

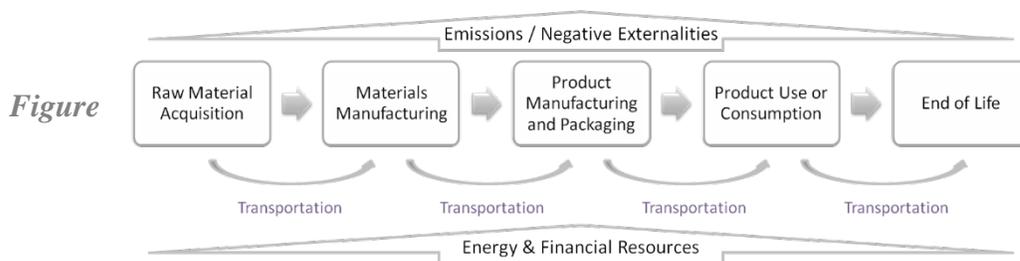
ENVR/ENRG 638: Life Cycle Assessment
Tuesday & Thursday 10:15 – 11:30 a.m.
Held Synchronously On-Line

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Office Hours by Appointment

COURSE DESCRIPTION

Today our world is confronted with sustainability challenges at an unprecedented scale. Human-induced climate change, the depletion of natural resources including water, and threats to food security threaten to adversely affect people's well-being at a time when many individuals also struggle to overcome poverty, inequity, and other affronts to human rights. The magnitude of these challenges and their wide-ranging adverse ramifications motivate proactive businesses and entrepreneurs to act, whether by participating in efforts to mitigate risk and negative externalities or by innovating to create positive change.

Sustainability managers commonly employ a life cycle perspective (Fig. 1) to comprehensively assess environmental impacts at all stages, including its design, transportation, raw materials acquisition, manufacturing, distribution, sale, consumer use, and fate at its end of life.



1: Life Cycle Framework for Comprehensive Environmental Impact Assessment

In this class, students will learn (1) how companies use the life cycle framework; (2) details about the international standard that defines how to conduct a rigorous life cycle assessment; (3) how to use life cycle assessment software; and (4) strategies corporations can implement to lead the transformation towards a more circular economy.

Specific learning outcomes include that students will be able to do the following:

1. Articulate the value of a Life Cycle Analysis (LCA) and its relationship to total cost accounting and carbon pricing.
2. Describe the theory of an LCA and how carbon foot printing relates to LCA.
3. Outline the steps to conduct an ISO compliant LCA.
4. Define a goal and scope statement of an LCA. Conduct a life cycle inventory of a product from cradle to grave.

5. Describe common environmental impacts associated with a life cycle inventory of processes.
6. Conduct a screening-level and ISO compliant life cycle assessment with LCA software.
7. Conduct a consequential LCA. Interpret, critique, and communicate LCA results.

Important Matters Needing to be Addressed Up Front

1. Basic Needs and Technology

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. Furthermore, please notify me if you are comfortable in doing so. This will enable me to provide any resources that I may possess.

Any student who faces challenges accessing course material and/or attending synchronous class sessions on-line due to technology issues should bring this to my attention. Accommodations can be made so that your participation and other grades do not suffer as a result of issues beyond your control. The most important thing you can do if/when you face technology issues is to communicate these to me as soon as possible. If you know in advance that internet connectivity will likely be a challenge, please communicate this at the start of the semester.

2. Solidarity and Anti-Racism

I, Professor Carol Hee, respect the inherent dignity of all people, especially my students, and know that long-standing and ever-present issues of systemic racism, anti-LGBTQ sentiment, and other forms of exclusion and injustice cause harm to many and all-too-often go unacknowledged. I have undergone unconscious bias training and am actively educating myself about how I can best be anti-racist and an ally to the marginalized. I endorse the Nicholas School's commitment to diversity, equity, and inclusion (<https://nicholas.duke.edu/about/diversity-equity-inclusion>). As an educator, I know that one of the most useful things I can do to support equity is to utilize the pedagogical methods known as "Inclusive Teaching." I remain open to learning and making changes, so students are welcome to discuss their ideas and concerns with me.

