



Sustainable Energy Syllabus

AEDE 4194 Spring 2024

Course Information

- **Course times and location:** Tuesday and Thursdays 12:45 PM-2:05 PM
- **Credit hours:** 3
- **Mode of delivery:** In person
- **Instructor Name:** Bruce Braine
- **Email:** braine.3@osu.edu ; bhbraine@gmail.com
- **Phone Number:** 614-292-7922
- **Office hours:** Flexible. To be scheduled via email or in-person with instructor.
- **Preferred means of communication:**
 - My preferred method of communication for questions is **email**.
 - My class-wide communications will be sent through the Announcements tool in Carmen Canvas. Please check your [notification preferences](https://go.osu.edu/canvas-notifications) (go.osu.edu/canvas-notifications) to be sure you receive these messages.

Course Prerequisites

AEDE 4320 or permission of the instructor

Course Description

Sustainable Energy covers the full range of sustainable energy options and technologies today and those projected to potentially play a role in the future. The course focuses on understanding the tradeoffs between the economics of technologies and their sustainability.

The course is structured to cover a range of energy areas and sustainability topics during the semester. In addition, students will learn through homework assignments and lectures how to apply energy-sustainability-economics metrics such as (1) cost of electricity (COE) for utility-scale projects and (2) net present value/return on investment for individual end-user decisions and (3) cost per ton CO₂ reduced for CO₂ reduction projects and carbon markets.



THE OHIO STATE UNIVERSITY

College of Food, Agricultural, and Environmental Sciences
Agricultural, Environmental, and Development Economics

Learning Outcomes

By the end of this course, students should be able to:

- Describe the concept of sustainable energy as well as the major types of sustainable energy investments available.
- Evaluate the economics of fossil, nuclear and renewable resources, as well as demand side management, distributed energy, and investments in energy efficiency.
- Understand the important role of baseload capacity such as nuclear and natural gas and what role they play in sustainability.
- Analyze the impact of various subsidies, regulations and policies associated with renewable energy.
- Evaluate the underlying finance/economics and sustainability of various specific energy projects.



How This Course Works

Mode of delivery: This course is 100% in person with homework, exams and other assignments completed on Carmen.

Pace of class activities: This course is organized into **weekly modules in Carmen** that are released at least one week ahead of time. Students are expected to keep pace with deadlines but may schedule their efforts freely within that time frame.

Credit hours and work expectations: This is a 3 credit-hour course. According to [Ohio State bylaws on instruction](https://go.osu.edu/credithours) (go.osu.edu/credithours), students should expect around 3 hours per week of time spent on direct instruction (instructor content and Carmen activities, for example) in addition to up to 6 hours of homework (reading and assignment preparation) for a Grade of C.

Attendance and participation requirements. Students are expected to attend class and participate actively in discussions. 10% of a student's grade will be based on regular attendance and class participation. "Excused" absences are not counted against the student's grade; however, students must contact me by email or in a prior class for the absence not to count against the grade.

Required Materials and/or Technologies

There is no required textbook. PDFs of required readings will be posted on Carmen:

- Annual Energy Outlook (AEO) 2023 – US Energy Information Agency EIA;
- International Energy Outlook (IEO)- 2023
- World Energy Outlook- International Energy Agency (IEA)- 2023
- The Future of Energy Storage: An Interdisciplinary MIT Study (2022)
- The Future of Nuclear Energy: An Interdisciplinary MIT Study (2018); U.S. National Electrification Assessment Electric Power Research Institute (EPRI) (2018); Strategies and Actions for Achieving a 50% Reduction in US GHG Emissions by 2030 (EPRI) (2021); LCRI Net-Zero 2050 (2022) -Low Carbon Resources Initiative
- Others from publicly available sites including [aceee.org](https://www.aceee.org), [nrel.gov](https://www.nrel.gov), [doe.org](https://www.doe.org), [epri.com](https://www.epri.com)

Required Equipment

- **Computer:** current Mac (MacOS) or PC (Windows 10) with high-speed internet connection.
- **Webcam:** built-in or external webcam, fully installed and tested



- **Microphone:** built-in laptop or tablet mic or external microphone
- **Other:** a mobile device (smartphone or tablet) to use for BuckeyePass authentication

If you do not have access to the technology you need to succeed in this class, review options for [technology and internet access](https://go.osu.edu/student-tech-access) (go.osu.edu/student-tech-access).

