Fundamentals of LCA

InLCA/LCM Conference

Seattle Center Northwest Rooms - Lopez Room

Seattle, Washington

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Objectives of Short Course

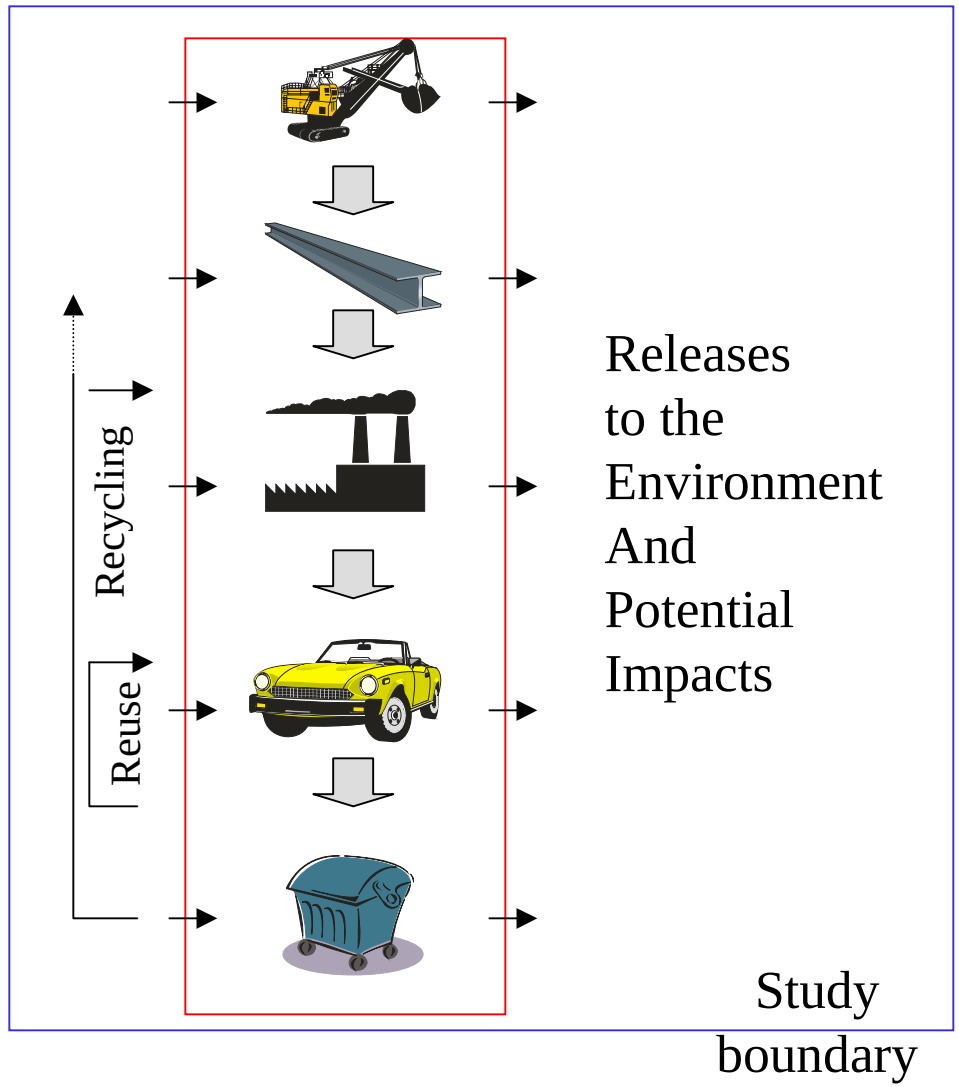
1. To present concepts, models and tools to estimate the life-cycle implications of material, process, or product choices
2. Describe the state-of-the-art of LCA
3. Demonstrate some of the available LCA software tools
4. Present applications of LCA to products

The Objectives of LCA

- System-wide examination
- Multi-media approach (air, water, waste)
- Identify trade-offs among alternatives
- Identify opportunities to improve systems
- Support environmental decision making
- Sustainable development

