Assessing Product Risk: A Study of Life-Cycle Assessment (LCA) Databases

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Overview

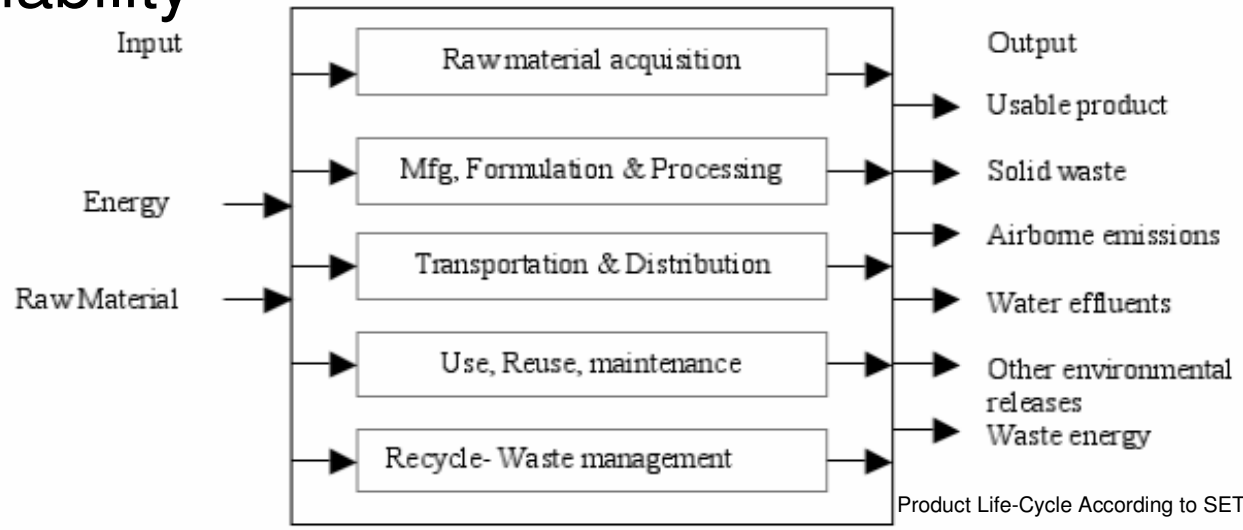
- LCAs are valuable for decision support

- Introduction to LCAs
  - What is it? How is it performed?
  - Why Perform It? Who needs it?
- Problems and Issues with LCA Tools, Suggestions
  - Electronic File Formatting
  - Database
- Conclusions

Life-Cycle Assessments

- Method for evaluating and comparing environmental impacts
- Reduces product risk and liability

- Users
  - Industry
  - Government
  - Consumer Interest Groups



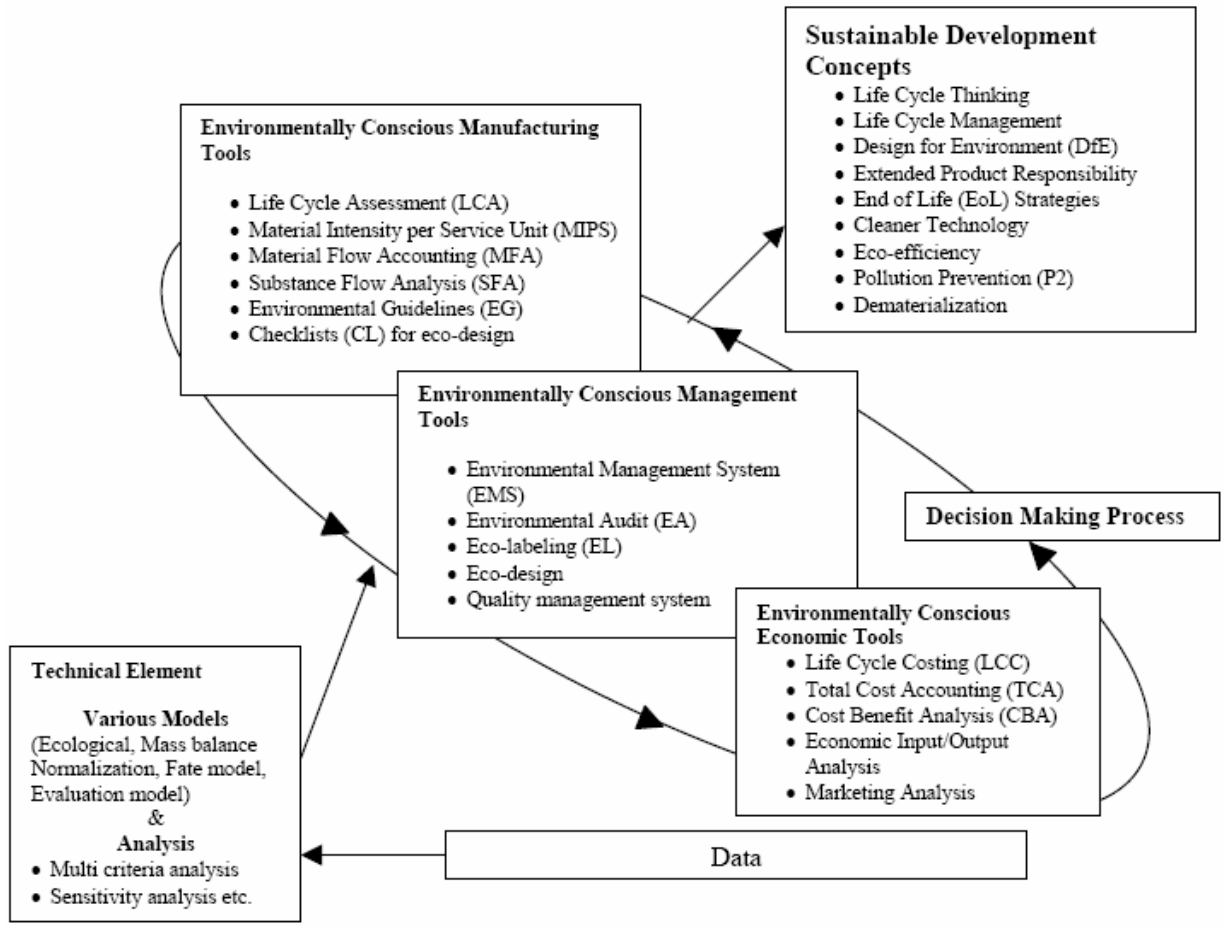
Product Life-Cycle According to SETAC (Ciambrone 1997).

