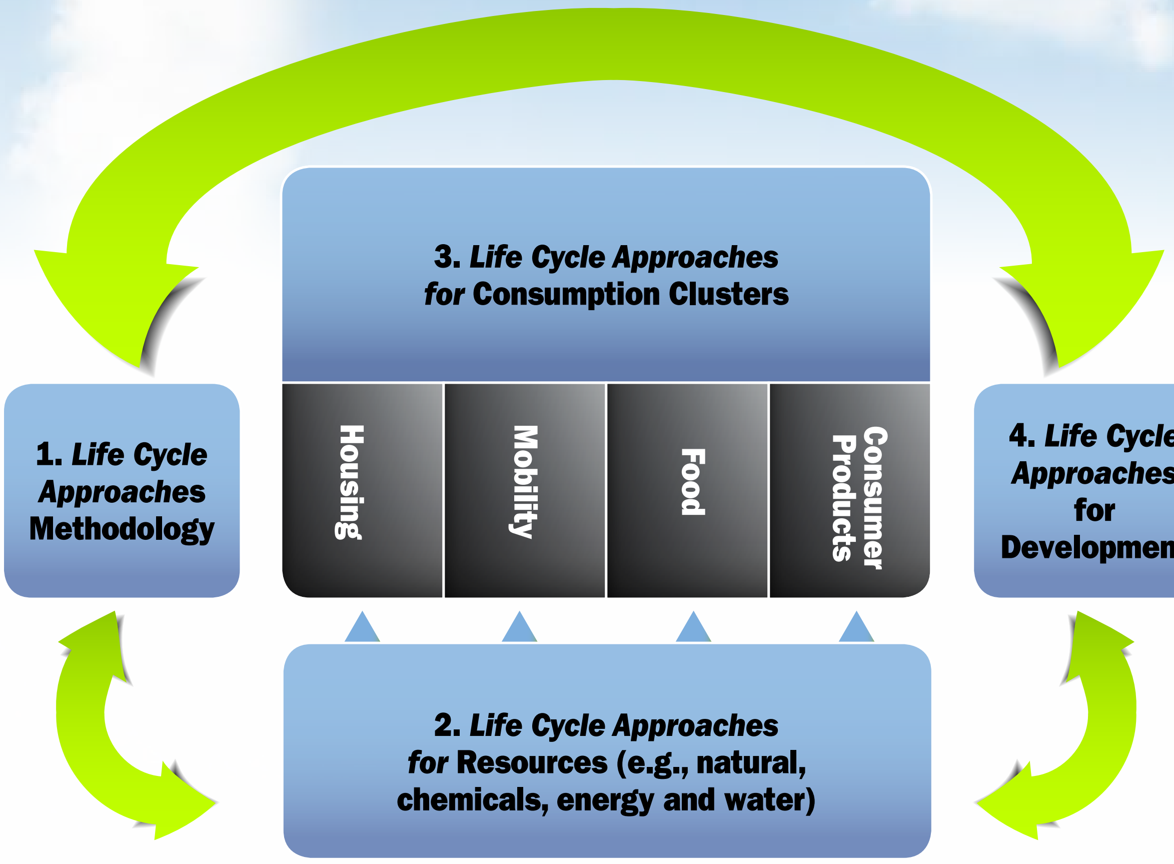
AN EXECUTIVE GUIDE

How to Know If and When it's Time to Commission a **Life Cycle Assessment**



INTERNATIONAL COUNCIL OF CHEMICAL ASSOCIATIONS

Responsible Care® OUR COMMITMENT TO SUSTAINABILITY

Contents

Forward

Through the development of new, innovative products and more efficient technologies, the chemical industry is playing an important role in addressing challenges related to energy and greenhouse gas (GHG) savings at the national, regional, and international levels.

As the worldwide voice of the chemical industry, the International Council of Chemical Associations (ICCA) works with organizations that address health, environmental, and trade-related issues around the globe. ICCA coordinates the work of its national and regional member associations and their member companies, through exchanging information and developing common positions on policy issues of international significance.

The ICCA Life Cycle Assessment (LCA) Task Force has developed this brief Executive Guide to help educate industry executives—and a much broader audience—on life cycle thinking and how and when to commission a full life cycle assessment.

Simply put, this guide will describe what constitutes an LCA, what are the benefits and limitations of different types of LCAs and related tools, and how to interpret and communicate LCA results.

So if you are thinking of conducting an LCA but not quite sure what this entails and want to learn more about where to go, what's available, and the ABC's of LCA, then this Executive Guide is for you.

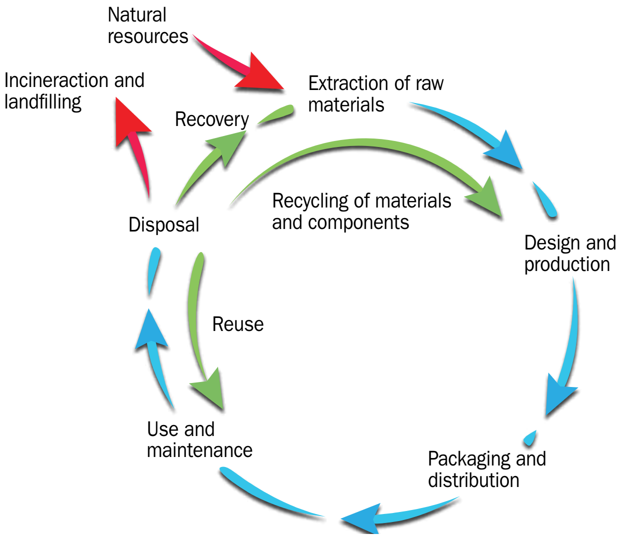
What is a Life Cycle Assessment (LCA)?