The LCA Concept

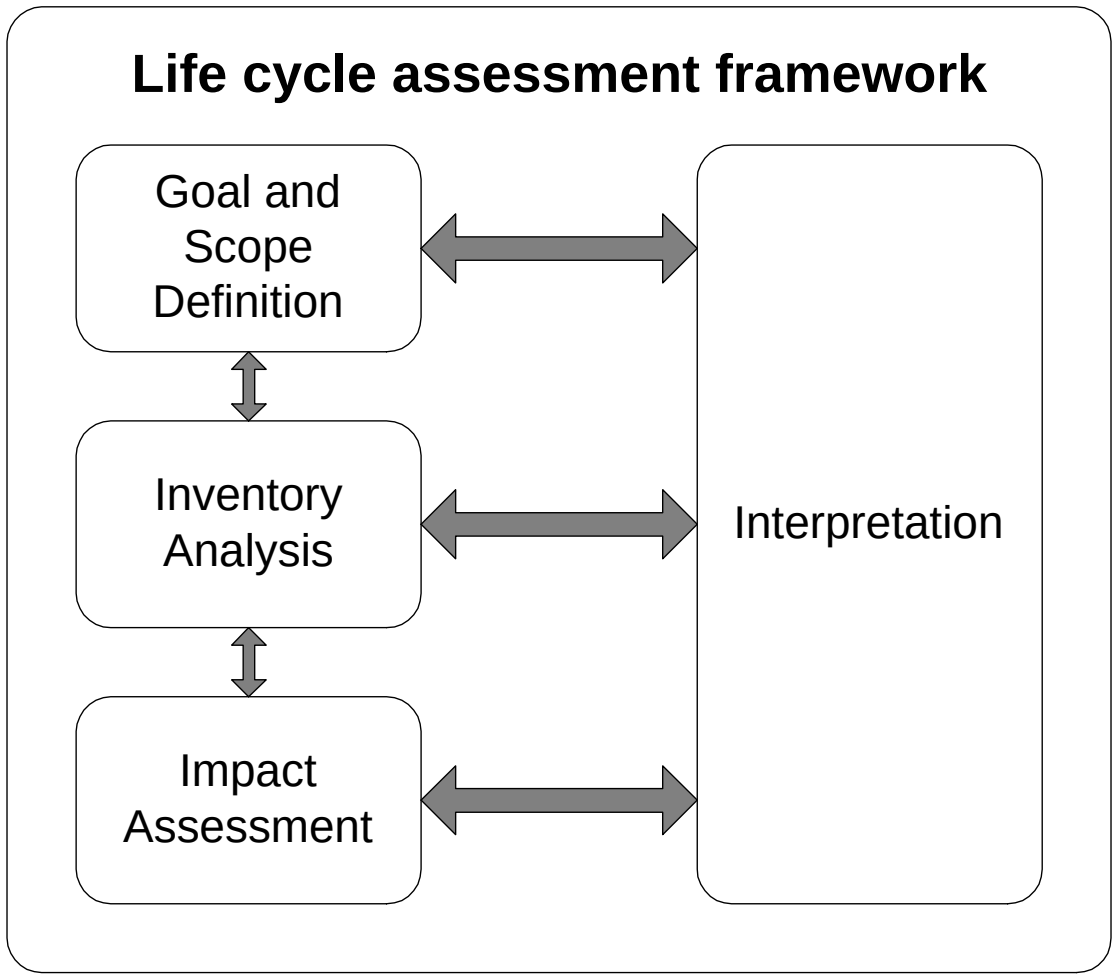
- Raw Material Extraction
- Material Processing
- Production
- Use and Maintenance
- Disposal



