Catalog Description

Cradle-to-grave analysis of new products, processes and policies is important to avoid undue environmental harm and achieve extended product responsibility. This mini-course provides an overview of approaches and methods for life cycle assessment and for green design of typical products and processes. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. Example software programs are used in assignments. A life cycle assessment project is required.

Course Objectives

- Develop an understanding of the concept and framework of Life Cycle Assessment (LCA)
- Develop an understanding of the methods and challenges involved in applying LCA to relevant industrial and social issues
- Gain experience in how and when to use process-based, input-output based, and hybrid LCA methods
- Understand the assumptions, strengths and weaknesses of these types of LCA models.
- Learn how to document and publish LCA studies

Meeting Time and Place
Monday and Wednesday, 3:00-4:30, PH 7F, Mini A3 schedule

Instructors
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TA: Aurora Sharrard, PH A7A, 412-268-7567, aluscher@andrew.cmu.edu

Overview

This course is part of the 'sustainable engineering' sequence within the graduate program in Civil and Environmental Engineering. This is the first substantive environmental LCA course to be taught at CMU, now in its third offering. CMU has been a leader in both sustainable engineering education, specifically LCA. You are taking the course at the right place.

As a mini, this course will be fast-paced and taught as a seminar/tutorial, with significant time and effort required for readings and work outside of the class period. Note that LCA is a conceptually simple idea – we teach the general method to high school students and they create valid and interesting models. The college-level difficulty comes from learning many methods of implementation, creating quantitative models, interpreting model results qualitatively and quantitatively, etc. Of course you are also expected to think more creatively and critically.

Those of you who have taken a class with me know that I try to create an environment for open discussion of material. This is reflected in my grading expectations, shown below.
Course Grading Notes

- Class participation is not explicitly part of your grade, but will be used in cases of borderline results (e.g., from B+ to A-).
- Assignments are due in class on the designated date (or in my office for final projects). The deliverable is a paper copy of your work. E-mailing your solutions is not sufficient. Homeworks submitted late will incur a penalty of 10% of total points per day late.
- Collaboration is working together to come to frame a problem and work through a solution, discussing results, and analyzing the process. All members of the group contribute, understand the process (sometimes by being taught by other members of the group), and are prepared to complete a similar problem by themselves afterward. Collaboration is encouraged on homework assignments. However, for individual assignments, individual submissions are required. While you may have worked with another in solving the problem the work you hand in must be your own.
- Cheating is copying someone else's work and handing it in as your own work. This is unacceptable.
- Plagiarism is using someone else's published work and not giving them credit. Several web sources or the library have guidelines for referencing work from published journals, books, or newspapers, and from websites.
- Cheating and plagiarism will be handled according to university policies, which include the penalty for the assignment (usually a zero grade), and reporting the incident to Student Affairs.
- Regrades are possible within a one week timeframe after the assignments are returned in class. After that time, no regrades will be considered (except for simple addition errors). To submit a regrade, you should attach a sheet of paper detailing your concerns about the score given and argue your point. Regrade requests should be handed to me in class and not put in my mailbox or under my door.

Four Problem Sets = 75%
One Final Project with Presentation = 25%

Course Materials
Where possible, all material handed out in class will be posted to the web site (http://www.ce.cmu.edu/~hsm/lca2006/). Lecture notes for the entire semester will be available as downloadable PowerPoint presentations. Ideally, slides will be posted weekly for the upcoming 2 class sessions. Students should still come to lecture, since the slide files only show overviews of the material being presented and additional instruction will be done on the board. Feel free to download and bring copies of these presentations to class to follow along. If you elect to do this, please help conserve paper by printing in PowerPoint's 'Handouts' option (2, 3, or 6 slides per page) and with duplex (double-sided) printing.

Textbook / Readings
No text is required. I will hand out or post all readings during the semester, and also provide copies of a nearly-published book on LCA written by several faculty and students of the Green Design Institute. Please help us check for errors – it will be published soon!
LCA is a field growing rapidly in scale and scope. Applications and results are released almost daily. Thus there is a large number of information available on the Internet.

**Student Roles and Responsibilities**

This class will be taught as a graduate course. For those of you unfamiliar with what this means, here is a short summary of how class will operate:

- All students are expected to read chapters or other handouts before each lecture
- I will lecture on the topic you read, and will lead discussions on the topic
- In lecture I will not generally review the text or use the same examples as done in the book
- There may be material/readings assigned that will not be lectured at all.

In short, this means that while we will follow the readings, I will not be simply reviewing them. Coming to lecture will not be a substitute for the reading, and vice versa. I will make more detailed lecture notes/annotations available for certain key concepts to help you. If you are uncomfortable with this arrangement, you should quickly decide whether to remain registered in the course.

**Class Schedule**

This preliminary course schedule is provided to you in the hopes that it will help you prepare for the first few weeks of class. There will certainly be changes to this schedule as the semester goes on based on the pace of class. The web site home page will always have the most up-to-date version, and changes will be announced in class. The topics, assignments, and suggested readings are given below.

