

Introduction

Human activities result in different types and levels of environmental impacts. Many decisions made at the design stage determine impacts of the products, structures, services and business units that manifest during production and use and beyond. Assessment of such impacts can be best done using a life cycle perspective. The analytical tool of life cycle assessment (LCA) supports informed decision-making by avoiding problem-shifting and sub-optimization. When dealing with measures of improving environmental performance, problem-shifting occurs between life cycle stages e.g. upstream to downstream parts of the life cycle. It may also occur between medium such as from air to water. Problem is also being shifted between space (e.g. from urban to rural) and between time (e.g. from today to future). LCA provides an opportunity to avoid such problem-shifting.

This course on LCA in design to be offered for undergraduate and graduate students helps would-be architects, engineers, business students and designers develop the skill of understanding the implications of the decisions they make at different levels of design.

Objectives

The course aims at developing an expertise in systems thinking of environmental implications of design and development of products, structures, services and business units. A basic competence in LCA will be provided by the course. After completing the course, students should be able to:

- Understand the overall purpose and principles of LCA.
- Describe the content and explain the purpose of the different steps of LCA.
- Carry out a complete LCA of a defined system according to the ISO standard for LCA.
- Write an LCA report complying with guidelines and terminology of the ISO standard.
- Discuss possible applications and limitations of LCA.
- Perform a third-party critical review of LCA works.

Teaching Approach

The course will be delivered through lectures, LCA Lab, and Project work and Critical Review.

Lectures

The lectures will provide a theoretical background of LCA covering:

1) Methodological

- Identification and delimitation of the system boundary
- Defining and handling of allocation problems
- Selection of characterization method
- Midpoint and endpoint approaches

2) Data

- Identification and use of data from LCA databases
- Collection and use of data from other sources

3) LCA Software Tools

- Tools available
- Use of LCA software tools

4) Results reporting and application

- Contents of an LCA report
- Analysis and interpretation of LCA results

LCA Lab

This will be a computer lab with an LCA software tool called SimaPro. Students will have the possibility to go through the different parts of the tool from the perspective of carrying an LCA work.

Projects and Critical Review

The project will be done in groups. The students will utilize the knowledge from the lectures and literature and will get an insight into the possibilities and challenges of carrying out an LCA by performing a full LCA of a product system of interest. SimaPro will be used for the project.

Three product systems namely, car, food and building will be the project areas. Groups will be formed and assigned with a topic by the course administration. Groups will have the possibilities for supervisions, if required and arranged in a timely fashion, at different phases of the project and are encouraged to make contact with relevant local industries.

Students will submit a group project report and will have access to another group report for a critical review. For more information, **see a separate memo on project.**

Content: Topic Areas

The main topic areas of the course are covered in the lectures outlined briefly below.

Introduction to LCA and to Project Work

This lecture reflects over how LCA can be used in different fields. It covers basic features of LCA including history of LCA and different phases of LCA. Introduction to the project work will also be given.

Goal and Scope Definition

This will give a basic framework of LCA covering aspects of system boundary, functional units, data quality requirements, etc.

Life Cycle Inventory Analysis

Based on the information from the Goal and Scope Definition, this will deal with the quantitative dimension of LCA including data collection and modeling of the product or service system under consideration.

Life Cycle Impact Assessment, Interpretations, Reporting and Critical Review

The methods and approaches for quantifying the environmental impacts using the data collected will be the focus of this lecture. Implication of the choices that are involved in applying the different methods of aggregating and weighting data will be covered. This will cover the different aspects of LCA reporting and critical view that are articulated in the ISO Standard for LCA.

Data availability and Data Quality in LCA and LCA Software Tools

Data uncertainty and associated issues will be the subject of this lecture. Brief outline of the selected LCA software tools available will be presented.

LCA Example 1– Food

This will consider issues related to an LCA of food products.

LCA Example 2– Automobile

This will consider issues related to an LCA of a car.

LCA Example 3– Building

This will consider issues related to an LCA of a building.

Means of Evaluation

The basis for final grade of the course will be composed of points achieved in the four components of the course namely, Project, Written Exam, LCA Lab and Class Participation. Each part will be graded out of 100 points.

The Project will be graded according to the structure shown below.