International Standards Organization (ISO) LCA Series

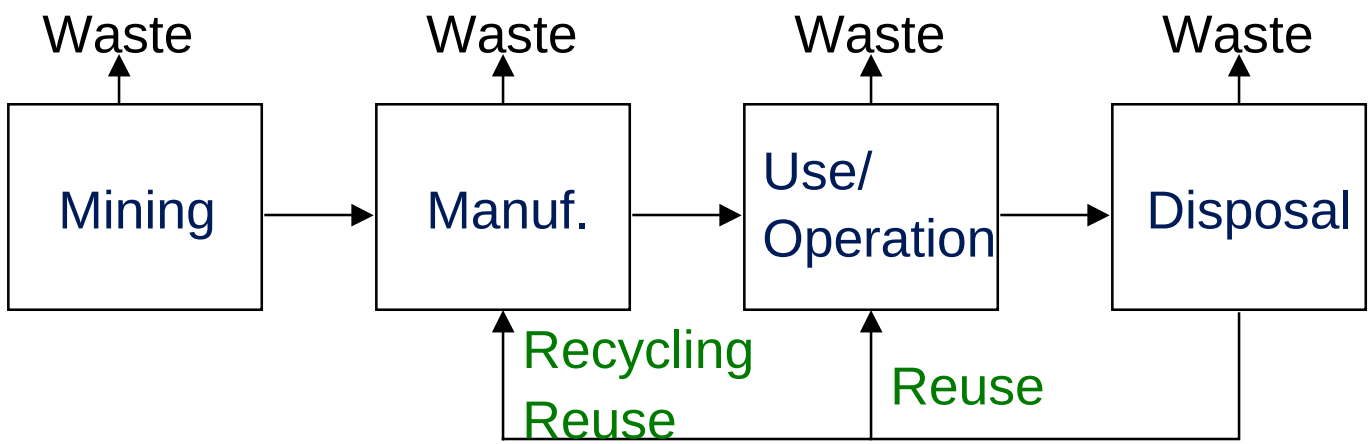
- ISO 14040: Principles and Framework
- ISO 14041: Goal, Scope & Inventory Analysis
- ISO 14042: Impact Assessment
- ISO 14043: Life Cycle Interpretation
- ISO 14047: Examples of Impact Assessment
- ISO 14048: Documentation Format
- ISO 14049: Examples of Inventory Analysis

ISO Definition of LCA - 1404X



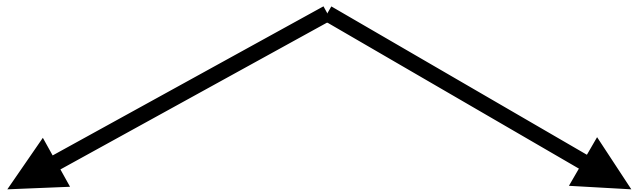
Life-Cycle Assessment (LCA)

- A concept and methodology to evaluate the environmental effects of a product or activity holistically, by analyzing the whole life cycle of a particular product, process, or activity (U.S. EPA, 1993).
- LCA studies analyze the environmental aspects and potential impacts throughout a product's life cycle (e.g., cradle-to-grave) from raw material acquisition through production, use and disposal (ISO).



Life Cycle Concept

Leads to two types of approaches



Pre-Selected Actions	OR	Input/Output Determination
Identifying opportunities to implement action, (e.g., recycling) across the life cycle		Using the ISO framework to account for and evaluate system flows and potential impacts

Goal Definition

Why is the study being done?

- Internal Screening LCA
- Internal Detailed LCA
- External Third Party Reviewed LCA
- Comparative Assertion Disclosed to the Public

The Goal establishes **Function & Functional Unit**

The goal must be revisited periodically as the study progresses to ensure consistency of data collection with end use of the results.

Functional Unit

- Functional unit is defined by the primary function fulfilled by a product system
- Enables equal comparison of alternative product systems
- Determines the reference flow on which amounts of inputs and outputs are calculated

Scope Definition

Setting the study boundaries to:

- Define Coverage:
  - Time
  - Geographical
  - Technology
- Justify limits:
  - Focus on select stages
  - Omitting small inputs

Issues on Inventory Data

- Data sources and accuracy are major barriers to conducting LCAs
- Data come from many different sources, such as:
  - Proprietary, company data
  - Consultants, labs, universities
  - Public, e.g., Toxics Release Inventory (EPA) and Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (DOE/ANL)
- Databases use different units or different reference flows and report across different time periods.
- Often more than one source is needed to calculate the necessary inventory data

Cut-Off and Data Estimation

- In a perfect world an LCA would track all the processes in the system under study.

  In practice this is impossible!
- Cut-off and estimation where data are lacking and *time* and *money* are limited.
- Occurs after data collection when items are unknown or undocumented.
- Revisit the goal to ensure the study has not deviated from the original intent.

