Life Cycle Assessment in Design EVDS 683.85/ ENEN 693 H(2-1)

Getachew Assefa **Fall 2016 (Thursdays 6:30PM-9:20PM)**

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Introduction

Human activities result in different types of environmental impacts at different levels. Many decisions made at the design stage determine impacts of the products, structures, services and business units that manifest during production, 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. Burden is also being shifted in space (e.g. from urban to rural) and in time (e.g. from today to the future). LCA provides an opportunity of, at least, minimizing such problem-shifting.

This course on LCA in design, offered for senior undergraduate and graduate students, helps would-be engineers, architects, designers and business professionals develop the skill of understanding the far-reaching and lasting implications of the decisions they make at different levels of product and service design and development.

Requirement of Prior Knowledge

There is no formal prior knowledge requirement.

Objectives

The course aims at contributing to the development of 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 based on the ISO standard for LCA.
- Write an LCA report complying with guidelines and terminologies of the ISO standard.
- Discuss possible applications and limitations of LCA.
- Understand how a third-party critical review of LCA is done.

Teaching Approach

The course will be delivered through Lectures, Case Study Presentation, LCA Lab, Project work (Presentation and Report), and Critical Review.

i) Lectures

The lectures will provide a theoretical background of LCA covering, among others, the following:

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

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.

Data availability and Data Quality in LCA and LCA Software Tools

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

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 also cover the different aspects of LCA reporting and critical review that are articulated in the ISO Standard for LCA.

LCA Examples

These will consider issues related to different product systems.

ii) LCA LAB (Individual Submission)

This will be a computer lab with an LCA software tool called SimaPro. Students individually will go through the different parts of the tool from the perspective of carrying out an LCA work that is related to the Project below. **See a separate LCA LAB Instruction.**

iii) Case Study (Group Presentation)

Case Study presentation will be done in groups based on published LCA studies (see below). The groups will be maintained to work on a project related to the same product system. The task here is to **present** the **content** and **result** of the article and add **own reflection and evaluation on weaknesses and strengths** of the LCA study reported. For summary of content and results, you may use the four phases of LCA i.e. GSD, LCI, LCIA and Interpretation as a guide. **For weakness and strengths evaluation, use the Critical Review format used in the Franklin Associates report under section (V) below**.

PV System

Fu, Y., Liu, X., & Yuan, Z. (2015). Life-cycle assessment of multi-crystalline photovoltaic (PV) systems in China. Journal of Cleaner Production, 86, 180-190.

Passenger Car

Schmidt, W. P., Dahlqvist, E., Finkbeiner, M., Krinke, S., Lazzari, S., Oschmann, D., ... & Thiel, C. (2004). Life cycle assessment of lightweight and end-of-life scenarios for generic compact class passenger vehicles. The International Journal of Life Cycle Assessment, 9(6), 405-416.

Building

Proietti, S., Sdringola, P., Desideri, U., Zepparelli, F., Masciarelli, F., & Castellani, F. (2013). Life cycle assessment of a passive house in a seismic temperate zone. Energy and Buildings, 64, 463-472.

SmartPhone (if more than three groups are required)

Zink, T., Maker, F., Geyer, R., Amirtharajah, R., & Akella, V. (2014). Comparative life cycle assessment of smartphone reuse: Repurposing vs. refurbishment. The International Journal of Life Cycle Assessment, 19(5), 1099-1109. doi:10.1007/s11367-014-0720-7

iv) Project (Group Presentation and Report)

The project will be done in groups, same as the Caste Study. 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 choice from the list below. SimaPro will be used for the project.

Project Topics:

- PV System
- Passenger Car
- Building
- SmartPhone (if more than three groups are required)

For detailed requirements regarding expectations on the project, see a separate Project Description.

v) Critical Review (Group submission)

The task here is to summarize the Critical Review entitled "Peer Review" that **starts on Page 91(Addendum 2)** of the LCA study report ***Franklin Associates (2009) Life Cycle Inventory of Three Single-Serving Soft Drink Containers. Franklin Associates, A Division of ERG, Prairie Village, KS. 6).***

For the critical review summary to be done in groups, students are encouraged to use the same structure used in their project to synthesize the Critical Review. **Reflecting on the weakness and strengths of the Critical Review in relation to Goal and Scope Definition, Life Cycle Inventory, Life Cycle Impact Assessment and Interpretation will result in additional points.** The Summary should be a maximum of **three (3) pages** [times new roman 12 points, single spacing, and 0.5 inches margin on all sides].