Item	Maximum Points
Goal and Scope Definition	20
Life Cycle Inventory	25
Life Cycle Impact Assessment	5
Interpretation	20
Overall analytical content of report	20
Critical Review	10

For more detail on project, **refer to a separate project memo.**

For the LCA Lab, points will be based on answers to written questions for each Lab session. The answers should be submitted before the start of the next Lab session.

Points for Class participation will be based on attendance of 75% of the non-Lab classes.

The points from the four components will be weighted as follows:

- | | |
|------------------------|-----------|
| 1. Project | 40% |
| 2. Written Exam | 30% |
| 3. LCA Lab | 25% |
| 4. Class Participation | <u>5%</u> |
| | 100% |

The final course points will be converted into final course grades as follows,

Final Course Points	Final Course Grade
92.5-100	A+
85-92.49	A
80-84.99	A-
76-79.99	B+
73-75.99	B
70-72.99	B-
66-69.99	C+
63-65.99	C
60-62.99	C-

56-59.99	D+
50-55.99	D
0-49.99	F

Correspondence between letter grades and 4-points scale will be based on EVDS standard grading scale.

Communication and Submission

Students are encouraged to contact course administration as follows,

Regarding the course as a whole:

E-mail: gassefa@ucalgary.ca

Phone: 403 220 6961

In person: PF 3191

Regarding LCA Lab:

E-mail: dydereri@ucalgary.ca

Submission of assignments (for both Project and LCA Lab) should be done via Blackboard. When and if Blackboard doesn't technically function for some reason during the time of submission, assignments can be submitted via e-mail.

Notes:

1. Written work, term assignments and other course related work may only be submitted by e-mail if prior permission to do so has been obtained from the course instructor.
2. It is the student's responsibility to request academic accommodations. If you are a student with a documented disability who may require academic accommodation and have not registered with the Disability Resource Centre, please contact their office at 220-8237. (<http://www.ucalgary.ca/drc/node/46>) Students who have not registered with the Disability Resource Centre are not eligible for formal academic accommodation. You are also required to discuss your needs with your instructor no later than fourteen (14) days after the start of this course.
3. Plagiarism - Plagiarism involves submitting or presenting work in a course as if it were the student's own work done expressly for that particular course when, in fact, it is not. Most commonly plagiarism exists when:(a) the work submitted or presented was done, in whole or in part, by an individual other than the one submitting or presenting the work (this includes having another impersonate the student or otherwise substituting the work of another for one's own in an examination or test),(b) parts of the work are taken from another source without reference to the original author,(c) the whole work (e.g., an essay) is copied from another source, and/or,(d) a student submits or presents work in one course which has also been submitted in another course(although it may be completely original with that student) without the knowledge of or prior agreement of the instructor involved. While it is recognized that scholarly work often involves reference to the ideas, data and conclusions of other scholars, intellectual honesty requires that such references be explicitly and clearly noted. Plagiarism is an extremely serious academic offence. It is recognized that clause (d) does not prevent a graduate student incorporating work previously done by him or her in a thesis. Any suspicion of plagiarism will be reported to the Dean, and dealt with as per the regulations in the University of Calgary Graduate Calendar.

4. Information regarding the Freedom of Information and Protection of Privacy Act (<http://www.ucalgary.ca/secretariat/privacy>) and how this impacts the receipt and delivery of course material
5. Emergency Evacuation/Assembly Points (<http://www.ucalgary.ca/emergencyplan/assemblypoints>)
6. Safewalk information (<http://www.ucalgary.ca/security/safewalk>)
7. Contact Info for: Student Union (<http://www.su.ucalgary.ca/page/affordability-accessibility/su-structure/contact-info>); Graduate Student representative (<http://www.ucalgary.ca/gsa/>) and Student Ombudsman's Office (<http://www.su.ucalgary.ca/page/quality-education/academic-services/student-rights>).

Readings

Text book (Recommended but not Required)

Baumann, H. and Tillman, A.-M. (2005) The Hitch Hiker's Guide to LCA. An orientation in life cycle assessment methodology and application. **Price at UofC Bookstore is 51.48 \$(New).**

Journal Articles (optional)

Reap J, Roman F, Duncan S, Bras B (2008a) A survey of unresolved problems in life cycle assessment—part 1: goal and scope and inventory analysis. *Int J Life Cycle Assess* 13(4):290–300

Reap J, Roman F, Duncan S, Bras B (2008b) A survey of unresolved problems in life cycle assessment—part 2: impact assessment and interpretation. *Int J Life Cycle Assess* 13(4):374–388

Khasreen ,MM, Banfill. PFG, and . Menzies, G.F. (2009) Life-Cycle Assessment and the Environmental Impact of Buildings: A Review. *Sustainability*, 674-701 28 pages Download from <http://mdpi.com/2071-1050/1/3/674/pdf>

Bare, J. C. and Gloria, T. P. (2006) Critical analysis of the mathematical relationships and comprehensiveness of life cycle impact assessment approaches. *Environmental Science and Technology*, 40(4), 1104-1113.

Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., Schmidt, W.-P., Suh, S., Weidema, B.P., Pennington, D.W. (2004) Life cycle assessment. Part 1: Framework, goal and scope definition, inventory analysis, and applications. *Environment International*, 30, 701-720.

Pennington, D.W., Potting, J., Finnveden, G., Lindeijer, E., Jolliete, O., Rydberg, T., Rebitzer, G. (2004) Life cycle assessment Part 2: Current impact assessment practice. *Environment International*, 721-739.

Hochschorner, E. and Finnveden, G. (2003) Evaluation of Two Simplified Life Cycle Assessment Methods. *International Journal of LCA*, 8, 119-128.

Schedule

Activity	Topic	Date	Time	Venue	Instructor	Rem.
Lecture 1	Introduction	Tuesday, Sept 11	18:00 - 19:10	PF2140	GAW	
No Lab	No Lab	Tuesday, Sept 11	19:20 - 20:50			
Lecture 2	Goal and scope definition	Tuesday, Sept 18	18:00 - 19:10	PF2140	GAW	
Lab 1	Overview and Goal and scope definition	Tuesday, Sept 18	19:20 - 20:50	PF2170	DYD	
Project 1	Project Work	Tuesday, Sept 25	18:00 - 19:10	PF2140	Unattended	
Project 2	Project Lab	Tuesday, Sept 25	19:20 - 20:50	PF2170	Unattended	
Lecture 3	Life Cycle Inventory	Tuesday, Oct 2	18:00 - 19:10	PF2140	GAW	
Lab 2	Life Cycle Inventory	Tuesday, Oct 2	19:20 - 20:50	PF2170	DYD	
Lecture 4	Life Cycle Impact Assessment and Interpretation	Tuesday, Oct 9	18:00 - 19:10	PF2140	GAW	
Lab 3	Life Cycle Impact Assessment and Interpretation	Tuesday, Oct 9	19:20 - 20:50	PF2170	DYD	
Lecture 5	Reporting and Critical Review	Tuesday, Oct 16	18:00 - 19:10	PF2140	GAW	
Project 3	Project Lab: Question and Answer	Tuesday, Oct 16	19:20 - 20:50	PF2170	DYD	
Lecture 6	Databases, Data availability, quality and LCA software	Tuesday, Oct 23	18:00 - 19:10	PF2140	GAW	
Lab 4	Databases	Tuesday, Oct 23	19:20 - 20:50	PF2170	DYD	
Lecture 7	Streamlined LCA and LCA in Practice	Tuesday, Oct 30	18:00 - 19:10	PF2140	GAW	
Lab 5	Uncertainty Analysis	Tuesday, Oct 30	19:20 - 20:50	PF2170	DYD	
Lecture 8	LCA Examples-Food and Car	Tuesday, Nov 6	18:00 - 19:10	PF2140	GAW	
Project 4	Project Lab: Question and Answer	Tuesday, Nov 6	19:20 - 20:50	PF2170	DYD	
Lecture 9	LCA Example-Building and Course Summary	Tuesday, Nov 13	18:00 - 19:10	PF2140	GAW	
Project 5	Project Lab: : Question and Answer	Tuesday, Nov 13	19:20 - 20:50	PF2170	DYD	
Project 6	Project Work : Question and Answer	Tuesday, Nov 20	18:00 - 19:10	PF2140	GAW and DYD	
Project 7	Project Lab	Tuesday, Nov 20	19:20 - 20:50	PF2170	DYD	
Project 8	Project Work : Question and Answer	Tuesday, Nov 27	18:00 - 19:10	PF2140	GAW and DYD	
Project 9	Project Lab: Question and Answer	Tuesday, Nov 27	19:20 - 20:50	PF2170	DYD	
Submission of Final Project Report		Wednesday, Dec 5	16:00			

GAW: Getachew Assefa Wondimeagegnehu DYD: Debebe Yilma Dererie