Required Software

Microsoft Office 365: All Ohio State students are now eligible for free Microsoft Office 365. Visit the [installing Office 365](https://go.osu.edu/office365help) (go.osu.edu/office365help) help article for full instructions.

CarmenCanvas Access

You will need to use [BuckeyePass](https://buckeyepass.osu.edu) (buckeyepass.osu.edu) multi-factor authentication to access your courses in Carmen. To ensure that you are able to connect to Carmen at all times, it is recommended that you do each of the following:

- Register multiple devices in case something happens to your primary device. Visit the [BuckeyePass - Adding a Device](https://go.osu.edu/add-device) (go.osu.edu/add-device) help article for step-by-step instructions.
- Request passcodes to keep as a backup authentication option. When you see the Duo login screen on your computer, click **Enter a Passcode** and then click the **Text me new codes** button that appears. This will text you ten passcodes, good for 365 days, that can each be used once.
- [Install the Duo Mobile application](https://go.osu.edu/install-duo) (go.osu.edu/install-duo) on all your registered devices for the ability to generate one-time codes in the event that you lose cell, data, or Wi-Fi service.

If none of these options will meet the needs of your situation, you can contact the IT Service Desk at [614-688-4357 \(HELP\)](tel:614-688-4357) and IT support staff will work out a solution with you.

Technology Skills Needed for This Course

- Basic computer and web-browsing skills
- [Navigating CarmenCanvas](https://go.osu.edu/canvasstudent) (go.osu.edu/canvasstudent)
- [CarmenZoom virtual meetings](https://go.osu.edu/zoom-meetings) (go.osu.edu/zoom-meetings)
- [Recording a slide presentation with audio narration and recording, editing and uploading video](https://go.osu.edu/video-assignment-guide) (go.osu.edu/video-assignment-guide)

Technology Support

For help with your password, university email, CarmenCanvas, or any other technology issues, questions or requests, contact the IT Service Desk, which offers 24-hour support, seven days a week.

- **Self Service and Chat:** go.osu.edu/it
- **Phone:** [614-688-4357 \(HELP\)](tel:614-688-4357)
- **Email:** servicedesk@osu.edu

Grading and Faculty Response

How Your Grade is Calculated

Assignments	Points
Homework	50 (25%)
Exam	60 (30%)
Final Project	70 (35%)
Class Participation/Attendance	20 (10%)
Total	200 (100%)

See [Course Schedule](#) for due dates.

Descriptions of Major Course Assignments

Homework (3) (50 Points) – There will be three homework assignments with 12-14 points per assignment. Homework will be completed **on-line** on Carmen during the semester. The three homework assignments will cover: (1) calculating the cost of electricity for sustainable, utility-scale, energy projects (2) calculating the net present value and internal rate of return for individual customer projects (e.g., demand-side management, rooftop solar, electric vehicles etc.) (3) calculating the cost effectiveness (cost-per-ton CO₂ reduced) of various CO₂ reduction approaches.

Exam (60 Points) – The late term exam will be given **on-line in Carmen** during class-time and will cover the material taught during the first two-thirds of the course. This includes all lecture material and slides provided as well as assigned readings during the course up to the exam date.

Final Project (70 Points) – The final project for this class is composed of two parts. The first part worth 50 points comprises work to develop an economic/financial/policy evaluation of a specific type of sustainable energy project. Each student will work with a team of 1-2 other students; each team will select a project that covers nuclear, geothermal, natural gas, offshore vs. onshore wind, solar, biomass, electric vehicles, or demand side management. The report should be written in a presentation-style format. The second part will be to present the results of your evaluation and answer questions on your findings in class. We will devote two classes at the end of the term to provide adequate time for each student team to present and discuss its findings and answer questions. This part is worth 20 points.

