SPEA-E-505

Renewable and Nuclear Energy and Climate Change

O'NEILL SCHOOL OF PUBLIC AND ENVIRONMENTAL AFFAIRS

Spring 2025
Tuesdays & Thursdays 2:20-3:35 PM
In person in PV 273

INSTRUCTOR INFORMATION

My name is **Rafael M. Almeida**, and I'm an Assistant Professor at the O'Neill School of Public and Environmental Affairs. I hold a Ph.D. in Ecology and my work broadly addresses pressing environmental challenges facing global energy, water, and food systems. Read more about me and my group on our website (https://ecslab.org).

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Office hours: Tue & Th 1:00-2:00 PM (by appointment)

WHAT IS THIS COURSE ABOUT?

Renewable and nuclear energy sources are more climate-friendly than carbon-intensive fossil fuels, but each individual technology presents a unique set of environmental tradeoffs. Environmental impacts are influenced by factors like project siting, design, and implementation. In this course we will examine these environmental dimensions and explore forward-looking strategies to minimize adverse impacts as societies work to decarbonize their energy systems in the context of climate change.

LEARNING OUTCOMES

By the end of this class, you should be able to:

- **Understand Key Low-Carbon Energy Technologies:** Gain a comprehensive understanding of the fundamental technologies underlying low-carbon energy sources, including wind, solar, hydropower, nuclear, bioenergy, and green hydrogen.
- **Analyze Tradeoffs:** Evaluate the tradeoffs associated with current and emerging low-carbon energy sources, with an emphasis on environmental considerations and their implications for development and implementation.
- **Enhance Communication Skills:** Sharpen your ability to communicate key concepts and ideas through oral and written formats, while facilitating discussions and participating in collaborative note-taking on class themes.
- **Strengthen Collaboration Skills:** Work collaboratively to research and produce holistic, integrated energy expansion plans, assessing technical potential and environmental impacts to support the development of low-carbon energy.

COURSE DESCRIPTION AND REQUIREMENTS

The course will be primarily discussion-based, requiring active engagement from all students. Assigned readings must be completed before class to ensure meaningful participation. Most discussions will be facilitated by a pair of students, with another pair assigned to take notes. Each student will lead about two sessions and serve as a note-taker for two others.

Half of your grade will be based on your contributions to in-class discussions, including your roles as a participant, discussion leader, and note-taker. Thus, regular attendance is important. I understand that students may occasionally need to miss class for a variety of reasons and such sporadic absences will not impact your grades. But you should expect frequent absences to result in a decrease in your participation points. If you are unable to attend class on the day you are scheduled to lead a discussion or take notes, please try to arrange a date swap with one of your classmates. Be sure to inform both me and the TA as soon as possible.

Beyond participating in class discussions, your primary deliverable will be a team-based research paper, which will account for the second half of your grade. Each team (4-5 students) will collaborate to propose a solar energy expansion and siting plan for a major region of the U.S. Teams will analyze real portfolios of potential solar sites, craft a comprehensive development plan, and evaluate the pros and cons of their proposed mix of energy projects—placing particular emphasis on minimizing negative environmental impacts.

Midwest Group: Gaju, Burnett, Krieg, Gealy, Siddiqui
Southwest Group: Del Claro, Asere, Rahman, Soyka, Ali
Northeast Group: Witkowski, Siregar, Giese, Salisu, Mathew
Southeast Group: Heyward-Rotimi, Majiga, Jamal, Saidy
West Group: Vianda, Robbins, Jones, Bhattarai

GRADING COMPONENTS

1. Pre-Class Discussion Prompts (10%)
    - For each assigned reading, submit a 1-2 sentence comment highlighting a specific idea, question, or insight that you would like to discuss in class (due 1 PM on the day of each class)

2. Class Discussions
    - Active and meaningful contributions during class discussions (10%)
    - Leadership and facilitation of specific class discussions (20%)
    - Note-taking role in specific class discussions (10%)

3. Class Project
    - One-page proposal (5%)
    - Mid-semester report and presentation (15%)
    - Final report and presentation (30%)