Data Availability

Efforts are underway to make inventory data more accessible:

- North American Database *(in progress)*

  NREL, EPA, GSA, Army, Auto Industry

  http://www.nrel.gov/lci/

- EPA's Data Portal – *LCAccess*

  www.epa.gov/ORD/NRMRL/lcaccess

EPA NRMRL Life-Cycle Assessment (LCA) Web Site - Microsoft Internet Explorer

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EPA Home > NRMRL > LCAccess

- Why LCA?
- LCA 101
- Data Sources
- LCA Resources
- Ongoing Efforts
- Upcoming Events

LCAccess HOME

Welcome to the National Risk Management Research Laboratory's Life-Cycle Assessment (LCA) website. This site's purpose is to promote the use of LCA to make more informed decisions through a better understanding of the human health and environmental impacts of products, processes, and activities. The site is divided in to six primary areas to help educate people new to the concept of LCA while serving as a focal point for LCA practitioners and decision-makers to stay current with field of LCA. LCAccess provides information on why one would want to perform an LCA, an overview of LCA, how to find LCI data sources, available LCA resources, on-going efforts in the field of LCA and upcoming LCA events.

BRAND NEW!
The Global LCI Directory contains over 370 data source profiles. Click here to search the directory.

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Last updated on Monday, July 1st, 2002
URL: http://www.epa.gov/ORD/NRMRL/lcaccess/index.htm

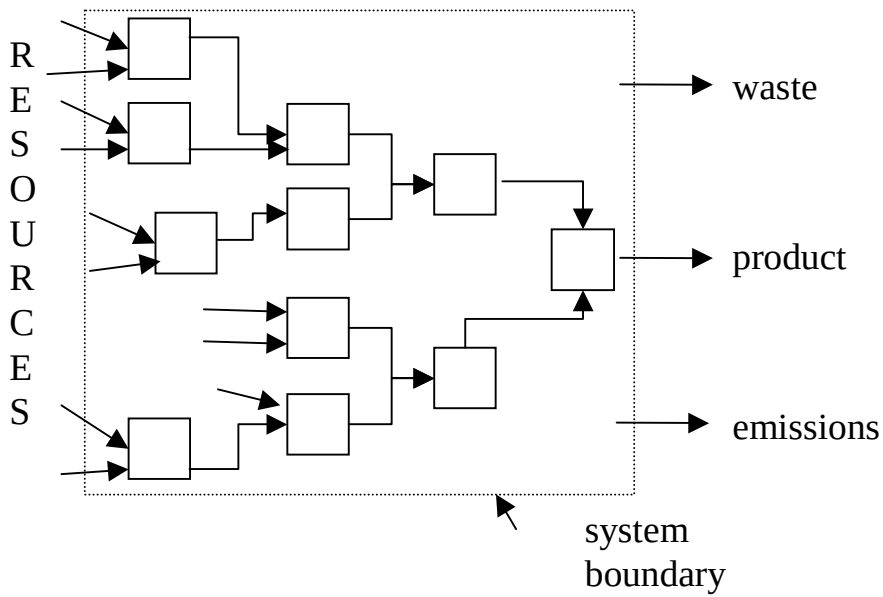
Internet

Procedural Organization

- Normative choices made prior to modeling the product system
- Choice of data sources and data quality requirements
- Enforcement of the accounting rules
- Processing of data choices
- The LCI calculation method
- Significance analysis
- Presentation of the results – MAINTAIN TRANSPARENCY OF WHAT WAS DONE

Circularity Effects

Circularity effects in the economy must be accounted for: cars are made from steel, steel is made with iron ore, coal, steel machinery, etc. Iron ore and coal are mined using steel machinery, energy, etc...



