USC Viterbi
School of Engineering
Daniel J. Epstein Department of Industrial and Systems Engineering

ISE 576, Industrial Ecology

Syllabus

Units: 3

Term — Day — Time: Spring 2018 — Mon — 12:30-3:20 pm

Location: OHE 100B & DEN@Viterbi

Instructor: Robert O. Vos, PhD GISP
Office: AHF B57B
Regular Office Hours: Mon and Wed 10 -11 am PT Also available other days and times by appointment via email.

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Course Scope and Purpose

Industrial ecology (IE) focuses on impacts to the natural world from the sharp increase in the rate and scale of human transformation of the earth following the industrial revolution. Concepts and tools covered in the course identify and measure impacts from the design and operation of the industrial system in categories such as ecological degradation, human health, and resource depletion. IE views these impacts as resulting from the interaction of underlying, complex technological, social, economic, and legal systems. IE is a heavily multidisciplinary field involving science and technology (engineering), public policy, economics, and business operations. The course focuses much less on problem sets than the traditional engineering course. Instead, it aims for understanding of major concepts and the ability to identify and execute a comparative environmental life cycle assessment (LCA) research project that meaningfully aids decision-making with regards to design, operation, or policymaking.

Learning Outcomes

On completion of this course, students should be able to:

- Articulate the core philosophy and principles of industrial ecology as it is practiced globally.
- Identify the benefits and limitations of tools like materials flow analysis, design for environment, environmentally extended input-output analysis, and process-based life-cycle assessment.
- Differentiate and choose appropriately among different tools for measuring environmental impacts of industrial systems.
- Relate the concepts of reverse logistics, industrial symbiosis, and biomimicry to design solutions for sustainability problems in the industrial system.
- Apply and operate screening-level life cycle assessment tools and software in case studies for product and packaging design.
- Conduct a comparative environmental life cycle assessment (LCA) in support of a decisions with respect to design, operations, or policy making for products, products systems, or infrastructure in the industrial system.

Prerequisite(s): Graduate standing or permission of the instructor
Co-Requisite(s): None

Course Structure

The main ongoing activities in this course comprise readings, attendance at lectures, and participation in discussions during lectures or asynchronously online. There are also four homework assignments to be completed, one midterm exam in Week 9 covering Weeks 1-8 of the course, and a cumulative final exam. The major activity of the semester is a final project, performing and reporting on comparative environmental life cycle assessment by teams of 3-5 students, as described below

The course is designed in three overarching sections. The first section of the course provides an overview of concepts and tools in industrial ecology. These include the concepts of systems thinking and industrial symbiosis, as well as an overview of design for the environment (DFE) and materials flow analysis (MFA). The second section of the course provides a more comprehensive coverage of life-cycle assessment (LCA) tools. The third section of the course looks at industrial ecology practice in the domains of consumer products, sustainable cities, energy, and water.

Workload – This is a 3-credit, one semester course. Students should expect to spend on average 9-hours per week completing the work in this course with weeks with heavier time commitment outside of class as the final project unfolds during Weeks 5-15.

Technological and Communication Requirements

Students will need to be able to competently use Microsoft Excel and Microsoft Office to produce the final project. Other than this, screening LCA modeling programs will be provided by the instructor or as freeware from the Internet. Instructions will be given on how to use this software during lectures, but will require additional self-study. These resources can be accessed from student's homes or offices using their own computers and Internet connections or from USC's on campus public (i.e., general) computer labs. All student will access course materials through the DEN learning content management system called "D2L." The DEN students will access class sessions via D2L and Cisco WebEx.

Required Readings and Supplementary Materials

The required textbooks for this course are:

- Graedel, T.E., and Allenby, B.R. 2010. *Industrial Ecology and Sustainable Engineering.* Upper Saddle River, New Jersey: Pearson Education. (This book is called "IE" in the course schedule below)
- Ashby, M.F. 2013. *Materials and the Environment: Eco-Informed Material Choice.* (2nd Edition) Amsterdam: Elsevier Publishers. (We call this book "Mat" in the course schedule below)

Supplementary readings will be provided on D2L from various sources including:

- Allenby, B.R. 2006. The ontologies of industrial ecology? *Progress in Industrial Ecology* 3: 28-40.
- Barnosky, A.D., et al. 2012. Approaching a state shift in Earth's biosphere. *Nature* 486: 52-58.
- Chertow, M.R. 2007. Uncovering industrial symbiosis. Journal of Industrial Ecology 11: 11-30.
- European Commission-Joint Research Centre-Institute for Environment and Sustainability. 2010. *International Reference Life Cycle Data System (ILCD) Handbook: General and Detailed Guidance*. (1st Edition). EUR 24708 EN. Luxembourg: Publications Office of the European Union.

For the final project in this course, you will also conduct online library research to find articles apply LCA methods in ways analogous to your own study or that provide data points for the system you are characterizing.

Description and Assessment of Assignments

Regular Course Assignments and Exams

Homework Assignments – 4 worth 20 points. There are four homework assignments worth five points each. Two of these are more like conventional problem sets, but require some conceptual work and operation of screening LCA software. The other two call on students to apply concepts learned in class to a case study and in an online discussion.

Extra Credit Homework Assignment – 1 worth 5 points extra credit. This homework calls on students to use a screening LCA software to evaluate two alternative designs for packaging orange juice.

Midterm Exam– 1 worth 15 points. The midterm is a closed book, 90-minute exam given during class in Week 9. It covers all material from reading, lectures, and homework from Weeks 1-8.

Final Exam– 1 worth 25 points. The final exam is a closed book, 120-minute exam given during the scheduled final examination period. It covers all material from reading, lectures, and homework from the entire course.

Final Project

The term project is designed to deepen the student's knowledge in the application of industrial ecology tools and techniques to technological systems. The learning objectives for the project are to be able to:

- Organize and structure a set questions for decision-making related to comparing technological systems, particularly on a life-cycle basis.
- Demonstrate creativity and initiative to analyze the interactions among complex technological system components.
- Competently model environmental impacts of the systems under study, where appropriate on an aggregated, quantitative basis.

The key parts of the final project are as follows:

Team Formation/Topic Selection - 2 points. Using the discussion function on D2L, I will give a list of topics to choose from and you should create threads to identify teams. Each team should have at least three and not more than five students. Each team should identify one student to act as "team leader," who will handle communication with the instructor. The team leader should email the instructor (also with a cc: to the teaching assistant) once the team is formed. This email should name the team members and briefly name and describe the topic in a few sentences. It should also be cc'd to all team members. This all must be accomplished no later than midnight Pacific Time on Sunday, January 21, 2018. Two points will be awarded

to each student who has been identified as joining a team by the deadline because experience shows that getting an early start on the project is essential to success.

First Project Presentation – 3 points. A detailed set of instructions and a grading rubric for the final project will be distributed during Week 2 of the course. During class in Week 8, teams will give a 10-minute first project presentation with an additional 5-minute discussion period. The first presentation will outline the research question or problem statement related to decision support, and it will give an initial proposal as to the analysis methods to be used. The presentation is graded, but it is worth relatively few points so that it serves primarily as an opportunity for formal feedback from the instructor to keep the team on a productive path. All students are required to be present live or on DEN WebEX for all presentations.

Final Project Oral Presentation - 15 points. A comprehensive 15-minute oral presentation of the final project given during the final class session in Week 15. It will be evaluated primarily on the effectiveness with which problem statement, methods, results, and limitations are concisely explained. All students are required to be present live or on DEN WebEX for all presentations.

Final Project Written Report - 20 points. A written report on your project methodology and outcomes. Detailed instructions will be given in the assignment distributed during Week 2. It will be evaluated both for technical proficiency and its writing quality.

Grading Breakdown

Assessment	Number	Points Each	Total Points
Regular Course Assignments and Exams			
Homework Assignments	4	5	20
Midterm Exam	1	15	15
Final Exam	1	25	25
Project Components			
Team Formation/Topic Selection	1	2	2
First Project Presentation	1	3	3
Final Project Oral Presentation	1	15	15
Final Project Written Report	1	20	20
Total	10	-	100 points

Course Policies

The following are the policies that apply in this course:

- Participate in class discussions and contribute individual or professional experiences when relevant to the topic so that others can benefit and learn.
- Take individual responsibility for completing homework assignments/term project activities and be responsible and collaborative team members for the final project.

- Readings are to be completed ***before*** the class sessions where they are indicated. Lectures will supplement but not cover readings, and the readings may be needed to effectively participate in exercises given during class time.
- In-class exercises, listed as *"Activity*," happen in the class period and are not graded.
- Unless otherwise noted, homework assignments are due the week ***after*** they are listed in the syllabus, allowing for questions or clarification during lectures and assistance during the week, if needed. Times/dates will be set as the Sunday before the next class at midnight on D2L. Links on D2L with specific assignment instructions and deadlines will be provided for submission.
- Late homework submissions or final project submissions will not be accepted and will receive a grade of F.
- Make-up examinations will only be offered in case of valid medical excuses, otherwise a missed examination will result in a grade of F.