Class Participation/Attendance (20 Points)- 10% of your grade will be from class participation and your regular attendance. You are not penalized for documented illness or emergencies, or if you have discussed this with me in advance.

Academic integrity and collaboration

The Exam and Homework are open-book and open-note and all other specific course material on Carmen, which you may consult freely during their completion. However, all exams and assignments must be completed without use of any other external sources (including all other persons). You are free to use all external sources for the final project. However, you should be sure to cite your sources in a bibliography and with footnotes (as needed) in your report. The report should be your own work and that of your teammates.

Late Assignments

Please refer to Carmen and the Course Schedule (below) for due dates. Due dates are set to help you stay on pace and to allow timely feedback that will help you complete subsequent assignments. Homework and exam assignments must be completed on time or in the time allotted or the student will receive no credit for that assignment. However, you are not penalized for documented illness or emergencies or if you have discussed with me in advance.

Instructor Feedback and Response Time

I am providing the following list to give you an idea of my intended availability throughout the course. Remember that you can call [614-688-4357 \(HELP\)](tel:614-688-4357) at any time if you have a technical problem.

- **Preferred contact method:** If you have a question, please contact me first through my email. I will reply to emails within **24 hours on days when class is in session at the university**.
- **Class announcements:** I will send all important class-wide messages through the Announcements tool in CarmenCanvas. Please check [your notification preferences](http://go.osu.edu/canvas-notifications) (go.osu.edu/canvas-notifications) to ensure you receive these messages.
- **Grading and feedback:** For assignments submitted before the due date, I will try to provide feedback and grades within **seven days**. I will provide all of you with overall class statistics on the midterm and before the final, so you are aware of your standing during the semester.

Grading Scale

93–100: A
 90–92.9: A-
 87–89.9: B+
 83–86.9: B
 80–82.9: B-
 77–79.9: C+

73–76.9: C
70–72.9: C-
67–69.9: D+
60–66.9: D
Below 60: E



Other Course Policies

Discussion and Communication Guidelines

The following are my expectations for how we should communicate as a class. Above all, please remember to be respectful and thoughtful.

- **In-class questions or comments:** You are highly encouraged to ask any questions that you may have or to respond to my questions to the class.
- **Tone and civility:** Let's maintain a supportive learning community where everyone feels safe and where people can disagree amicably. Remember that sarcasm doesn't always come across online or in-class. Please be conscious of the fact that students learn in different ways; I welcome all questions on the course material.

Academic Integrity Policy

Ohio State's Academic Integrity Policy

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the university's [Code of Student Conduct](http://studentconduct.osu.edu) (studentconduct.osu.edu), and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the university's *Code of Student Conduct* and this syllabus may constitute "Academic Misconduct."

The Ohio State University's *Code of Student Conduct* (Section 3335-23-04) defines academic misconduct as: "Any activity that tends to compromise the academic integrity of the university or subvert the educational process." Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the university's *Code of Student Conduct* is never considered an excuse for academic misconduct, so I recommend that you review the *Code of Student Conduct* and, specifically, the sections dealing with academic misconduct.

If I suspect that a student has committed academic misconduct in this course, I am obligated by university rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the university's Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the university. If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact me.



Other sources of information on academic misconduct (integrity) to which you can refer include:

- [Committee on Academic Misconduct](http://go.osu.edu/coam) (go.osu.edu/coam)
- [Ten Suggestions for Preserving Academic Integrity](http://go.osu.edu/ten-suggestions) (go.osu.edu/ten-suggestions)
- [Eight Cardinal Rules of Academic Integrity](http://go.osu.edu/cardinal-rules) (go.osu.edu/cardinal-rules)

Copyright for Instructional Materials

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Creating an Environment Free from Harassment, Discrimination, and Sexual Misconduct

The Ohio State University is committed to building and maintaining a community to reflect diversity and to improve opportunities for all. All Buckeyes have the right to be free from harassment, discrimination, and sexual misconduct. Ohio State does not discriminate on the basis of age, ancestry, color, disability, ethnicity, gender, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, pregnancy (childbirth, false pregnancy, termination of pregnancy, or recovery therefrom), race, religion, sex, sexual orientation, or protected veteran status, or any other bases under the law, in its activities, academic programs, admission, and employment. Members of the university community also have the right to be free from all forms of sexual misconduct: sexual harassment, sexual assault, relationship violence, stalking, and sexual exploitation.

