially exceeds their total current wealth. Cross-border project finance will be imperative to close the gap.

Although most of the projects this course will examine are US projects, most of the content of this course will be valuable for understanding any project—whether in the US or elsewhere. A cross-border component adds a myriad of additional issues to any project. Before one can tackle those extra issues, one should be conversant in the art of doing a project that has no cross-border elements. And even before getting to any cross-border issues, this course is already quite fulsome in content. So, because of time constraints and surely not as an indication of relative importance, this course will provide only an introduction to the specific issues of cross-border development and finance. That subject would make for a rather worthy and fulsome course on its own. If only the Instructors had the time.

And note that in their team projects (more on which below), students can focus (and in the past often have focused) on non-US projects, as and if chosen by the student team.

What students can get from this course

**Project development.** Obviously, if the course succeeds in its goal of teaching the discipline and analytical methods of project development and finance, the students who wish to pursue low-carbon projects will be aided in their efforts.

**Policy.** Less obviously but notably, students who prefer a career in the policy domain should find the course helpful in analyzing the merits or demerits of policy programs, which are written by very smart and well-meaning people who often have little or no experience in actually getting projects done and who therefore often do not fully appreciate the challenges facing the implementation of their policy prescriptions. A feedback loop of input from the “micro” side into the “macro side” would yield better public policy.4

**Climate tech.** Students who aspire to a career in climate tech should find some knowledge of project development to be rather useful, particularly if (as is often the case) their intended technology requires deployment via real “steel in the ground” as opposed to deployment via software. The climate tech /

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4 The discipline and analytical methods of project finance can integrate closely with the crafting of government policy. When governments wish to incentivize the development of various types of low-carbon projects, governments in the West rarely pay for projects “whole hog.” Instead, governments provide one or more specific incentives—such as a “feed-in tariff,” a “renewable portfolio standard,” a tax credit, one or more forms of carbon pricing, a loan guaranty, some form of concessionary (subsidized) financing, etc. Governments try to craft enough of an incentive package so that the private sector (often, if not typically, using project finance) will achieve the government’s policy objective of seeing the completion of the desired projects. Importantly, the policy challenge is not solely about crafting the right package of incentives. Rather, governments also need to understand (and then unblock) the obstacles to the successful development of the desired projects that remain even after the adoption of incentives. (As an example, in the stalled Build Back Better legislation, there is a proposed new tax credit for transmission lines. But the Instructors will tell you that the tax credit is spending money in the wrong place as it is not addressing the real impediments to building critical new transmission lines.)
clean tech highway is strewn with the carcasses of companies whose investors, boards and management
teams had strong confidence in a particular technology, but an insufficient understanding of what it would
take to get commercial projects built.

The duality of this course

On one level, this course is somewhat timeless and old news. The discipline and analytical methods of
project development and finance have been around for decades and, once learned (albeit no easy task), are
a set of skills constituting a way of thinking that can be applied to nearly any project.

On a separate level, this course is very much at the cutting edge. This course dives into some new (and
difficult) topics: industrial decarbonization and carbon dioxide removal. The course will also touch on
how new technologies should try to work their way to being accepted by the project finance markets.

Interdisciplinary nature

The University has sought to emphasize interdisciplinary research and interdisciplinary teaching. This
course presents the latter feature on steroids.

The successful development and financing of large projects requires a very broad and interdisciplinary set
of very specialized knowledge and skills. In fact, it is hard to think of many activities that are more
interdisciplinary. Any competent person who seeks to lead the development of large projects by necessity
needs to know a lot about markets, technology, engineering, law and finance.

Naturally then, this course too is very interdisciplinary. Its interdisciplinary nature presents in three ways:

1) The course content by looking at projects holistically and not as any one-siloed discipline
(engineering, business, finance, law) might,

2) The student mix across many schools at Stanford and

3) The course structure whereby (through a team project—more on which below) the students
interact with each other. In that way, the course reflects the real world where the development
and financing of projects requires people with different roles and specialties—businesspeople,
political people, environmental permitting specialists, lawyers of all sorts, engineers, finance
people—to work together in a common effort.

Perhaps this course is so interdisciplinary that a warning label ought to apply. The mix of students from
Earth, Engineering, GSB, Law and elsewhere means that inevitably what is new and interesting to one
student on topic A may be rather basic and boring to another student and just the reverse on topic B.
Hence, the Instructors ask students for some patience in this regard.

