MECH 328
Life Cycle Assessment

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Q: What is LCA?

A: LCA, also called (Life Cycle Analysis) is a rigorous way of assessing the environmental impact of human activities

- N.B. Some forms of LCA consider both environmental and social impacts

Motivation and Objectives

- Life Cycle Analysis (LCA) is way too complicated a topic to cover in a single lecture
- The purpose of this lecture is to give you a flavour of what LCA involves, not all the details. Professor Bi in CHBE teaches two courses on the topic!
- By the end of this lecture you should be able to:
  - Define LCA
  - Describe in general terms how to carry out a Life Cycle Assessment

Overview of Product Life Cycle

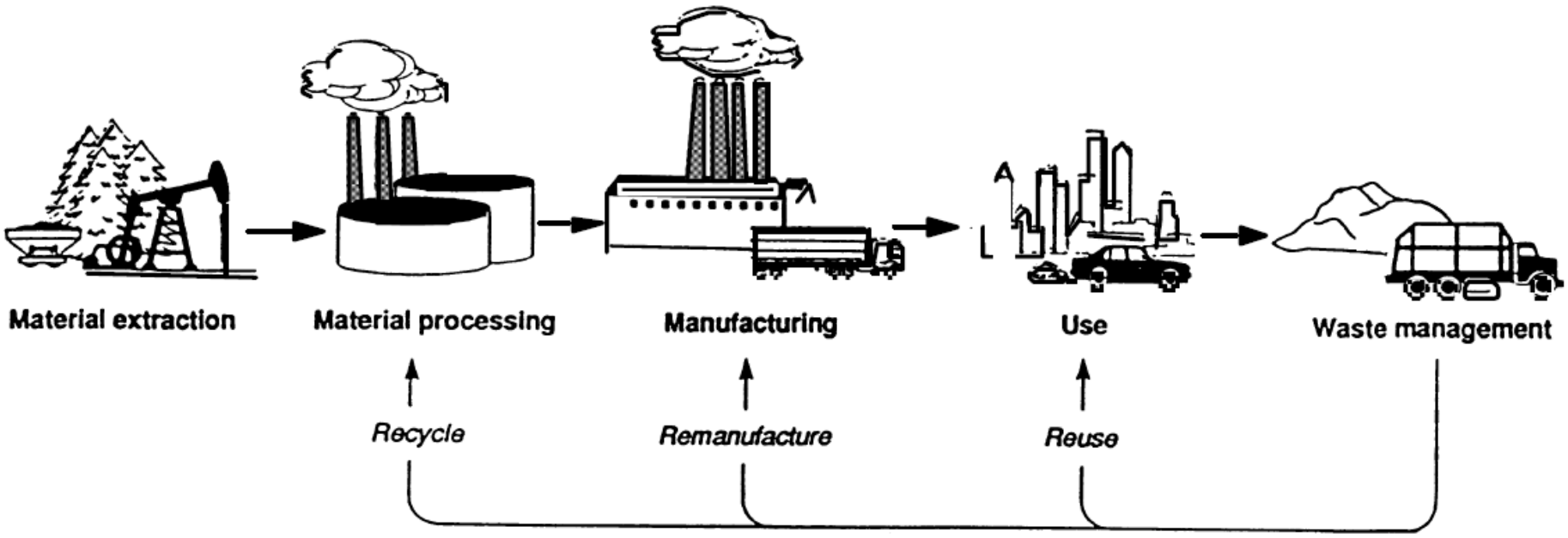

Figure 1-1: Overview of a Physical Product Life Cycle (OTA, 1992)

Example: Paper

Material Extraction:
- Trees
- Clay
- Chemicals

Material Processing:
- Debarking
- Chipping
- Pulping

Manufacturing:
- Forming
- Pressing
- Drying

Use:
- Transport to consumer

Recycle:
- Repulping

Remanufacture:
- Not applicable for paper

Reuse:
- Scrap paper

System Boundary

- A key aspect of LCA is defining carefully what you are analyzing
- You can define the system boundary as “the papermill” (“gate to gate”). Not a true LCA.
- You can define the system boundary as “the forest to the dump”, (“cradle to grave” or “cradle to cradle”)
- IT IS ESSENTIAL TO CLEARLY DEFINE THE SYSTEM BOUNDARY

Environmental Impacts of Papermaking

- Road construction to access trees
- Electricity to grind up trees, pump slurry, etc.
- Water to generate pulp slurry
- Heat (from burning bark, etc.) to dry paper
- Chemicals used to produce paper
- Gasoline to take paper to consumer
- Power, etc. needed to build papermachine
- ETC., ETC.

➢ Analyzing each one is complex

➢ Thinking about the sum is even more complex!

Some Counterintuitive Results

- "Environmental implications of electric cars", Science, 1995
- Conventional cars better because lead-acid batteries of EV produce lots of lead pollution during recycle phase
- https://www.gov.uk/government/publications/life-cycle-assessment-of-supermarket-carrierbags-a-review-of-the-bags-available-in-2006
- Plastic bags better owing to large energy to produce paper

e.g. Water Footprint of Paper

- Google “water footprint of paper”

Q: How much water to produce one A4 sheet?

A:

(reference:https://link.springer.com/article/10.1007/s11269-011-9942-7)

Q: This number seems very high. What used most of the water (refer to abstract)?

A:

- LCA best when used to compare two different technologies with similar goals

LCA Exercise

Data: Assume two types of electricity supply are present in a country's grid: photovoltaics (30 g CO_2/kWh) and coal-based electricity (850 g CO_2/kWh). Hertwich et al. 2015. Proc. Natl. Acad. Sci. 112, 6277–6282.

Q: Why is the CO_2 output of photovoltaics not zero?

A:

LCA Exercise (cont'd)

More data and assumptions: Energy need of passenger cars during the use phase: 0.85 MJ/km (electricity, for battery electric vehicles), and 2.2 MJ/km (gasoline for int comb eng (ICE) vehicles).
Modaresi et al. 2014 Environ. Sci. Technol. 48, 10776–10784.

Q: Why does an EV need much less energy than ICE?

A:

More data: The CO_2 – intensity of gasoline is 14 MJ/kg CO_2. The CO_2 – intensity of gasoline supply 10g CO_2/MJ of gasoline. Neglect emissions from vehicle production and disposal.

LCA Exercise (cont'd)

Q: Calculate the break-even point of the share of renewable energy in the grid where the EV is less carbon-intensive than the ICE.

A: