# ESM 273: Life Cycle Assessment

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| **Instructor**: | Sangwon Suh<br>Bren hall 3422<br>suh@bren.ucsb.edu |
| **TA**: | Joe Palazzo<br>jpalazzo@bren.ucsb.edu |
| **Course hours**: | Tuesday and Thursday, 1:00-2:15pm |
| **Course credit**: | 4 credit |
| **Course location**: | BH 1424 (Jan 8th – Feb 12th; Mar 14th), Bren Computer lab (Feb 14th – Mar 12th) |
| **Office hours:** | Tuesday 1-1:30pm and Wednesday 11-11:30am unless traveling (travel schedules will be communicated in advance); or by appointment (**Use Google Calendar for any and all appointment. No email confirmation required.**) |
| **Midterm:** | **Feb 12th at the classroom** |
| **Final exam**: | No written exam. Final presentation on the March 14st at BH 1424; and a blog article for each inquiry due by the 19th March |

**Assessment**:

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| Homework: | 20% |
| Midterm (Feb 12th; written exam): | 20% |
| Presentation of a group project (Mar 14th): | 30% |
| Blog article (final report, March 19th): | 30% |

**Homework due:** Jan 24th (See HW instruction at the end of this syllabus)

**Textbook**: Matthews et al., 2014: Life Cycle Assessment. Green Design Initiative, Carnegie Mellon University, Pittsburgh, PA (pdf version uploaded to the class Gauchospace).

**Course objectives**:

1. Students understand the overall process of performing an LCA following the ISO Standards.
2. Students are able to answer a question that can be addressed in part by an LCA.
3. Students are able to communicate the results to a broader audience.

**Course schedule (items for class inquiries marked in blue and relevant textbook chapters in red)**

**Jan 8:** Introduction. What is LCA? #1 & 3

**Jan 10:** Goal and Scope definition; Define goals for each inquiry. #4

**Jan 15:** Life Cycle Inventory I—concept; Literature review, and initial data requirements. #5

**Jan 17:** Life Cycle Inventory II—calculation; List of data collected, and identification of data gaps. #5, 8.1 & 9.1

**Jan 22:** Life Cycle Inventory III—methodological issues; Report the progress of LCI data collection. #5, 6, & 9.4-9.7

**Jan 24 (HW due):** Life Cycle Impact Assessment I—concept; Report the progress of LCI data collection and the plan for filling out data gaps using proxy values or assumptions (guest: Natalie Colvin, Teva Associate Product Line Manager). #10

**Jan 29:** Life Cycle Inventory II—calculation (guest: Dr. Joe Bergesen at Amazon.com on LCA at his company); Finalize all data for LCI #10

**Jan 31:** Life Cycle Inventory III—methodological issues; Identify and collect characterization factors. #10

**Feb 5:** Life Cycle Interpretation I—contribution analysis and sensitivity analysis; finalize data needed for characterization. #12

**Feb 7:** Life Cycle Interpretation I—uncertainty analysis, reporting and communication; draft outline of the communication material based on expected outcome. #7

**Feb 12:** Midterm exam

--- LAB PORTION BEGINS FROM HERE ---

**Feb 14:** Construction of A, B, and C matrices I

**Feb 19:** Construction of A, B, and C matrices II; Suh out of town

**Feb 21:** LCI calculation I; Suh out of town

**Feb 26:** LCI calculation II, intermediate interpretation

**Feb 28:** Characterized results calculation, intermediate interpretation

**Mar 5:** Interpretation I—contribution analysis, sensitivity analysis and analysis

**Mar 7:** Interpretation II—uncertainty analysis, drawing conclusions, visualize the results

**Mar 12 (BH 1424): Final presentation (3 groups)**

**Mar 14 (BH 1424): Final presentation (3 groups)**

**Mar 19: Blog article due**

**Midterm Exam instruction**
Exams will be about basic knowledge on the concept and the terms of LCA and the ability to compute LCI and LCIA results. Please bring your calculator.

**Final presentation instruction**
Each group will have 15 min presentation + 5 min Q&A. Cover: (1) goals and objectives, (2) product description, (3) data and data sources, (4) main results and key findings including major contributors, (5) recommendations, and (6) sensitivity analysis/uncertainty analysis results and limitations.

**Blog article instruction**
Choose the blog site at your discretion. There is no style guidance, but I recommend organizing the article in such a way that it answers a question that is broadly interesting. Try to translate the findings into the metrics and language that can be more easily accessible to the public. There is no limit on length, but I recommend up to 2,000 words. Use graphics whenever useful. Add the following note at the end: "Disclaimer: this article is written as a part of the course requirements under ESM 273: Life Cycle Assessment taught by Professor Sangwon Suh at the Bren School of Environmental Science and Management, University of California, Santa Barbara. The results used in this article were generated from in-class project designed to serve an educational purposes and they have not been third-party peer-reviewed. We do not recommend using our results or the content of this article as the sole basis for major decisions including but not limited to investment decisions and purchasing decisions."

## Homework instruction

1. Representation of a unit process: the following table shows direct inputs to make 1 kg of hot rolled coil steel making. Represent this information using boxes (for processes) and arrows (for intermediate flows). Note the quantity of flow next to the corresponding arrow **(2%)**.

| Name of inputs | Unit | Amount (input to 1 kg hot rolled coil) |
|---|---|---|
| Hot rolled coil | kg | 0 |
| Cokes | kg | 1.5 |
| Iron ore | kg | 0.7 |
| Lime | kg | 0.2 |
| Transportation | Ton-km | 0.5 |
| Electricity | kWh | 0 |
| Diesel | liter | 0 |

2. Converting input/output information into a matrix: you have acquired following information from the suppliers to the steel maker.
   - To produce 1 kg of cokes, 200kWh of electricity and 0.1 ton-km of transportation are needed.
   - To produce 1 kg of iron ore, 100kWh of electricity is needed.
   - To produce 1 kg of lime, 50kWh of electricity and 0.3 ton-km of transportation are needed.
   - To produce 1 ton-km of transportation, 0.15 liter of diesel is needed.
   - To produce 1 kWh of electricity, no input is needed.
   - To produce 1 liter of diesel, no input is needed.

   You are to store this information together with the table in the question 1 in the same way the table is structured. I.e., each column shows the amount of inputs needed to produce one unit of the output from the corresponding process. A blank table is shown below. Fill in the table using the information provided **(2%)**.

| Name of inputs | Unit | Hot rolled coil making | Cokes making | Iron ore production | Lime production | Transpor tation | Power plant (hydro) | Diesel production |
|---|---|---|---|---|---|---|---|---|
| Hot rolled coil | kg | 0 | | | | | | |
| Cokes | kg | 1.5 | | | | | | |
| Iron ore | kg | 0.7 | | | | | | |
| Lime | kg | 0.2 | | | | | | |
| Transportation | Ton-km | 0.5 | | | | | | |
| Electricity | kWh | 0 | | | | | | |
| Diesel | liter | 0 | | | | | | |

3. Converting a direct requirement matrix into a process flow diagram: using the table constructed as a result of the question 2, draw a process flow diagram **(1%)**. If each process generates 1kg of $CO_2$ to produce 1 unit of its output, how much of $CO_2$ will be generated to produce 1 kg of hot rolled coil **(2%)**?

4. Converting a process flow diagram to a direct requirement matrix: the following process flow diagram shows an ice cream product system. Using the information provided with the process flow diagram, populate a direct requirement matrix following the same rule as the one in question 2 **(3%)**.