

Master of Science in Sustainability Management

SUMA PS5221: Climate Technology and Innovation

Wednesdays: 6:10PM-8:00PM EST [Location]

3 Credits

Elective

Instructor: [Jason Prince, jason@momentumx.ventures]
Office Hours: By appointment
Response Policy: I aim to respond within 24 hours, and students can email anytime at jp3276@columbia.edu

Facilitator/Teaching Assistant: Jack Killcoyne

Office Hours: [TBD]

Course Overview

This course is designed to furnish students with a conceptual framework for understanding climate tech innovation and an overview of practical ways to professionally engage in it. We focus on climate tech because the current global rate of decarbonization is not sufficient to limit warming to 1.5°C. To accelerate the rate of change and stabilize our planet's climate, innovative technology development and diffusion is required. Beyond the moral imperative, rapid decarbonization represents an unprecedented economic opportunity. To realize the promise of a low-carbon economy, new practitioners must join the innovation ecosystem and drive it forward. This course will prepare students to do so.

The course starts by framing what climate tech means (i.e., all technologies focused on mitigating greenhouse gas emissions and addressing the impacts of climate change) and how climate tech innovation will occur (i.e., as a complex process including co-evolution of technology, regulations, infrastructure, and consumer behavior). It then provides an overview of the innovation value chain including various stakeholders and avenues for professional involvement. It concludes with a survey of sectoral innovation opportunities. Considerations of equity and just transition are covered throughout.

It is a full-semester on-campus elective course open to any SUMA student, or student across CU academic programs who is interested in climate entrepreneurship, investing, and technology innovation. The course includes 14 two-hour interactive lectures, with regular guest practitioners representing various career paths in the innovation economy. Students are assumed to have had little previous exposure to the startup venture building ecosystem or decarbonization innovation pathways.

Learning Objectives

The primary goal for the course is to familiarize students with the climate tech innovation landscape including key stakeholders and sectoral opportunities. Through this course, students will:

- LO1 - Analyze what climate technologies are, where they are most needed, and how to scale them up to gain an understanding of how to develop innovative solutions to drive deep decarbonization
- LO2 - Assess how to professionally engage across the climate tech innovation landscape, for example as entrepreneurs, venture capitalists, or ecosystem collaborators to prepare for selecting and excelling in careers focused in climate tech
- LO3 - Evaluate the innovation value chain capital stack, including grants, venture capital, venture debt, growth equity, and project finance to develop an understanding of how to most efficiently capitalize climate technologies are various stages of scale-up

- LO4 - Develop investment theses and business cases for priority climate innovations to gain practical experience performing tasks typical in climate tech investing and business building