To report harassment, discrimination, sexual misconduct, or retaliation and/or seek confidential and non-confidential resources and supportive measures, contact the Office of Institutional Equity:

1. Online reporting form at equity.osu.edu,
2. Call 614-247-5838 or TTY 614-688-8605,
3. Or Email equity@osu.edu

The university is committed to stopping sexual misconduct, preventing its recurrence, eliminating any hostile environment, and remedying its discriminatory effects. All university employees have reporting responsibilities to the Office of Institutional Equity to ensure the university can take appropriate action:

- All university employees, except those exempted by legal privilege of confidentiality or expressly identified as a confidential reporter, have an obligation to report incidents of sexual assault immediately.
- The following employees have an obligation to report all other forms of sexual misconduct as soon as practicable but at most within five workdays of becoming aware of such information: 1. Any human resource professional (HRP); 2. Anyone who supervises faculty, staff, students, or volunteers; 3. Chair/director; and 4. Faculty member."

Diversity

The Ohio State University affirms the importance and value of diversity of people and ideas. We believe in creating equitable research opportunities for all students and to providing programs and curricula that allow our students to understand critical societal challenges from diverse perspectives and aspire to use research to promote sustainable solutions for all. We are committed to maintaining an inclusive community that recognizes and values the inherent worth and dignity of every person; fosters sensitivity, understanding, and mutual respect among all members; and encourages each individual to strive to reach their own potential. The Ohio State University does not discriminate on the basis of age, ancestry, color, disability, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, race, religion, sex, gender, sexual orientation, pregnancy, protected veteran status, or any other bases under the law, in its activities, academic programs, admission, and employment.

To learn more about diversity, equity, and inclusion and for opportunities to get involved, please visit:

- <https://odi.osu.edu/>
- <https://odi.osu.edu/racial-justice-resources>
- <https://odi.osu.edu/focus-on-racial-justice>
- <http://mcc.osu.edu/>

In addition, this course adheres to **The Principles of Community** adopted by the College of Food, Agricultural, and Environmental Sciences. These principles are located on the Carmen site for this course; and can also be found at <https://go.osu.edu/principlesofcommunity>. For additional information on Diversity, Equity, and Inclusion in CFAES, contact the CFAES Office for Diversity, Equity, and Inclusion (<https://equityandinclusion.cfaes.ohio-state.edu/>). If you have been a victim of or a witness to a bias incident, you can report it online and anonymously (if you choose) at <https://equity.osu.edu/>.

Your Mental Health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing.

If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614-292-5766. CCS is located on the 4th floor of the Younkin Success Center and 10th floor of Lincoln Tower. You can reach an on-call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available 24/7 by dialing 988 to reach the Suicide and Crisis Lifeline.

For students in the College of Food, Agricultural, and Environmental Sciences, David Wirt, wirt.9@osu.edu, is the CFAES embedded mental health counselor on the Columbus campus. To contact David, please call 614-292-5766. Students should mention their affiliation with CFAES if interested in speaking directly with David.

Accessibility Accommodations for Students with Disabilities

Requesting Accommodations

The university strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability including mental health, chronic or temporary medical conditions, please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with [Student Life Disability Services \(SLDS\)](#). After registration, you should make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. In light of the current pandemic, students seeking to request COVID-related accommodations may do so through the university's [request process](#), managed by Student Life Disability Services.

Disability Services Contact Information

- Phone: [614-292-3307](tel:614-292-3307)
- Website: slds.osu.edu
- Email: slds@osu.edu
- In person: [Baker Hall 098, 113 W. 12th Avenue](#)

Accessibility of Course Technology

This online course requires use of CarmenCanvas (Ohio State's learning management system) and other online communication and multimedia tools. If you need additional services to use these technologies, please request accommodations as early as possible.

