Energy Systems Lab
ESM 293 (4-units) - Fall 2025

Course Description:
This is a practical approach to exploring renewable energy systems using engineering concepts and data modeling applications. In this course discover both the practical and technical aspects of renewable energy generation. We will discuss and learn the workings of renewable energy systems including: solar, wind turbines, battery storage systems and microgrids. As renewable energy systems continue to penetrate the energy market, a working knowledge of these systems translates into a viable skill set within this rising industry. This class experience will provide valuable insight and a working knowledge of existing technologies for renewable energy systems. This introductory hands-on course intends to deliver a broader/comprehensive understanding of renewable energy systems.

Instructor:	Sage Davis, 1021 Bren Hall (BH) on 1L
Email:	sage@ucsb.edu (Include “ESM 293” in subject line)
Teaching Assistant:	TBD
Office Hours:	By appointment.
Time & Location:	Lecture on Tuesdays 3:30 - 4:45p; Lab on Friday 9a -12p, 1424 BH No lecture 11/11/25 (VD), No Lab on 11/28/25 (Thanksgiving)

Instruction:
All lectures and labs will be held in person unless there is a change in University policy. Please contact me if you are unable to make a class or lab session. Classes will not be recorded or saved on Zoom. Lab participation is essential due to the hands-on nature of this course.

Readings:
Reading assignments will be posted weekly on Canvas at least one week prior to lecture. There is a volunteer signup sheet for inclass reading summary and discussion, which will include extra credit points. Please read before coming to the lecture so you can contribute to the class discussion. The reading list, which will include academic papers, reports, and news articles will follow the course outline.There are no assigned textbooks for this class.

Labs: Labs attendance is required so please contact me if you need to miss a class. Lab reports should demonstrate your understanding of the exercise, explain what you learned and how it helps your understanding of energy. All labs will be conducted in groups and graded individually - teams assigned.

Group presentation: A topic of each group's choice relating to course content. More of a small research project to share.

Rubric - All assignments besides attendance & participation shall be graded as a group.

All assignments due before the following lab session.

Metric	Weight (%)	Due
Attendance & Participation	10	
Lab 1 Report	10	Week 2 Lab
Lab 2 Report	10	Week 3 Lab
Lab 3 Report	10	Week 4 Lab
Lab 4 Report	10	Week 5 Lab
Presentation Topic Submitted	3	Week 6 Lab
Lab 5 Report	10	Week 6 Lab
Lab 6 Report	10	Week 7 Lab
Lab 7 Report	10	Week 8 Lab
Lab 8 Report	5	Week 9 Lab
Presentations	12	Week 10 Lab
Total	**100**	

Course timeline (all readings completed before class)

	Week 0	**Introduction**
09/26/25	Class	Topics: - Energy systems - Heat engines - Primary Energy Conversions - DERs Reading: - History of electricity table
09/26/25	Lab	Lab Intro - Safety, Common Sense, Measurement Tools Introduction to various safety scenarios, personal protective equipment, measuring devices, and data loggers. Emphasis on safety behavior in the lab and on site visits. Familiarize yourself with electrical safety, electrical measuring devices, and energy dataloggers.
	Week 1	**Energy System Units, Electrical Diagrams, & troubleshooting**
09/30/25	Class	Topics: - Units & Unit Conversion - Electrical Block Diagrams - AC/DC Electricity - Electrical Transmission/Distribution/Transformation - Electrical Troubleshooting Readings: - Energy Types - IET Units and Symbols 12. Graphical Symbols, p22-26 (p26 in pdf) - Famous Unit Mishaps
10/03/25	Lab	Lab 1 - Practice Troubleshooting an Energy System The purpose of this lab is to familiarize yourself with common electrical measuring instruments, electrical safety equipment, and wiring diagrams routinely used to troubleshoot a malfunctioning energy generating system. You will be presented with an energy generation system that is not functioning. Determine the cause of the electrical generator system malfunction. You will be provided with required tools.

	Week 2	Solar Energy Systems
10/07/25	Class	Topics: - Solar Energy Technology - Solar Photovoltaics (PV) - Concentrated Solar Power (CSP) - Efficiency and Capacity Factor Reading: - NREL Solar Photovoltaic - NREL CSP - Fundamentals Of Solar Energy - CAISO - Today's Outlook Look at a few dates. Look around the site.
10/10/25	Lab	Lab 2 - Bren Hall Site Survey and PV Exercises The learning objectives are to understand the workings of a solar photovoltaic (PV) energy system that uses sunlight to generate power. You will immerse yourselves in the Bren Hall PV solar array. You will be provided with an electrical diagram, practice proper safety and use industry measuring tools to assess the production of the system and subsystems. This will help you determine the capacity factor and actual production of the system.