Readings

Required

- Baldi, Dan et al., (June 2023) “The Future of Climate Tech: A look at the technologies driving a sustainable future” Silicon Valley Bank (19 pages)
<https://www.svb.com/globalassets/trendsandinsights/reports/the-future-of-climate-tech-2023.pdf>
- Christensen, Andrew et al (June 16, 2023) “Atmospheric Carbon Dioxide Tagged by Source” NASA Scientific Visualization Studio <https://svs.gsfc.nasa.gov/5110>
- CTVC (February 24, 2023) “Exiting Cleantech to Climate Tech” Climate Tech VC (12 pages)
<https://www.ctvc.co/exits-analysis-clean-tech-climate-tech/>
- CTVC (March 22, 2021) “From Cleantech to Climate Tech” Climate Tech VC (4 pages)
<https://www.ctvc.co/from-cleantech-to-climate-tech/>
- Davila, Tony, Marc Epstein, Robert Shelton (2012) “Making Innovation Work: How to Manage it, Measure it, and Profit from it” (10 pages)
https://books.google.com/books/about/Making_Innovation_Work.html?id=F2_S8FFaSKMC
- Denholm, Paul, Patrick Brown, Wesley Cole, et al. (2022) “Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035” National Renewable Energy Laboratory (22 pages)
<https://www.nrel.gov/docs/fy22osti/81644.pdf>
- Environmental Defense Fund / Deloitte (October 2022) “Pathways to Net Zero: The Innovation Imperative” EDF / Deloitte (42 pages)
https://business.edf.org/wp-content/blogs.dir/90/files/Innovation-Imperative_Digital.pdf
- Hellstern, Tom et al., (October 28, 2021) “Innovating to Net Zero: An executive’s guide to climate technology” McKinsey (11 pages)
<https://www.mckinsey.com/capabilities/sustainability/our-insights/innovating-to-net-zero-an-executives-guide-to-climate-technology>
- International Energy Agency (November 2021) “Global Hydrogen Review, 2021” International Energy Agency (35 pages)
<https://iea.blob.core.windows.net/assets/5bd46d7b-906a-4429-abda-e9c507a62341/GlobalHydrogenReview2021.pdf>
- Koch-Blank, Thomas (September 2019) “The disruptive potential of Green Steel” RMI (7 pages)
<https://rmi.org/wp-content/uploads/2019/09/green-steel-insight-brief.pdf>
- Lalit, Radhika and Chen, Zhinan (June 2023) “The 3Cs of Innovation in Low-Carbon Concrete” RMI (19 pages) <https://rmi.org/insight/innovation-in-low-carbon-concrete/>
- Lee, Sangji and Baumgartner, Lisa (2022) “How a Just Transition Can Help Deliver the Paris Agreement” The United Nations Development Program (14 pages)
https://climatepromise.undp.org/sites/default/files/research_report_document/Just%20Transition%20Report%20Jan%202020.pdf
- Matos, Stelvia et al. (September 2022) “Innovation and climate change: A review and introduction to the special issue” Technovation, Volume 117 (13 pages)
<https://www.sciencedirect.com/science/article/pii/S0166497222001596>
- Mind Tools “SWOT Analysis: Understanding Your Business, Informing Your Strategy” Mind Tools (4 pages) <https://www.mindtools.com/amtbj63/swot-analysis>

- Nabuurs, Gert-Jan et al., (2022) “Agriculture, Forestry and Other Land Uses (AFOLU)” Intergovernmental Panel on Climate Change (31 pages)
https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter07.pdf
- Popovitch, Nadja and Plumer, Brad (April 14, 2023) “How electrification became a major tool for fighting climate change” The New York Times
<https://www.nytimes.com/interactive/2023/04/14/climate/electric-car-heater-everything.html>
- Purdom, Sophie and Zhou, Kim (October 29, 2021) “The Climate Capital Stack” CTVC (12 pages)
<https://www.ctvc.co/the-climate-capital-stack/>
- PwC (November 3, 2022) “State of Climate Tech 2022: Overcoming Inertia in Climate Tech Investing” PwC (16 pages)
<https://www.pwc.com/gx/en/services/sustainability/publications/overcoming-inertia-in-climate-tech-investing.html>
- Smith, S. M. et al., (2023) “A global, independent scientific assessment of Carbon Dioxide Removal” The State of Carbon Dioxide Removal (29 pages)
<https://static1.squarespace.com/static/633458017a1ae214f3772c76/t/63e3d4602156db24bc18c91c/1675875445298/SoCDR-1st-edition.pdf>
- Ward, Matthew, “The Ultimate Guide to Non-Dilutive Startup Funding” 4Ward.VC (10 pages)
<https://4ward.vc/the-ultimate-guide-to-non-dilutive-financing-venture-debt-vs-revenue-based-financing-for-climate-startups/>
- World Bank (2022) “Squaring the Circle: Policies From Europe’s Circular Economy Transition” World Bank (20 pages)
<https://documents1.worldbank.org/curated/en/099425006222229520/pdf/P174596025fa8105a091c50fb22f0596fd1.pdf>
- Wyne, et al., (2023) “The Climate Tech Opportunity” Oxford Climate Tech Initiative (22 pages)
<https://www.oxclimate.tech/the-climate-tech-opportunity>