Means of Evaluation

The final grade of the course will be composed of points achieved in the components of the course namely Case Study Presentation, Project Presentation and Report, Critical Review, two Tests, LCA Lab and Class Participation.

The points from each component will be graded as follows:

1. GSD	5
2. Project Report	25
3. Project Presentation	10
4. Test 1	15
5. Test 2	15
6. Case Study Presentation	10
7. LCA LAB	10
8. Critical Review	5
9. Class Participation	5
	100

The **Project Report** will be graded according to the marks shown below.

Item	Maximum Points
GSD	3
Life Cycle Inventory	7
Life Cycle Impact Assessment	5
Interpretation	10

Note that the **Goal and Scope Definition** part to be submitted on **October 27** will be graded separately and it should also be submitted as part of the **Project Report**. For a potential additional points for this part, a resubmission of a revised version as more knowledge is gained as the Project progresses is possible as part of the Final Project Report.

Case study Presentation **will be a maximum of 20 minutes per group** and will be marked based on individual performance during the Presentation and answers to questions asked. Hence substantial contribution from each group member is expected during preparation and presentation

and quality of content of presentation file.

Project Presentation **will also for a maximum of 20 minutes per group and** will be marked based on individual performance during the Presentation and answers to questions asked and quality of content of presentation file.
Hence substantial contribution from each group member is expected during preparation and presentation.

Presentations files for the Case Study should be submitted via DropBox in D2L before 9 AM on November 24, 2016.

Presentations files for the Project should be submitted via DropBox in D2L before 9 AM on December 8, 2016.

Project Report will be marked based on group performance except in the case where peer-rating and minutes signed by all members of the group are submitted and imply differential contribution.

For more detail on the project, **refer to a separate Project Description.**

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 LCA LAB session on the indicated dates and times (**See a separate LCA Lab Instruction).**

To get the minimum point of 3 out of 5 **for Class Participation**, an attendance of 75% of the non-Lab classes is enough. To exceed this minimum point, active participation in class is required.

Final grades will be reported as letter grades, with the final grade calculated according to the 4- point range. Correspondence between letter grades and 4-points scale will be based on the following grading scale.

Grade	Grade Point Value	4-Point Range	Percent	Description
A+	4.00	4.00	95-100	Outstanding - evaluated by instructor
A	4.00	3.85-4.00	90-94.99	Excellent - superior performance showing comprehensive understanding of the subject matter
A-	3.70	3.50-3.84	85-89.99	Very good performance
B+	3.30	3.15-3.49	80-84.99	Good performance
B	3.00	2.85-3.14	75-79.99	Satisfactory performance
B-	2.70	2.50-2.84	70-74.99	Minimum pass for students in the Faculty of Graduate Studies
C+	2.30	2.15-2.49	65-69.99	All final grades below B- are indicative of failure at the graduate level and cannot be counted toward Faculty of Graduate Studies course requirements.
C	2.00	1.85-2.14	60-64.99	

C-	1.70	1.50-1.84	55-59.99	
D+	1.30	1.15-1.49	50-54.99	
D	1.00	0.50-1.14	45-49.99	
F	0.00	0-0.49	0-44.99	

Notes:

- A student who receives a "C+" or lower in any one course will be required to withdraw regardless of their grade point average (GPA) unless the program recommends otherwise. If the program permits the student to retake a failed course, the second grade will replace the initial grade in the calculation of the GPA, and both grades will appear on the transcript.
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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: Vrinda Narayan

E-mail: vsnaraya@ucalgary.ca

Submission of assignments (for both Project and LCA Lab) should **ONLY** be **done via Dropbox on D2L.**

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. Submissions must come from an official University of Calgary (ucalgary) email account.

2. Academic Accommodations. Students who require an accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a protected ground other than disability, should communicate this need, preferably in writing, to their Instructor or the designated contact person in EVDS, Jennifer Taillefer (jtaillef@ucalgary.ca). Students who require an accommodation unrelated to their coursework or the requirements for a graduate degree, based on a protected ground other than disability, should communicate this need, preferably in writing, to the Vice-Provost (Student Experience). For additional information on support services and accommodations for students with disabilities, visit www.ucalgary.ca/access/

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 (https://www.su.ucalgary.ca/contact/); Graduate Student representative(http://www.ucalgary.ca/gsa/) and Student Ombudsman's Office (http://www.ucalgary.ca/ombuds/).

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.

