
ES 268 – Life Cycle Assessment Fall 2021 Syllabus

Instructor: Dr. Marie-Odile P. Fortier

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Office location: As office hours will be held virtually this semester, our office hours location will be on Zoom (the link will be provided on CatCourses).

Office hours: To be determined by the end of the first week of class.

Class time: lectures on Mondays and Wednesdays from 3:30pm to 5:20pm, and discussions on Wednesdays from 5:30pm to 6:20pm.

Class location: Granite Pass building, room 145.

Materials: No textbook required. Assigned readings will be provided on CatCourses.

Prerequisites: Graduate student or instructor permission.

Course Description: (4 credits) Study in the quantification of the cradle-to-grave environmental impacts of products and systems using the tool of life cycle assessment (LCA). Training in mathematically defining the life cycles of products and systems, performing an LCA, interpreting LCA results, and evaluating LCAs within the context of the scientific literature. Includes lectures and discussions. Project-based towards a complete LCA with a literature review, sensitivity analysis, and uncertainty analysis using available data and impact assessment methods.

Course Goals: In this course, students will learn the fundamental principles of life cycle assessment (LCA), how to perform an LCA, and how to evaluate the designs and results of LCAs. Students will understand the standard steps of an LCA and their connections: goal and scope definition, inventory analysis, impact assessment, and interpretation. This course aims to equip students with the decision-making and systems thinking skills involved in designing and performing an LCA.

Student Learning Outcomes: After completing this course, students should be able to:

After completing this course, students will be able to:

1. Define the goal, scope, functional unit, and system boundary for life cycle assessment (LCA).
2. Synthesize systems diagrams that facilitate the evaluation of environmental impacts by each process involved in the life cycle of a product or system.
3. Develop equations to describe the relationships between processes and mass and energy flows in a system to be evaluated through LCA.
4. Assess sources of data and life cycle inventories for their appropriate use in LCA.
5. Critically review LCAs in the scientific literature and interpret their results.

6. Design and perform a life cycle assessment according to international standards.
7. Summarize and justify LCA design choices at the goal and scope definition, inventory analysis, and impact assessment stages.
8. Perform sensitivity analyses and uncertainty analyses of LCA results.
9. Interpret the implications of statistics from LCA sensitivity and uncertainty analyses.
10. Describe the scientific basis for life cycle assessment impact categories.
11. Evaluate new LCA results in the context of the existing scientific literature.
12. Explain the role of LCA in industry, research, and policy.
13. Identify career pathways, professional organizations, and research opportunities that utilize LCA skills.

Environmental Systems (ES) Program Learning Outcomes:

This interdisciplinary course contributes to the ES program learning outcomes of:

- Core Knowledge - Graduates will be knowledgeable, skillful and self-directed in the observation and analysis of environments systems in terms of their capacity to independently identify important research questions, formulate experimental plans, data analysis and formulation of conclusions in the context of a doctoral dissertation.
- Communication Skills - Graduates will be conversant in at least two areas of environmental systems, and be adept at oral, written and visual communication of research results to peers and non-technical decision makers.
- Ethics, Community, and Life-long Learning - Graduates will understand the importance of research and professional ethics, engagement in the needs of their community and life-long learning.
- Career Placement and Advancement - Graduates will find suitable career placement and achieve advancement in government agencies, non-government organizations, private industry, and/or academic teaching and research institutions.

Student Evaluation:

Student attendance and participation will be expected during all lectures, and students are expected to have completed assigned readings prior to class. Students will be graded based on the elements in the table below. Detailed guidelines for these items will be provided as they are introduced during the semester.

Graded item	Percentage of final grade (%)
<i>Partnered assignments:</i>	
Discussion leads (4 at 3% each)	12
Homework assignments (4 at 7% each)	28
<i>Independent assignments:</i>	
Project milestones (4 at 8% each)	32
Project feedback meetings (2 at 2% each)	4
Project paper	16
Project presentation	3
Class participation	5

Partnered assignments are to be completed with an assigned classmate partner, while all the elements of the semester-long project are to be completed independently. Discussion leads will involve summarizing key items learned from the assigned readings, preparing questions and/or topics of conversation on the readings, and leading the majority of the discussion section on a given week with your partner. Homework assignments will precede project milestones on similar topics in order to provide students with practice and feedback on different aspects of LCA prior

to applying those skills to their projects. Two project feedback meetings of about 15 to 20 minutes via Zoom will be scheduled at a time that is convenient to both Dr. Fortier and each student within a week of Dr. Fortier's provision of written feedback on a project milestone. It is up to individual students to choose which two of their four project milestones will be followed by a feedback meeting. Class participation will be calculated based on attending lectures and discussions from start to finish.

Grading Scale:

Range	Grade	Range	Grade
92.5 – 100	A	77.5 – 79.4	C+
89.5 – 92.4	A-	72.5 – 77.4	C
87.5 – 89.4	B+	67.5 – 72.4	C-
82.5 – 87.4	B	60.0 – 67.4	D
79.5 – 82.4	B-	< 60.0	F

Class Guidelines and Useful Information:

