

Winter 2019: ENBUS 307

Industrial Ecology: Life Cycle Assessment and Management in Business and Policy

Faculty of Environment, University of Waterloo

Room: EV1-350

Date & Time: M and W 10:00-11:20 am

Instructor: Prof. Goretty Dias gdias@uwaterloo.ca; EV3-4251; 519-888-4567 X 38571

Office Hours: Wednesday 1 to 2

TA: Alben Bukurova

Pre-requisite

ENBUS 204; Level: at least 3A Environment and Business students

Course description

This course builds students' technical competencies in life cycle assessment (LCA) and in critical analysis of products' environmental impacts through an understanding of life cycle management. Course content covers the ISO life-cycle assessment framework, how to conduct technical LCA (including applying quantitative approaches using LCA software and databases, as available and appropriate), challenges of application of LCA to a range of product systems, limitations of LCA, and product life cycle management concepts for business and policy decisions. Students will use the knowledge gained to conduct their own technical LCA, with a focus on using it for business and policy decisions.

Course Objectives and Learning Outcomes

The desired outcomes from this course are to:

1. Describe the 4 phases in doing an LCA study and explain the limitations in applying the framework
2. Critically analyze LCA studies using ISO guidelines
3. Learn the technical skills required to conduct an ISO standard LCA
4. Understand and articulate the appropriate use and limitations of LCA as a tool for sustainability assessment

Course Text & Readings

Required (posted on Learn):

E-text (free):

Matthews S, Hendricks and Matthews D. 2015. LCA: Quantitative approaches for decisions that matter.

<https://www.lcatextbook.com/>

Case study

Montalbo T, Gregory J, Kirchain R. 2011. Life Cycle Assessment of Hand Drying Systems. Materials systems Laboratory Massachusetts Institute of Technology, 51 pp.

Supporting Readings

Finnveden G, Hauschild MZ, Ekvall T, Guinée J, Heijungs R, Hellweg S, Koehler A, Pennington S, Suh S. 2009. Recent developments in Life cycle assessment. J. Environmental Management, 91 (1) pp. 1-21.

Reap, J., Roman, F., Duncan, S., and 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. 13:290–300.

Reap, J., Roman, F., Duncan, S., and Bras, B. 2008b. A survey of unresolved problems in life cycle assessment-Part 2: impact assessment and interpretation. Int J Life Cycle Assess. 13:374-388.

Rebitzer, G., T. Ekvall, R. Frischknecht, D. Hunkeler, G. Norris, T. Rydberg, W. -P. Schmidt, S. Suh, B. P. Weidema and D. W. Pennington. 2004. Life cycle assessment: Part 1: Framework, goal and scope definition, inventory analysis, and applications, Environ. Int. 30 (5), 701-720.

Sim, S., H. King, and E. Price. 2016. The Role of Science in Shaping sustainable Business: Unilever Case Study. Ch. 15 Taking Stock of Industrial Ecology. R. Clift, A. Druckman (Eds.). DOI 10.1007/978-3-319-20571-7_15. https://link.springer.com/chapter/10.1007%2F978-3-319-20571-7_15

Weidema, B.P. and Wesnaes MS. 1996. Data quality management for life cycle inventories-an example of using data quality indicators. J. Cleaner Prod. 4 (3-1), pp. 167-174.

Reading for Critical Review Test

Ellingsen H and Aanonsen SA. 2006. Environmental impacts of Wild Caught Cod and Farmed Salmon-A comparison with chicken. Int. J. LCA. 11: 60-65.

Optional Reading for Critical Review Test

Pelletier N, P Tyedmers, U Sonesson, A Scholz, F Ziegler, A Flysjö, S Kruse, B Cancino and H Silverman. 2009. Not All Salmon Are Created Equal: Life Cycle Assessment (LCA) of Global Salmon Farming Systems. Environ. Sci. Technol. 2009 43, 8730–8736.

Other resources/readings are provided on Learn.

Summary of Course Assessment Items

Please note: Unless otherwise indicated, all assignments should be submitted online using LEARN. A detailed description of the requirements for each assignment is available on LEARN.