Assignments and Assessments

1. Short individual assignments [LO1, LO2]: Setting the foundation for understanding climate tech innovation with a landscape analysis intended to provide students a sense of where they might be most interested in focusing across the innovation value chain.
 - a. *Assignment 1 - ‘Innovation Levers’* – Per ‘Figure 2.1: The Six Levers of Innovation’ on page 31 of the Davila et al., reading, select a lever for innovation that most interests you and explain why you think it holds potential for driving climate impact. Identify 1 real-world example of a business pursuing this innovation lever in a manner related to climate, and describe in 2-3 paragraphs how that business applies the lever.
 - i. The desired deliverable for *Assignment 1* is a 1-2 page write-up explaining why you chose your lever, providing your business example, and including your description of how the business applied the lever.
 - b. *Assignment 2 – ‘Career Path Thought Experiment’* – Per the course overview of stakeholders in the climate tech innovation value chain, select a stakeholder category (e.g., National Labs), and identify one US-based organization that falls in that category. For the organization you select, summarize its value proposition in terms of how it supports climate tech innovation. Provide 1 illustrative example of a career path you could consider pursuing at this organization.
 - i. The desired deliverable for *Assignment 2* is a 1-2 page write-up identifying the stakeholder category and the specific organization you select, describing how that organization supports climate-tech innovation, and detailing a specific role at that organization including its primary responsibilities and why it interests you.

2. Guest speaker preparation [LO3]: In preparation for each Guest Speaker session, students will review the relevant organizations' websites and submit 1 question to be relayed to the guest speakers in advance of the session. Questions can relate to the nature of the guest speakers' organization, the nature of their specific role, or their perspective on climate tech innovation. These crowdsourced questions will be provided to the guest speakers before the sessions to enable guests to tailor presentations to address empirical student interests, and to support robust class discussions and potential networking opportunities. In addition to the question, students will develop a 2-3 slide overview describing what the organization does, what its competitive landscape looks like, and what impact it drives. By developing these organizational overviews and specific speaker questions, students will be prepared to constructively network with the climate tech practitioners during their guest lectures.
 - a. *Questions 1* (for public agencies)
 - b. *Questions 2* (for accelerators)
 - c. *Questions 3* (for capital providers)
 - i. The desired deliverable for Questions 1, 2, and 3 is an email from each student with 1 question directed at one of the speakers for the relevant session and 2-3 associated slides related to the organization the speaker works with.

3. Project 1 – 'Investor Case Study' [LO4]: Due diligence is a form of investigation that enables the conductor to comprehensively evaluate an investment and develop insights regarding the relative strengths and weaknesses of such investment. Due diligence exercises are equally valuable for climate tech investors determining where to deploy capital as they are for students evaluating where to invest their time and effort. To support students in thinking critically about working across different climate tech innovation pathways, students will review the top 10 technologies with highest abatement potential across sectors per 'Figure 1: Prioritized Innovations' on page 6 of the EDF/Deloitte reading. Students will then select 1 of the 10 technologies, identify a startup working with that technology, and using the SWOT framework per the Mind Tools reading, they will comprehensively evaluate the startup's business. Students will also develop investment memos detailing the decision-making process and result for the evaluation of investment in that startup.
 - i. The desired deliverable for *Project 1* will be a ~4 slide deck outlining the Strengths, Weaknesses, Opportunities, and Threats to that startup, as well as a 2-3 page written investment memo explaining an investment decision.

4. Project 2 – 'Entrepreneur Case Study' [LO4]: Having reviewed a range of sectoral innovations across the climate landscape, students will take the opportunity to experiment as entrepreneurs building an innovative climate tech startup. This experiment will enable students to apply all that they have learned in the class to-date regarding levers for innovation, the climate tech support ecosystem, and sectoral and technological innovation pathways, and apply that knowledge to a hypothetical business. In groups of 3-4, students will develop the idea for a startup and develop the business case and action plan for how to de-risk and pursue the startup.
 - i. The desired deliverable for *Project 2* will be a ~10 slide PowerPoint pitch deck, including slides on the problem being addressing, the proposed solution, the value proposition, the product or service being offered, the business model, the competitive landscape, and the go-to-market strategy including key stakeholders involved and next steps for scaling

Grading

The final grade will be calculated as described below:

| 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 |
|----------------------------|----------|--------------------------------|
| Participation / Attendance | 10% | Individual |
| Assignment 1 | 10% | Individual |
| Assignment 2 | 10% | Individual |
| Questions 1 | 5% | Individual |
| Questions 2 | 5% | Individual |
| Questions 3 | 5% | Individual |
| Project 1 | 25% | Individual |
| Project 2 | 30% | Group |