Content

The Course Sessions Matrix below lays out the current version of the content of the course broken out by
course session. The Instructors will update it from time to time. *Please look at Canvas each week to check for updates.*
The course will focus on the critical skills needed to evaluate, develop, finance (usually on a non-recourse basis), and complete standalone projects. The course will teach the key building blocks of non-recourse project development and financing for a broad range of technologies. In addition to analyzing key principles, the course will use transaction documents from proposed and operating projects to give students a practical grounding in project development and finance and its application to low-carbon projects.

**Course Organization:** The course will include: (i) lectures/readings presented and discussed in a seminar format; (ii) various written assignments regarding key readings or concepts, (iii) in-depth group projects (typically four-person teams) presented to the full class as the culmination of the course sessions.

- **Lectures:** Sometimes the Instructors will pre-record a lectures will for students to watch prior to class in lieu of a reading. The advantage of pre-recording the lectures is that so doing will allow us to spend our class time on lively discussion.

- **Approach to Readings and Documents:** Please refer to the Canvas for links to reading assignments and specific questions we will be addressing in particular sessions. The primary course materials include documents from several representative projects. Part of the experience of this class is for students to come across real documents. And the reality is that they are often long. HOWEVER, please note that the Instructors do not expect students to read or read carefully the entirety of all of the assigned source deal documents. Sometimes students will only need to skim the deal documents. Sometimes students will only need to read specific parts to learn a specific concept—and we will give references to specific pages and definitions to help you. But, even in those situations, it adds to the learning experience for students to have the whole document and not just some highly-curated excerpts. Please check Canvas for updates to reading assignments and for specific guidance on the assigned readings before panicking over the length of some of the deal document portions of readings. Also, we recognize that reading long documents on a computer screen can be difficult. So, we will see if we can arrange for some copies of the documents to be printed out and available for reading at some location.

- **Written Individual Assignments:** We will have various relatively brief written assignments that will be due at the start of certain lecture. These individual assignments are designed to make sure students master the basic quantitative tools and document review skills of project finance.

- **In-Class Seminar Format Discussion:** We try to focus our class sessions on discussions of the hardest technical, legal, and financing concepts as informed by the lectures, readings, and homework. We hope that the small class size and moving some lectures to the pre-recorded format will leave lots of room for every student to participate actively.

- **Guest Speakers:** In past years, the Instructors have invited speakers to join the class. We are still lining up our speakers for this coming term.

- **Team Projects:** The course (lectures, readings and written assignments) will build towards and support team-based projects presented during the last two sessions of the term. In past years, team projects were a bit hit with the students, at least after an initial period of trepidation. Each project team will analyze the energy project development and finance process for a particular technology, as illustrated by actual projects and informed by key financial, legal, policy, and engineering
principles and mechanisms. Students will form +/-four-person multi-disciplinary teams organized by particular technologies as follows:

1. Solar PV (utility scale only, not residential/commercial rooftops), with or without storage
2. Solar thermal
3. On-shore wind
4. Off-shore wind (whether sea-floor-mounted or floating)
5. Geothermal (whether conventional or EGS)
6. Nuclear (whether large or small modular)
7. Storage (battery, pumped storage, hydrogen, gravity or other)
8. Transmission
9. Carbon capture and storage
10. Biomass power
11. Biomass with carbon capture
12. Hydropower (large or mini)
13. Ocean/tidal energy
14. Direct Air Capture (DAC) -- carbon dioxide recovery from atmosphere
15. Ocean CDR-- carbon dioxide removal from the oceans
16. Other, as a student team may propose

In general, for the team projects, we will try to keep comparability across technologies by using a common set of evaluation questions/criteria including: financial feasibility, manageability of environmental issues, constructability and ability to control cost over-runs, ability to obtain off-takers at prices sufficient to cover expenses and financing, and exposure to carbon limits/taxes. Further information on the team projects will be provided early in the term. In past years we have done our best to honor student preferences on projects, balanced against the need to cover enough different types of technologies to benefit the entire class.

Course Logistics and Administration

Course sessions:

i) Regular attendance is mandatory. If you have to miss a class, please notify Greg prior to that session.

ii) There will be a brief break around the middle of each Thursday class.

iii) The class has benefitted in the past from lively participation of students from different schools (Earth, Engineering, GSB, and Law), different professional experiences, and different home-country perspectives. Class participation is part of the grade and is valued. Students who have concerns about public speaking should confer with the instructors as to accommodation.
Grading:

Class Participation: 30%
Brief Written Assignments: 30%
Group Project: 40%

Class Dinner

Every year, the Instructors have hosted a dinner for the class and even managed to navigate COVID to have a dinner in 2021. We will figure out a date and let everyone know. Former students from past years often attend. Like all things in this class, the Instructors want there to be some fun.