In accord with Title IX, [Duke prohibits](#) discrimination and harassment based on any protected status—i.e., race, religion, gender, ethnicity. Discriminatory or harassing behavior will not be tolerated in this class. If a student is experiencing harassment, they should feel welcome to discuss this problem with Professor Hee who is willing to serve as an advocate on their behalf.

Duke University exists on land that was originally the territory of several Native nations, including the Shakori, Catawba, and Eno peoples and, to a large extent, was built by slave labor. One (1) way to give honor to those who suffered injustices related to the creation of our university is for you to make the most of your education—to be the best student you can be, as I will strive to be the best teacher I can be, and to use what you learn at Duke to make the world a better place. In the words of Peter Parker's uncle "With great power, comes great responsibility." The goal that drives me to teach this course is to empower you with knowledge, insight, and confidence that will empower you to drive change. Being a student at Duke is a privilege that comes with responsibility.

3. Physical and Mental Health

Given that we are living through a pandemic, special attention must be given to physical and mental health. The website [Updates for Students - Coronavirus Response \(duke.edu\)](https://updatesforstudents.duke.edu/coronavirus-response/) has information you may find useful. If you feel sick, visit <https://coronavirus.duke.edu/if-you-feel-sick/> for guidance.

Many of my past students have benefited from counselling through University Health Services. I was a beneficiary of this support while a graduate student at UNC in the late 1990s and remain a strong supporter of having professional support for one's mental health in the same way people have a primary care physician for their physical health. You may find helpful support starting at <https://coronavirus.duke.edu/support/>.

If your health or concern about the health and well-being of a loved one is getting in the way of you doing your best work in this class, *please communicate this to me and do so sooner rather than later*. Across the 14 years I have taught graduate and undergraduate students, I have worked with many students to devise plans that prevent their grades from being affected by physical and mental health issues. Please do not wait until the end of the semester or after grades are submitted to tell me that you deserve a break because of a hardship. At that point it will be too late. Instead, own your power and advocate for yourself. I am one of many who stand ready to do what we can to help.

ADDITIONAL INFORMATION ABOUT THIS COURSE

COURSE MATERIALS

Required Software: You must purchase a student license for Sustainable Minds at this website: <http://www.sustainableminds.com/get-started>. (\$49)

Required Textbook: *Environmental Life Cycle Assessment*. Olivier Jolliet, Myriam Saade-Sbeih, et al. CRC Press. ISBN-13: 978-1439887660. Download as a FREE e-book or purchase a hardcopy with prices starting at \$67 on Amazon. ([Link](#)), https://www.amazon.com/Environmental-Cycle-Assessment-Olivier-Jolliet-ebook-dp-B07S2SSGQF/dp/B07S2SSGQF/ref=mt_other?encoding=UTF8&me=&qid=

Additional Readings: Posted on Sakai and linked to through this syllabus.

OPTIONAL Textbook: *Life Cycle Assessment: Quantitative Approaches for Decisions That Matter*. Scott Matthews, Chris T. Hendrickson, and Deanna H. Matthews ([Link](#))

ATTENDANCE AND PARTICIPATION

Participation in this course is defined as a combination of attendance and contributions to class discussions.

Attendance (10%)

Living in the Time of COVID presents unprecedented challenges. I understand that you may not be able to make every class, whether that's due to technology issues or personal issues. *Nevertheless*, you should make every effort to attend class IF you are healthy. If you are unable

to join class for whatever reason, please do the professional and courteous thing and send me an email *before class*. If your internet connection drops you from the class or you need to leave to attend to an emergency, send me an email after class. If you have more than two unexcused absences, your participation grade will decrease. If you do not communicate with me to tell me you will miss class, your attendance grade will be decreased.

