

COMPSCI 590X: Decarbonization and Data Science, 3 credits
Fall 2024

Instructor: Jay Taneja
Email: jtaneja@umass.edu
Meetings: Mon/Wed 2:30 - 3:45, Agriculture Engineering Room 119
Taneja Office Hours: Tuesday 10 - 11 and Friday 1:30 - 2:30, or by appointment. In person.
Office Location: Lederle Graduate Research Center A267
Eligibility: Open to Undergraduate and Graduate Students
Prerequisites: Undergraduates with a C or better in COMPSCI 240 (or STATS 515) and CICS 210 (or COMPSCI 187), or a C or better in INFO 348)

Syllabus Version 0 (Sept 2024)

DESCRIPTION:

This course examines applications of Data Science in the decarbonization of energy systems. The course covers (i.) basic energy systems concepts and background with US and global examples, (ii.) an introduction to relevant methods in statistical and geospatial data analytics and machine learning, and (iii.) trends and challenges affecting decarbonization in the electricity sector and beyond, with a focus on end-uses of energy. This course incorporates a significant programming component, with assignments on electricity supply implications from fluctuating solar photovoltaic and wind generation; residential energy system planning including heat pumps, solar photovoltaic systems, and energy storage; and demand side management, including smart appliances and electric vehicles.

COURSE OBJECTIVES:

By the end of the course, students will be able to:

- Manipulate large-scale datasets in the service of better planning and operations of energy systems.
- Critically evaluate the opportunities for data-driven decision-making in different end-use sectors of the energy sector, with a focus on the electricity grid.
- Understand the large-scale trends influencing decarbonization of the energy system, including the Energy Transition and electrification.

READINGS & ASSIGNMENTS:

(1) *Readings and homework questions:* All readings and discussion questions will be posted to Canvas (<https://umamherst.instructure.com>) for you to download. These are an integral part of this class. I expect you to come to class having read the assignment listed for that day and be ready to participate in discussions throughout the class periods. If you do not understand something in the readings, please ask questions in class or in office hours. There is no textbook for the course.

Answers to homework will be due **through Canvas** by the start of class time (2:30pm). Homeworks will consist of questions about previous class materials or will include questions covering the reading for the current and previous class sessions. Late assignments will accrue a penalty of a 10% deduction from the total score for each day late. **Paper assignments will not be accepted.**

- (2) *Lab Assignments:* There will be one lab assignment during the semester. This will consist solely of software (code) completed individually and a short assignment write-up that should be no more than two pages. Code should be commented clearly. Lab assignments will focus on decision-making in different segments of the energy sector. Assignments are to be completed in Python.
- (3) *Sector Presentation and Report:* Groups of three students will choose an energy end-use sector (candidates include space heating, space cooling, cooking, light duty vehicles, heavy duty vehicles, air travel, sea travel, water heating, industrial heat, and open to additional suggestions) and provide a 6 to 8-minute presentation (in class) and 5-7 page report detailing how the end-use is provided today (primarily in the US), what opportunities there are to decarbonize the end-use, and how data can be used to better plan or operate this end-use. The sector report is due via Canvas **by the beginning of the next class session after the sector presentation.** The presentation and sector report are required to include **at least two figures** (using collected data) that were created by the team (these should be noted in the write-up, with code included). Groups may be chosen by the students, but are not required to be. Professor Taneja will provide a sample presentation for one sector during class, and student presentations will be distributed throughout the second half of the semester. After each session, each student besides the presenters will be responsible to provide a brief summary of the 3 most interesting and/or surprising findings from the sector presentation. These summaries are due via Canvas **by the beginning of the next class session after the sector presentation.** These write-ups will contribute to the participation portion of the course grade. Sector presentation dates will be scheduled in early October for dates from late October to early December.
- (4) *Final project:* There will be a final project, to be completed in groups of 2 (this partner should be different than the partners from the sector presentation). This project will consist of software (code) and a short assignment write-up. Code should be commented clearly. The final project will focus on decision-making in different segments of the electricity sector. The project is to be completed in Python. **There will be no final exam for this course.**

