

EAS 677.023: Technologies and Policies for Deep Decarbonization to Mitigate Climate Change

Syllabus

Term: Winter 2021

Course Time: Friday 1-3 PM EST

Location: Zoom (<https://umich.zoom.us/j/93482177014>)

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Professor: Michael Craig (he/his/him), mtcraig@umich.edu

Professor Office Hours: Friday 3-4 PM EST via Zoom (<https://umich.zoom.us/j/93451021667>)

Graduate Student Instructor: Meiye (May) Wang (she/her/her), meiye@umich.edu

GSI Office Hours: Friday 10-11 AM EST (or by appointment) via Zoom (<https://umich.zoom.us/j/97437555722>)

Land Acknowledgement

I acknowledge the university's origins through an 1817 land transfer from the Anishinaabek, the Three Fires People: the Odawa, Ojibwe, and Bodewadami as well as Meskwahkiasahina (Fox), Peoria and Wyandot. I further acknowledge that our university stands, like almost all property in the United States, on lands obtained, generally in unconscionable ways, from indigenous peoples. Research on environmental science and sustainability has benefited and continues to benefit from access to land originally gained through the exploitation of others. Knowing where we live and work does not change the past, but understanding and acknowledging the history, culture, and impacts of colonial practices is an important step towards the creation of an equitable and sustainable future. This Land Acknowledgement serves as a starting point in my commitment to holding myself and our university more accountable to the recognition and sovereignty of indigenous people.

Welcome

Welcome to EAS677.023, or "Deep Decarbonization"! I am very excited to offer this course and to discuss and hear your thoughts on one of the defining issues of our generations, climate change. Climate change and decarbonization are global challenges that require cooperation between communities around the world to solve. Students from all backgrounds and perspectives are most welcome and valued.

This year, we will hold all of our classes and office hours remotely via Zoom. **Synchronous** participation is required. Please download and test Zoom before the first day of class. You can download Zoom and find help resources at <https://its.umich.edu/communication/videoconferencing/zoom>. You can join class and office hour Zoom meetings through links provided above or through Canvas (see Navigation Menu).

Course Description

This discussion-based seminar will explore technologies and policies for deep decarbonization of the economy consistent with aggressive climate change mitigation, e.g. to achieve 1.5 or 2 degrees Celsius targets. Readings will come from diverse sources, including non-governmental reports and peer-reviewed journal articles. The course will review climate change science and impacts, examine emission reduction trajectories consistent with deep decarbonization, delve into sectoral decarbonization strategies and technologies, analyze current and potential global climate policies, and explore crosscutting issues such as equity.

Student Course Learning Objectives

Upon completion of this course, students will have a better appreciation for the need to and the scale of action required to mitigate climate change. Specifically, students will be able to understand the magnitude of action needed for deep decarbonization, critically evaluate decarbonization policies, and understand sectoral

decarbonization strategies and trade-offs. This course will help prepare students for any job related to climate mitigation, including in corporations, academia, governments, and non-governmental organizations.

Enrollment Qualifications

This course is designed for SEAS graduate students, but junior and senior undergraduates and graduate students from other schools are welcome. Some familiarity with climate change and decarbonization is preferred.

Grading

Class attendance	50%
Class participation from peer evaluation	15%
Discussion leader	15%
Semester project	20%

Class Format

As indicated by the grading scheme, this course will be a discussion-based seminar. I expect each student to **participate in class daily**, meaning our class will meet **synchronously** on Zoom. Each class will have assigned readings that you must read before class. We will spend most of each class discussing each reading in small breakout groups (via Zoom breakout rooms). To facilitate discussion, each group will have one voluntary discussion leader, discussed below. Meiyue and I will rotate through breakout groups to listen in, answer questions, and offer some thoughts. In the last 15 minutes, we will debrief as a class. In this debrief, groups will share a few important or difficult ideas they discussed. Professor Craig will conclude class with some thoughts and responses.

The remote environment poses some challenges to effective breakout discussions, but I have no doubt we can have effective, fun, and educational discussions via Zoom if everyone follows the below Participation Guidelines. Last year, our transition from in-person to remote went extremely smoothly.

Office Hours

We will hold office hours remotely via Zoom (see above links). When you join the Zoom meeting, please type a message in the chat window. We will work through individuals in order. As in class, please ensure your microphone is muted if you are waiting in line.

Class Participation, Attendance, and Electronics Policy

Participation and Attendance The majority of your grade will depend on your class attendance and participation. **Attendance and participation are required and tracked, but each student may have two unexplained absences without reduction in their class participation grade.** If justified (such as for religious observances, professional development, course conflicts, illness, or family matters) students can miss additional classes without penalty, but they must email me a justification for their absence. Please do not include personal information in the justification you are not comfortable sharing. For more details on how I will grade participation, please see the rubric at the end of this syllabus.

Peer Evaluation Part of your participation evaluation will come from feedback from other members in your discussion group. In the last few minutes of each class, you must fill in a brief Google form (<https://forms.gle/Gzk1cK8GtdFoT9X7>) for every other member in your discussion group. Participation will be evaluated based on three criteria:

- Compliance with following participation guidelines (see below) to facilitate an inclusive discussion
- Level of preparation and demonstrated understanding of the reading materials
- Quality of contributions to the discussion

Participation Guidelines

When engaging in class, please follow these simple ground rules:

- Speak from the “I” perspective
- Listen to understand, not to respond
- Give room for others to participate
- Express disagreement without attacking, shaming, or blaming

- Practice both/and thinking (often multiple answers are correct)

Following these rules is particularly valuable in a remote environment, where it is easy to monopolize time by talking at your computer. Please be particularly cognizant of providing space to your group members. Throughout class, if you are not speaking, please also ensure your microphone is muted.

Discussion Leaders and Secretaries

Each class, I will ask for volunteers to serve as **discussion leaders** for the next class by filling out this [Google spreadsheet](#) in the last few minutes of class. Discussion leaders will be responsible for closely reading the assigned papers and preparing at least five questions for discussion in their respective breakout groups. Your discussion leader grade will depend on your preparation for class, including whether you have made a good faith effort to have a firm grasp of the materials and have prepared at least five questions for discussion.

Each class, we will also ask for volunteers to be **secretaries** for that class. The secretaries will keep **brief** notes on their respective discussions on a shared Google document that we will provide each class.

Project

This course will have one assignment, due on the last day of class. Students can choose one of two projects to complete. Each option will require some simple calculations and less than 7 pages of writing. We will release more details on both projects later in the semester.

Option A: INDC Analysis

Students must select and discuss one Intended Nationally Determined Contribution (INDC), or a country decarbonization plan submitted under the Paris Agreement. Please read several INDCs before choosing one to get a sense for the diversity and typical format of INDCs. Students must describe the INDC, place the INDC in the context of deep decarbonization, and critique and suggest improvements for the INDC.

Option B: Planning for the Biden Administration

As we will discuss in class, the Biden Administration has ambitious plans for fighting climate change. Students must describe the Administration's existing plans, place those plans in the context of deep decarbonization, and critique and suggest improvements for the plans.

Email Policy

We strongly prefer questions during office hours rather than by email. If you must email a question, please email Meiye first unless it is a personal matter. If Meiye cannot help, please then contact Professor Craig. Please label all emails with a subject beginning [EAS677].

Academic Misconduct (or Cheating and Plagiarism)

Plagiarism in the creative writing assignment will result in a failing grade on the assignment and possibly in the course. Additionally, all cases of academic misconduct will be referred to the Office of the Assistant Dean for Undergraduate Education. You are responsible for knowing what constitutes academic misconduct (see <http://www.lsa.umich.edu/academicintegrity/examples.html>), although I will be glad to answer your questions. Academic misconduct includes cutting and pasting from a website and lying about illnesses or other details related to missed work or classes.

Mental Health

Being a student can be extremely stressful and can lead to feelings of anxiety, depression, difficulty eating or sleeping, and drug and alcohol problems. If you have any of these feelings, you are not alone. Throughout my schooling, I (Professor Craig) often experienced some of these feelings, and I guarantee you many of your classmates and friends have wrestled with these feelings as well at some point. In addition to these feelings, students can also be the victim of interpersonal or sexual violence, loss or grief, and other challenges. These feelings and experiences can take a significant toll on our lives, not to mention our academic performance. In order to support you during such challenging times, the University of Michigan provides a number of confidential resources to all enrolled students, including Counseling and Psychological Services (CAPS) (734-764-8312), Sexual Assault Prevention and Awareness Center (SAPAC) (24-Hour Crisis Line: 734-936-3333), Psychiatric Emergency Services (734-996-4747), and Services for Students with Disabilities (734-763-3000; 734-615-4461 [TDD]; 734-619-6661 [VP]). SEAS has an embedded CAPS counselor, Andrea Sieg. Andrea is available for

appointments Tuesdays from 10-6 and Thursdays from 1-5. Please email her at andsieg@umich.edu to set up an appointment. In addition to these services, if you are feeling overwhelmed please reach out to Professor Craig to figure out what we can do at least through this course to bring more happiness and stability to your life.

Sexual Misconduct

Title IX prohibits discrimination on the basis of sex, which includes sexual misconduct in the forms of harassment, domestic and dating violence, sexual assault, and stalking. Sexual violence can undermine students' quality of life and academic success, so I encourage anyone dealing with sexual misconduct to talk to someone about their experience and get the support they need. Confidential support and academic advocacy can be found with the Sexual Assault Prevention and Awareness Center (SAPAC) on their 24-hour crisis line, (734) 936-3333 and at sapac.umich.edu. Alleged violations can be non-confidentially reported to the Office for Institutional Equity (OIE) at institutional.equity@umich.edu.