“Being a Beneficial Presence” (10%)

This class is designed as a synchronous course in order to enable real-time discussion. Active, participation is expected. By actively participating in discussion, you will be a “beneficial presence”: you, your peers, and your professor will all learn more.

Please remember: (1) quality is more important than quantity and (2) silence is not a reliable indicator of preparation or thoughtfulness. Excellent comments possess one or more of the following attributes: (1) they offer an original and relevant perspective on the issue, (2) they move the analysis forward by building on previous contributions or by revealing fresh insights, (3) they transcend the “I feel” syndrome by including evidence that is based on more than personal experience — in other words, your thinking should reflect and integrate examples from other contexts. Please do not hesitate to ask for clarification or for something to be repeated when you need it; chances are several others are in the same position as you.

If you are not comfortable volunteering to participate, taking this class will provide you with the opportunity to gain experience and confidence doing so. It is important for your long-term career success to practice speaking up as a way to demonstrate that you are a beneficial presence. I encourage participation from all students, but the burden of participating remains with you. One recommendation is to prepare in advance one point or one question you would like to contribute; another is to set a personal goal of volunteering to make contribution at least once a week.

Students who do not participate in discussions and are only silent observers will earn a maximum participation grade of 7.5/10. Students with >2 excused absences or a lack of timely communication will earn a maximum attendance grade of 7.5/10.

ASSIGNMENTS

All completed assignments should be uploaded to Sakai through the “Assignments” section. Late assignments will be accepted up to 1 week after their due date with a penalty. After 1 week, late assignments will not be accepted.

NB: Unless specified otherwise, papers should be submitted in MS Word (not as a PDF) and formatted with 1 in margins, 1.5 or double spaced, in left-justified Times New Roman 12-point font. These directions may seem like micromanaging, but research shows font style and document formatting can influence a reader’s perception of the quality of a document’s content. If all students submit their work in the same format, this potential source of bias will be removed.

1—HWs from LCA Textbook (10% total)...INDIVIDUAL

- Exercise 2.2 at end of Ch 2, due Sunday, February 21, 11:59 pm.
- Exercise 3.2 in our Textbook, due Sunday, February 28, 11:59 pm.

2—Carbon Pricing Brief (15%)... INDIVIDUAL

Due Sunday, January 31st, 11:59pm.

- a) Select a publicly traded company (other than Apple) that publishes its carbon emissions data.
- b) From the company's 10k and emissions data, create an Excel spreadsheet that contains 5 years of data for net income (i.e., profits). Include a note of the source of this data.
- c) From the company's sustainability report or website, add carbon emissions data for the past 5 years to your spreadsheet, broken down into as many subcategories as provided. Include a note of the source of this data.
- d) Calculate the effect of a carbon price on the company's profits for the following scenarios:
 - i. The current average price used by corporates: \$10
 - ii. The min and max amount environmental economists think is required to drive transformational change (\$40-\$80)
 - iii. What % of total profits are these carbon costs?
 - iv. Is this cost high or low? To answer this question, you will need to think critically about how to best put this number into context. I included two points for comparison: R&D expenses and CEO salary. You may use these two, but you need to include at least 3 other methods of assessing whether the carbon cost is high or low. You must not only do the calculation; in your brief, you must also include commentary on whether these calculations demonstrate that the cost is high or low.
- e) Write a 2-page brief to the company's CFO making the case based on the quantitative information you just compiled as to whether you believe the company should implement an internal carbon price.

NB: An example spreadsheet for Apple is available on our Sakai site in the description for this assignment. Do **not** chose Apple as your company. I recommend you select a company informed by your career preferences.

3—Quiz on Carbon Footprinting Standard (5%)... INDIVIDUAL

Due Sunday, February 14th, 11:55pm.

See **Sakai**.

