ChE/EID447: Sustainability and Pollution Prevention

Prof. Davis

Spring 2017 Syllabus

Class meeting times:

Tuesdays 2:00 PM - 2:50 PM in room 503
Fridays 1:00 PM - 2:50 PM in room LL210

Course motivation and overview:

The population of the earth is at its highest level and still growing; we have long since exceeded a level at which people can ignore their effects on their environment. Scientific research in fields such as climate science, ecology, water systems, and environmental science has done a commendable job in exposing the environmental impacts of our constantly growing society. Impacts such as climate change, species extinction, disease epidemics, desertification, air emissions, toxic spills, depletion of fisheries, deforestation, soil eutrophication, water pollution, and many more affect the current course of our global society. A question thus arises as to the consequences of our actions: how sustainable is our present course? (The answer is, unfortunately, "Not very.")

This question begs for a definition of (and a measurement scheme for) sustainability; we need to find a path for society (or set of paths) which can be followed for a "long time" and then identify a feasible way to pursue one of those paths. 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 have an understanding and awareness of the professional, ethical, and safe application of their knowledge; this course aims to help achieve that goal by instructing you in environmentally and socially responsible (but still economically sound) manufacturing.

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). The course then proceeds 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 operations).

My goal is to provide you with perspective on what issues must be considered to make things for our growing (and increasingly affluent) population in an economical way, while still having minimal impact on our valuable ecosystems (which humans are ultimately at the top of).

Course goals and objectives:

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

- Explain what sustainability is and how it is affected by time, geography, and people
- Choose a set of indicators which could be used to approximate or assess 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 and environmental impact of a corporation relative to its industry
- Perform a sensitivity analysis which identifies the most 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 chemical process 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 the material needed to understand the various topics will (hopefully) be covered in class. The class is aimed towards senior and masters level ChE students, but it is open to anyone with 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 ($102 new on Amazon). We have one printed copy on reserve in the library: HC79.E5 P5134 2009. The book is also available electronically on ebrary; you can use and annotate it online, download chapters in PDF, or download the entire book for 2 weeks. Direct URL is: http://site.ebrary.com/lib/cooper/detail.action?docID=10660206 (on campus).

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 or Matlab 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 will be assigned at least one week prior to its due date. It will consist of problems and essay questions which reinforce concepts from lecture and the textbook(s). I expect you to spend about 6 hours per week outside of class on work for this class.

The first project will be to evaluate the sustainability of an entity (typically a corporation) 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 advise you to 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. This second project 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 Moodle.

Attendance and Grading Policy:

Attendance in class is mandatory; please E-mail me before class if you cannot attend. If you miss class, come to my office hours to find out what you missed. There will be no make-up or extra credit work associated with this class. Please ensure that you hand in your assignments on time and that 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	12	27	10	10	41

Letter grades will be determined at the end of the semester using each student's raw score from above, the average raw score for the class, and my discretion (in that order). My discretion will be based on class attendance / participation, effort on homework 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 meet with me and the Dean of Students 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 myself and the Dean. This policy is modified from Monmouth University via Professor Topper.

Office hours:

T 3:00 – 4:00 PM, W 4:00 – 5:00 PM, and R 3:00 – 4:00 PM

Please do your best to bring questions to me during those times only. My E-mail address is bdavis@cooper.edu if you have a question which is brief or if you need to let me know you're going to be absent, late, etc. If you send me an E-mail, please put "ChE/EID447" as the start of the subject, e.g. "ChE/EID447 HW1 Question".

Resources which may (or may not) 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
Sustainable Fossil Fuels by M. Jaccard, ISBN# 0521679796
Sustainable Energy by J. Tester et al., ISBN# 0262201534
GaBi software tool for LCA - http://www.gabi-software.com/america/software/gabi-education/getting-your-copy-of-gabi-education/
ecoinvent LCI database - http://www.ecoinvent.org/database/
NREL LCI database - https://www.lcacommons.gov/nrel/search
ISO standards for LCA - http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_tc_browse.htm?commid=54854
SimaPro for LCI/LCA - http://www.pre-sustainability.com/simapro

Group work and academic integrity policy:

I believe group work is important to learning; however, each student MUST submit their own work product for each assignment unless explicitly stated otherwise. Plagiarism is the presentation of another person's "work product" (ideas, words, equations, 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
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 the work of other students on an in-class examination or communicate with other individuals in any fashion 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 I have a strong suspicion that you have plagiarized your submission for an assignment (homework or project,) you will receive a zero on that assignment. If you commit another act of plagiarism during the course after this first act, I will refer the matter to the Dean's office. Other prohibited acts of academic dishonesty include (but are not limited to):

6. Attempting to obtain a copy of an examination before it is administered
7. Dishonesty in dealing with me or another professor, such as misrepresenting the statements of another professor
8. Bringing a text or study materials of any kind (including electronically) into an exam when forbidden to do so

9. Bringing an electronic device into class at any time when not expressly permitted by me
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 receive a zero on that examination and likely receive a D or F in the course. The above was modified from the course catalog from the 2009-10 academic year.

Sequence of topics and class schedule:

Hour	Day	Date	Topic(s)	Due
1,2	Fri	1/20	Introduction to the class	
3	Tues	1/24	Ch1: Sustainability and SD	
4,5	Fri	1/27	Ch1: IPAT and examples	
6	Tues	1/31	Ch2: Introduction to fuzzy logic	
7,8	Fri	2/3	Ch2: Linguistic values and fuzzy sets	
9	Tues	2/7	Ch2: Fuzzy implication / T-norms / S-norms	HW 1
X	Fri	2/10	Ch2: Rule bases / fuzzy systems	
10	Tues	2/14	Ch2: Constructing rule bases	
11,12	Fri	2/17	**NO CLASS** – Founder's / Presidents' Day	HW 2
13	Tues	2/21	Ch2: Fuzzy system properties	
14,15	Fri	2/24	Ch3: Sustainability indicators	
16	Tues	2/28	Ch4: SAFE model	Proj. 1 companies
17,18	Fri	3/3	Ch4: Indicators for corporations	HW 3
X	Tues	3/7	Review for Midterm Exam	
X	Fri	3/10	Midterm Exam (**THREE HOURS**, 12-3 PM)	MT
X	Tues	3/14	**NO CLASS** – Spring break	
X	Fri	3/17	**NO CLASS** – Spring break	
19	Tues	3/21	Ch5: Modifications to SAFE model	
20,21	Fri	3/24	Ch5: Sensitivity analysis, missing data	
22	Tues	3/28	Pollution Prevention - Wastes and Emissions	Project 1 draft
X	Fri	3/31	Report edits / individual meetings	
23	Tues	4/4	Ch5: Industrial Ecology/LCA	
24,25	Fri	4/7	Process Design for Sustainability	Pick Proj. 2 scope
26	Tues	4/11	VCM Case study: Description	
27,28	Fri	4/14	VCM Case study: Unit operations	
29	Tues	4/18	VCM Case study: Waste treatment	Project 1 final
30,31	Fri	4/21	VCM Case study: Overview / Summary	
32	Tues	4/25	Optimization techniques for waste minimization / pollution prevention	
33,34	Fri	4/28	Heat integration / Pinch analysis	HW 4
35	Tues	5/2	Analogy between HEN and MEN	
36,37	Fri	5/5	Mass exchange network synthesis	
X	Tues	5/9	**NO CLASS** – Final presentations in exam slot	