Religious Observances and Special Circumstances

I realize students may have religious obligations during the term. If you are aware of a conflict with a course expectation and your observance of a religious holiday, please contact me as soon as possible. I will do my best to make the necessary accommodations. The following link is to the University policies and guidelines specific to holiday observances: <http://www.lsa.umich.edu/facstaff/saa/holidays>.

Students with Children

I am happy for students to bring their children to class. Before doing so, please speak with me so we can ensure appropriate accommodations are made and boundaries are set.

Accommodations and Accessibility

If students think they may need an accommodation for a disability, they should let me (Professor Craig) know at the beginning of the term. They should then contact the Services for Students with Disabilities (SSD) office. Once their eligibility for an accommodation has been determined, they will be issued a Verified Individual Services Accommodation (VISA) form and I will arrange for their accommodation. Any information students provide is private and confidential and will be treated as such. If students already have a VISA form from SSD, they should present this form to me at the beginning of the term, but no later than at least two weeks prior to the need for the accommodation so that there is enough time for the appropriate arrangements to be made.

Course Materials

We will use various materials that will be available on Canvas. No textbook is required.

Student Feedback

I am extremely interested in student feedback. There will be several defined opportunities for feedback but I welcome it at any point. At several points throughout the semester, I will distribute a survey for feedback.

Writing Resources

The Sweetland Center for Writing offers free one-to-one writing support to all undergraduate and graduate students at the University of Michigan, regardless of background or discipline. Sweetland faculty and peer writing consultants meet with student writers to help with any stage of the writing process, from initial brainstorming to final revisions. Learn more about Sweetland's writing support, locations, and online writing consultations at <https://www.lsa.umich.edu/sweetland>.

Course Schedule

Acronyms: IPCC = Intergovernmental Panel on Climate Change; AR5 = Fifth Assessment Report

Date (Lecture Number)	Topic	Required Readings
I. The Urgent Need for Deep Decarbonization		
1/22 (1)	Welcome and Introductions	None
1/29 (2)	State, drivers, and impacts of climate change	1. IPCC, AR5 Working Group 1, Summary for Policymakers, Sections C-D 2. IPCC, AR5 Working Group 3, Technical Summary Document, Section TS.2 3. UNEP, Emissions Gap Report 2020, Sections 3.1-3.3 4. IPCC, AR5 Working Group 1, Summary for Policymakers, Section E 5. Seneviratne et al., “The many possible climates from the Paris Agreement’s aim of 2 °C warming”
2/5 (3)	Emission trajectories and frameworks for achieving deep decarbonization	1. Pacala and Socolow, “Stabilization wedges: Solving the climate problem for the next 50 years with current technologies” 2. Moss et al., “The next generation of scenarios for climate change research and assessment” 3. Riahi et al., “The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview” 4. IPCC, Global Warming of 1.5 °C, Chapter 2 Sections 2.1-2.3 Beach Reading Ritchie and Dowlatabadi, “Why do climate change scenarios return to coal?”
II. Sectoral Technologies and Strategies for Deep Decarbonization		
2/12 (4)	Cross-sector deep decarbonization needs	1. IPCC, AR5 Working Group 3, Technical Summary Document, Section TS.3.2 2. IPCC, Global Warming of 1.5 °C, Chapter 2 Sections 2.4-2.4.3 (stop at 2.4.3.1), 2.5.3, and 2.6 3. International Energy Agency, Perspectives for the Energy Transition, Executive Summary
2/19 (5)	Deep decarbonization of the electric power sector	1. IPCC, AR5 Working Group 3, Chapter 7, Sections 5-6, 8-11 2. Loftus et al., “A critical review of global decarbonization scenarios: What do they tell us about feasibility?” 3. Global CCS Institute, The Global Status of CCS, pp. 13-22 4. Cui et al., “Quantifying operational lifetimes for coal power plants under the Paris goals”
2/26 (6)	Deep decarbonization of transportation	1. Gota et al., “Decarbonising transport to achieve Paris Agreement targets” 2. Creutzig et al., “Transport: A roadblock to climate change mitigation?” 3. Alarfaj et al., “Decarbonizing US passenger vehicle transport under electrification and automation uncertainty has a travel budget”
3/5 (7)	Deep decarbonization of industry	1. International Energy Agency, Perspectives for the Energy Transition, pp. 90-94 2. IPCC, AR5 Working Group 3, Chapter 10 Sections 10.5, 10.7 (figures), 10.8 (skim), 10.9-10.10

