ChE/EID447: Sustainability and Pollution Prevention

Prof. Davis

Fall 2021 Syllabus

Class meeting times:

Tuesdays 5:00 – 6:50 PM in room 106 and Thursdays 12:00 – 12:50 PM in room 106

Course motivation and overview:

The population of the earth is at its highest level and still growing; with this growth, we can no longer ignore the effects of human society on our environment. Scientific research in climate science, ecology, water systems, marine biology, environmental science, and others has done a commendable job in exposing our collective environmental impacts. In your lifetime, the consequences of climate change, species extinction, increased spread of disease, desertification, toxic spills, depletion of fisheries, deforestation, soil eutrophication, water pollution, the current global air pollution epidemic, and many more will profoundly affect the course of global society. Addressing these problems is simultaneously cultural, political, and technical.

We would like to create environmental and economic conditions which can sustain human happiness and well-being for a "very long" time. Development of human society in this manner is called sustainable development. We need to agree on a path for society (or a possible set of paths) and then identify a feasible way to pursue it. Once we can identify what it means for something to be sustainable, it is then important to identify what you, as a citizen and as an engineer, can do about explaining and improving our current path.

One of the goals of the engineering curriculum at Cooper is for students to be able to "recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts"; this course aims to help achieve that by instructing you in environmentally sound and socially responsible engineering. My goal is to provide you with perspective on what issues must be considered to make things at scale to benefit our growing (and increasingly affluent) society in an economical way, while still having minimal impact on our valuable ecosystems (which humans are at the top of).

Course goals and objectives:

The first part of this course discusses in detail one methodology for defining and assessing the sustainability of an entity (typically a corporation, though it doesn't have to be one). We then proceed with more traditional topics in pollution prevention for chemical processes, outlining concepts on the macroscale (life-cycle assessment) and mesoscale (pollution prevention for processes and unit ops). By the end, you should be able to:

- Explain what sustainability is and how it is affected by time, geography, and people
- Choose a set of indicators to approximate the sustainability of a country, company, university, etc.
- Use a fuzzy-logic-based methodology to define and assess sustainability
- Write a detailed report assessing the sustainability of a corporation relative to its industry
- Perform a sensitivity analysis identifying critical components of sustainability for a given corporation
- Explain what a life cycle assessment is and what needs to be considered to create one
- Perform a life-cycle assessment on two or more process or product alternatives to assess their relative costs and impact on people and the environment
- Apply engineering design methods to find targets (lower or upper bounds) for waste minimization, energy efficiency, and minimal environmental impact

Prerequisites and other requirements:

The course has no prerequisites; all material needed to understand the various topics will be covered in class. The class is generally aimed towards senior and masters level chemical engineering students, but students of all majors have taken it with success as long as they have a specific interest in the topics addressed. The course has a required textbook, Fuzzy Measurement of Sustainability by Y. Phillis and V. Kouikoglou, ISBN# 1606920529. We have one printed copy on reserve in the library: HC79.E5 P5134 2009. The book is also available electronically; you can annotate it online, download chapters in PDF, or download the entire book for 2 weeks.

Please bring your book (in some form) to class every day. You will also need materials to take notes and do problems during lecture (paper, pencil, and a calculator). For the project assignments and the homework, you will need access to a computer (with a spreadsheet program, Python, or Matlab on it) and you will need to use the library and other internet resources to do research for your project assignments.

Homework, projects, and exams:

There will be four (4) homework assignments, one written project report, a midterm exam, and one group poster presentation for this class. Homework will be due before class on the date listed on the assignment and be assigned one week prior to its due date; it will be problems and short answer questions which reinforce concepts from lecture and the textbook(s). I expect you will spend 6 hours/week outside of class on work for this class.

The first project will be to evaluate the sustainability of an entity of your choice using a fuzzy logic-based method outlined in class. You should take your project 1 reports to the writing center before they are due; I recommend you sign up for a writing center appointment the day before the project is due as soon as appointments are available. The midterm exam will be an assessment of your ability to implement the model for Project 1 on fuzzy assessment of sustainability. The second project will be to perform a life-cycle assessment on two similar products or process alternatives. It will be a group project and your group will be required to create a poster which will be presented on the last day of class. Only one poster is required per group. You are also REQUIRED to submit a group member evaluation form for each group member you have. The evaluation form will be available to print out on Teams.

Attendance and grading policy:

Attendance in class is mandatory; please E-mail me before class if you cannot attend. If you miss class, please come to office hours to find out what you missed. There will be no make-up or extra credit work associated with this class. Please ensure you hand in your assignments on time and you can attend the midterm exam. All assignments and exams must be completed for a passing grade in the class. Students will be graded as follows:

	Homework	**Proj. 1**	**Proj. 2 Poster**	**Proj. 2 Pres.**	**MT Exam**
% of grade	16	40	10	10	24

Letter grades will be determined at the end of the semester using your raw score from above, the average raw score for the class, and the instructors' discretion (in that order). My discretion will be based on class attendance / participation, effort on assignments and projects, and improvement over the course of the semester.

Special accommodations for exams:

Students with disabilities or who need special accommodations for this class are required to notify the Dean of Students and meet with me **immediately** so that arrangements can be made. The Cooper Union has limited resources and extra lead time is required for such arrangements to be feasible. In order to receive accommodations for an exam, you must notify me in writing at least two weeks before the accommodations are

needed and you must also be registered with the Dean of Students. Students will not be afforded any special accommodations retroactively, i.e., for academic work completed prior to disclosure of the disability to the instructors and the Dean of Students.

