Course Memo
LIFE CYCLE ASSESSMENT AL2608 (7.5 hp)
2021

Welcome to the course in Life Cycle Assessment!

Please take your time to read this document carefully at the beginning of the course!

Read it again before lectures, computer labs, supervision meetings, and seminars.

Digital teaching in fall 2021

Lectures will be held interactively in Zoom, but will also be recorded.

Seminars and computer labs will be held in zoom. Computers are accessed through remote lab or on campus.

Some group supervision may be scheduled on campus

Instructions and links are posted in Canvas

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CONTACT INFORMATION

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Questions about admission, registration, access to Canvas.	

Teaching unit:	Dept. of Sustainable development, Environmental science and Engineering (SEED).
Visiting address:	Teknikringen 10B
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CONTENT AND INTENDED LEARNING OUTCOMES

Course contents

Products, services and infrastructure cause environmental impact throughout their life cycle - from the extraction of raw materials, through use to waste management. LCA is a method for quantifying effects throughout the life cycle. It is used to identify important environmental aspects and avoid environmental problems being shifted to other parts of the life cycle. LCA and life cycle thinking are used for decision making in industry and for public planning and decision making. In this course, students learn the basics of methodology, using LCA software and practice in projects with applications in systems for technology and community planning.

The course covers:

- LCA methodology
- LCA tools and – databases
- Specialisation of life cycle impact in a specific field that the students choose independently
- Lecture from industry with examples of use of LCA for decision making

Groups of 5 students perform LCA using the software SimaPro. Projects are presented in a report and at a seminar. Each group will also make a critical review of the LCA of another group.

Intended learning outcomes

The general aim of the course is to develop the student's ability to assess environmental impact of complex systems in technology and urban planning based on a life-cycle perspective by giving theoretical and practical skills in Life Cycle Assessment (LCA).

After passing the course, the students should be able to:

1. Give an account of the aim applications of the LCA method.
2. Explain the analytical phases and central concepts of the LCA method.
3. Apply the analytical phases and central concepts of the LCA method on complex systems in technology and urban planning.
4. Identify uncertainties in LCA method and data and evaluate how these influence the results.
5. Report in writing the completed LCA study according to ISO's standard for LCA.
6. Use LCA software.
7. Give an account of the results orally of the completed LCA the study.
8. Work in a collaborative project setting
9. Report in writing and give an account of a critical review orally of an LCA report.

PREPARATIONS BEFORE COURSE START

Course literature

Book

Curran, M. A. (ed) (2015) *Life Cycle Assessment Student Handbook.* Wiley.

You can order this book from for instance AdLibris ([www.adlibris.se)](www.adlibris.se) or Bokus (www.bokus.se). It will not be available at the student book store, simply because it would be much more expensive.

Scientific papers (available in Canvas)

As listed under each lecture above in this document.

SimaPro manuals (available in Canvas)

- PRé Consultants (2016) *Introduction to LCA with SimaPro*
- PRé Consultants (2014) *SimaPro Tutorial*

Useful web resources

- *LCA Compendium - The Complete world of Life Cycle Assessment* (Springer Link): https://link.springer.com/search?facet-series=%2211776%22&facet-content-type=%22Book%22
- Jolliet, O. et al (2915) *Environmental Life Cycle Assessment.* Boca Raton: https://www.taylorfrancis.com/books/oa-mono/10.1201/b19138/environmental-life-cycle-assessment-olivier-jolliet-myriam-saade-sbeih-shanna-shaked-alexandre-jolliet-pierre-crettaz

Support for students with disabilities (Funka)

Students with a disability may get support from KTH

https://www.kth.se/en/student/studentliv/funktionsnedsattning/funka-stod-for-studenter-med-funktionsnedsattningar-1.953214

Schedule, deadlines, and signing up for appointments

The schedule with lectures, seminars, and computer labs is available in TimeEdit: https://cloud.timeedit.net/kth/web/public01/

All course related deadlines (assignments, signing up in Calendar for appointments such as supervision and seminars) are listed in Canvas Syllabus. Instructions for signing up in Calendar are posted in Canvas, course "Home" page.

NOTE: You need to add the course AL2608 to your Canvas Calendar in order to see calendar events and sign up for appintments.

Expected work load in this course

The course covers 7.5 credits. This corresponds to 5 weeks of full time work.

Note: week 47 will be especially intense, with pre-seminar and home exam! Take this into account when you plan your work.