Assessment	Description	Due Date	Weight (%)
Minor assignments (I)*	To be described and explained in class and due by 7 pm of date assigned, unless otherwise stated.	As per lecture schedule and below*	30
Goal and Scope document (G)	Detailed report describing how you will conduct your LCA, and what data you will use.	February 13 March 6	3 (Draft) 7 (Final)
Tests (I)	Critical review test (Open-book- Review an LCA study for adherence to ISO standards)	February 27	10
	Final test (Open-book- Test on LCA concepts from lectures and presentations)	April 3	10
Group Presentation (G)	Present how LCA concepts are being used to provide decision-support to companies/ Business/ policy	Slides due March 17, 7 pm Presentations will be on March 18,20,25,27	13
Participation	Attendance during group presentations	Sign in on March 18,20,25,27	4
Final project report and model (G)	LCA study report, detailed Excel calculations, and software model results.	April 5, 11:59 pm	23
Peer evaluation	Evaluate your group members' contributions. This is used to adjust individual's contributions to group work (LCA project and presentations).	<ul style="list-style-type: none"> • Mid-term evaluation: February 13, 11:59 pm • Final evaluation: April 5, 11:59 pm 	N/A

*Assessment category: G=group; I= individual

*** Minor assignments-due at 7 pm on due date.**

Minor Assignment #	Date Due	In-class assignment name	Weight (%)
1	January 14	Functional unit exercise	2
2	January 16	Flow diagram exercise	2
3	January 21	Estimations and Assumptions	3
4	January 23	Data quality exercise	2
5	January 28	Functional unit calculations	2
6	January 30	Allocation calculations	2
7	February 4	Impact assessment exercise	2
8	February 6	Gantt chart for group work	4
9	February 25	Goal and Scope Review	3
10	March 4	Excel spreadsheet best practices	5
11	March 31	Thought-provoking questions	3

TENTATIVE LECTURE SCHEDULE

The following is the tentative weekly schedule for this course. I will adjust as needed and will provide information on changes during class. **CS**= Case study; **E&A** = Ellingsen & Aanondsen (2006)

The readings and case study support course lecture material and are to be used to help understand concepts for tests and for your LCA project. They can be read thoroughly or skimmed through depending on your understanding or needs. The critical review reading (E&A) must be read thoroughly in order to succeed in the critical review test, and should be read with the accompanying lecture material/readings in mind.

Date	Class #	Topic	Readings	Case study & Critical Review Reading	Assignment/Activity	Due Date
M-Jan. 7	1	Course expectations and Introduction to LCA-Dimensional Analysis			Initiate choosing group for presentations & project –Work in groups of three	
W-Jan. 9	2	Introduction to ISO framework, Case study, and Major LCA Project	Text Ch. 1; Ch. 4, 80-83; Rebitzer et al. (2004), 701-704; Reap et al. (2008a) Part 1, 290-296	CS : Section 1	Initiate discussion on which product to do your LCA on	See the following for ideas https://www.sciencedirect.com/sdfe/pdf/download/eid/3-s2.0-B9780123859716000087/first-page-pdf
M-Jan. 14	3	Goal and Scope- Part 1: SDPs and Functional Units	Text Ch. 4, 83-88; Reap et al. (2008a) Part 1, 290-296	CS : Section 2, 6-8; E&A (2006): Section 1	Functional unit exercise (2%)	Jan. 14 at 7 pm
W-Jan. 16	4	Goal and Scope- Part 2: Boundaries and impact categories + Introduction to Flow Diagrams	Text Ch. 4, 88-94 Read assignment description for “Goal and scope”	CS : Section 2.2.2, 8-10; E&A (2006): Section 1	Flow diagram exercise (2%) Finalize group and topic for LCA project Define boundaries and impact categories for your G&S assignment	Jan. 16 at 7 pm
M-Jan. 21	5	LCI-Part 1: Quantitative methods for LCA- Estimations, assumptions and Introduction to excel skills	Text Ch. 2, 34-58	E&A (2006): Section 2	Estimation and assumption exercise in Excel (3%)	Jan. 21 at 7 pm
W-Jan. 23	6	LCI-Part 2: Data collection and data quality-Excel skills continued	Text Ch. 5, 98-109; Weidema and Wesnaes (1996), 167-171	CS : Section 3, Section A.1 & A.2;	Data quality exercise (2%)	Jan. 23 at 7 pm

