14:540:487 – Energy Systems Modeling and Optimization

Syllabus

Instructor: Prof. Robert Mieth (robert.mieth@rutgers.edu)

Energy systems sit at the intersection of engineering, economics, and society. This course introduces the models and optimization methods used to plan and operate modern energy systems, with a particular focus on electric power. Topics include energy economics, generation planning, power-system operation, renewable energy and storage, electricity markets, power flow, and distributed energy resources.

Students will learn to translate real-world energy decisions into mathematical models, solve them using optimization, and interpret the resulting engineering and economic tradeoffs. The course emphasizes hands-on computational modeling with **Python and AMPL**, providing experience with tools and workflows that are widely used in energy-system analysis and professional practice.

S.1 General Information

Note that this syllabus is for the regular in-person section of this course (14:540:487:01).

Semester:	Fall 2026
Class Meetings:	Tuesday and Thursday, 2:00–3:20 PM
Location:	SEC 209
Instructor:	Prof. Robert Mieth (robert.mieth@rutgers.edu)
Office:	CoRE 616
Office Hours:	TBD
Teaching Assistant:	Mehrnoush Ghazanfariharandi (mg1918@scarletmail.rutgers.edu)
TA Office Hours:	TBD
Course Website:	Canvas

S.1.1 Prerequisites

The prerequisite for this course is 14:540:311 (Deterministic Models), or equivalent fundamental knowledge of optimization and mathematical programming.

S.1.2 Software

The course will use **Python** and **AMPL** for computational modeling and optimization. No prior experience with AMPL is expected. Basic familiarity with Python is helpful.

S.1.3 Course Materials and References

There is no required textbook for this course. Lecture notes, selected readings, assignments, and other course materials will be provided through Canvas.

The course draws in part on material from the following references, but none of these books will be used in its entirety or is required for students to purchase:

- D. S. Kirschen and G. Strbac, *Fundamentals of Power System Economics.* John Wiley & Sons, 2026.

- F. Vanek, L. D. Albright, and L. Angenent, *Energy Systems Engineering*. McGraw-Hill Professional Publishing, 2008.
- A. Papavasiliou, *Optimization Models in Electricity Markets*. Cambridge University Press, 2024.

S.2 Course Overview

Module 1: Energy Systems and Optimization Foundations

Learning Goals: Develop a systems-level understanding of how energy supports modern society and how engineering, economics, reliability, and environmental impacts shape energy decisions. Review/recap of optimization fundamentals to turn real-world questions into useful mathematical models and solve first optimization problems using Python and AMPL.

Module 2: Energy Economics and Investment Planning

Learning Goals: Learn how to make meaningful comparisons between technologies with very different costs and lifetimes. Use life-cycle analysis, time value of money, learning curves, LCOE, load-duration and screening curves, and optimization to answer the fundamental planning questions.

Module 3: Power System Operations

Learning Goals: Explore how an electric power system is operated from hour to hour and how different generators compete to meet demand. Build your own economic dispatch model, connect physical operating limits to optimization constraints, and investigate how load patterns, generator technology, and flexibility affect operations.

Module 4: Renewable Energy and Energy Storage

Learning Goals: Understand how wind and solar convert natural resources into electricity and why their variability changes power-system planning and operation. Model renewable production, curtailment, net load, and energy storage, and use optimization to explore how storage can move energy across time.

Module 5: Electricity Markets and Power Flow

Learning Goals: Discover how electricity markets turn engineering constraints and economic preferences into dispatch decisions and prices. Analyze market clearing, marginal prices and welfare, and then add the realities of unit commitment, transmission networks, congestion, power flow, and locational electricity prices.

Module 6: Demand-Side and Distributed Energy Systems

Learning Goals: Shift perspective from the bulk power system to the energy consumer and the grid edge. Explore tariffs, flexible demand, distributed generation, storage, microgrids, and resilience, and bring these ideas together in practical site-level energy planning.

S.3 Grading

Component	Contribution to Final Grade
Midterm Exam	20%
Final Exam	30%
Coding Assignments	15%
Project	25%
Attendance	10%
Total	**100%**
Extra Credit / Participation	up to +10%
Project Competition Bonus	up to +3%

S.3.1 Exams [50%]

The course includes one **midterm exam** and one **final exam**. Both exams will be administered **in person, closed book, and on paper**.

Students may bring one standard U.S. letter-size sheet of notes (**8.5 in** × **11 in**) to each exam. Notes must be **handwritten** and may be written on **both sides** of the sheet. No additional notes, textbooks, electronic devices except for a **non-programmable calculator**, or other reference materials may be used unless explicitly authorized by the instructor.

The **midterm exam** accounts for **20% of the final course grade** and covers all course material up to the date of the exam.

The **final exam** accounts for **30% of the final course grade** and covers the entire course.

Both exams may include conceptual questions, calculations, mathematical modeling, interpretation of results, and problems that require students to formulate or analyze models discussed in class. Students are responsible for all material covered in lectures, assigned readings, labs, and course assignments unless explicitly excluded by the instructor.

S.3.2 Module Coding Assignments [15%]

There will be a coding assignment **per module**. Coding assignments account for **15% of the final course grade**. These assignments are designed to provide regular practice with the computational and modeling tools introduced throughout the course.

Each coding assignment will be graded using the following three-level scale:

- **2 points – Complete:** The submitted analysis meaningfully addresses the assigned task, produces the required outputs, and provides a correct or substantially correct interpretation of the results.
- **1 point – Partial:** The submission demonstrates a substantive attempt but contains a meaningful error, incomplete implementation, missing output, or incorrect/incomplete interpretation.
- **0 points – Missing or non-substantive:** The assignment is not submitted or does not meaningfully address the assigned task.

The course AI Policy applies to these assignments. The instructor reserves the option to ask students about their submissions during lectures for extra credit.

S.3.3 Project [25%]

The course project accounts for **25% of the final course grade** and will be completed in groups. Detailed instructions and data will be provided separately during the semester.

The project is designed to assess students' ability to integrate concepts from across the course, apply quantitative modeling tools appropriately, interpret results, and communicate a clear and well-supported engineering recommendation.

General project grading: The project grade will be determined by the instructional team according to the following components:

- **Technical analysis and modeling (40%):** Correct formulation and implementation of the analysis, appropriate use of course methods, and technical validity of the results.
- **Interpretation and recommendation (25%):** Quality of the interpretation, identification of important assumptions and tradeoffs, and ability to support a clear recommendation using quantitative evidence.
- **Written submission (15%):** Clarity, organization, documentation of assumptions and methods, presentation of results, and overall quality of the technical communication.
- **Final project pitch (20%):** Each group will submit a recorded presentation of no more than three minutes summarizing and defending its proposed solution. The pitch will be evaluated based on clarity, technical accuracy, effective use of evidence, and the strength of the recommendation.

The course AI policy applies.

Team contribution: Unless there is evidence of substantially unequal participation, all members of a group will receive the same regular project grade. The instructor reserves the right to adjust an individual student's project grade when documented contributions, confidential peer evaluations, or other evidence demonstrate a substantial difference in participation.

Project pitch competition and bonus credit: Multiple groups may be assigned to the same project case. At the end of the semester, the competing pitches for each case will be presented as part of the course-wide project competition, and students will select one winning proposal for each case. To be eligible for the competition bonus, a submission must meet a minimum standard of technical completeness and correctness as determined by the instructional team. Members of the winning group for each case will receive a **bonus** of **3 percentage points**.

S.3.4 Attendance and Extra Credit [10%]

Attendance accounts for **10 percentage points** of the final course grade. During lectures, students will be selected at random to answer questions or briefly discuss material covered in class. A selected student will receive one of the following scores:

- **0**: absent,
- **1**: present, but no answer or an unsatisfactory answer,
- **2**: satisfactory answer,
- **3**: very good or complete answer.

For attendance purposes, scores of 1, 2, and 3 all count equally as being present. The random draws are used only to obtain a sample of each student's attendance over the semester. Students are given the benefit of the doubt: not being selected does **not** count against a student, and an occasional absence identified through a random draw will generally not result in a grade reduction. Attendance reductions are based on the overall evidence from the random sampling and are intended to identify repeated or substantial absence rather than individual missed classes.

Students are **not penalized for the quality of their answer** when they are selected. A score of 1 counts as full attendance credit for that observation. Scores of 2 and 3 may contribute toward extra credit for strong participation. Additional opportunities to earn extra credit may also be offered during the semester, and the instructor will make sure that students have multiple opportunities to earn such credit. The instructor may also give extra credit for strong "voluntary" participation during the lecture. Extra credit is separate from the 10-percentage-point attendance component and can increase the final course grade by up to **10 percentage points**.

S.4 AI Policy

Generative AI tools are increasingly common in engineering and professional practice. Their use is permitted in this course unless an assignment or assessment explicitly states otherwise. AI may be used as an assistant for tasks such as brainstorming, coding, debugging, data processing, figure generation, editing, or background research.

Students remain fully responsible for all work they submit. This includes verifying the correctness of AI-generated content, checking calculations and code, validating results, and understanding the methods and conclusions presented. Use of AI does not reduce the expectation that students are able to explain and defend their submitted work.

All assignments must include a brief **AI-use disclosure**. The disclosure must state either:

1. that no generative AI tools were used in completing the assignment; or
2. which AI tools were used and a brief description of how they contributed to the work.

Examples of AI use that should be disclosed include, but are not limited to, assistance with model formulation or analysis, data processing, code generation or debugging, simulation, figure creation, writing or editing, and searching for or summarizing background information.

Students are discouraged from using AI to generate complete answers, arguments, analyses, or substantial portions of written work without meaningful independent engagement. Regardless of how AI is used, students must critically evaluate the output and take responsibility for the final submission.

All standard academic integrity requirements continue to apply. It is unacceptable to fabricate or falsify results, methods, data, references, or sources; to misrepresent the origin of submitted work; or to present AI-generated or external content without the required disclosure. Failure to disclose AI use when disclosure is required may be treated as an academic integrity violation.

Students are responsible for reviewing all materials before submission. Clearly recognizable generative-AI artifacts that included in a submission for whatever reason (for example, pasted prompts, chat transcripts, model instructions, unfinished AI responses, or other raw fragments from an AI interaction) may be treated as evidence of undisclosed or improperly represented AI use. Where such material clearly demonstrates a violation of this policy, the assignment may receive **zero credit**. This provision does not apply when an assignment explicitly asks students to submit AI prompts, transcripts, outputs, or related material as part of the required work.

Individual exams, quizzes, or other assessments may impose additional restrictions on AI use. Any such restrictions will be stated explicitly in the instructions for that assessment.