SCALE:
A+ 97% A 93% A- 90%
B+ 87% B 83% B- 80%
C+ 77% C 73% C- 70%
D+ 67% D 63% D- 60%
F < 60%

COURSE SCHEDULE

#	Date	Topic	Discussion Leaders	Note Takers
1	14-Jan	Welcome and Course Overview	Almeida	
2	16-Jan	Achieving Net-Zero Energy Systems	Almeida	TA
3	21-Jan	Ten Simple Rules for Using Generative AI	Almeida	TA
4	23-Jan	Lifecycle Environmental Footprint of Electricity Sources	TA and Almeida	Krieg, Salisu
5	28-Jan	The Global Hydropower Landscape	Jones, Gealy	Del Claro, Robbins
6	30-Jan	Reducing Hydropower's GHG Footprint	Soyka, Salisu	Burnett, Gealy
7	4-Feb	Balancing Competing Environmental Objectives in Hydropower	Del Claro, Saidy	Gaju, Jamal
8	6-Feb	Environmental Tradeoffs of Hydropower in VRE Grids	Gaju, Bhattarai, Gease	Heyward-Rotimi, Del Claro
9	11-Feb	Hydropower and Climate Change	Ali, Robins, Siregar	Giese, Witkowski
10	13-Feb	U.S. Solar Futures and Class Project	Almeida	Ali, Gealy
11	18-Feb	Land Use and Environmental Impacts of Solar Energy	Jamal, Asere, Vianda	Jones, Saidy, Mathew
12	20-Feb	Solar-Pollinator Interactions (Guest Lecture)	Deisy Garcia, MS Student @ UT Rio Grande Valley	Krieg, Salisu
13	25-Feb	Techno-Ecological Synergies for Low-Impact Solar Power	Rahman, Del Claro, Salisu	Asere, Burnett
14	27-Feb	Agrivoltaics: Co-Locating Solar Energy and Agriculture	Krieg, Witkowski, Heyward-Rotimi	Soyka, Vianda
15	4-Mar	Floating Solar Power Overview	Vianda, Gealy, Mathew	Asere, Jones
16	6-Mar	Floating Solar Impacts (Guest Lecture)	Simone Cardoso, Assistant Professor @ UFJF (Brazil)	Gaju, Giese
17	11-Mar	Mid-Semester Project Presentations (Midwest, SW, SE)	Almeida	
18	13-Mar	Mid-Semester Project Presentations (West, NE)	Almeida	
SB	18-Mar	SPRING BREAK		
SB	20-Mar	SPRING BREAK		
19	25-Mar	Environmental Impacts of Wind Energy	Witkowski, Gaju, Majiga	Siddiqui, Robbins
20	27-Mar	Wind Energy and Climate Change	Ali, Soyka	Majiga, Jamal, Mathew
21	1-Apr	Bioenergy with Carbon Capture and Storage	Siddiqui, Siregar, Mathew	Saidy, Bhattharai
22	3-Apr	The Role of Nuclear in Future Energy Systems	Burnett, Robins, Jones	Heyward-Rotimi, Majiga
23	8-Apr	Nuclear Energy (Guest Lecture)	Greg Crouch, Adjunct Faculty @ O'Neill	Soyka, Rahman
24	10-Apr	Geothermal Energy	Asere, Giese, Bhattarai	Ali, Siregar
25	15-Apr	Green Hydrogen: Emissions and Resource Constraints	Majiga, Krieg, Saidy	Siregar, Vianda
26	17-Apr	Sustainable Materials for Low-Carbon Energy Systems	Heyward-Rotimi, Jamal	Siddiqui, Rahman
27	22-Apr	Renewable Energy and the AI Revolution	Siddiqui, Burnett, Rahman	Witkowski, Battharai
28	24-Apr	Wild Card Class	TBD	
29	29-Apr	Final Project Presentations (Midwest, SW, SE)	Almeida	
30	1-May	Final Project Presentations (West, NE)	Almeida	

*This schedule is tentative and may change as the semester goes. Readings associated with class discussions will be available on Canvas.

Important Deadlines:

- Pre-class discussion prompts: Due by 12 PM on the day of each class (not required for guest lectures and presentation days)
- Post-class note summaries: Week note-takers must submit their summaries by Friday 11:59 PM
- Class project proposal: Due by 02/12 11:59 PM
- Mid-semester class project report: Due by 03/16 11:59 PM
- Final class project paper: Due by 05/04 11:59 PM

RESPONSIBLE USE OF AI

Generative AI is clearly becoming the elephant in the room for instructors, and we will address it openly and transparently in this class. I personally believe that large language models have the potential to do more good than harm if used correctly. But AI should never replace your ability to think critically. Instead, think of it as an extension of your capabilities—something that, when used appropriately, can enhance your productivity and serve as an effective learning tool. Importantly, don't trust it blindly. The quality of AI output depends on the quality of the input: garbage in, garbage out. To guide you, here is an article on ten simple rules for leveraging large language models in science—which we will discuss in class. By the way, I asked ChatGPT to read my syllabus and propose five simple rules for responsible AI use in this class. In the AI bot's own words, and with my full endorsement, here are the rules:

1. **AI as a Tool, Not a Substitute.** You may use AI tools to assist with brainstorming, drafting, or editing, but your work must remain original and reflective of your own understanding.
2. **Cite AI Contributions.** If you use AI to generate ideas, content, or suggestions for any assignment, clearly state how and where you used it (e.g., in a footnote or acknowledgment).
3. **Prohibited for Certain Tasks.** Do not use AI tools to complete graded components requiring personal analysis, interpretation, or critical thinking, such as discussion prompts, peer reviews, or class participation.
4. **Verify AI-Generated Content.** If you use AI for research or data, double-check the accuracy and credibility of the information with reliable sources. Do not submit unverified or false information.
5. **Respect Ethical Standards.** Use AI responsibly and ethically, ensuring that it enhances your learning experience without violating academic integrity or class guidelines.

STUDENT RESOURCES

•Teaching Technology Lab (TTL): A multi-function lab space and service offered to IU students who are learning and beginning to practice the thoughtful integration of computing technologies into teaching and learning.

•Office of Disability Services for Students (DSS): Assists with a broad range of services and is responsible for determining reasonable academic accommodations for students with both physical and learning disabilities. If you are a student requiring special accommodations of any kind, you should contact this office.

•Counseling and Psychological Services (CAPS): Support for students who are looking for an opportunity to discuss problems with someone they can trust, including but not limited to serious mental health crises.

•Writing Tutorial Services (WTS): Offers free help at any phase of the writing process, from brainstorming to polishing the final draft. When you visit WTS, you'll find a tutor who is a sympathetic and helpful reader of your prose.

•Code of Student Rights, Responsibilities & Conduct