Date	Class #	Topic	Readings	Case study & Critical Review Reading	Assignment/Activity	Due Date
				E&A (2006): Section 2	Define your data quality requirements for G&S Assignment	
M-Jan. 28	7	LCI-Part 3: Normalizing data based on functional unit	Text Ch. 5, 98-109; Rebitzer et al. (2004), p. 706-713	CS: Section 3, Section A.1 & A.2	Functional unit calculations (2%)	Jan. 28 at 7 pm
W-Jan. 30	8	LCI-Part 4: Allocation	Text Ch. 6; Reap et al. (2008a) Part 1, 296-299	CS: Section A.4, 95; Section 2.2.2-2.2.3	Allocation calculation (2%)	Jan. 30 at 7 pm
M-Feb. 4	9	Life Cycle Impact Assessment	Text Ch. 10, 283-298, 302-308; Reap et al. (2008b), 379-386	CS: Section 4; E&A (2006), Section 3	Impact assessment exercise (2%)	Feb. 4 at 7 pm
W-Feb. 6	10	Life Cycle Interpretation + group work if time allows	Text Ch. 2, 59, 110-111; Reap et al. (2008b), 379-386	CS: Section 5 (omit 5.2); Section 6; E&A (2006), Section 4&5	Gantt chart for group work on LCA project and presentation (4%) Work on your G&S Assignment	Feb. 6 at 7 pm
M-Feb. 11	11	In-class group work on G&S Assignment			Work on your G&S assignment	
W-Feb. 13	12	Presentations: Introduction to LCA for business/policy decisions + group work if time allows	Read assignment description for "Group Presentation"		Choose a company for doing your presentation on Submit finalized draft of G&S (3%) Peer evaluation	Feb. 13, end of class Feb. 13, 7 pm Feb. 13, 11:59 pm
Reading Week (Feb. 19-22)						
M-Feb. 25	13	Critical review Q&A In-class Goal and Scope Review			Review another group's assignment (3%)	Feb. 25, 7 pm
W-Feb. 27	14	Critical Review Test	E&A (2006)		Open-book test (10%)	Due at end of class

Date	Class #	Topic	Readings	Case study & Critical Review Reading	Assignment/Activity	Due Date
M-Mar. 4	15	Good practice in Excel for project modeling <i>+ group work if time allows</i>	Text Ch. 5, 151-155		Excel spreadsheet exercise (5%)	Mar. 4, 7 pm
W-Mar. 6	16	Introduction to EarthSmart software <i>+ group work if time allows</i>	Review description of EarthSmart example (On Learn)		G&S assignment (final version-7%)	Mar. 6, 11:59 pm
M-Mar. 11	17	In-class group work			Work on your project and/or presentation	
W-Mar. 13	18	In-class group work			Work on your project and/or presentation	
M-Mar. 18	19	Presentations			Submit visuals for presentation (15%)	March 17, 7 pm
W-Mar. 20	20	Presentations				
M-Mar. 25	21	Presentations				
W-Mar. 27	22	Presentations				
M-Apr. 1	23	Summary of course, presentations, and Limitations of LCA for sustainability	Sim, King, and Price (2016)		Submit 2 thought-provoking questions 1 on Sim et al. paper 1 on course content (3%)	March 31, 7 pm
W-Apr. 3	24	Final test			(10%)	10:05-11:10 am
Final project and peer evaluation due on April 5 at 11:59 pm						

Course Policies

Communications with Instructor and Teaching Assistants:

All communication with students must be through either the student's University of Waterloo email account or via Learn. If a student emails me or the TA from a personal account they will be requested to resend the email using their personal University of Waterloo email account.

I want to help you succeed in this course. To help me help you, please keep the following in mind:

I will try to reply to legitimate inquiries from students within 2 business days (M to F). Please ensure that you include the **course number** in the subject line, as well as a meaningful descriptor of the topic of your inquiry (I will delete emails without a Subject Line). I will not answer any questions that have already been answered through the course outline or other course materials, so make sure you consult your course resources before submitting inquiries. General questions on process, assignments, evaluations, etc. should be posted on LEARN and "General Discussion". Please see me during office hours for help with any course material or email me to make an appointment if you can't make it to office hours. I will meet you based on my availability. I have another course to teach, graduate students to mentor, and a research program to run, so I'm not widely available. I will work with you to try to find a reasonable time that works for a meeting outside office hours.

Policy on Late Submissions

I do not allow late submissions unless you have compassionate grounds for lateness. Should you not be able to meet a deadline due to compassionate reasons (e.g. illness or death in the family), you must try to contact me and let me know BEFORE the deadline, or as soon as possible thereafter. It is unacceptable to wait to contact me more than a couple of days after a deadline. In the event you require an extension due to compassionate reasons, you may **be asked for documentation**. Technology failures are NOT acceptable reasons for lateness.