Course Schedule/Course Calendar

| Session | Topic | Guest Speaker(s) | Reading (due on this day) | Evaluation |
|---------|---|------------------|---|---------------------|
| 1 | What is “climate tech,” what is “climate tech innovation,” and why is it needed | | Davila, Tony, Marc Epstein, Robert Shelton (2012) “Making Innovation Work: How to Manage it, Measure it, and Profit from it” (read pages 30-40) Matos, Stelvia et al. (September 2022) “Technovation, Innovation and climate change: A review and introduction to the special issue, 2022” Technovation Volume 117 (13 pages) Hellstern, Tom et al., (October 28, 2021) “Innovating to Net Zero: An executive’s guide to climate technology” McKinsey (11 pages) | <i>Assignment 1</i> |
| 2 | Overview of stakeholders involved in the innovation value chain | | Students are required to familiarize themselves with each of the key stakeholders listed below by reviewing their websites and preparing questions per <i>Assignment 2</i> <ul style="list-style-type: none"> • National Labs e.g., NREL • Government agencies e.g., ARPA-E, NYSERDA • Universities e.g., Columbia Tech Ventures • Incubators/Accelerators e.g., YC, Elemental, Greentown, D3 • Angels e.g., AngelList • Venture Capital e.g., BEV, EIP | <i>Assignment 2</i> |

| | | | | |
|----|---|--|--|--------------------|
| | | | <ul style="list-style-type: none"> • Venture debt e.g., SVB | |
| 3 | Public agency overviews where guest speakers share overviews | Panel: NREL, NYSERDA, Columbia Tech Ventures | The session will include brief overviews from each representative, and then Q&A. Students must review the websites of each speaker's relevant organization | <i>Questions 1</i> |
| 4 | Accelerator/ Incubator overviews | Panel: Elemental, D3 | The session will include brief overviews from each representative, and then Q&A. Students must review the websites of each speaker's relevant organization | <i>Questions 2</i> |
| 5 | Capital Stack | Panel: TBD from relevant climate-tech VCs | <p>The session will include brief overviews from each representative, and then Q&A. Students must review the websites of each speaker's relevant organization</p> <p>CTVC (February 24, 2023) "Exiting Cleantech to Climate Tech" Climate Tech VC (12 pages)</p> <p>CTVC (March 22, 2021) "From Cleantech to Climate Tech" Climate Tech VC (4 pages)</p> <p>Purdom, Sophie and Zhou, Kim (October 29, 2021) "The Climate Capital Stack" CTVC (12 pages)</p> <p>Ward, Matthew, "The Ultimate Guide to Non-Dilutive Startup Funding" 4Ward.VC (10 pages)</p> | <i>Questions 3</i> |
| 6 | Sectoral innovation priorities | | <p>Environmental Defense Fund / Deloitte (October 2022) "Pathways to Net Zero: The Innovation Imperative" EDF / Deloitte (read pages 8-50)</p> <p>Mind Tools "SWOT Analysis: Understanding Your Business, Informing Your Strategy" Mind Tools (4 pages)</p> | <i>Project 1</i> |
| 7 | Carbon management (including NBS, CDR and CCUS) | | Smith, S. M. et al., (2023) "A global, independent scientific assessment of Carbon Dioxide Removal" The State of Carbon Dioxide Removal (read pages 8-27 and 35-45) | |
| 8 | Hydrogen and Synfuels | | International Energy Agency (November 2021) "Global Hydrogen Review, 2021" International Energy Agency (read pages 5-40) | |
| 9 | Buildings including steel and cement | | <p>Lalit, Radhika and Chen, Zhinan (June 2023) "The 3Cs of Innovation in Low-Carbon Concrete" RMI (19 pages)</p> <p>Koch-Blank, Thomas (September 2019) "The disruptive potential of Green Steel" RMI (7 pages)</p> | |
| 10 | Electrification including renewables, the grid and transportation | | <p>Popovitch, Nadja and Plumer, Brad (April 14, 2023) "How electrification became a major tool for fighting climate change" The New York Times</p> <p>Denholm, Paul, Patrick Brown, Wesley Cole, et al. (2022) "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035" National Renewable Energy Laboratory (read pages 1-20 and 68-70)</p> | |
| 11 | Waste, Agriculture, Forestry, Land Use | | <p>Nabuurs, Gert-Jan et al., (2022) "Agriculture, Forestry and Other Land Uses (AFOLU)" Intergovernmental Panel on Climate Change (read pages 750-66 and 815-830)</p> <p>World Bank (2022) "Squaring the Circle: Policies From Europe's Circular Economy Transition" World Bank (read pages 1-18)</p> | <i>Project 2</i> |