Scheduled studies (~1 week)

- Lectures: 20 h
- Computer labs: 12 h
- Supervision meetings: 4 h

Own studies (~4 weeks)

- Reading course literature: 1 week
- Completing home exam: 6-8 hrs (if you have done the reading before the exam!)
- Project work: 2.5 weeks
- Critical review and final revision of report: 0.5 week

LEARNING ACTIVITIES

The learning activities in this course are:

- Lectures
- Computer labs
- Project supervision and project seminars
- Home exam

Lectures - overview

The oerview below indicates what parts of the course literature relates to the topic of each lecture. Use this to plan your studies.

We will not go through the literature specifically in lectures, but lectures and literature complement each other. You are encouraged to do the exercises in the course book, ideally together with fellow students, but we do not work on these together in class.

NOTE: Study the literature and lecture notes *before* the home exam. Experience from students earlier years tells that it will otherwise be a very stressful exam. You will not have time to study *during* the exam.

L1 - What is LCA? & Course overview

Lecturer: Anna Björklund

Content: Introduction to key features of LCA to give an overview of course content and a possibility to start reflecting over how LCA can be used in various fields of industry and society. Throughout the remainder of lectures, LCA methodology will be covered in depth.

We will also go through practical issues and course design in this lecture.

Literature:

- Curran, M. A. (2015) *Life Cycle Assessment Student Handbook*. Preface and Chapter 1.
- PRé Consultants (2016) *Introduction to LCA with SimaPro*. Chapter 1.

L2 – Forming project groups & Goal and scope definition

Lecturer: Anna Björklund

Content 1st hour: How to set up and design a LCA study. This is important for you to make an adequate and meaningful formulation for the topic of your project. This is necessary as background for the first project supervision meeting (PS1).

Content 2nd hour: We will brain storm about project ideas and form project groups. You must prepare before Lecture 2, instructions will be sent to all students.

> **NOTE:** If you miss this lecture, you need to contact the course coordinator ASAP in order to make sure that you join a project group!!! Project groups start working already during the first week of the course.

Literature:

- Curran, M. A. (2015) Life Cycle Assessment Student Handbook. Chapter 2.
- PRé Consultants (2016) *Introduction to LCA with SimaPro*. Chapter 2.

L3 –Goal and scope definition continued.

Lecturer: Anna Björklund

Content: Goal definition and scoping continued (2h).

Literature:

- Curran, M. A. (2015) Life Cycle Assessment Student Handbook. Chapter 2.
- PRé Consultants (2016) *Introduction to LCA with SimaPro*. Chapter 2.

L4 - Inventory analysis. The Ecoinvent database

Lecturer: Anna Björklund

Content: Constructing a flow model and collecting data of the technical system. Understanding this phase of LCA is important for you to make a detailed description of the technical system of your project, and to start collecting relevant data. This is necessary as background for the 2nd project supervision meeting (PS2). A few words about the Ecoinvent database.

Literature:

- Curran, M. A. (2015) Life Cycle Assessment Student Handbook. Chapter 3.
- PRé Consultants (2016) *Introduction to LCA with SimaPro*, chapter 3.
- Finnveden, G., Hauschild, M., Ekvall, T., Guinée, J., Heijungs, R., Hellweg, S., Koehler, A. ,Pennington, D., and Suh, S. (2009) Recent developments in Life Cycle Assessment. Journal of Environmental Management 91, 1–21.

Introduction to Ecoinvent (supplementary studies):

- https://www.youtube.com/watch?v=0lVEf3yAIyM&t=20s
- https://www.youtube.com/watch?v=nJTFRMBo0sU
- https://ecoinvent.org/the-ecoinvent-database/system-models/

L5 – Impact assessment

Lecturer: Göran Finnveden

Content: Principles and methods for impact assessment in LCA. Understanding this phase is important when you start interpreting the results of your project. This is necessary as background for the 3rd project supervision meeting (PS3).

Literature:

- Curran, M. A. (2015) Life Cycle Assessment Student Handbook. Chapter 4.
- PRé Consultants (2016) *Introduction to LCA with SimaPro*. Chapter 4.1 - 4.4.
- Finnveden, G., Hauschild, M., Ekvall, T., Guinée, J., Heijungs, R., Hellweg, S., Koehler, A. ,Pennington, D., and Suh, S. (2009) Recent developments in Life Cycle Assessment. *Journal of Environmental Management 91,* 1–21.
- Huijbregts et al. (2017) ReCiPe2016: a harmonised life cycle impact assessment method at midpoint and endpoint level. *Int J Life Cycle Assessment,* 22:138, 138-147.