4—Review of a Published LCA (5%)... INDIVIDUAL

Due Wednesday, February 17th, 11:55pm

This assignment aims to familiarize students with professionally conducted life cycle analyses that have been published in peer-reviewed literature.

- a) Students should find and read an LCA published in the *International Journal of Life Cycle Assessment* or the *Journal of Cleaner Production*. Duke's e-library
- b) Fill out the information specified on the following Google Sheet. (Students should reference this sheet to ensure there are no duplicates.)

NB:

- You should select an LCA that is relevant to your specific career interests. For example, if you are interested in working in the fashion industry on sustainable textiles, you may want to find an LCA that compares two different types of fabric such as cotton versus bamboo.
- You may not understand all of the details in the paper; that is OK; by the end of the course, you will.
- You may ask “Why are we reading an *academic* LCA when we will never write something like this?” The reason is that although you may not author a paper like this, if you do conduct an LCA, you will need to record all of the same details. This will be true whether you present the information in the form of a paper published in a journal or in a Power Point presentation to a client. Additionally, you may need to rely on such papers to answer LCA-related questions or to provide insights before starting your own LCA. You will be able to save time, money, and effort knowing where to find and how to understand published LCAs. Finally, LCAs conducted by brands are normally proprietary or part of publicly inaccessible databases.

5—Screening-Level LCA using Sustainable Minds (20%)...TEAM

Due Sunday, March 14, 11:59pm.

- A natural health and beauty company wants to know which packaging option they should use for a new deodorant they wish to market as exceptionally “green.”
- Use Sustainable Minds to compare four packaging options using the data provided via **Sakai**.
- Create a PowerPoint presentation that describes your work, results, and your recommendations.

6—GaBi Assignments...(3 x 10%)... INDIVIDUAL

Due dates will be announced when the HW is assigned. Timing will depend on the amount of material covered during each class. See **Sakai**.

GRADING SCHEME

Raw scores will be converted to percentages. Percentages will be converted using this table:

94.0 ≤ A ≤ 100	73.0 ≤ C < 76.9
90.0 ≤ A- < 93.9	70.0 ≤ C- < 72.9
87.0 ≤ B+ < 89.9	67.0 ≤ D+ < 69.9
83.0 ≤ B < 86.9	63.0 ≤ D < 66.9
80.0 ≤ B- < 82.9	60.0 ≤ D- < 63
77.0 ≤ C+ < 79.9	0 ≤ F < 60

Pass/Fail Option

As stated on the Nicholas School web site: “Letter grades will be the default grading option for MEM and MF students spring semester 2021. Recognizing that COVID-19, the economic crisis, significant changes in course delivery, concerns about equity, and the U.S. election will combine to increase student stress over the coming months, the Nicholas School will allow its professional students to request Pass-Fail (P/F) grade in one or more classes this semester.”

In accord with school guidance, I am setting the threshold to receive a “Pass” at 69.9 in this class. Note the school’s language regarding this cut-off: “Instructors will need to define explicit criteria for a Passing grade and may set this threshold high. ”

How?

Students must make their request in writing to the instructor of each class for which they are requesting a change in grading basis.

Timing?

Students must make their P/F request by mid-semester (Friday, March 5, 2021) for full-semester classes, or by the end of the third week of half-semester courses. Instructors will only consider requests after this deadline in the event of personal emergencies, including significant health crises and family concerns.

For more information, please visit [LINK](#).

ACADEMIC INTEGRITY

All activities of Nicholas School students, including those in this course, are governed by the Duke Community Standard, which states:

Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity. To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

During COVID times, additional community standards are in effect and must be followed by students in this class as detailed at <https://returnto.duke.edu/the-duke-compact/>.

COURSE SCHEDULE

The instructor reserves the right to adapt the course schedule as necessary throughout the semester. Students are responsible to stay abreast of any changes through Sakai. *If a link is broken*, try to find the resource listed by google-ing the name of the reading before emailing Prof. Hee.