Submissions are due by the times and dates indicated. Submissions received after this time will be penalized 5 per cent per day, or any part thereof, including weekends (i.e. 5% of an assignment that is worth 10% of your course grade would be penalized 0.5% of your final grade per day). Only in exceptional cases will this penalty be waived!

Lecture Attendance and In-class Assignments

You are responsible for attending all lectures or getting notes and information from your peers if you miss a lecture. I will not provide individuals with course notes, information that was provided in class, etc. I will post all lectures within 24 hours after the class. If you miss an in-class assignment, you will get 0 unless there are extenuating circumstances. It is **your responsibility** to contact me as soon as possible in this situation.

Learn (D2L)

I will be using Learn (D2L) online for this course. The course website will be the PRIMARY mode of communication for this course. Please ensure that you check this website regularly for announcements and other material that may be added from time to time. You will also be posting in-class assignments to Learn, where appropriate. It is your responsibility to ensure that your Learn (D2L) email address is kept up to date in case I need to send you a message individually. Unless otherwise noted on the Assignment outline, all assignments must be **submitted electronically to Learn (D2L)** by the indicated deadline. Any handouts as well as lecture notes that are important will also be added to the website throughout the semester. **Detailed descriptions of the requirements for each assignment are also placed on Learn (D2L).**

Policy on Use of Electronics and Electronic Media in Class

Laptop use in-class

Laptops are permitted in class for **course-related purposes only**. **You will need a laptop (or calculator) in most classes for in-class assignments.** While I encourage the use of laptops in this course, I request that you have a sense of **courtesy and respect** and do not misuse the computer in class. Anybody found accessing the internet for other purposes (e.g. checking email, chatting, Facebook, noncourse sites, playing on-line games, etc.), or using laptops off-line for non-course purposes (e.g. games, movies, music), **will be asked to leave the class**. I also refer you to university policy:

University Policy 33 ("Ethical Behaviour") states that "no member of the University community (faculty, staff, student) may unduly interfere with the study, work or working environment of other members of the University or any aspect of another's University activity." The policy adds that "A 'poisoned environment' (or one that is intimidating, hostile or offensive) can be created based on any of the prohibited grounds under the Ontario Human Rights Code, and can be described as comment or conduct that is contrary to the aims of maintaining a supportive, respectful and tolerant environment." Using a laptop to view potentially offensive or inappropriate images during class could certainly contravene this policy, and an instructor would therefore have the responsibility to direct a student to refrain from this activity during class. Similarly, if a student is using a laptop in class to view material that is not offensive per se but merely distracting to others -- for example, a video of a high-speed car-chase -- it might reasonably be deemed to "interfere with the study, work or working environment of other members" of the class.

I may ask that you close your laptops for short times during certain activities, such as during a small group discussion.

Cell phones and other mobile devices

Please make sure that all cell phones, iPhones, smart phones, similar devices are turned off while in-class. If you are found using these during lectures, you will be asked to leave the classroom if you want to continue using them.

General Academic Information**Academic Integrity**

Academic integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check the Office of Academic Integrity for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions. [Check the Office of Academic Integrity for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties, check Guidelines for the Assessment of Penalties.

Appeals: A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72, Student Appeals.

Note for students with disabilities: AccessAbility Services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Turnitin.com: Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit alternate assignment.

Intellectual Property:

For further information on IP related to teaching, please see https://uwaterloo.ca/legal-and-immigration-services/sites/ca.legal-and-immigration-services/files/uploads/files/volume_1_issue_3_winter_2018.pdf and the Guidelines for Faculty, Staff and Students Entering Relationships with External Organizations Offering Access to Course Materials, <https://uwaterloo.ca/secretariat/faculty-staff-and-students-entering-relationships-external>. The following text is recommended:

Students should be aware that this course contains the intellectual property of their instructor, TA, and/or the University of Waterloo. Intellectual property includes items such as:

- Lecture content, spoken and written (and any audio/video recording thereof);
- Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides);
- Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and
- Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Course materials and the intellectual property contained therein, are used to enhance a student's educational experience. However, sharing this intellectual property without the intellectual property owner's permission is a violation of intellectual property rights. For this reason, it is necessary to ask the instructor, TA and/or the University of Waterloo for permission before uploading and sharing the intellectual property of others online (e.g., to an online repository).

Permission from an instructor, TA or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years. In many cases, instructors might be happy to allow distribution of certain materials. However, doing so without expressed permission is considered a violation of intellectual property rights.

Please alert the instructor if you become aware of intellectual property belonging to others (past or present) circulating, either through the student body or online. The intellectual property rights owner deserves to know (and may have already given their consent).