L6 – Weighting, normalisation and interpretation

Lecturer: Göran Finnveden

Content: Methods for further aggregation results, as an aid to interprete the impact assessment results. This is necessary as background for the 4th supervision meeting (PS4).

Literature:

- Curran, M. A. (2015) Life Cycle Assessment Student Handbook. Chapter 5.
- PRé Consultants (2016) *Introduction to LCA with SimaPro*. Chapter 4.5 – 4.6.
- Hellweg, S. and i Canals, L. M. (2014) Emerging approaches, challenges and opportunities in life cycle assessment. Science, 344, 1109-1113.

Lecture 7 – Data quality, uncertainty, representativity

Lecturer: Anna Björklund

Content: Sources of uncertainty in LCA and examples of approaches to handle uncertainty

Literature:

- Curran, M. A. (2015) Life Cycle Assessment Student Handbook. Chapter 6.3.

Lecture 8 – Modelling bio-based systems in LCA

Lecturer: Miguel Brandão

Content: Modeling of biogenic carbon cycles in LCA.

Literature:

- Curran, M. A. (2015) Life Cycle Assessment Student Handbook. Chapter 3.3.6.
- Schmidt et al. (2015). A framework for modelling indirect land use changes in life cycle assessment. Journal of Cleaner Production, 99, 230-238.
- Brandão, M. et al (2013) Key issues and options in accounting for carbon sequestration and temporary storage in life cycle assessment and carbon footprinting. Int J of Life Cycle Assessment, 18, 230-240.

Lecture 9 – Review of exam & mid-course analysis

Lecturer: Anna Björklund

We will go through the correct answers of the home exam and spend some time on discussing the course to have feedback from all students

Lecture 10 – Social LCA

Lecturer: Elisabeth Ekener

Content: Overview of Social LCA, its main characteristics, methodology and guidlines.

Literature:

- Curran, M. A. (2015) Life Cycle Assessment Student Handbook. Chapter 7.4.
- Wu, R. Yang, D., and ChenWu, J. (2014) Social Life Cycle Assessment Revisited. Sustainability, 6, 4200-4226.

Lecture 11 – LCA in Practice

Lecturers:

- Michael Martin, IVL Swedish Environmental Research institute (and alumn of the LCA course)
- Tova Billstein, IVL Swedish Environmental Research institute (and alumn of the LCA course)

Content: Invited LCA professionals present examples of using LCA in practice in their organisations.

Literature:

- Curran, M. A. (2015) Life Cycle Assessment Student Handbook. Chapter 6.8.*(Comment: EPD is a good example of LCA being used in practice in business-to business communication)*

Videos to complement lecture 10 (links also posted on Canvas):

- The Life Cycle Perspective at the Swedish Environmental Protection Agency: https://www.youtube.com/watch?v=pbEg54Wegh4
- The Life Cycle Perspective at Vattenfall: https://www.youtube.com/watch?v=MbM4IKklrQc&t=38s
- The Life Cycle Perspective at Chalmers University of Technology: https://www.youtube.com/watch?v=7ZPLwM0XHjc&t=50s

Computer labs

There are six scheduled computer lab meetings to work on SimaPro, with teachers present to help you out with exercises and working on your projects. You also need to work on your own at other times in the computer lab with exercises and projects! Learning to use SimaPro early on in the course is important to be able to complete a successful project.

See separate document with instructions for computer labs in Canvas Modules/Simapro and computer labs: "*Instructions Computer labs (AL2608)*"

Literature:

- PRé Consultants (2016) *Introduction to LCA with SimaPro.*
- PRé Consultants (2014) *SimaPro Tutorial*

Course requirement – Computer lab meetings

Minimum attendance at 5 (out of 6) meetings in the computer lab is required.

In case you cannot attend, you need to get in touch with your supervisor and your group in advance. You also ned to submit a compensation assignment in Canvas. See Canvas Assignments for details.

Project supervision, seminars, and report

The aim of the project is to put theory from lectures and the course literature into practice and to give practical experience of LCA modelling with LCA software.

