EPA's Computational Toxicology Communities of Practice Series: Using Life Cycle Assessment for Risk Management

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Topics:

• Brief Description of LCA Methodology
• Risk Assessment Modeling compared to Life Cycle Impact Assessment
• Chemical Life Cycle Risk Assessment
Toward Sustainability: The True North of EPA Research

The Agency’s focus on sustainability brings an integrated approach to research, partnerships, and seeking solutions to help society now - and in the future.

“Historically, environmental programs have largely focused on how to reduce air and water pollution, and how to identify and monitor chemical and environmental risks to human health and the environment. Today’s challenges depend on the sustainable use of natural resources, and require solutions that stress the linkages between energy use, water use, land use, material consumption, environmental protection, human health, quality of life, and the global economy.”

EPA Science Matters Newsletter, March/April 2011
Life Cycle Assessment

An **industrial** environmental management approach to look **holistically** at products, processes, and activities.

- Raw Material Acquisition
- Production
- Material Processing
- Reuse/Recycling
- Use/Reuse/Maintenance
- End-of-Life Management
Life Cycle Stages

- Raw Material Acquisition
- Material Processing
- Production
- Use and Maintenance
- End-of-Life

Natural Resources:
Water
Metals
Minerals
Fossil Fuel
Crops
Forestry
Land
Etc.

Product System Boundary

Air Emissions
Water Effluents
Solid Waste

Study Boundary
Cradle-to-Gate Studies

Exclude downstream activities past product manufacture – but conclusions must relate to what was studied and not be overstated. Such studies are helpful in improving the product supply chain but may miss important impacts that occur during use and at end of life.
• **Goal & Scope Definition:**
  - Determine the scope and system boundaries

• **Life Cycle Inventory:**
  - Data collection, modeling & analysis

• **Impact Assessment:**
  - Analysis of inputs/outputs using category indicators
  - Group, normalize, weight results

• **Interpretation:**
  - Draw conclusions
  - Checks for completeness, contribution, sensitivity analysis, consistency w/goal and scope, analysis, etc.
From “Sustainable Innovation Products”
Len Sauers, PhD
VP, Global Sustainability, Procter & Gamble
Cold-Water Wash Savings

• According to P&G’s calculations, if every U.S. household used cold water for laundry, the energy savings would be 70 to 90 billion kilowatt hours per year, which is 3% of the nation’s total household energy consumption. These savings would translate into 34 million tons of carbon dioxide per year not released into the environment, which is nearly eight percent of the Kyoto target for the U.S.
Functional Unit

- The product system (boundary definition) is defined by the function that the product under study provides.
- A clearly defined functional unit allows for comparisons to be made on an equal basis.

So, how many volumes do you need to read on your e-reader to break even?

With respect to fossil fuels, water use and mineral consumption, the impact of one e-reader payback equals roughly 40 to 50 books. When it comes to global warming, though, it’s 100 books; with human health consequences, it’s somewhere in between.
No. of published LCA-related papers is growing as reported by SCOPUS
Life Cycle Impact Assessment (LCIA)
Modeling the Inventory Data

<table>
<thead>
<tr>
<th>Life Cycle Inventory</th>
<th>Classification</th>
<th>GWP Characterization (CO2-e)</th>
<th>Human Health Toxicity Characterization (1,4 DCB-e)</th>
<th>Ecological Toxicity Characterization (1,4 DCB-e)</th>
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</thead>
<tbody>
<tr>
<td>Resources</td>
<td></td>
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<td>CCl4: 220</td>
<td>CCl4: 0.000143</td>
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<tr>
<td>Minerals, ores, crops, etc.</td>
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<td></td>
<td>C6H6: 1900</td>
<td>C6H6: 6.35 E-5</td>
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<td>Airborne Emissions</td>
<td></td>
<td></td>
<td>C7H8: 0.327</td>
<td>C7H8: 5.04 E-5</td>
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<tr>
<td>Carbon Dioxide</td>
<td></td>
<td></td>
<td>C8H8: 0.43</td>
<td>C8H8: 0.382</td>
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<td>Carbon Monoxide</td>
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<td>Methane</td>
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<td>Nitrous Oxide</td>
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<td>Carbon Tetrachloride</td>
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<td>Sulfur Hexafluoride</td>
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<td>Benzene</td>
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<td>Toluene</td>
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<td>Xylene</td>
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<td>Etc….</td>
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<td>Waterborne Emissions</td>
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<td>Solid Wastes</td>
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</table>

Characterization Factors
Sample LCIA Results

Impact Indicator Categories
Example Impact Indicator Results

**Eutrophication**

- kg PO₄³⁻ equivalents

A, B, C categories with different processes and their contributions.
An Effective Life Cycle Assessment

• Examines system-wide effects (cradle-to-grave)
• Analyzes multi-media (air, water, waste, etc.)
• Analyzes multi-attributes (all impacts)

• Helps identify trade-offs among alternatives
• Identifies opportunities for improvement
• Supports environmental decision making
• Provides the cornerstone of Sustainability
LCIA versus RA

- **Life Cycle Impact Assessment (LCIA)** characterizes emissions over a product's life cycle; it reports emissions at an aggregated level and for a chosen functional unit basis (e.g., 1,000 gal of product).

- **Risk Assessment (RA)** characterizes the nature and magnitude of health risks to humans and the environment from potential chemical contaminants and other stressors at the site-specific level.
(Chemical) Life Cycle Risk Assessment

The focus is on identifying where release and exposure might occur in the life of a chemical.
Integrated Decision-Making

- Technical Feasibility
- Environmental Impacts
- Costs ($)
- Viability
- Societal Impacts
- Sustainability
- Risk Assessment
LCA is an Iterative Approach

Life cycle assessment framework

Goal and Scope Definition

Inventory Analysis

Impact Assessment

Interpretation

ISO 14040
Suggested Reading

www.epa.gov/ORD/NRMRL/lcaccess