Course Sessions Matrix

<table>
<thead>
<tr>
<th>Session</th>
<th>General Subject</th>
<th>Lectures</th>
<th>Readings (See Canvas to Download)</th>
<th>Homework</th>
</tr>
</thead>
</table>
| #1 Tues Mar 29 Live 1 hr. | Introduction and Welcome | A) Introduction and Welcome  
B) The Challenges of Decarbonizing the Energy Sector  
C) Overview of Project Finance (Pre-Recorded) | Skim: J Brown textbook chapter on financing clean energy; Read: Hoffman textbook excerpt on project finance | None |
| #2 Thurs Mar 31 Live 2 hr. | Technology of the Power Sector | How fuel, intermittency, capacity, & emissions viability of different power plant types | Lazard annual survey of electric generation and storage “levelized costs”; Example spreadsheet “Quick Cost per MWh” | #1 Energy math: Getting the basics of fixed, variable, and emissions costs |
| #3 Tues Apr 5 Zoom 1 hr. | U.S. Electric Power Industry | The Electric Utility Industry in the USA: How Ownership and Regulation of Utilities Affects Project Opportunities | EEI’s summary of investor-owned utility (IOU) “cost of service regulation”; FERC description of regional energy markets; great article summarizing IOUs make money | None |
| #4 Thurs Apr 7 Live 2 hr. | Project finance vs. corporate finance. | A) How Project Finance Math Differs from Corporate Finance: Review of “Regular” Corporate Debt and Equity  
B) How Cost of Funds (Debt, Equity, & Tax) Becomes Embedded in Energy Project Output Prices (Lease Rates and Capital Charge Factors) | Various spreadsheets that are the backup to Lectures 4B and 4C | #2 Energy finance: Excel spreadsheet to complete for NPV, IRR, and Cash Flow Available for Debt Service (CFADS) problems. |

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5 This matrix will be subject to regular updates that the Instructors will communicate to the students through postings on Canvas. Note that this Matrix contains a fair amount of topic-specific terminology, jargon and the like, all of which will get explained in the readings or class sessions. Accordingly, students who are unfamiliar with the some of the terminology here should not be discouraged, much less conclude for that reason that they are not a fit for this class.