Klöpffer, W. and Grah, B. (2014) Life Cycle Assessment (LCA): A Guide to Best Practice. John Wiley & Sons. (e-book through University of Calgary Library website) http://site.ebrary.com.ezproxy.lib.ucalgary.ca/lib/ucalgary/detail.action?docID=10855742

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.

Project files

Ardente, F., Beccali, G., Cellura, M., & Lo Brano, V. (2005). Life cycle assessment of a solar thermal collector. Renewable Energy, 30(7), 1031-1054. doi:10.1016/j.renene.2004.09.009

Martínez, E., Sanz, F., Pellegrini, S., Jiménez, E., & Blanco, J. (2009). Life-cycle assessment of a 2-MW rated power wind turbine: CML method. The International Journal of Life Cycle Assessment, 14(1), 52-63. doi:10.1007/s11367-008-0033-9

Castro, M., Remmerswaal, J., & Reuter, M. (2003). Life cycle impact assessment of the average passenger vehicle in the Netherlands. International Journal of Life Cycle Assessment, 8(5), 297-304. doi:10.1065/lca2003.07.127

Scheuer, C., Keoleian, G. A., & Reppe, P. (2003). Life cycle energy and environmental performance of a new university building: Modeling challenges and design implications. Energy & Buildings, 35(10), 1049-1064. doi:10.1016/S0378-7788(03)00066-5

Apple (2014) iPhone 6 Environmental Report
https://www.apple.com/environment/pdf/products/iphone/iPhone6_PER_Sept2014.pdf

Tentative Schedule

Date	Time	Activity	Topic	Venue	Instru
Thursday, Sept 15	18:30 - 19:40	Lecture 1	Introduction and Project	PF2140	GA
	19:50 - 21:20	Lecture 2	LCA Example – Coffee Machine	PF2140	GA
Thursday, Sept 22	18:30 - 19:40	Lecture 3	Sustainability assessment and LCA: The Case of DIRTT	PF2140	AI
	19:50 - 21:20	Lecture 4	LCA Example – Wooden Shed and Biofuel and SimaPro Overview :Coffee Machine	PF2140	GA
Thursday, Sept 29	18:30 - 19:40	Lecture 5	Goal and Scope Definition	PF2140	GA
	19:50 - 21:20	Special Lab	SimaPro Overview: Wood Shed	PF2170	GA
Thursday, Oct 06	18:30 - 19:40	Lecture 6	Life Cycle Inventory	PF2140	GA
	19:50 - 21:20	Lab 1	Goal and scope definition	PF2170	GA
Thursday, Oct 20	18:30 - 19:40	Special Lab	SimaPro Overview: Wood Shed continued	PF2140	GA
	19:50 - 21:20	Lab 2	Life Cycle Inventory	PF2170	GA
Thursday, Oct 27	18:30 - 19:30	Test	Test 1	PF2140	GA
	After test	Lecture 7	Data availability, quality and Databases	PF2140	GA
		Lab 3	Databases	PF2170	GA
Thursday, Nov 03	18:30 - 19:40	Lecture 8	Life Cycle Impact Assessment, LCA software and Interpretation	PF2140	GA
	19:50 -21:20	Lab 4	Life Cycle Impact Assessment and Interpretation	PF2170	GA
Thursday, Nov 17	18:30 - 19:40	Lecture 9	Reporting and Critical Review	PF2140	GA
	19:50 - 21:20	Lecture 10	Environmental Product Declarations	PF2140	GA
Thursday, Nov 24	18:30 - 21:20	Presentation	Case Study Presentation	PF2140	GA
Thursday, Dec 01	18:30 - 19:30	Test	Test 2	PF2140	GA
	After test	Lecture 11	Streamlined LCA and LCA in Practice	PF2140	GA
		Project	Project Lab: Q & A	PF2170	GA
Thursday, Dec 08	18:30 - 21:20	Presentation	Project Presentation	PF2170	GA

GA: Getachew Assefa AI: Andrée Iffrig

Submission Deadlines

Goal and Scope Definition (word and pdf file)	**Thursday, Oct 27**	**12:00 am**
Case Study Presentation (ppt file)	**Thursday, Nov 24**	**9:00 am**
Project Presentation (ppt file)	**Thursday, Dec 08**	**9:00 am**
Project Report (word and pdf file)	**Thursday Dec 15**	**12:00 am**
Summary of Critical Review (word and pdf file)	**Friday Dec 16**	**12:00 am**