Environmental Life Cycle Assessment
PSE 476/WPS 576/WPS 595-005

Fall 2012
Richard A. Venditti
Forest Biomaterials
North Carolina State University
Raleigh, NC 27695-8005

Richard_Venditti@ncsu.edu
Go.ncsu.edu/venditti
Lecture 4: Goal and Scope:
Goal definition

• Goal of study should unambiguously state (ISO 14044: 2006E):
  – The intended application
  – Reasons for carrying out the study
  – Intended audience (who will the LCA be communicated to?)
  – Whether the results are intended to be used in comparative assertions intended for the public
    • Comparative assertion: environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function.

Refs: Michael Hauschild, DTU
Goal definition

• **Goal:** Reasons for carrying out the study
  – ID opportunities to improve the environmental performance of products at various points in their life cycle
  – Informing decision makers in industry, government, non-government organizations (NGO’s)
    • Strategic planning, priority setting, product or process design or redesign
  – Selection of relevant indicators of environmental performance, including measurement techniques
  – Marketing
    • Environmental claims
    • Eco labeling
    • Environmental product declaration

Refs: ISO 14044: 2006E
Goal definition

Goal and Scope Definition

Inventory Analysis

Impact Assessment

Interpretation
Scope

- Project Scope "The work that needs to be accomplished to deliver a product, service, or result with the specified features and functions."

Scope definition

- Scope definition must be in accordance with the goal definition
- Scope definition should consider and clearly describe (ISO 14044: 2006E):
  - The product system studied
  - The functions of the product(s) studied
  - The functional unit
  - The system boundary
  - Allocation procedures
  - LCIA methodology and types of impacts
  - Interpretation to be used
  - Data requirements
  - Assumptions
  - Value choices and optional elements
  - Limitations
  - Data quality requirements
  - Type of critical review, if any
  - Type and format of the report required for the study
  
  - temporal scope
  - technological scope
  - allocation or system equivalency

Refs: Michael Hauschild, DTU
Functional Unit and Reference Flows

- **Functional unit**: Quantified performance of a product system for use as a reference unit (ISO 14044: 2006E)

- Reference flow: measure of the outputs from processes in a given product system required to fulfill the function expressed by the functional unit
Functional Unit and Reference Flows

• Example: We are critically evaluating the environmental LCA of students having breakfast. We believe there are two options that we would like to study:
  – A bowl of cereal
  – A traditional eggs and meat breakfast

• What is the functional unit?

• What are the reference flow(s)?
System Boundary

- Which unit processes are included in the LCA
- Must be consistent with the goal
- Deletion of a life cycle stage, process, inputs or outputs only permitted if it does not significantly affect the overall conclusions
- Any decision to omit must be justified

- Ideally, the system boundary so that inputs and outputs are all elementary flows and product flows

Refs: ISO 14044: 2006E
Example: System Boundary for a Catalog
System Boundary

- Cut off criteria: specification of the amount of material or energy flow or the level of environmental significance associated with unit processes or product system to be excluded from the study
  - Mass, all the inputs that contribute less than X% to the total mass input of the product system
  - Energy, all the inputs that contribute less than X% to the total energy input of the product system
  - Environmental significance, any input that contributes less than X% of the environmental significance of a specially selected environmentally relevant individual data

- Similar criteria for outputs

Refs: ISO 14044: 2006E
Allocation

- **Allocation**: partitioning the input and output flows of a process or a product system between the product system under study and one or more of the other product systems

(ISO 14044: 2006E)
Allocation Procedures

• Step 1: allocation should be avoided
  – by dividing the unit process into 2 or more subprocesses and tracking data for both separately
  – Expanding the system to include the additional functions of the related co-products

• Step 2: partition the inputs and outputs between products in a way that reflects underlying physical relationships

• Step 3: partition the inputs and outputs between products in a way that reflects other relationships between them, eg, economic value

Refs: Michael Hauschild, DTU
Allocation Issues: Divide the process

- Example: A plastic injection molding device makes beverage containers and also makes toy parts.
Allocation Issues: System Expansion

• Example: municipal waste is burnt, reducing the amount of waste landfilled but also producing electricity
Allocation Issues: Co-products:

- **Co-products Allocation**: a single process produces multiple products,
  - Burdens can be partitioned by mass flows, volume flows, piece flows monetary values….
  - Must use process/product knowledge to determine partitioning method
  - Example for paper production: paper, Tall Oil, turpentine, electricity…
Allocation Issues: Co-products:

- Example: Papermaking process co-products:
  - paper
  - tall oil
  - turpentine
  - electricity
Allocation Issues: Recycling

- Recycling Allocation: a virgin product is recycled or re-used in a subsequent life
  - There exists operations that are required by the virgin and the recycled products (shared operations)
  - Example shared operations: virgin raw material production, final disposal
  - Many ways to allocate the burdens of the common operations
Life Cycle Impact Assessment Methodology and Types of Impacts

- Endpoints
- Midpoints
- Inventory

LCI result

Environmental mechanism

Radiation
Smog
Carcinogen
Climate
Ozone layer
Acidification
Land use
Nutriphication
Ecotoxicity
Minerals
Fossil fuel

Respiratory deseases
Seawater level
cancer
Dying forests
Extinction of species
Reduced resource base
Life Cycle Impact Assessment Methodology and Types of Impacts

- TRACI, The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts
  - Global Warming
  - Acidification
  - Human health: Carcinogenics
  - Human Health: Non carcinogenics
  - Respiratory Effects
  - Eutrophication
  - Ozone Depletion
  - Ecotoxicity
  - Smog

Fig. 1: Overall scheme of the IMPACT 2002+ framework, linking LCI results via the midpoint categories to damage categories, based on Jolliet et al. (2003a)
Data Quality Requirements

- Age of data
- Geographical coverage of data
- Technology data: specific or mix
- Precision: measure of variability
- Completeness: % of flow that is measured
- Representativeness
- Consistency
- Reproducibility
- Sources
- Uncertainty: for instance models

Refs: Michael Hauschild, DTU
Scope definition: Milk Example

- Design a goal and scope for milk production and sales functions up to the point of purchase.

Refs: Michael Hauschild, DTU
Milk: Goal and Scope

– Goal

– The product system studied

– The functions of the product(s) studied

– The functional unit

Refs: Michael Hauschild, DTU
Milk: Goal and Scope

– The system boundary

Refs: Michael Hauschild, DTU
Milk: Goal and Scope

– Allocation procedures

Refs: Michael Hauschild, DTU
Milk: Goal and Scope

– LCIA methodology and types of impacts

– Data requirements

– Assumptions

– Limitations

Refs: Michael Hauschild, DTU
Summary

• Goal
• Scope
• Functional unit
• Reference flow(s)
• System boundary
• Cut off criteria
• Allocation
• System expansion