COLUMBIA UNIVERSITY
School of Professional Studies

Master of Science in Sustainability Management

SUMAPS5650: SOLAR PROJECT DEVELOPMENT
Dates: Session X (May 20 - Aug 9), Wednesdays: 6:10 PM – 8:00 PM Location: TBD
3 Credits
[Area 2E, Area 5]

Instructor: Dan Giuffrida, djg2149@columbia.edu
Office Hours: By appointment
Response Policy: Please send me an email with questions or to set up an appointment. I will respond within 24 hours with an answer or to set up a meeting time.

Teaching Assistant TBD
Office Hours: TBD
Response Policy: TBD

Course Overview

At the end of this course, students will be prepared to fully evaluate the technical and financial aspects of a solar project. They will be equipped with skills allowing them to either develop or rigorously vet solar project proposals. The course introduces and provides students with a holistic understanding of the end-to-end solar development process. The course has two goals:

1. To provide students a deep understanding of the dozens of critical interrelated steps critical to developing a successful operating solar project.
2. To equip the students with the tools and understanding of the skills necessary to develop a solar project beginning with site selection encompassing the entire process to commissioning and operations.

We begin the course providing the students with an understanding of the different segments of the solar industry; covering the upstream business, the main players both upstream and downstream and then outlining the different downstream markets: utility, commercial, and residential. We will then hone in on the distributed generation segment of the market; commercial, and residential. To begin, we will cover the critical value drivers of solar: sunlight resource, grid energy cost, tax credits, state and utility incentives including renewable energy credit markets. Energy consumption and production, despite what critics will say about renewables, is the main value driver of the move to renewables. In that light, we will cover in detail, net metering, national and local electricity markets, and electric utility tariff structure to understand how value is generated and measured. We will conduct energy consumption analysis for different end-users to see how solar can and will be deployed and valued across different geographic and utility tariff classes. We will focus on site selection, delving deep into how site characteristics affect system design and ultimately energy production; building azimuth, roof age, RTU locations and parapet walls, roof tilts and materials. We will utilize satellite imagery software to identify viable solar locations as well as utilizing automated solar design software (Helioscope) to design systems. We will cover how to use energy production modeling software, PV Watts and PV Syst, which accurately predicts energy production based on dozens of parameters. In addition to energy, incentives still play a key role in driving value for solar projects. We will cover state incentive markets, focusing on their design, how they drive value and how and when they de-risk projects for investors and owners. We will also cover federal tax incentives. We will cover interconnection requirements to be a grid-tied power facility. In addition, we will cover required authorities having jurisdiction and when and how a solar development project must meet their requirements. Financial valuation and modeling will be a heavy part of this course. The course will cover how to build an income and cash flow statement for a solar project, concepts around valuing solar projects, as well as how investors structure and value solar projects. Students will build capabilities around solar project financial modeling. They will leave the course with the ability to build from scratch a viable

solar financial model. All course concepts will culminate with the creation of a term project in which students create a solar proposal. Students will select from a list of sites around the country. They will utilize resources learned in the course to conduct energy consumption and production analysis, design a system, create a proposed financial structure, outline the financial and environmental benefits for all stakeholders, and provide the financial model backing those benefits. The proposal will include any interconnection and incentive applications required to get their project "shovel ready."

Learning Objectives

Learning Objectives It is imperative that sustainability managers can rigorously analyze solar and other distributed energy technology projects. A key aspect of careers in sustainability is energy procurement and management. To effectively do this, one must be able to vet and analyze how to procure green energy. The course will provide skills to those who wish to pursue careers in corporate sustainability with the requisite understanding and toolset to evaluate solar opportunities and shape future green energy corporate strategy. Additionally, it will prepare students with ambitions of entering the solar industry in sales, origination, development, finance or project management.

Students will learn and develop the following skills and objectives:
L1: Demonstrate understanding of solar value drivers and how geographic, financial, regulatory and legislative changes will affect solar project valuations and more broadly accelerate or decelerate solar adoption.
L2: Explain in clear and concise detail many foundational concepts in solar such as: net metering, variable and demand rates, insolation, power purchase agreement, partnership flip, ITC, kilowatt hour, internal rate of return, discount rate, net present value, solar renewable energy credit among others.
L3: Explain in clear detail how geographic differences can explain varied financial return due to sunlight, seasonality, energy rates, electric rate structure, and incentive market design.
L4: Explain why certain solar system financial ownership structures work better with different types of property ownership structures.
L5: Explain how solar system value is split amongst stakeholders in different financial structures. L6 Develop skills to build a viable, bankable financial model after being give only a system's address.
L6: Develop skills necessary to prepare a solar project for funding including: energy consumption analysis, system design, system energy production analysis, financial model creation, interconnection application preparation, and incentive capture.