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<thead>
<tr>
<th>Lect. No.</th>
<th>Topics / Readings</th>
<th>Misc</th>
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<tbody>
<tr>
<td>1 (Jan 18)</td>
<td>Green Design / Links with Sustainability Sequence</td>
<td><strong>Project Assign. Out</strong></td>
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<td>Readings:</td>
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<td></td>
<td>• US EPA Introduction to LCA</td>
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<td></td>
<td><strong>Discussion Topics:</strong></td>
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<td></td>
<td>• Connections with embodied energy discussions from 12-712</td>
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<td></td>
<td><strong>How do we approach 'designing a better/ &quot;green&quot; computer', i.e. how do we translate this high-level goal into a plan of attack? How do we define better? What information do we need to know in advance to be able to know if we succeeded?</strong></td>
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<tr>
<td>2 (Jan 23)</td>
<td>LCA: History and Framework (cont.)</td>
<td><strong>HW 1 Out</strong></td>
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UNEP, Life Cycle Assessment: What It Is and How to Do It, UNEP 1996.

ISO Framework Documents

3 (Jan 25) Process LCA Theory
3 (Jan 25) Proj. Proposal Due

4 (Jan 30) Process LCA Software?
4 (Jan 30) HW 1 Due
4 (Jan 30) HW 2 Out

5 (Feb. 1) Process LCA Case Studies

6 (Feb, 6) Issues in Process LCA
6 (Feb, 6) connection with EIO – process flow diagram with dollars as units

7 (Feb. 8) Economic Input-output (EIO) Based LCA Theory

8 (Feb. 13) EIO-LCA Software
8 (Feb. 13) HW 2 Due
8 (Feb. 13) HW 3 Out

9 (Feb. 15) EIO-LCA Case Studies

Ochoa et al JIS Residential Buildings LCA

"Environmental Implications of Service Industries" Rosenblum, Jeffrey, Arpad Horvath and Chris Hendrickson, Environmental Science & Technology; 34(22); 4669-4676, 2000

Joshi 2000 JIE Product-EIO Fuel Tanks

10 (Feb. 20) Issues in EIO-LCA

11 (Feb. 22) Process/EIO-LCA Comparisons
11 (Feb. 22) Hybrid LCA Models
11 (Feb. 22) HW 4 Out
11 (Feb. 22) HW 3 Due

12 (Feb 27) Life Cycle Impact Assessment
12 (Feb 27) Closed-Loop Supply Chains/Full Cost Accounting

13 (Mar. 1) Project Presentations
13 (Mar. 1) HW 4 Due

14 (Mar 6) Project Presentations (cont.)
14 (Mar 6) Project Due
Life Cycle Assessment
Course Project Assignment Details

The course project is intended to provide a realistic opportunity to apply the tools and methods covered in the mini-course. Be sure to cover all aspects of the LCA process (i.e., including suggestion of improvements). For the project, your assignment is to:

- choose an existing or proposed product or process
- select a set of impacts of interest for evaluation
- define an appropriate analysis boundary
- conduct a hybrid life cycle cost and environmental impact inventory
- develop a hybrid life cycle cost and environmental impact assessment
- compare your results to any similar analyses appearing in the literature
- suggest improvements to the product or process
- prepare a 1-2 page summary (that can be posted on the eiolca.net website) of how you could replicate your results there
- report your results in a project report (of less than 20 pages plus data tables) and a presentation

You may choose any product or process you would like. Some suggestions include:

- Texas’ plan to build truck-only toll highways
- Comparing granite to concrete
- Comparing hydrogen to existing power or transportation energy sources
- Electro/mechanical devices such as solar cells, wind power generators or Segway transporters.
- Networks such as highways, railways, trucking companies, or power systems.
- Processes/systems such as telework, pharmaceutical production or cleaning.

You should choose your application domain carefully. An ideal topic would be one for which data are readily available, one for which you have familiarity or expert knowledge, one which is of a manageable size, and one which has not been already analyzed.

You will be expected to work in groups, typically of 3 to 5 students. Your reports and presentations should be professional in nature, with calculations and results explained. The body of your report should be no more than 20 pages, although you may have data and sample calculations in an appendix.

Critical dates for the project:

January 25: Project proposals due, including group members, topic, short description of data sources and review of literature for existing studies. One or two pages in length.

March 1: First presentation date. (Groups will be assigned presentation times randomly).

March 6: Project reports due and second presentation date.
One of the difficulties in life cycle assessment is making trade-offs between different categories or types of impacts. Various methods have been proposed. For example, the EPA Science Advisory Committee chose to make priorities on the basis of:

- The spatial scale of the impact (large scales being worse than small)
- The severity of the hazard (more toxic worse than less)
- The degree of potential exposure
- The penalty for being wrong.

Suppose you have a large budget to work on pollution prevention in a company. Based solely on your perception of the relative hazards (that is, ignoring relative amounts of plant emissions or the cost of pollution prevention for different categories), what fraction of your budget would you place on the following impact reductions? Total must equal 100%.

1. Toxic water emissions:
2. Toxic air emissions:
3. Electrical energy efficiency
4. Toxic materials in products
5. Greenhouse gas emissions
6. Petroleum use
7. Solid waste reduction
8. Product recycling
9. Renewable energy production
10. Other: ____________________
11. Other: ____________________

Please fill out these categories and make percentage allocations. We will compile and discuss the class responses. Note: This is not a graded assignment, so feel free to express your own beliefs.

Name: ______________________________