1. Thursday, January 21

Topic: Introductions, course details, and plans

Assignments:

- a) Review course syllabus and come to class with any questions you have
- b) Complete the draft of your personal page in the slide deck available at:
- c) NOTE: There is A LOT of reading assigned for class on Feb 2. You would be wise to get a head-start on this reading NOW instead of waiting in case you are not “in the mood” to do all of the reading on Feb 1.

2. Tuesday, January 26

Topic: Assessing Life Cycle Impacts at the Individual Scale

Assignments:

- **Calculate** your own carbon footprint using the calculator at <https://depts.washington.edu/i2sea/iscfc/calculate.php>. Record your data so you can share your numbers with the class! Make note of what components contributed the most.
- **Read** “Food Miles or Poverty Eradication? The Moral Duty to Eat African Strawberries at Christmas.” ([Link](#))

3. Thursday, January 28

Topic: Strategic Sustainability Uses of Life-Cycle Analysis

Read:

- “Strategic Sustainability Uses of Life-Cycle Analysis” by Gregory Unruh. *MIT Sloan Management Review*. September 22, 2015. ([Link](#))
- “PUMA: Leading the Pack with an Environmental Profit and Loss Statement” by Carol Hee and Nikita Uday Godbole. UNC Kenan-Flagler Business School. Fall 2014. ([Link](#))

4. Tuesday, February 2

Topic: LCA and LCC: Tools for Quantifying Environmental Externalities

Read:

- Pages 1-15. “An Introduction to Environmental Accounting as a Business Management Tool” by EPA. Office of Pollution Prevention and Toxics. June 1995. ([Link](#))
- 1-page website “Total Cost Assessment Methodology” ([Link](#)). Note that this site contains a link to the full report ([Link](#)) which you may want to download as a useful reference!

5. Thursday, February 4

6. Tuesday, February 9

7. Thursday, February 11

Part A - Individual Meetings and Three Asynchronous Training Sessions on Carbon Footprinting

- Meetings: A 15-min time slot to meet with Professor Hee via Zoom.

Part B - The Greenhouse Gas Protocol’s Corporate Standard 3-Part training webinar

- Instructions:
 1. Access the 3-Part training by clicking on the “GoToStage channel” link in the final paragraph on the page: : <https://ghgprotocol.org/Corporate-Standard-Training>
 2. NOTE: Each session is approximately 1 ¼ hrs and will serve as a substitute for meeting during our regular class time.
 3. *Edit your resume* to include the fact that you completed WRI’s 3-part training on the Greenhouse Gas Protocol’s Corporate Standard.

8. Tuesday, February 16

Topic: Overview of the ISO LCA Standard

Read: Textbook Chapter 2: General Principles of Life Cycle Assessment

Assignments:

- Complete Q2 at end of Ch 2. Upload answer in Word doc to Sakai before class.
- Pay for your student subscription to Sustainable Minds if you have not done so already: <http://www.sustainableminds.com/> (\$49)

9. Thursday, February 18

Topic: Examples of Published LCAs

Assignment:

- See description of HW required in advance of today’s class above in “Assignments” section.

10. Tuesday, February 23

Topic: The ISO LCA Standard – Step 1a: Goal and Scope

Read: Chapter 3, Section 3.1 and 3.2.

11. Thursday, February 25

Topic: The ISO LCA Standard – Step 1b: Defining the Functional Unit and Setting Boundaries

Assignments:

- **Read** Chapter 3, Sections 3.3, 3.4, and 3.5
- **Watch**
 - 1) “Overview & Tour of Sustainable Minds”: https://youtu.be/z_aCvUc-YjA (2:30)
 - 2) “Sustainable Minds LCA Demo”: <https://youtu.be/hzKN5Tb4W7U> (9:47)
- **Solve** Exercise 3.2 in our Textbook and upload your work to Sakai by 11:59 pm Sunday, February 28.