Readings

There is no single textbook that covers this course. Readings will be selected from various textbooks, publications, journals, and other sources. The main required reading will be available below and in the resources section of each module.

Tools

You will be using these tools throughout the course. Please familiarize yourself with them, and please feel free post questions in the discussion forum.

- PV Watts energy production tool.
    - Used for midterm exam
- Trial version of the Helioscope software.
- Microsoft Excel
    - Used for financial modeling exercises, both exams, and term project

Resources

Columbia University Information Technology

Columbia University Information Technology (CUIT) provides Columbia University students, faculty and staff with central computing and communications services. Students, faculty and staff may access University-provided and discounted software Downloads Links to an external site.

Columbia University Library
Columbia's extensive library system ranks in the top five academic libraries in the nation, with many of its services and resources available online.

SPS Academic Resources
The Office of Student Affairs provides students with academic counseling and support services such as online tutoring and career coaching.

Course Requirements (Assignments)

Participation & Homework

Participation in all lectures and project activities is required. Contributions are expected to enhance the quality of the class experience for all students. All students are expected to be prepared for class having read the required reading that is posted on canvas. They can also post on the course discussion board with responses to weekly current events as well as other related topics that they find in their independent reading. Students should be thorough in presenting key issues as well as providing insights and implications of the event at hand. Students are also expected to bring to class comments on and sources for current events that occurred during the prior week and are reasonably related to the course topic. Students should be prepared to discuss current events presented by other students. There will additionally be periodic homework sets that students are expected to complete.

Midterm Exam

The Midterm exam in week 8 will consist of 15 short answer questions covering key terms and computational questions covering energy production utilizing the PVWatts tool. In addition, students will be asked to respond to 3 long form questions covering the calculations regarding the Investment tax credit, deprecation, energy consumption, and electric rate analysis. Final Exam Final exam will cover short answer questions on financial valuation topics. It will consist of 15 short answer questions covering financial valuation metrics, financial valuation calculations, and solar energy specific financial concepts. The majority of the exam will require students to construct a financial model from given parameters and answer questions about the model. The students will be provided with the necessary solar energy and financial assumptions needed to construct a full financial cash flow model that allows students to conduct valuation on an example solar project.

Term Project

Students will be put into groups of 2-3 and will create a solar proposal for a preselected location. The students will choose a location in the US and create a solar proposal. The proposal will require students to create a solar system design, justification for solar system sizing based on electric consumption and rate analysis. They will be required to create a solar system production projection model to approximate system energy production. They will be required to create a cash flow financial model. Based on their understanding of the occupant of the building and their financial position, they will propose a financial structure that best fits the building occupant and defend their approach. In their proposal, they will provide completed interconnection and incentive applications specific to their solar system.

Evaluation / Grading

The final course grade will be computed using a weighted index of numeric grades that combine performance under attendance and participation, midterm exam, final exam, and term project. The weighted index will be scaled into a

letter grade scale from F to A+ based on an expectation that a class representative of the population of Columbia masters students will receive a median grade of B+ or A-. The final grade will be calculated as described below:

FINAL GRADING SCALE

Grade	Percentage
A+	98–100 %
A	93–97.9 %
A-	90–92.9 %
B+	87–89.9 %
B	83–86.9 %
B-	80–82.9 %
C+	77–79.9 %
C	73–76.9 %
C-	70–72.9 %
D	60–69.9 %
F	59.9% and below

Assignment/Assessment	% Weight	Individual or Group/Team Grade
Class participation & Homework	5%	
Midterm exam	25%	
Final exam	30%	
Term project	40%	

Course Schedule/Course Calendar

Date	Topics and Activities	Readings (due on this day)	Assignments (due on this date)
Week 1	Introduction to Solar: Understanding the industry Verticals	Posted on Canvas: 1) Woodmac Solar Market Insight Report 2) NREL Solar Industry Overview 3) Inflation Reducation ACT overview 4)https://www.canarymedia.com/articles/solar/could-the-inflation-reduction-act-revive-solarmanufacturing-in-the-u-s	• Attend Session • Review Resources • Review Term • Project Expectations
Week 2	Solar Project Value Drivers	Posted on Canvas: 1) NREL Tracking the Sun 2) Net Metering NREL report 3) Interconnection backlog 4) Permitting Reform 5) Us Solar Manufacturing 6) IRA overview	• Attend Session • Review Resources
Week 3	Electricity Markets	• Canvas posted articles • California Net Metering articles	• Attend Session • Review Resources