- Attendance Policy:** The course will be held synchronously in person at the posted times. Attendance is required in the course and will be recorded daily, which will count towards the class participation grade. This course continuously builds upon prior topics and thus keeping up with the class materials is necessary to be successful in the course. Students are expected to complete the assigned readings prior to weekly discussions and to be informed participants to be marked as present in discussions. Still, some absences may be excused on a case-by-case basis. Please email Dr. Fortier to request an excused absence if needed.
- Late Assignment Policy and Extensions:** Late assignments will be penalized 5% per day. No late assignments will be accepted beyond one week after the due date, unless permitted via email by Dr. Fortier. On a case-by-case basis for emergencies, illness, and unusual circumstances, a penalty-free extension to turn in a graded item may be granted. Please email Dr. Fortier to request an extension if needed. However, please note that homework assignments and milestones build upon each other and so delays in turning in work may affect successful completion of the next deliverables and/or Dr. Fortier's ability to return graded work at the same time as your classmates' graded work.
- Authorship:** By participating in this course, students will be guided by the instructor through complete LCA projects on an approved subject of their choice, with feedback on all project milestones and with data collection and analysis assistance. To reflect the work involved in the development of the LCA projects, if a project from this course is subsequently prepared for publication in a peer-reviewed journal, Dr. Fortier must be listed among the authors, with authorship order dependent on the project and on the authors' individual involvement. If you choose to complete a project closely related to your research in this course, please disclose this authorship condition with your advisor and any potential coauthors who are not enrolled in the course. Please contact Dr. Fortier via email if you have questions about this policy.
- COVID-19 Pandemic Classroom Rules:** The following classroom rules will be enforced to mitigate the risk of COVID-19 transmission. All people in the classroom must wear a face mask covering their nose and mouth at all times. No eating or drinking is allowed in the classroom in order to maintain this policy. There will be a brief break during each lecture and between the Wednesday lecture and discussion section to provide time for everyone to step

outside if needed to eat, drink, and/or use a restroom. While outdoors during these breaks, please maintain a physical distance of at least 6 ft from others if your mask is removed. Please feel free to discuss with Dr. Fortier if there are any concerns about these rules. They are subject to revision throughout the semester but will remain in line with campus rules.

5. **Academic Dishonesty:** Academic dishonesty is a breach of trust between a student, one's fellow students, or the instructor(s). Academic penalties at the University level may result from infractions of academic integrity, which include plagiarism and cheating. Please review the UC Merced Academic Honesty Policy at <http://studentconduct.ucmerced.edu/> and ask Dr. Fortier any questions that you may have on what constitutes an infraction in our class. Unless a graded item is explicitly labeled as partnered work, it must be completed independently in order to follow the academic honesty policy.
6. **Inclusive Excellence:** As an institution, we embrace inclusive excellence by addressing inequities in student success, utilizing best educational practices, and embracing the strengths of a diverse and inclusive community. During classroom discussions, we may be challenged by ideas different from our lived experiences and cultures. Understanding individual differences and broader social differences will deepen our understanding of each other and the world around us. In this course, people of all races, ethnicities, genders and gender identities, religions, ages, sexual identities, disabilities, socioeconomic backgrounds, regions and nationalities (as examples) are strongly encouraged to share their unique perspectives and experiences, respectfully.
7. **Accommodations for Students:** University of California, Merced is committed to creating learning environments that are accessible to all. If you anticipate or experience physical or academic barriers based on a disability, please feel welcome to contact Dr. Fortier privately in order to discuss options. In addition, please contact Student Accessibility Services (SAS) at (209) 228-6996 or disabilityservices@ucmerced.edu as soon as possible to explore reasonable accommodations. All accommodations must have prior approval from Student Accessibility Services on the basis of appropriate documentation. If you anticipate or experience barriers due to pregnancy, temporary medical condition, or injury, please feel welcome to contact Dr. Fortier in order to discuss options. You are encouraged to contact the Dean of Students for support and resources at (209) 228-3633 or <https://studentaffairs.ucmerced.edu/dean-students>. If an emergency or a different challenge occurs during the semester, please let Dr. Fortier know and begin a discussion for the possibility of an alternative plan that meets your needs and the course requirements. If Dr. Fortier's office hours do not work with your schedule for you to attend, please email at least 3 days in advance of an assignment due date to schedule an alternative time to meet.
8. **Basic Needs Resources and Technology Resources:** Any student who has difficulty affording groceries or accessing sufficient food, or who lacks a safe and stable place to live, is urged to contact the Dean of Students for support. Additional resources exist through the campus' Basic Needs services at <https://basicneeds.ucmerced.edu/>. If you face difficulties with access to technology or stable internet, please see this page about borrowing items from UC Merced: <https://ue.ucmerced.edu/technology-resources>.

Course Schedule (subject to revision; any updates will be announced):

Week	Dates	Lecture Topics
1	8/25	<i>No class due to shift in semester start – online readings & survey for attendance</i>
2	8/30 9/1	Introduction to life cycle assessment (LCA) Introduction to life cycle assessment (LCA) & Standards of LCA practice
3	9/6 9/8	<i>No class – Labor Day</i> Goal and scope definition
4	9/13 9/15	Functional unit Functional unit
5	9/20 9/22	Reference flows, system diagrams, and tracking relationships in LCA Coproduct allocation and system expansion
6	9/27 9/29	Defining parameters and equations for an LCA Defining parameters and equations for an LCA
7	10/4 10/6	Defining parameters and equations for an LCA Data collection for LCA
8	10/11 10/13	Data collection for LCA Life cycle impact assessment (LCIA) methods
9	10/18 10/20	Software packages and other calculation approaches for LCA Selecting life cycle inventories
10	10/25 10/27	Baseline scenario analysis Baseline scenario analysis
11	11/1 11/3	Sensitivity analysis Sensitivity analysis
12	11/8 11/10	Uncertainty analysis Uncertainty analysis
13	11/15 11/17	Interpretation of LCA results Economic input-output LCA
14	11/22 11/24	Social LCA <i>No class – Non-Instructional Day ahead of Thanksgiving</i>
15	11/29 12/1	Dissemination of LCA results and professional LCA practice Challenges and emerging research in LCA
16	12/6 12/8	Challenges and emerging research in LCA Project Presentations