LCA Process Steps

- Four-phased approach
- Defined in ISO 14040 series

Typical representation of the four-phased LCA approach with the Three I's (US EPA).

Sustainable Product Development



Overview of tools concerning environmental management (Choi et al. 2003).

Basic Issues with LCAs

- Data intensiveness makes lengthy process
- Expensive to pay researcher
- Inventory data often difficult, sometimes impossible to acquire
- Technologies have short product life-cycles that end within several years or months

Decision Support Systems (DSSs)

- Not required to complete LCAs
  - But eases complexity of study
- Helps humans make well informed decisions based on technical foundation
- Systems provide
  - Sharing of expertise
  - Pooling of expertise from multiple sources
  - Freeing experts from routine analysis

Data Collection and Storage

- Types of LCA Data
  - Type I: Product data, Material Production data, and Study-specific data
  - Type II: Secondary data
- Three barriers to poor data integration (Denzer & Ruttler):
  - Heterogeneity
  - Autonomy (explains multiculturalism issues)
  - Dynamics
- Overcome barriers with standard electronic file format

Electronic File Format

- Accompanying documentation
  - Especially in describing time and space
- Metadata
  - Serves as historical documentation
    - Samples produced by different technologies
    - Data structures change
    - Changing methods produce comparability problems
    - Geographical differences
- Categories of specification for LCA dataset
  - General descriptors
  - Function Specification
  - Data characteristics

Electronic File Format - Examples

- SPOLD
  - SPOLD ’99
  - SPOLD Data Exchange Software
  - Used by – SimaPro, Team 3.0, KCL-Eco, Umberto, etc.
- SPINE
  - XFR (Spine Transfer Format)
  - SPINE@CPM Data Tool
  - Used by –EcoLab, LCAiT, etc.

Databases

- Groups collect environmental and LCA data
  - Remove errors to provide quality data
- Sold separately or in software packages
- Can be imported/exported

Data Networks and Directories

- Provide medium for search and trade
- Administrators should –
  - Require data to follow required electronic file format and naming conventions
  - Require one person in data submitting organization defined as responsible
  - Ensure tools available for publishing/exchanging data
  - Clarify input procedures and phases of data management and inspection for quality ratings
  - Inspect data

Points adopted from Carlson et al (2000)

Databases and Networks – Examples

- SPOLD Database Network
  - Data placed on local ftp-servers is searchable
  - Allows suppliers
    - To define what part of dataset is made available
    - To set up “user clubs”
    - To place restrictions to datasets through passwords
- SPINE@CPM
  - Data from suppliers must meet requirements
  - Initiated trade structures for LCI data

Databases and Networks – Examples (II)

- Global LCI Directory
  - US EPA
  - Information on how to obtain needed data
    - Does not store or provide data
    - Provides data source profiles, voluntary
- EcoInvent Database
- Life-Cycle Inventory Database Project

Conclusions

- Decision Support Systems as LCAs powerful
  - More powerful when issues resolved
    - Data collection
    - Data storage
    - Standardization of Electronic File Format
- SPOLD ’99 vs. SPINE XFR
- Commercialization is good

QUESTIONS?

