Course 1: Life Cycle Assessment: theory and practice

Lecturer

Prof. Sangwon Suh, Bren School of Environmental Science and Management, University of California, Santa Barbara, CA, USA

Abstract

This class is based on in-class discussions and hands-on exercises as well as lectures. In this class, the concept of product's 'life cycle' is introduced and environmental impacts across product's life cycle will be discussed using a number of illustrative examples such as "Zero Emission Vehicles" and "Carbon Neutral Plastics". The class will discuss how to represent the product's life cycle using graphical and mathematical notations using numerical examples. The class will be given a life cycle inventory problem. Practical challenges in compiling a life cycle inventory including data availability and the problem of multi-functionality will be discussed. The concept of attributional and consequential modeling will be introduced, and the limitations of the approach that was used as an exercise will be discussed. The class will discuss the concept of 'marginal technology' using examples around biomass production and recycling. The problem of truncation in life cycle inventory problem will be introduced, and a possible solution via hybrid approach will be discussed using a simplified example. The class will discuss how the life cycle inventory result can be interpreted. The concept of 'environmental mechanism' will be introduced, and the class will learn about the basics of characterization, normalization, and weighting, for which a numerical example will be presented. Life cycle interpretation will be introduced. The class will be given an exercise problem on sensitivity analysis and interpretation. The class will conclude with an overview of the process for conducting a life cycle assessment study from goal and scope definition, life cycle inventory, life cycle impact assessment, life cycle interpretation, and their iterations.

Course Objectives

Understand the key concepts in LCA and be able to solve simple LCA problems.

Preliminary timeline (9:00 – 17:20)

The course is planned for 6 hours.

Lesson 1	Conceptual framework: products' life cycle - The case of "Zero Emission Vehicle" - The case of "Carbon Neutral Plastics" Discussion - Life Cycle environmental impacts of plastic packaging: a difficult choice - The biofuel debate: an intellectual history Exercise - Apples to apples? Drawing some system boundaries for two lunch options: sushi v.s. ham burger
Lessons 2-3	Life cycle inventory problem - How to represent a life cycle inventory problem? Process flow diagram and matrix approaches

	- A numerical example Discussion - Where the data come from?: Mock data collection activity—divide the class into groups and the group reports on potential data sources for their LCI problem. - Multi-functionality problem - Average v.s. marginal: the case of cotton and corn; where the marginal corn - Truncation errors Exercise - Numerical example of an LCI problem (PET bottle)
Lessons 3-4	Input-output and hybrid LCA - Brief history - How a national input-output table is organized? - Treatment of imports, multi-regional IO approaches - Hybrid approach Discussion - Data age, price inhomogeneity, and aggregation errors - Hybridizing a process LCA database Exercise - Numerical example of hybrid LCI problem
Lessons 4-6	Life Cycle Impact Assessment and Interpretation - The concept of 'environmental mechanism' - Characterization, normalization, and weighting - Interpretation of LCA results - Uncertainty and sensitivity analysis Discussion - 1kg v.s. 100 tonnes: the issue of scale - Our understanding of the environmental mechanisms: fate, transport, exposure, and toxicity - The issue of congruency between normalization and weighting - Uncertainty of uncertainty analysis? Exercise - Numerical example for characterization, normalization, and weighting - Sensitivity analysis

Requirements

Requirements: The class will be given some pre-read materials and the participants are recommended to bring their laptops with Microsoft Excel with it.

Pre-read:

1. System boundary selection in life-cycle inventories using hybrid approaches

S Suh, M Lenzen, GJ Treloar, H Hondo, A Horvath, G Huppes, O Jolliet, ...

Environmental Science & Technology 38 (3), 657-664

2. Methods for life cycle inventory of a product

S Suh, G Huppes

Journal of Cleaner Production 13 (7), 687-697

3. On the uncanny capabilities of consequential LCA

S Suh, Y Yang

The International Journal of Life Cycle Assessment 19 (6), 1179-1184

4. The importance of normalization references in interpreting life cycle assessment results

J Kim, Y Yang, J Bae, S Suh

Journal of Industrial Ecology 17 (3), 385-395

5. Marginal yield, technological advances, and emissions timing in corn ethanol's carbon payback time

Y Yang, S Suh

The International Journal of Life Cycle Assessment 20 (2), 226-232

6. Industry-Cost-Curve Approach for Modeling the Environmental Impact of Introducing New Technologies in Life Cycle Assessment

A Kätelhön, N von der Assen, S Suh, J Jung, A Bardow

Environmental science & technology 49 (13), 7543-7551

7. Land cover change from cotton to corn in the USA relieves freshwater ecotoxicity impact but may aggravate other regional environmental impacts

Y Yang, S Suh

The International Journal of Life Cycle Assessment 20 (2), 196-203