GRADING AND GRADING SCALE:

Homeworks and Participation (responses, etc.)	25%
Labs (3 x 10%)	30%
Sector Electrification Presentation and Report	25%
Final Course Project (project report and commented code)	20%

A == 93-100%, A- == 90-93%
B+ == 87-89%, B == 83-86%, B- == 80-82%
C+ == 77-79%, C == 73-76%, C- == 70-72%
D+ == 67-69%, D == 60-66%
F <= 59%

Please note that adjustments to grading ranges may be made, and a grade may also be assigned based on extenuating circumstances and/or judgment. Please also note that graduate students can only receive grades between A and C.

COURSE SCHEDULE (SUBJECT TO CHANGE):

Readings should be completed before the class date they are listed on.

Week	Date	Topic	Assignments
1	Sep 4 (Wed)	Introduction, course background	
2	Sep 9 (Mon)	Energy units, primary energy vs. electricity	HW1 Assigned
	Sep 11 (Wed)	Energy system background (I)	
3	Sep 16 (Mon)	Energy system background (II)	
	Sep 18 (Wed)	"The Energy Transition"	HW1 Due
4	Sep 23 (Mon)	"Big Data" background + Data-driven decision-making in energy (I)	HW2 Assigned
	Sep 25 (Wed)	Data-driven decision-making in energy (II)	
5	Sep 30 (Mon)	Tools for Data Science	
	Oct 2 (Wed)	Energy and electricity consumption – end-use sectors + decarbonization (I)	HW2 Due; Lab 1 Assigned
6	Oct 7 (Mon)	Energy and electricity consumption – end-use sectors + decarbonization (II)	
	Oct 9 (Wed)	Electricity sector operations – markets and services	
7	Oct 14 (Mon)	NO CLASS – Indigenous Peoples' Day	
	Oct 15 (Tues)	Electricity generation (I) – Monday class schedule followed	
	Oct 16 (Wed)	Electricity generation (II)	Lab 1 Due
8	Oct 21 (Mon)	Electricity generation (III)	Lab 2 Assigned
	Oct 23 (Wed)	System and network planning (I)	
9	Oct 28 (Mon)	System and network planning (II)	Sector reports begin
	Oct 30 (Wed)	Energy storage for electricity (I)	
10	Nov 4 (Mon)	Energy storage for electricity (II)	Lab 2 Due
	Nov 6 (Wed)	Decarbonizing non-electricity energy (I)	
11	Nov 11 (Mon)	Decarbonizing non-electricity energy (II)	Lab 3 Assigned
	Nov 13 (Wed)	Demand-Side Resources (I)	
12	Nov 18 (Mon)	Demand-Side Resources (II)	
	Nov 20 (Wed)	Demand-Side Resources (III)	
13	Nov 25 (Mon)	TBD	Lab 3 Due
	Nov 27 (Wed)	NO CLASS – Thanksgiving Holiday	Sector reports conclude; Final Project Assigned
14	Dec 2 (Mon)	TBD	
	Dec 4 (Wed)	TBD	
15	Dec 9 (Mon)	Last Class - Summary and synthesis	
		No final exam - final project due 12/14 by 5pm	Final Project Due 12/14

PYTHON RESOURCES:

Required for those who are less familiar with Python:

- Read or watch a pandas tutorial:
https://pandas.pydata.org/pandas-docs/stable/getting_started/tutorials.html
- (Optional) Read McKinney (2013): Python for Data Analysis. O'Reilly Media, Inc. [focus on Chapters 3-5, 9]
- Read and complete at least the "Introduction" to this Python tutorial:
<http://interactivepython.org/courselib/static/pythonds/index.html>
- Read and complete lessons 1-7 of Learn Pandas:
<https://bitbucket.org/hrojas/learn-pandas>
- Consider Pandas Tutor for visualizing Pandas dataframes: <https://pandastutor.com/>

Attendance and late work submission policy

You are expected to attend lectures -- this is the best way to engage in discussion and understanding of the material. Participation is a part of the course grade. If you cannot attend (e.g., for medical reasons), you are expected to inform the Professor, and may request access to a recording of that class, though it is not guaranteed to be available.

Academic Honesty Policy Statement

Since the integrity of the academic enterprise of any institution of higher education requires honesty in scholarship and research, academic honesty is required of all students at the University of Massachusetts Amherst. Academic dishonesty is prohibited in all programs of the University. Academic dishonesty includes but is not limited to: cheating, fabrication, plagiarism, and facilitating dishonesty. Appropriate sanctions may be imposed on any student who has committed an act of academic dishonesty. Instructors should take reasonable steps to address academic misconduct. Any person who has reason to believe that a student has committed academic dishonesty should bring such information to the attention of the appropriate course instructor as soon as possible. Instances of academic dishonesty not related to a specific course should be brought to the attention of the appropriate department Head or Chair. The procedures outlined below are intended to provide an efficient and orderly process by which action may be taken if it appears that academic dishonesty has occurred and by which students may appeal such actions. Since students are expected to be familiar with this policy and the commonly accepted standards of academic integrity, ignorance of such standards is not normally sufficient evidence of lack of intent.

For more information about what constitutes academic dishonesty, please see the Dean of Students' website: http://umass.edu/dean_students/codeofconduct/acadhonesty/

Course Materials Recording Policy

Lectures and class materials are copyrighted materials and should not be shared with outside-of-class students or shared with any online or offline repositories. This prohibits use of automated speech-to-text tools as well as use of Internet-based course help tools.

Disability Statement

The University of Massachusetts Amherst is committed to making reasonable, effective and appropriate accommodations to meet the needs of students with disabilities and help create a barrier-free campus. If you are in need of accommodation for a documented disability, register with Disability Services to have an accommodation letter sent to the Professor. It is your responsibility to initiate these services and to communicate with faculty ahead of time to manage accommodations in a timely manner. For more information, consult the Disability Services website at: <http://www.umass.edu/disability/>

UMass Amherst Diversity Mission Statement

The University of Massachusetts Amherst, as a public land-grant institution, has a responsibility to provide access and opportunities for all people, while demonstrating our commitment to inclusion of historically underrepresented groups. We believe that a culturally diverse campus is integral to academic excellence and that our students, faculty, and staff should reflect the diverse world in which we live. The university recognizes and values the wide range of voices and perspectives in all spheres of the academic enterprise. UMass Amherst is committed to policies that promote inclusiveness, social justice, and respect for all, regardless of race, color, religion, creed, gender, sexual orientation, age, national or ethnic origin, physical or mental disability, political belief or affiliation, marital status, veteran status, immigration status, gender identity and expression, genetic information, or any other characteristic or status protected by state or federal laws.

Civility, Respect, and Inclusivity Statement

We are all members of an academic community with a shared responsibility to cultivate a climate where all students/individuals are valued and where both they and their ideas are treated with respect. The diversity of the participants in this course is a valuable source of ideas, problem solving strategies, and engineering creativity. If you feel that your contribution is not being valued for any reason, please speak with me privately. If you wish to communicate anonymously, you may do so in writing or speak with Erika Dawson Head, Executive Director of Diversity & Inclusion for the College of Information and Computer Sciences (erikahead@cics.umass.edu, 413.577.0338, 218 CS Building).

Title IX Statement

Title IX of the Education Amendments of 1972 is a federal civil rights law that prohibits discrimination on the basis of sex in any education program or activity that receives federal funding. Sex discrimination includes sexual harassment, sexual battery, sexual assault, and rape. Title IX applies to all public and private educational institutions receiving federal financial assistance. If you have been the victim of sexual violence, gender discrimination, or sexual harassment, the university can provide you with a variety of [support resources](#) and accommodations. UMass is committed to providing these resources with minimal impact and costs to survivors on a case-by-case basis. Resources are available to survivors with or without them filing a complaint. No upfront costs are charged to any currently enrolled students for University Health Services or the Center for Counseling and Psychological Health, and no fees exist for services in the Dean of Students Office, the Center for Women and Community, Student Legal Services, or by live-in residential staff.