Format and Data Categories

- Choice of data categories should be made in relation to impact categories
- Use a transparent format
- Conformity with a data exchange standard can be useful:
  - ISO 14048 - Data documentation format (2002)

Data Quality

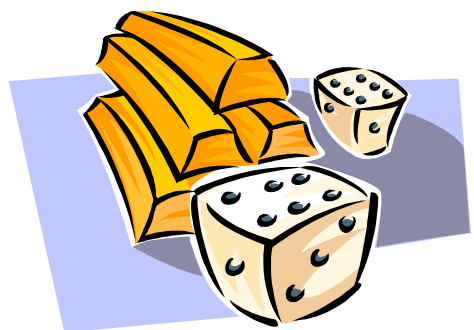
- Specific vs. general
- Measured, calculated or estimated
- Precision as a measure of variability
- Completeness as a percentage
- Representativeness
- Consistency
- Reproducibility
- Reliability of data source
- Mass and energy balances

Co-Product Allocation

- Processes often make more than one product
- If possible avoid allocation by:
  - Splitting up processes
  - Expanding the system boundary to include the additional functions
- If allocation is required,
  - Partition by physical relationship (mass; volume)
  - Partition by economic value

Impact Modeling

- There is still no consistent way to model impacts for LCA, however,
- The practice is converging on similar impact categories.



Impact Assessment - Common Impact Categories

Impact Category	Indicator Measurement
Resources	kg scarce Resources
Water	m^3 Water
Global Warming	kg CO_2 Equivalents
Ozone Depletion	CFC 11 Equivalents
Acidification	kg SO_2 Equivalents
Eutrophication	kg PO_4^{3-} Equivalents
Smog Formation	kg Ethene Equivalents
Human Toxicity	HTx Equivalents
Eco Toxicity	ETx Equivalents
Waste	kg Waste
Land Use	equivalent hectares
Noise	equivalent decibels] More common
Odor	??] in Europe

Inventory of Stressors
Land Use
Chemical Emissions
Water Use
Fossil Fuel Use

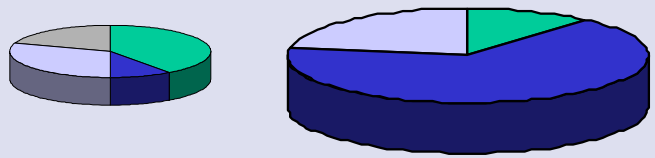
Impact Categories
Land Use
Ozone Depletion
Global Warming
Acidification
Carcinogenicity
Noncarcinogenicity
Eutrophication
Smog Formation
Water Use
Fossil Fuel Use

Characterization (e.g., Carcinogenicity)

TRACI

Tool for the Reduction and Assessment Of Chemical and Other Environmental Impacts

.....
Ozone Depletion
Global Warming
Carcinogenicity



Option A

Option B

Methodology Issues (Limitations)

- There is no single LCA method that is universally agreed upon.
- Different boundary definitions will lead to different results.
- There is lack of comprehensive data for LCA.
- Data reliability is questionable.
- LCA is too slow for application in the design process.
- Conventional LCA ignores economic and societal effects.
- LCA cannot capture the dynamics of changing markets and technologies.
- LCA is most useful as an iterative process to identify where more information is needed (e.g., risk assessment).

LCA Software

• BEES 3.0	NIST
• ECO-it 1.0	PRé Consulting
• EcoManager 1.0	Franklin Associates, Ltd.
• EcoPro 1.5	EMPA
• GaBi 3.0	PE International/IKP
• IDEMAT	Delft Univ. of Technology
• LCAD	Battelle/DOE
• LCAiT 2.0	CIT EkoLogik
• LCNetBase	Sylvatica
• PEMS	PIRA
• REPAQ 2.0	Franklin Associates, Ltd.
• SimaPro 5.1	PRé Consulting
• TEAM 3.0	Ecobalance
• Umberto 4.1	IFU
• ……	

Suggested Reading

- Curran, M.A. (ed.). 1996. *Environmental Life Cycle Assessment.* McGraw-Hill, New York
- Jensen, A.A., et al. 1997. *Life Cycle Assessment (LCA): A Guide to Approaches, Experiences and Information Sources* . Report to the European Environment Agency. Copenhagen, Denmark
- Heijungs R, et al. 1992. *Environmental Life Cycle Assessment of Products. Vol. I: Guide, and Vol. II: Backgrounds*. Leiden: CML Center for Environmental Studies, Leiden University
- U.S. Environmental Protection Agency. Office of Research and Development. 1993. *Life Cycle Assessment: Inventory Guidelines and Principals*. EPA/600/R-92/245
- Environment Canada. 1997. *Environmental Life Cycle Management*
- *International Journal of Life Cycle Assessment*
- *Journal of Industrial Ecology*
- *Journal of Cleaner Production*