6 There will be various guest speakers and “cameo topics” in addition to the primary topics. Stay tuned on Canvas.

7 This column will be supplemented.
<table>
<thead>
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</thead>
<tbody>
<tr>
<td>#5</td>
<td>Tues Apr 12&lt;br&gt;Zoom 1 hr.</td>
<td>Key areas of law you’ll have to become familiar with in your career</td>
<td>Key Legal Principles for Businesspeople to Keep in Mind in Energy Deals</td>
<td>TBD</td>
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<td>Assorted documents to familiarize you with issues: Excerpt from Ivanpah Solar Thermal EIS; law firm paper on siting wind; what is a “major federal action” that triggers NEPA; example of a Record of Decision after EIS complete</td>
<td>None</td>
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<tr>
<td>#6</td>
<td>Thurs Apr 14&lt;br&gt;Live 2 hr.</td>
<td>Project permitting</td>
<td>Environmental Permitting and Siting Challenges for Energy Projects</td>
<td>None</td>
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<tr>
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<td></td>
<td>Assorted documents to familiarize you with issues: Excerpt from Ivanpah Solar Thermal EIS; law firm paper on siting wind; what is a “major federal action” that triggers NEPA; example of a Record of Decision after EIS complete</td>
<td>None</td>
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<tr>
<td>#7</td>
<td>Tues Apr 19&lt;br&gt;Zoom 1 hr.</td>
<td>Solar Case Part 1 &amp; Simple Project Assessment Models</td>
<td>High Level Feasibility Assessment</td>
<td>#3 Simple model: Read the case and then convert a super-simple feasibility snapshot model for a wind project to match our solar project.</td>
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<td>ECR Solar Case Part 1. Engineer’s report for a solar project. Backup model for interest during construction sneaky shortcut method.</td>
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<td>#8</td>
<td>Thurs Apr 21&lt;br&gt;Live 2hr.</td>
<td>Solar Case Part 2 &amp; the “Big Four” Jobs of Project Development</td>
<td>The Big Four Jobs of a Developer: Estimating Output, Construction Contracts, Output Contracts, and Governmental Approvals</td>
<td>#4 Tweak Simple Model: Read the case and update Session 7’s super-simple model to account for new (and better facts).</td>
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<td>ECR Solar Case Part 2.</td>
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<td>#9</td>
<td>Tues Apr 26&lt;br&gt;Zoom 1 hr.</td>
<td>Solar Case Part 3 &amp; Debt/Loan Capital Markets; Multi-Year Project Models</td>
<td>Successfully Obtaining Energy Project Debt Financing via Capital Markets (Bonds) or Credit Markets (Bank Loans)</td>
<td>#5 Multi-Year Model with Detailed Debt Tabs: A hard one. A full-on multi-year project model, and an attempt to figure out whether the project should use bonds or bank financing.</td>
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<td>ECR Solar Case Part 3. Debt readings from rating agency and a law firm; tongue-in-cheek article on “how to lose a banker in 10 minutes.”</td>
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<tr>
<td>#10</td>
<td>Thurs April 28&lt;br&gt;Live 2 hr.</td>
<td>Solar Case Part 4 &amp; Raising Equity/Federal Tax Issues</td>
<td>Raising Project Equity &amp; Federal Tax Issues as they Affect Equity Returns</td>
<td>#6 Solar Case Wrap up: Do sensitivity analysis on Session 9’s model, updated for some new factors, so you can make a go/no-go recommendation to the Board of Directors.</td>
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<td>ECR Solar Case Part 4. Challenge of Institutional Investment in Renewable Energy. Also, backup models for lecture on (i) how energy project ownership changes hands; (ii) tax examples.</td>
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<tr>
<td>#11</td>
<td>Tues May 3&lt;br&gt;Zoom 1 hr.</td>
<td>Power Purchase Agreements and Other Project Revenue Contracts</td>
<td>Getting bankable long-term fixed price sales contracts for energy project output</td>
<td>#7 Solar PPA Contract dissection and questions. Going through real documents to figure out what they mean.</td>
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<td>Instructor note on PPAs; info for assignment re Copper Mtn solar (i) LA city staff report &amp; (ii) the contract itself; LaFratta article on PPAs (one of the best we’ve ever read).</td>
<td></td>
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<td>Readings (See Canvas to Download)</td>
<td>Homework</td>
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| #12 Thurs May 5 Live 2 hr. | EPC Agreements | Getting bankable contracts for construction of energy projects, including bankable completion, schedule, and performance guarantees/penalties:  
A) Project Construction Contracts: Legal, Engineering, and Financial Considerations  
B) EPC Contract Basics Generally  
C) Worked Examples of Delay and Performance Liquidated Damages—the key commercial issue | Hoffman textbook excerpt re EPC contracts; J Brown backup excel model for Lecture 12 that calculates size of contractor penalty payments; Kemper project—example of a trainwreck when there was not a good EPC contract. Plus read the source materials for Homework. | #8 Engineer, Procure, Construct (EPC) contract for a real Natural Gas Combined Cycle project. Dissecting real documents, finding the weak points and scary bits. |
| #13 Tues May 10 Zoom 1 hr. | Storage | Energy Storage in the Emerging Power Grid: Short Burst vs. Long-duration Storage | EJ Baik et al “What’s different about deep decarbonization”; skim as interested class project paper on Storage (from J Brown / D Reicher Stanford law school project for Senate Energy Committee); Energy Innovations paper on wholesale mkt design. | Details to come |
| #15 Tues May 17 Zoom 1 hr. | Low and Zero Carbon Fuels | Low and Zero Carbon Fuels for Process Heat and Transportation: Hydrogen/Ammonia from Methane Reforming with CCS & Zero Carbon Electric Generation + Electrolysis | Details to come | Details to come |
| #16 Thurs May 19 Live 2 hr. | Advanced Nuclear; Cross-Border Projects | Details to come | Details to come | Details to come |
| #17 Tues May 24 Zoom 1 hr. | Direct Air Capture: Emerging Technology | Details to come | Joule Magazine article re Carbon Engineering | Details to come |
| #18 Thurs May 26 Live 2 hr. | Student Team Presentations | None | None | None |
| #19 Tues May Live 1 hr. | Student Team Presentations | None | None | None |