Group work and Academic Integrity Policy:

The Cooper Union School of Engineering Policy on Academic Integrity is posted here:

https://cooper.edu/engineering/curriculum/academic-standards-regulations

I believe group work is important to learning; you will work in groups on your projects and homeworks and I understand that your submissions are a team effort. However, each student MUST contribute as equally as possible to the group's submissions. Plagiarism is the presentation of another person's "work product" (ideas, words, equations, pictures, slides, computer code, etc.) as one's own. Whether done intentionally or unintentionally, plagiarism will not be tolerated in this class. You are plagiarizing if:

1. You present as your own work product a submission that includes the work product of your other group members and not your own
2. You present as your own work product a submission that contains the efforts or work product of other individuals aside from your other group members
3. The help and contributions of other individuals are not acknowledged in writing on your submission (by writing their names / citing them)
4. You copy other students' work on an examination or communicate with others during an exam
5. You submit, as part of a homework assignment or project, material that has been copied from any source (including, but not limited to, a textbook, a periodical, an encyclopedia, the internet) without properly citing the source, and/or without using quotation marks. It is also prohibited to submit such materials in a minimally altered form without proper attribution. Improperly copied material might include text, graphics (computer or otherwise), computer source code, etc. **Wikipedia is not a source.**

If we have a strong suspicion that you have plagiarized your submission for an assignment (homework or project,) you will be reported to the Dean's Office and likely receive a zero on that assignment. Other acts of academic dishonesty include:

6. Attempting to obtain a copy of an examination before it is administered
7. Dishonesty in dealing with us or another professor, such as misrepresenting statements of another professor
8. Bringing a text or study materials of any kind (including electronically) into an exam
9. Bringing an electronic device into class at any time when not expressly permitted (laptops, phones)
10. Bringing any device into an examination that allows communication with other individuals or computer databases (i.e. no cell phones or laptops during exams)

If I have a strong suspicion that you have cheated on an examination, you will be reported to the Dean's Office and likely receive a zero on that examination and a D or F in the course.

Office hours:

My office is room 419; you can E-mail me at ben.davis@cooper.edu. My office hours are **M 3-4 PM, W 2:30-3:30 PM, and R 10-11 AM**. Please do your best to bring questions to me during those times only. Please E-mail me if you have a question which is brief or if you need to let us know you're going to be absent, late, etc. If you send an E-mail, please put "ChE/EID447" as the start of the subject, e.g. "ChE/EID447 HW1 Question".

Resources which may be helpful:

Website on SAFE method - http://www.sustainability.tuc.gr/index.html
Pollution Prevention for Chemical Processes by D. Allen and K. Rosselot, ISBN# 0471115878
Sustainable Development for Engineers by K. Mulder, ISBN# 1874719195
Green Engineering by D. Allen and D. Shonnard, ISBN# 0130619086
Sustainable Development in Practice by A. Azapagic and S. Perdan, ISBN# 9780470718728
First Course on Fuzzy Theory and Applications by K. Lee – available here.

Sequence of topics and class schedule:

Non-bolded rows are in-person weeks – class will be in our normal room
Rows in **BOLD** are remote weeks – class will be via MS Teams

Week	Hour	Day	Date	Class Topics	Due
1	1,2	Tues	8/31	Introduction to the class	
1	3	Thu	9/2	Ch1: Sustainability and SD	Proj. 1 posted
2	4,5	Tues	9/7	Ch1: IPAT and examples	
2	6	Thu	9/9	Ch2: Introduction to fuzzy logic	
3	**7,8**	**Tues**	**9/14**	**Ch2: Linguistic values and fuzzy sets**	
3	**9**	**Thu**	**9/16**	**Ch2: Fuzzy implication / T-norms / S-norms**	
4	10,11	Tues	9/21	Ch2: Fuzzy logic	
4	12	Thu	9/23	Ch2: Constructing rule bases	HW1
6	13,14	Tues	9/28	Ch2: Fuzzy system properties	
5	15	Thu	9/30	Ch3: Sustainability indicators	HW2
6	**16,17**	**Tues**	**10/5**	**Ch4: SAFE model**	
6	**18**	**Thu**	**10/7**	**Ch4: Indicators for corporations**	Proj. 1 proposal
7	19,20	Tues	10/12	Ch5: Modifications to SAFE model	
7	21	Thu	10/14	Ch5: Sensitivity analysis, missing data	HW3
8	--	Tues	10/19	Midterm Exam (THREE HOURS, 5-8 PM)	MT
8	22	Thu	10/21	Catch up on SAFE / Project 1 questions	
9	**23,24**	**Tues**	**10/26**	**Pollution Prevention - Wastes and Emissions**	
9	**25**	**Thu**	**10/28**	**Ch5: Industrial Ecology/LCA**	
10	26,27	Tues	11/2	Report edits / project 1 feedback	
10	28	Thu	11/4	Process Design for Sustainability (PDS)	Proj.1 draft
11	--	Tues	11/9	NO CLASS (AIChE Annual Meeting)	Proj. 2 posted
11	--	Thu	11/11	NO CLASS (AIChE Annual Meeting)	
12	**29,30**	**Tues**	**11/16**	**PDS Case study: Description**	
12	**31**	**Thu**	**11/18**	**PDS Case study: Unit operations**	Proj. 2 goal & scope / HW4
13	--	Tues	11/23	NO CLASS (Thanksgiving)	
13	--	Thu	11/25	NO CLASS (Thanksgiving)	
14	32,33	Tues	11/30	PDS Case study: Waste treatment	
14	34	Thu	12/2	PDS Case study: Overview / Summary	Proj. 1 final
15	35,36	Tues	12/7	Optimization for waste min. / pollution prev.	
15	--	Thu	12/9	NO CLASS (Study Period)	
16	37,38	Tues	12/14	Project 2 Final Presentations (in class)	Proj. 2 poster
16	--	Thu	12/16	NO CLASS (Winter Break)	