Supplemental Slides

LCA Process Steps (II)

- Goal Definition and Scoping
  - Identifies decisions or applications for which results will be used. Who needs the study? And Why?
  - Defines the life-cycle of product and all operations that contribute to the life-cycle
  - Defines boundaries, assumptions, and limitations
  - What activities and impacts are included/excluded. Why?

LCA Process Steps (III)

- Life-Cycle Inventory (LCI)
  - Data collection and quantitative calculations of net inputs and outputs through entire life-cycle
  - Dictated by the fundamental laws of science and engineering – more objective.
  - Limitations
    - Improvement assessments based only on energy and emissions, NOT for effects on human health or the environment.

LCA Process Steps (IV)

- Life-Cycle Impact Assessment (LCIA)
  - Evaluates significance of potential environmental impacts using LCI results
  - Four stages –

1. Category Definition	▪E.g. Global Warming
2. Classification	▪E.g. Carbon Monoxide (CO), Methane (CH_4)
3. Characterization	▪CO x Equivalency Factor = CO Indicator Score ▪CH_4 Equivalency Factor = CH_4 Indicator Score ▪CO Indicator Score + CH4 Indicator Score = Global Warming Potential
4. Weighting	▪Global Warming Potential compared to Ecotoxicological Impacts, etc. to determine priority rankings for each category.

LCA Process Steps (V)

- Life-Cycle Improvement
  - All previous information brought together to facilitate decision
  - Needs and opportunities to reduce environmental burdens evaluated

Abridged/Streamlined LCAs (II)

Streamlining approaches (US EPA 1997).

Streamlining Approach	Application Procedure
Removing upstream components	All processes prior to final material manufacture are excluded. Includes fabrication into finished product, consumer use, and post-consumer waste management.
Partially removing upstream components	All processes prior to final material manufacture are excluded, with the exception of the step just preceding final material manufacture. Includes raw materials extraction and precombustion processes for fuels used to extract raw materials.
Removing downstream components	All processes after final material manufacture are excluded.
Removing up-and downstream components	Only primary material manufacture is included, as well as any precombustion processes for fuels used in manufacturing. Sometimes referred to as “gate-to-gate” analysis.
Using specificentries to represent impacts	Selected entries are used to approximate results in each of 24 impact categories, based on mass and subjective decisions; other entries within each category are excluded.
Using specifcentries to represent LCI	Specific entries from the individual processes comprising the LCI that correlate highly with full LCI results are searched for; other entries are excluded.
Using “showstoppers” or “knockout criteria”	Criteria are established that, if encountered during the study, can result in an immediate decision
Using qualitative or less accurate data	Only dominant values within each of 6 process groups (raw material acquisition, intermediate material manufacture, primary material and product manufacture, consumer use, waste management, and ancillary materials) are used; other values are excluded, as are areas where data can be qualitative, or otherwise of high uncertainty.
Using surrogate process data	Selected processes are replaced with apparently similar processes based on physical, chemical, or functional similarity to the datasets being replaced.
Limiting raw materials	Raw materials comprising less than 10% by mass of the LCI totals are excluded. This approach was repeated using a 30% limit.

Current LCA Leaders

- International Organization for Standardization (ISO)
  - ISO 14040 Series, part of ISO 14000
- SETAC/UNEP
  - Life Cycle Initiative
- CPM and Chalmers University
  - Global SPINE
- US EPA
  - Life Cycle Assessment Team
- SPOLD, 1992-2002
  - SPOLD Data Exchange Format/ Database Network

Electronic File Format (III)

- Four principle types
  - Semantical metadata
  - Syntactical metadata
  - Structural metadata
  - Navigational metadata

Software (I)

- Two types –
  - For LCA practitioners
  - For Lay users
- Historically, guided by preferences and assumptions of environmental experts
- No software engineering principles
  - Software often do not do intended job or are frustrating to use

Software – Examples (I)

- Common characteristics –
  - Most use SPOLD ’99 or XFR
  - Comply with ISO 14040 standards
  - Communicate in English
  - Allow import/export of datasets
  - Provide several LCIA methods
    - Allow users to modify or create their own

Software – Examples (II)

- Industry Specific
  - ATHENA, BEES 3.0, KCL-Eco, etc.
- Runs in various languages
  - SimaPro
- Considers cost factors
  - Gabi 4.0, BEES 3.0

Other file formats

- Streamlined SPOLD, SPOLD ’97, unique to software (e.g. Boustead 4.0)
- Misc.
  - SimaPro’s SCRIPT feature, TEAM’s Source modules and Local Modules