Recording lectures:

- Use of recording devices during lectures is only allowed with explicit permission of the instructor of the course.
- If allowed, video recordings may only include images of the instructor and not fellow classmates.
- Posting of videos or links to the video to any website, including but not limited to social media sites such as: facebook, twitter, etc., is strictly prohibited.

Mental Health:

The University of Waterloo, the Faculty of Environment and our Departments/Schools consider students' well-being to be extremely important. We recognize that throughout the term students may face health challenges - physical and / or emotional. Please note that help is available. Mental health is a serious issue for everyone and can affect your ability to do your best work. Counselling Services <http://www.uwaterloo.ca/counselling-services> is an inclusive, non-judgmental, and confidential space for anyone to seek support. They offer confidential counselling for a variety of areas including anxiety, stress management, depression, grief, substance use, sexuality, relationship issues, and much more.

Religious Observances:

Students need to inform the instructor at the beginning of term if special accommodation needs to be made for religious observances that are not otherwise accounted for in the scheduling of classes and assignments.

Unclaimed assignments

Unclaimed assignments will be retained until one month after term grades become official in Quest. After that time, they will be destroyed in compliance with UW's confidential shredding procedures.

Research Ethics:

The University of Waterloo requires all research conducted by its students, staff, and faculty which involves humans as participants to undergo prior ethics review and clearance through the Director, Office of Human Research and Animal Care (Office). The ethics review and clearance processes are intended to ensure that projects comply with the Office's Guidelines for Research with Human Participants (Guidelines) as well as those of provincial and federal agencies, and that the safety, rights and welfare of participants are adequately protected. The Guidelines inform researchers about ethical issues and procedures which are of concern when conducting research with humans (e.g. confidentiality, risks and benefits, informed consent process, etc.). If the development of your research proposal consists of research that involves humans as participants, the please contact the course instructor for guidance and see: <https://uwaterloo.ca/research/office-research-ethics>

Co-op interviews and class attendance:

Co-op students are encouraged to try and choose interview time slots that result in the least amount of disruption to class schedules. When this is challenging, or not possible, a student may miss a portion of a class meeting for an interview. Instructors are asked for leniency in these situations; but, a co-op interview does not relieve the student of any requirements associated with that class meeting.

When a co-op interview conflicts with an in-class evaluation mechanism (e.g., test, quiz, presentation, critique), class attendance takes precedence and the onus is on the student to reschedule the interview. CECA provides an interview conflict procedure to manage these situations.

Students will be required to provide copies of their interview schedules (they may be printed from WaterlooWorks) should there be a need to verify class absence due to co-op interviews.

Special Instructions for this Course

Assignment Checklist

The following student signed Checklist was developed by the Secretariat as a means of emphasizing the importance of attribution of referenced work and reducing plagiarism, and must be included for your group assignments, where you have been asked to do so in the Assignment outlines. Please add lines as appropriate for names and signatures of all team members.

Academic Integrity-Assignment Checklist	
Please read the checklist below following the completion of your assignment. Once you have verified these points, hand in this signed checklist with your assignment.	
1. I/We have referenced and footnoted all ideas, words or other intellectual property from other sources used in the completion of this assignment.	
2. I/We have included a proper bibliography, which includes acknowledgement of all sources used to complete this assignment.	
3. This is the first time I/We have submitted this assignment or essay (either partially or entirely) for academic evaluation, other than aspects of my/our previous work in ENBUS 402A/B allowed by the instructor.	
Signed: _____	Date: _____
Print Name: _____	UW-ID# _____

Group Work

Any work submitted by a group of students should **document** that:

1. each member of the group has read the full content of the submission and is assured that the content is free of violations of academic integrity.
2. each student has identified his or her individual contribution to the work submitted such that if violations of academic integrity are identified, then the student primarily responsible for the violations may be identified. Note that in this case the remainder of the team will also be subject to disciplinary action, but the penalties for the extended team members may be less severe.

The following signed Checklist must be included for your group assignments. Please add lines as appropriate for names and signatures of all team members.

Group Work-Assignment Checklist

Please read the checklist below following the completion of your assignment. Once you have verified these points, hand in this signed checklist with your assignment.

1. I have read the full content of the submission and am assured that the content is free of violations of academic integrity.
2. I have identified, in a separate document available for viewing by the instructor, or others (e.g. Deans if requested), my own contribution to the work submitted.

Signed: _____ Date: _____

Print Name: _____ UW-ID# _____