- [CarmenCanvas accessibility](http://go.osu.edu/canvas-accessibility) (go.osu.edu/canvas-accessibility)
- Streaming audio and video
- [CarmenZoom accessibility](http://go.osu.edu/zoom-accessibility) (go.osu.edu/zoom-accessibility)

Course Schedule

Please refer to the Carmen Canvas for up-to-date due dates and class schedule.

Jan. 9: Introduction/What is Sustainable Energy?

Readings- AEO Narrative 2023 pp. 1-17

Jan 11: The Electric Sector and Sustainability

Readings- AEO 2023 Release Presentation

Jan 16: The Electric Sector/Levelized Cost of Electricity/In class exercise

Readings- Assumptions AEO 2023 Electricity Market Module pp. 1-18

Jan. 18. Natural Gas —Efficiency and Sustainability?

Readings- AEO Narrative pp. 22-29

HW 1: Understanding Electric Power Economics (Due Jan.22 5PM)

Jan. 23: Nuclear Power

Readings – EIA Nuclear Power Outlook and Nuclear Explained Documents; MIT Future of Nuclear Energy Report (2018)—Background and Executive Summary; Nuclear Fusion Breakthrough WSJ article (Dec. 2022)

Jan. 25: Renewable Energy—Background and Policy Pt.1

Jan. 30: Renewable Energy Pt. 2 Wind and Solar and Role of Storage

Readings: Summer 2023 Solar Update (NREL)pp. 3-49; US Wind Watch H1 2023 (Wood Mackenzie)

Feb 1: Renewable Energy Pt. 3: Hydro, Geothermal and Biomass--Evaluating the Economics of Intermittent Renewables vs Baseload Capacity – In Class Exercises

Readings: EIA Geothermal Explained); MIT Technology Review Geothermal Startup (March 2023)

Feb 6: End-Use Energy Efficiency and Demand Side Management

Readings-ACEEE Reports: Appliances (2020), Building Efficiency Standards (2023), State Industrial Decarbonization Handbook for Utilities (2023)

Feb 8: End Use Electricity Economics—Review and In-Class Exercises

Feb. 13: International Energy Pt. 1

Readings: International Energy Outlook (2023)-EIA

Feb. 15: International Energy Pt. 2

Readings: World Energy Outlook (2023)-IEA Executive Summary and Chapter 1

HW 2: Understanding End-Use Electricity Economics (Due: Feb 21 5PM)



Feb 20: Electrification

Readings-*US National Electrification Assessment (2018)* pp. 5-26, pp. 31-38 and Chapter 4.
Powering Decarbonization Strategies for Net Zero Emissions – EPRI (2021) AEO Narrative 2023 CH. 2 pp. 14-21; MIT Technology Review Heat Pumps (2023)

Feb. 22: Transmission and Smart Grid Investments

Feb. 27: Transportation/ Vehicles

Readings: *US National Electrification Assessment (2018)* pp. 27-31

Feb. 29: Carbon Policy/Markets; Carbon Offsets and Carbon Capture

Readings: *EPRI Whitepaper: Strategies and Actions for Achieving a 50% Reduction in US GHG Emissions by 2030 (2021);*

Mar. 5: -Carbon Policy Pt. 2

Readings: *Net Zero 2050- Low Carbon Research Initiative LCRI (2022)*

Mar. 7 -Hydrogen Fuels

HW 3: Understanding Carbon Market Economics (Due Mar. 8, 5PM).

SPRING BREAK March 11-15

Mar. 19 – Batteries/Storage

Readings: *The Future of Energy Storage- MIT Interdisciplinary Study Exec. Summary, Ch. 1*

Mar. 21: Course Review

Mar. 26: **Exam- – ONLINE/CARMEN**

Mar. 28: Final Project Topics Selection; Final Team Formation

April 2: Developing a Presentation-Style Report—Writing Dos and Don'ts

April 4: Oral Presentation Tips/In Class Time for report

April 9: Zoom Class on Final Project Questions

April 11: **Summary of Class**

Final Report Due: April 16 by Start of Class

April 16: In Class Presentations and Q&A.

April 18: In Class Presentations and Q&A.