	Week 3	Energy Storage Systems
10/14/25	Class	Topics: - Chemical - Electrochemical - Mechanical - Thermal - Electric Energy Reading: - VERTIV BESS - Ultracapacitor - Buses - FESS: Flywheel Energy Storage System - Battery Storage
10/17/25	Lab	Lab 3 - Site Visit - Goleta BESS The learning objectives are to understand how Battery Energy Storage Systems (BESS) function within an electrical grid. This should give you an understanding of how electrical energy

		storage functions in grid health and renewable energy production.
	Week 4	**Solar PV Microgrids**
10/21/25	Class	Topics: - What are Microgrids? - Distributed Energy Resources (DERs) - Energy Storage - Loads - System Controllers Reading: Look at - CEC Final Project Report, Microgrid Analysis and Case Studies Report - pages i, ii, 1-9, 30-33 (Stone Edge), 64-66 (EaglePicher) more - Blue Lake Rancheria (Canvas)
10/24/25	Lab	Lab 4 - Site Visit - San Marcos High School (SBUSD) The learning objectives are to understand how a solar PV microgrid provides resilience and functions in an electrical grid. You should gain an understanding of how a microgrid functions as part of an electrical grid. We should learn how it is profitable, saves money, and/or used for emergency backup (islanding).
	Week 5	**ReOpt – Energy Modeling Software**
10/28/25	Class	Topics: - Create an account with REopt - Project demonstration - Assignment discussion Reading: - NREL REopt User Manual: 13-16, 20-22, 25-29
10/31/25	Lab	Lab 5 - REopt Modeling Software Project The learning objectives are to become familiar with using online energy analysis tools to assess energy generation systems. Energy software analysis tools are useful in the design, proposal, and verification of energy generation systems. These tools integrate many variables and scenarios for sizing a system that make analysis easier, faster and hopefully more accurate than making your own model. This lab involves using a free energy software analysis provided by NREL named REopt.

	Week 6	**Xendee – Modeling Software**
11/04/25	Class	Topics: - Xendee Login - Project demonstration - Assignment discussion Reading: - Watch Video - The Most Comprehensive DER Design & Operation Platform
11/07/25	Lab	Lab 6 - Xendee Modeling Software Project The learning objectives are to become familiar with using online energy analysis tools to assess energy generation systems. Energy software analysis tools are useful in the design, proposal, and verification of energy generation systems. These tools integrate many variables and scenarios for sizing a system that make analysis easier, faster and hopefully more accurate than making your own model. This lab involves using an energy software analysis provided by Xendee.
	Week 7	**REopt & Xendee Modeling Software Comparison**
11/11/25	Class - **Holiday**	
11/14/25	Lab	Lab 7 - Modeling Software Comparison Compare REopt and Xendee model outputs. Compare outputs using the same load profile and parameters. Which was more useful for your project. Which was more user friendly. Do you trust one model over the other?
	Week 8	**Wind Energy Generator Systems**
11/18/25	Class	Topics - Fluid energy technology - Horizontal Wind Turbines - Vertical Wind Turbines - Wind Power Curtailment Reading: - NREL WInd Energy Basics - DOE Wind Energy Basics - ASME Vertical Wind Turbines

11/21/25	Lab	Lab 8 - Site Visit - Strauss Wind Energy Project The learning objectives are to understand how a wind turbine power plant functions within an electrical grid. This instruction and corresponding site visit should give you an understanding of how wind energy functions in the grid. Explore the wind farm production efficiency. Use annual data and spec sheets (or given system efficiency) provided for the wind farm to understand the system efficiency, Cp, average electricity, carbon and savings.
	Week 9	**Guest Speaker & Thanksgiving**
11/25/25	Class - TBD	Guest Speaker Reading: - TBD
11/28/25	Lab - Holiday	No Lab
	Week 10	**Group Presentations**
12/02/25	Class	Energy System Innovations Group presentations
12/05/25	Lab	Group presentations

Detailed Policies and Procedures

I am committed to creating a safe and inclusive climate for all at Bren, so I am available to talk with you if you have any concerns. Below I've collected many of the policies and resources that you might need. But I'm also happy to help you to find the resources. Please feel free to be in touch if you have questions.

I know that sickness or other issues may affect your ability to be in class. Please reach out if you are struggling with any elements of this class or if you need accommodations or support. I welcome your feedback at any time.

Distressed Students

UCSB is committed to providing a quality learning environment for its students. It is not uncommon for students to encounter emotional and mentally stressful challenges over the course of their studies. If you would like to talk with a counselor, please reach out to Counseling and Psychological Services (CAPS) at 805-893-4411. If you know of someone else in distress who may need help, please encourage them to contact CAPS or submit a referral online. UCSB's Student Wellbeing site and the Bren School's Student Resources website include other links to resources that can help you take care of yourself and others in our community. Please be kind to yourself and others and reach out if you need support.

Assignment Completion Policy

You must complete all assignments to the best of your ability to pass the course, even if skipping an individual assignment would not result in a non-passing grade by percentage. Late assignments will be accepted but with a 10% score reduction.

Grading

I take student evaluation seriously and do not entertain requests to re-grade assignments unless I receive a formal, written request for a re-grade that compellingly documents a serious oversight on my part. A serious oversight on my part indicates that the entire assignment should receive further attention. Your score may go up or down if I decide that an assignment needs this kind of attention, so plan accordingly. I strongly encourage you to meet with me to discuss feedback on your assignments.

Syllabus Subject to Minor Changes

You agree to complete the assignments in a timely manner in accordance with the schedule printed in the syllabus and to participate in the class using proper student conduct and etiquette. As part of this agreement, your responsibilities are printed clearly within this syllabus with deadlines so that you will know well in advance when readings and assignments are due. The syllabus is also subject to change if deemed necessary by the instructor. You will be afforded ample warning before any new responsibility or assignment is due. Most often, a change to the syllabus will constitute a minor change in reading materials or the cancellation of a day of class. If such a change occurs, a revised syllabus will be made available to students and replace any old copies of the syllabus.