| | | | | |
|----|---------------------------------------|--|--|--|
| 12 | Project 2 Student Presentations | | N/A | |
| 13 | Just Transition | | Christensen, Andrew et al (June 16, 2023) "Atmospheric Carbon Dioxide Tagged by Source" NASA Scientific Visualization Studio Lee, Sangji and Baumgartner, Lisa (2022) "How a Just Transition Can Help Deliver the Paris Agreement" The United Nations Development Program (read pages 8-22) | |
| 14 | The Future of Climate Tech Innovation | | PwC (November 3, 2022) "State of Climate Tech 2022: Overcoming Inertia in Climate Tech Investing" PwC (16 pages) Baldi, Dan et al., (June 2023) "The Future of Climate Tech: A look at the technologies driving a sustainable future" Silicon Valley Bank (19 pages) | |

Course Policies

Participation and Attendance

I expect you to come to class on time and thoroughly prepared. I will keep track of attendance and look forward to an interesting, lively and confidential discussion. If you miss an experience in class, you miss an important learning moment and the class misses your contribution. More than one absence will affect your grade.]

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 standard citation format (e.g., MLA, APA, Chicago), cite sources, and be submitted to the course website (not via email).]

School and University Policies and Resources

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 posted at <https://sps.columbia.edu/students/student-support/academic-integrity-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.

Diversity Statement

It is our intent that students from all diverse backgrounds and perspectives be well-served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that the students bring to this class be viewed as a resource, strength and benefit. It is our intent to present materials and activities that are respectful of diversity: gender identity, sexuality, disability, age, socioeconomic status, ethnicity, race, nationality, religion, and culture.

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: <https://health.columbia.edu/content/disability-services>.

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 confidential and it is prohibited to share the recording outside of the class.

SPS Academic Resources

The Division of Student Affairs provides students with academic counseling and support services such as online tutoring and career coaching: <https://sps.columbia.edu/students/student-support/student-support-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](#).

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.

The Writing Center

The Writing Center provides writing support to undergraduate and graduate students through one-on-one consultations and workshops. They provide support at every stage of your writing, from brainstorming to final

drafts. If you would like writing support, please visit the following site to learn about services offered and steps for scheduling an appointment. This resource is open to Columbia graduate students at no additional charge. Visit <http://www.college.columbia.edu/core/uwp/writing-center>.

Career Design Lab

The Career Design Lab supports current students and alumni with individualized career coaching including career assessment, resume & cover letter writing, agile internship job search strategy, personal branding, interview skills, career transitions, salary negotiations, and much more. Wherever you are in your career journey, the Career Design Lab team is here to support you. Link to <https://careerdesignlab.sps.columbia.edu/>

Netiquette

[Only applies to courses using online platforms]

Online sessions in this course will be offered through Zoom, accessible through Canvas. A reliable Internet connection and functioning webcam and microphone are required. It is your responsibility to resolve any known technical issues prior to class. Your webcam should remain turned on for the duration of each class, and you should expect to be present the entire time. Avoid distractions and maintain professional etiquette.

Please note: Instructors may use Canvas or Zoom analytics in evaluating your online participation.

More guidance can be found at: https://jolt.merlot.org/vol6no1/mintu-wimsatt_0310.htm

Netiquette is a way of defining professionalism for collaborations and communication that take place in online environments. Here are some Student Guidelines for this class:

- Avoid using offensive language or language that is not appropriate for a professional setting.
- Do not criticize or mock someone's abilities or skills.
- Communicate in a way that is clear, accurate and easy for others to understand.
- Balance collegiality with academic honesty.
- Keep an open-mind and be willing to express your opinion.
- Reflect on your statements and how they might impact others.
- Do not hesitate to ask for feedback.
- When in doubt, always check with your instructor for clarification.