		• How do electric utility make money • Introduction to Electricity Markets • LNG Growth Canary Media article	
Week 4	Net Metering & Rates	Canvas posted articles 1) Suncast episode 395 2) Hawaii Net metering VPPs 3) Community Solar White Paper 4) Net Metering Trends 5) Solving Americas Solar Inequality 6) Disparities in Rooftop Solar	• Attend Session • Review Resources
Week 5	Site Selection, System Design & Production Modeling	Canvas posted articles 1) String Inverter overview 2) P90 production 3) Bifacial Module overview	• Attend Session • Review Resources • Familiarize self with PV Watts. • Sign-up with and familiarize self with • Helioscope
Week 6	Incentive Markets	Canvas posted articles 1) Community solar in the IRA 2) Virginia RPS updates 3) California RPS updates 4) Rhode Island RPS updates	• Attend Session • Review Resources
Week 7	Tax! The ITC & MACRs	Canvas posted articles 1) Inflation Reduction Act articles 2) SEIA IRA Summary	• Attend Session • Review Resources • Utility Bill Analysis
Week 8	Midterm exam	• Midterm Study Guide • Review course material	• Attend Session • Review Resources • Exam Preparation Activity • Midterm Exam
Week 9	Interconnection, permitting and other AHJs	Canvas posted articles 1) Valuing Development – Part I, II and III 2) Rural vs Urban on land use article 3) Articles on streamlining interconnection & permitting 4) Interconnection timelines	• Attend Session • Review Resources • Solar System Design in HelioScope for Term Project • Work on Term Project
Week 10	Project Financial Modeling	Canvas posted articles 1) SEIA Power Purchase Agreement 2) Corporate Finance, Ivo Welch chp 1 & 2	• Attend Session • Review Resources
Week 11	Project Valuation	Canvas posted articles 1) Valuation of Solar Generation Assets 2) Renewable Energy Finance Primer	• Attend Session • Review Resources • Project Cash Flow

		3) Damodaran on Valuation pg 1-66	
Week 12	Financial Structures	Canvas posted articles 1) Tax Equity 101 2) Tax Equity 201 3) Project Finance for Solar Projects ● Attend Session ● Review Resources ● Project Cash Flow with project valuation	● Attend Session ● Review Resources ● Project Cash Flow with project valuation
Week 13	Project Financing & Investing	Canvas posted articles 1) "What are Yieldcos" 2) Energy Finance 101 – intro to yieldcos 3) Solar Securitization	● Attend Session ● Review Resources
Week 14	Final exam	● Final Exam Study Guide ● Review course materials	● Review Resources ● Final Exam ● Term Project

Course Policies

Participation and Attendance: You are expected to complete all assigned readings, attend all class sessions, and engage with others in online discussions. Your participation will require that you answer questions, defend your point of view, and challenge the point of view of others. If you need to miss a class for any reason, please discuss the absence with us in advance.

Late Work: Work that is not submitted on the due date noted in the course syllabus without advance notice and permission from the instructor will be graded down 1/3 of a grade for every day it is late (e.g., from a B+ to a B).

Citation & Submission: All written assignments must use APA, cite sources, and be submitted to the course website via the assignments link (not via email, unless arranged specifically).

School Policies

Copyright Policy: Please note—Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:
The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research."If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use,"that user may be liable for copyright infringement.

Academic Integrity: Columbia University expects its students to act with honesty and propriety at all times and to respect the rights of others. It is fundamental University policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University community is unacceptable and will be dealt with severely. It is essential to

the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based.

Academic honesty in class assignments and exams is expected of all students at all times. SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards. You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

Accessibility: Columbia is committed to providing equal access to qualified students with documented disabilities. A student's disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website.

Class Recordings: All or portions of the class may be recorded at the discretion of the Instructor to support your learning. At any point, the Instructor has the right to discontinue the recording if it is deemed to be obstructive to the learning process.

If the recording is posted, it is considered confidential and it is not acceptable to share the recording outside the purview of the faculty member and registered class.