12. Tuesday, March 2

Topic: ISO LCA Standard – Step 2: Inventory Analysis, Introduction to Data Acquisition and Management for LCA Inventory

Assignments:

- **Read** Chapter 5 from “Free LCAText” on LCA Sakai

13. Thursday, March 4

Topic: ISO LCA Standard – Step 2: Inventory Analysis and Sustainable Minds Project Intro.

Assignments:

- **Read** Ch 4: 4.1, 4.2, and 4.3 in our class textbook
- **Complete** a screening-level LCA using Sustainable Minds following the instructions provided on Sakai. **Due Sunday, March 14, 11:59pm. (Team project)**

00. Tuesday, March 9

Wellness Day – No class!

14. Thursday, March 11

Topic: ISO Step 3 and 4: Impact Assessment and Interpretation

Read:

- Chapter 6, sections 6.1, 6.2, 6.3, and 6.4 in our textbook

15-22. For Four Weeks (Wks 9-12): Using GaBi to Conduct a Detailed LCA

Assignments:

- For **Thursday, March 16**, watch “LCA Software GaBi in 5 Minutes”:
<https://www.youtube.com/watch?v=ETWsM4RReRc&t=53s>
- Throughout these four weeks, you will complete three small assignments using GaBi that will build your comfort using this complex software. Details will be provided on **Sakai**.
- To prepare for class, you should
 - 1) Review materials covered the prior day by replicating the work in GaBi that we did together as a class.
 - 2) Using what we did in class as a model, create your own GaBi project that you can build on and alter as we cover new material.
- At the end of this section, you should update your resume to include that you have beginner- or intermediate-level proficiency using GaBi.

23. Tuesday, April 13

Topic: Circularity and Net Positive – Part I

Assignments:

1. **Watch:**

- “Navigating the Circular Economy: A Conversation with Dame Ellen MacArthur.”
<https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/navigating-the-circular-economy-a-conversation-with-dame-ellen-macarthur> (4:28)
- *Optional but awesome!* Bill McDonough’s TED Talk at
https://www.ted.com/talks/william_mcdonough_on_cradle_to_cradle_design?language=en

2. **Read:**

- “Towards a Circular Economy: Business Rationale for an Accelerated Transition” by the Ellen MacArthur Foundation and McKinsey Consulting. November 2015. ([Link](#))
- “Eight Companies to Watch in the Circular Economy” GreenBiz. August 10, 2016.
<https://www.greenbiz.com/article/8-companies-watch-circular-economy>.

3. **Consider** the following questions:

- What examples of circularity are you personally familiar with?
- Environmentalists are sometimes criticized for being “anti-growth”? What argument does McDonough make that addresses the question of whether growth is good?
- What do you believe are the largest impediments to a circular economy?
- What product or business types do you think most need to become more circular? For which would the change be easiest? hardest? most popular with consumers?

24. Thursday, April 15

Topic: Circularity and Net Positive – Part II

Assignments:

- o **Read:** this article...it is on the long side, but trust me, it's worth it:
 - a) “Net Positive: The Future of Sustainable Business” by Jeffrey Hollender. *Stanford Social Innovation Review*. April 29, 2015. ([Link](#))

- o **Watch** the following videos:
 - a) Jeffrey Hollender: “Less Bad Does Not Equal Good.” [Link](#) (1:58)
 - b) Ray Anderson: [Link](#) (5:56)
 - c) NetWorks: [Video 1](#) (8:24), [Video 2](#) (2:10), [Video 3](#) (2:32)
 - d) Weaving a Better Life: [Link](#) (3:50)

25. Tuesday, April 20

Topic: Socially-focused Life Cycle Assessments (SLCA)

Read:

- o Executive Summary, Introduction (Ch1), and What is Social Life Cycle Assessment (Ch2) in *Guidelines for Social Life Cycle Assessment of Products and Organizations*. 2020. ([Link](#))

26. Thursday, April 22

Topic: LDOC – Course Wrap UP