In addition to the computer labs, project work includes project supervision meetings and seminars, and writing a report. See separate documents with instructions in Canvas Modules/Project work:

- *"Instructions Project supervision and seminars AL2608"*
- *"Instructions Project report AL2608"*
- *"Project group agreement"*
- *"Scientific LCA journals"*

Summary of course requirements – Project supervision, seminars, and report

- Compulsory attendance in supervision meetings
- Upload project status report before supervision meetings

- Compulsory attendance in seminars, plus:
  - Seminar 1 (Pre-seminar): Submit *Pre-seminar reflection* **after** seminar
  - Seminar 2 (Peer review seminar): Submit *Draft project report* **before** and *Peer review assessment* **after** seminar
  - Seminar 3 (Final seminar): Submit *Project report* and *Critical review* **before** seminar. Submit *Revised project report* **after** Final seminar.

In case you cannot attend compulsory activities, you need to get in touch with your supervisor and your group in advance. You also ned to submit a compensation assignment in Canvas. See Canvas Assignments for details.

Home-exam

A two-day home-exam is given at mid-term. The purpose of this exam is to ensure that all students learn the basics of LCA methodology that is necessary to actively contribute in a good way to the group projects.

The exam covers Lectures 1-7 and the corresponding literature. You will be tested for knowledge of LCA terminology through:

- multiple choice questions (part A, 15 points),
- ability to apply LCA knowledge to explain or draw conclusions (part B, 15 points)
- ability to apply LCA knowledge to make own LCA calculations (part C, 15 points)

Make sure to study the literature along with the lecture notes in advance. Starting to read when the home exam opens is not a good path to success and will be very stressful!

Maximum points is 45 distributed over parts A-C with 15 points each. In order to pass the exam, you need to have 20 points or more in total on parts A and B. Part C is not graded unless you fulfill this requirement. If you fulfill this requirement, the grading limits are as follows:

> A: ≥ 40 p
>
> B: ≥ 35 p
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> C: ≥ 30 p
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> D: ≥ 25 p
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> E: ≥ 20 p
>
> Fx: < 20 p)

Course requirement – Home exam

To pass the course, you need to acquire the grade E or higher on the exam.

Exams graded as Fx (fail with the possibility of supplementing) will require supplementing through an oral exam. After supplementing, the exam will be graded as E.

EXAMINATION AND COMPLETION

The course examination consists of the following parts:

- Home exam (2,5 hp), grade scale: A, B, C, D, E, Fx, F
- Project work (5 hp), grade scale: A, B, C, D, E, Fx, F

The final grade (A-F) is a weighted average of the home exam and the project. The project is weighted slightly less than its corresponding credits (Exam weight = 2.5; Project weight = 4).

In order to receive a final grade, the requirements for an "E" for the home exam and all compulsory elements of the project work must be fulfilled.

Fx represents a failing grade but which can be complemented to reach the grade E.

Home exam (2.5 hp, A-F)

- The exam covers intended learning outcomes 1-2.
- If you do not pass the exam, but receive Fx, you have the possibility to pass the written exam by oral eaxmination. After oral examination, the student can only receive the grade E.

Project work (5 hp, A-F)

- The group project examines intended learning outcomes 3-8.
- The project report is graded A-F.
- In order to pass the project, you also need to fulfill other compulsory elements (attendance, compensation assignments in case of absence, active participation at seminars and supervision, meeting deadlines) which are graded as (P/F).
- The grade of the project report is based on the following factors (details in appendix):
  - *Report content* (your understanding of LCA methodology, and ability to design and perform an LCA study)
  - *Report formal qualities* (outline, clarity, language, referencing).

Opportunity to raise an approved grade via renewed examination (upping)
Upping is not allowed in this course.

APPENDIX: EVALUATION CRITERIA FOR PROJECT REPORT

	A (5)	C (3)	E (1)	0 (Fx) (must be compensated for E)
1. Report content	A (5)	C (3)	E (1)	0 (Fx) (must be compensated for E)
LCA methodology and terminology	Throughout all sections of the report, LCA methodology is explained wherever necessary and with correct terminology.	For the most part, LCA methodology is explained wherever necessary and with correct terminology.	LCA methodology is documented in a way that the reader gets a rough understanding of project and results. No severe mistakes in methodology and terminology.	Severe mistakes or gaps in LCA methodology.
Introduction & Goal and scope definition	Research problem and G&S are introduced and explained in a clear and complete manner.	For the most part, research problem and G&S are explained in a clear and complete manner.	Problem & G&S mirror aim and scope of the project, with some unclarities, but without creating severe misunderstanding.	Because of lacking or unclear information on G&S, the reader does not get a good understanding of the project.
Life cycle inventory	The LCI is documented in a complete and transparent manner, so that the reader easily understands what data was used and how the project was modelled.	Data documentation is for the most part complete and transparent.	Documentation of data but gives the reader rough understanding of how the project was modelled, without severe gaps.	It is not possible from the documented data to get a general understanding of what was modelled and how.
Life cycle impact assessment and interpretation	Results and interpretation relate clearly to the goal. The report contains an advanced and relevant analysis of results.	The goal is met through simple but relevant analysis of results.	The research question is answered by the results, but through weak analysis and interpretation of results.	Research question is not answered in analysis and interpretation of results.