		<p>3. Allwood et al., “Options for achieving a 50% cut in industrial carbon emissions by 2050”</p> <p>4. Wesseling et al., “The transition of energy intensive processing industries towards deep decarbonization: Characteristics and implications for future research”</p>
3/12 (8)	Deep decarbonization of agriculture and other sectors	<p>1. IPCC, AR5 Working Group 3, Chapter 11 Sections 11.3 (skip blue boxes), 11.4, 11.6, 11.7, 11.9</p> <p>2. Bastin et al., “The global tree restoration potential”</p> <p>3. Clark et al., “Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets”</p> <p>4. Stevanovic et al., “Mitigation strategies for greenhouse gas emissions from agriculture and land-use change: Consequences for food prices”</p>
III. Policies for Deep Decarbonization		
3/19 (9)	Policy options	<p>1. Hafstead, “Carbon pricing 101”</p> <p>2. Meckling et al., “Policy sequencing toward decarbonization”</p> <p>3. World Resources Institute, “Putting a Price on Carbon”</p> <p>4. Peñasco et al., “Systematic review of the outcomes and trade-offs of ten types of decarbonization policy instruments”</p> <p>Beach Reading Weitzman, “Fat-tailed uncertainty in the economics of catastrophic climate change”</p>
3/26 (10)	The Paris Agreement	<p>1. United Nations, “Paris Agreement” (Articles 1-7 and 9-15)</p> <p>2. Fawcett et al., “Can Paris pledges avert severe climate change?”</p> <p>3. Rogelj et al., “Paris Agreement climate proposals need a boost to keep warming well below 2 °C”</p> <p>4. Indigenous Environmental Network et al., “Carbon pricing: A critical perspective for community resistance”</p>
IV. Cross-Cutting Issues Related to Deep Decarbonization		
4/2 (11)	Geoengineering	1. The Royal Society, Geoengineering the Climate
4/9 (12)	Equity in decarbonization: trade and stranded assets	<p>1. Peters et al., “Growth in emission transfers via international trade from 1990 to 2008”</p> <p>2. Inter-American Development Bank, Stranded Assets Report (Sections 2.1 and 2.3)</p> <p>3. McGlade and Ekins, “The geographical distribution of fossil fuels unused when limiting global warming to 2 °C”</p> <p>4. Pye et al., “An equitable redistribution of unburnable carbon”</p>
<i>* 4/16 – Project due</i>		
4/16 (13)	United States opportunities under the Biden administration	<p>1. Obama Administration, United States Mid-Century Strategy for Deep Decarbonization, Chapter 3</p> <p>2. Biden Administration, “The Biden Plan to Build a Modern, Sustainable Infrastructure and an Equitable Clean Energy Future”</p> <p>3. Biden Administration, “Executive Order on Tackling the Climate Crisis at Home and Abroad”</p> <p>4. U.S. Congress, Ocasio-Cortez, “H.Res.109 – Recognizing the duty of the Federal Government to create a Green New Deal”</p> <p>Beach Reading Hultman et al., “Fusing subnational with national climate action is central to decarbonization: the case of the United States”</p>

Rubric for Assessing Student Participation¹

	Exemplary (95% - 100%)	Proficient (85% - 95%)	Developing (75% - 85%)	Unacceptable (<75%)
Frequency of participation in class	Student initiates contributions more than once in each recitation.	Student initiates contribution once in each recitation.	Student initiates contribution at least in half of the recitations.	Student does not initiate contribution & needs instructor to solicit input.
Quality of comments	Comments always insightful & constructive; uses appropriate terminology. Comments balanced between general impressions, opinions & specific, thoughtful criticisms or contributions.	Comments mostly insightful & constructive; mostly uses appropriate terminology. Occasionally comments are too general or not relevant to the discussion.	Comments are sometimes constructive, with occasional signs of insight. Student does not use appropriate terminology; comments not always relevant to the discussion.	Comments are uninformative, lacking in appropriate terminology. Heavy reliance on opinion & personal taste, e.g., "I love it", "I hate it", "It's bad" etc.
Listening Skills	Student listens attentively when others present materials, perspectives, as indicated by comments that build on others' remarks, i.e., student hears what others say & contributes to the dialogue.	Student is mostly attentive when others present ideas, materials, as indicated by comments that reflect & build on others' remarks. Occasionally needs encouragement or reminder from T.A of focus of comment.	Student is often inattentive and needs reminder of focus of class. Occasionally makes disruptive comments while others are speaking.	Does not listen to others; regularly talks while others speak or does not pay attention while others speak; detracts from discussion; sleeps, etc.

¹ From <https://www.cmu.edu/teaching/assessment/examples/courselevel-bycollege/cfa/tools/participationrubric-cfa.pdf>