Schedule

	Topic	Readings and Lecture Slides	Deliverables/Due Dates
Week 1 1/8	**Introduction**: Syllabus and key concepts. Are we approaching a state shift in Earth's biosphere? *Activity:* Project descriptions and team formation.	ISE 576 Syllabus IE Ch. 1-3 Mat Ch. 1 Barnosky et al. (2012) Slide Set: Course Intro	No deliverables
Week 2 1/16	**Martin Luther King Holiday** (no regular class meeting)		Team Formation due on Sunday, 1/21
Week 3 1/22	**Systems Thinking**: An overview of industrial ecology with a focus on complex systems and the scope of the field. *Activity:* Discussion of Allenby (2006)	IE Ch. 15 Mat Ch. 2 & 11 Allenby (2006) Slide Deck: Overview of IE Slide Set: Complex Systems	Homework 1: IE 15.1 & 15.3
Week 4 1/29	**Industrial Symbiosis:** Key opportunities and challenges for increased symbiosis, including spatial aspects of systems and design of infrastructure for eco-industrial parks. *Activity:* Work IE 16.4 together during class.	IE Ch. 5 & 16 Mat Ch. 4 Chertow (2007) Slide Set: Industrial Symbiosis Biomimicry Video (23 minutes): http://www.ted.com/index.php/talks/janine_benyus_shares_nature_s_designs.html	No deliverables
Week 5 2/5	**Life Cycle Assessment (LCA) Overview:** The LCA analysis process, including scoping, activity, and inventory stages. *Activity:* LCA system scope for a T-shirt and MAT	IE Ch. 12 Mat Ch. 3 Slide Set: LCA Overview Slide Set: LCA Process & Life Cycle Inventory (LCI)	No deliverables

	Topic	Readings and Lecture Slides	Deliverables/Due Dates
	3.4 & 3.6		
Week 6 2/12	**Life Cycle Assessment (Con't):** The LCA analysis process, with a focus on life cycle impact assessment models and interpretation stages.	IE Ch. 13 & 8-10 Slide Set: Life Cycle Impact Assessment	No deliverables
Week 7 2/19	**Presidents' Day Holiday** (No regular class meeting)		
Week 8 2/26	**First project presentations and midterm exam review**	None	Submit presentations to D2L *before* class on 2/26!
Week 9 3/5	**Midterm Exam and Streamlined Life Cycle Assessment (SCLA)**	IE Ch. 14 Slide Set: Streamlined LCA	Homework 2 Problem Set on SLCA
3/12	*Spring Recess 3/11-3/18*		
Week 10 3/19	**Economic Input-Output LCA:** An overview and software demonstration of environmentally extended input-output (EEIO) methods. *Activity: EIO-LCA group simulation*	IE Ch. 18 Slide Set: EIO-LCA Introduction Slide Set: EIO-LCA Policy Application Slide Set: EEIO for National Materials Accounts	Homework 3: Problem Set on EIO-LCA
Week 11 3/26	**Design for Environment (DfE) Overview:** Discussion of DfE, especially as applied to consumer packaging and packaging LCA software demonstration.	IE Ch. 10 Slide Set: Design for X Slide Set: Packaging LCA	No deliverables
Week 12 4/2	**Sustainable Consumption:** Overview of issues with consumption including sustainable commodity procurement and the role of LCA in product labeling	IE Ch. 7 Mat Ch. 5 Slide Set: Consumption and Consumer Products Slide Set: Carbon Footprint of Paper Products	Extra Credit Homework: Packaging LCA Comparison
Week 13 4/9	**Energy and Water:** An overview of IE concepts and tools related to energy and water. *Activity:* Discussion of renewables integration	IE Ch. 19 & 20 Slide Set/ Recorded Lecture: "Reaching 50% Renewables by 2030: Implications for Grid Operations"	Homework 4: Online Discussion

	Topics/Daily Activities	Readings and Lecture Slides	Deliverables/Due Dates
Week 14 4/3	**Sustainable Cities and Risk:** An overview of IE concepts and tools related to the practice area of sustainable cities and a concluding lecture on managing risk in IE	IE 6, 26,21, & 27 Mat 12 Slide Set: Sustainable Cities and Urban Metabolism Slides: Concluding Lecture on Risk and Earth Systems Engineering and Management (ESEM)	No deliverables
Week 15 4/10	**Final Project Presentations**	No readings or lecture slides	Project Papers to D2L **and** in hard copy at the end of class
Final Exam	Friday, May 4 from 11 a.m.-1 p.m. OHE 100B		

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems

Student Counseling Services (SCS) – (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. engemannshc.usc.edu/counseling

National Suicide Prevention Lifeline – 1 (800) 273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. www.suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender-based harm. engemannshc.usc.edu/rsvp

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: sarc.usc.edu

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086

Works with faculty, staff, visitors, applicants, and students around issues of protected class. equity.usc.edu

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. studentaffairs.usc.edu/bias-assessment-response-support

The Office of Disability Services and Programs
Provides certification for students with disabilities and helps arrange relevant accommodations. dsp.usc.edu

Student Support and Advocacy – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. studentaffairs.usc.edu/ssa

Diversity at USC
Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. diversity.usc.edu

USC Emergency Information
Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. emergency.usc.edu

USC Department of Public Safety – UPC: (213) 740-4321 – HSC: (323) 442-1000 – 24-hour emergency or to report a crime.
Provides overall safety to USC community. dps.usc.edu

Library Resources for DEN Students

All registered students can access electronic library resources through the link https://libraries.usc.edu/. Also, the USC Libraries have many important resources available for distance students through the link: https://libraries.usc.edu/faculty-students/distance-learners. This includes instructional videos, remote access to university resources, and other key contact information for distance students.