	A (5)	C (3)	E (1)	0 (Fx) (must be compensated for E)
Conclusions and recommendations	Conclusions and recommendations relate very clearly to the goal, with well elaborated explanation showing that they are well-founded based on the results.	Conclusions and recommendations relate clearly to the goal, and are based on the results.	Conclusions and recommendations relate satisfactory to the goal and are satisfactory based on the results.	Conclusions and recommendations not connected to goal of the study. Conclusions not based on results.
2. Written presentation, language and format	A (5)	C (3)	E (1)	0 (Fx) (must be compensated for E)
Language	Good language throughout report, both in terms of spelling and grammar, and reader friendliness of the text.	For the most part good language, both in terms of spelling and grammar, and reader friendliness of the text.	Report is readable.	Severe lack of language quality, so that the content is difficult to understand.
Disposition and coherence	Content is well-disposed, coherent, follows outline in report instructions, and is easy to follow.	Content is mostly well-disposed, follows outline in report instructions, and is mostly easy to follow.	The report outline follows the report instructions.	Deviations from report instructions, without apparent reason, which make it difficult to follow the report.
Relevance	Content is well delimited, including only relevant information with regard to the goal and scope of the LCA.	Content is fairly well delimited, including mostly relevant information, and not missing too much important information, with regard to the goal and scope of the LCA.	The report is readable with regard to relevance of content.	The report is difficult to read because of too much/too little relevant information.
Figures and tables	All figures and tables are relevant and contribute to the content, have legends using consistent format, are consistently numbered, and are referred to and explained in the text.	Most figures and tables are relevant to the content, have legends, are numbered, and are referred to in the text. Explanations are missing or are incomplete.	Figures and tables have legends and are mentioned in the text, but either are not explained in the text or are not relevant.	Figures and tables not included in a way that contributes to the understanding of the text. Legends missing. Not explained in the text.

References	References are included wherever necessary (in documentation of data and in text), in a way that would be acceptable in a scientific context.	References are included in a mostly complete and consistent way.	References are used so that it is mostly clear when information comes from other sources, but are not complete and consistent.	Important references are missing. Referencing not done in a consistent way.
3. Oral presentation (P/F)	Pass			0 (Fx) (must be compensated for E)
Presentation	Very well disposed presentation, with regard to content of slides and explanation of project. Content presented within time limits.	Mostly well-disposed presentation, with regard to content of slides and explanation of project. Time limits not severely surpassed.	Presentation and slides cover most relevant parts of the project. Time limits not severely surpassed.	Presentation does not communicate content of project. Severe surpassing of time limits.
Participation	All group members actively and equally involved in both presentation and discussion.	All group members contribute, but with some unbalance of contribution.	All group members contribute, but with very uneven contribution.	Some group members totally dominate while others do not contribute.
4. Group process (P/F)	Pass			0 (Fx) (must be compensated for E)
Professional project management	The group comes well-prepared and on time to supervision. The group actively includes all group members in the project. Problems are communicated at an early stage to supervisor.	The group comes prepared and on time to supervision. All group members make some contribution during supervision.	The group mostly comes prepared and on time to supervision.	Group repeatedly does not show up on time. Group fails to communicate problems in time so that the project work does not proceed.
Independence	The group is able to independently and in a creative manner manage the research project.	The group is sometimes able to independently manage the research.	The group is able to complete the project assignment, but with little independence and only after clear instructions from supervisor.	The group was not able to complete the project.

| Log book and deadlines | The group uses the log book in a good way to plan and show progress of the project. Submissions of log book and other project deliverables meet deadlines. | The group uses the log book in a way that shows progress of the project. Submissions of log book and other project deliverables mostly meet deadlines. | The group uses the log book. Project deliverables are submitted, but often fail to meet deadlines. | Group repeatedly fails to use log book and/or repeatedly fails to meet deadlines for project deliverables. |