Life cycle thinking means taking account of the environmental, social and economic impacts of a product over its entire life cycle

LCA evaluates these impacts throughout a product's entire lifespan, from raw material extraction through materials processing, manufacturing, distribution, use, repair and maintenance, and eventual disposal or recycling (see Figure 1).

This Guide is focused on explaining life cycle thinking and how it can be used to understand the contributions of the chemical industry to a more sustainable economy through the application of its products. A full life cycle analysis will help identify both the negative and positive aspects of a product or service.

Figure 1: Life Cycle Assessment Iterative Process



LCA is standardized in the International Standards Organisation (ISO) 14040 series. Typical types of systems boundaries include:

a. Cradle-to-gate: From raw material extraction to factory gate.

b. Cradle-to-grave: From raw material extraction through product use and disposal.

c. Gate-to-Gate: From one defined point along the life cycle (e.g., where incoming raw materials cross the fence-line of a manufacturing site) to a second defined point further along the life cycle (e.g., where a finished product is delivered to an end user).

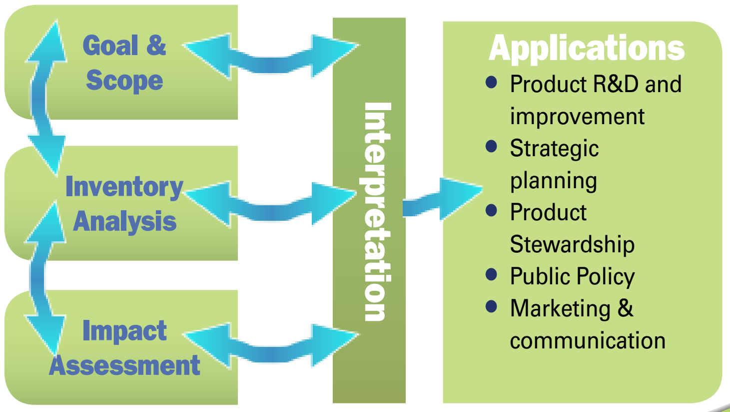
The system boundary is determined based on the study objective—whether the aim is to understand the environmental impact of the raw materials, intermediate components or the final product.

There are also designs and concepts derived from the life cycle approach, such as the "cradle-to-cradle" design approach developed by McDonough & Braungart. Such approaches are complementary to LCA, although the term "cradle-to-cradle" is sometimes used by LCA practitioners to indicate a cradle-to-grave study where the product is recycled at end of life.

ISO provides a succinct definition of "Life Cycle Assessment," describing it as a technique for assessing the environmental aspects and potential impacts associated with a product, by:

- Compiling an inventory of relative inputs and outputs of a product system;
- Evaluating the potential environmental impacts associated with those inputs and outputs; and
- Interpreting the results of the Inventory Analysis and Impact Assessment phases (see Figure 2) in relation to the study's objectives.

Figure 2: LCA is carried out in four basic, interdependent stages



1. ***Goal and Scope*** **includes the following:**
   - Specifying the reason for conducting the study, including identifying a product's function.
   - Identifying intended audience and use of results.
   - Setting system boundaries (cradle-to-gate, cradle-to-grave, gate-to-gate).
   - Identifying data requirements.
   - Acknowledging study limitations.
   - Establishing a time and geographic reference.
2. ***An Inventory Analysis*** **of resource use and emissions includes:**
   - Collecting, validating and aggregating input and output data to quantify material use, energy use, environmental discharges, and waste associated with each life cycle stage.
3. ***Impact Assessment*** **includes:**
   - Using impact categories, category indicators, characterization models, equivalency factors, and weighting values to translate the raw data into potential impact on human health and the environment.
4. ***Interpretation*** **of results:**
   - This is an important stage that takes place throughout the first three stages as an iterative process to assess the results in the context of project goals. Results must be validated through a third-party critical review panel of interested parties if the intent is to use the results externally for comparative assertions (e.g., claims that Product X has lower or higher environmental impacts than Product Y). The study results must indicate significant impacts and recommend methods for reducing material use and environmental burdens.

Identifying a Product's Functions

In defining the scope of an LCA study, a clear statement of the specific functions, or performance characteristics, of the product must be made. The functional unit defines and quantifies the identified functions and should be consistent with the goal and scope of the study. Typically, functional unit includes an identification of the product, an amount of the function, a time value and a quality value.

EXAMPLE: For the function of packaging for food, an amount (e.g. 1 liter liquid volume), a quality (e.g. aseptic FDA standards) and a time factor (e.g. protection for two weeks). The functional unit would be a food container for one liter of liquid in conformity with aseptic FDA standards and lasting two weeks. This function could be supplied by plastic, metal or paper products. For each system, it is possible to determine the reference flow, e.g. the average mass of paper or plastic or metal for one liter of food. For all systems, it is possible to compile an inventory of inputs and outputs on the basis of the reference flows. At its simplest level, this would be related to the material consumed.

History of LCA

Life cycle assessment was first developed in the late 1960s/early 1970s, during the oil crisis. People were waiting in line for gasoline, and energy costs were skyrocketing. Companies were looking for ways to save on their energy bills as their customers were asking for energy-efficient products. Companies also began to use LCA internally to improve their products. Thus, the impetus for the first life cycle inventories came into being.

In the late 1980s, life cycle inventories of product systems' energy and mass began to be undertaken. In 1990, the Society of Environmental Toxicology and Chemistry (SETAC) held LCA workshops and identified the various stages of the LCA framework. Two years later, the framework for LCA was reviewed, and the "Goal and Scope" stage, central to LCA, was added.

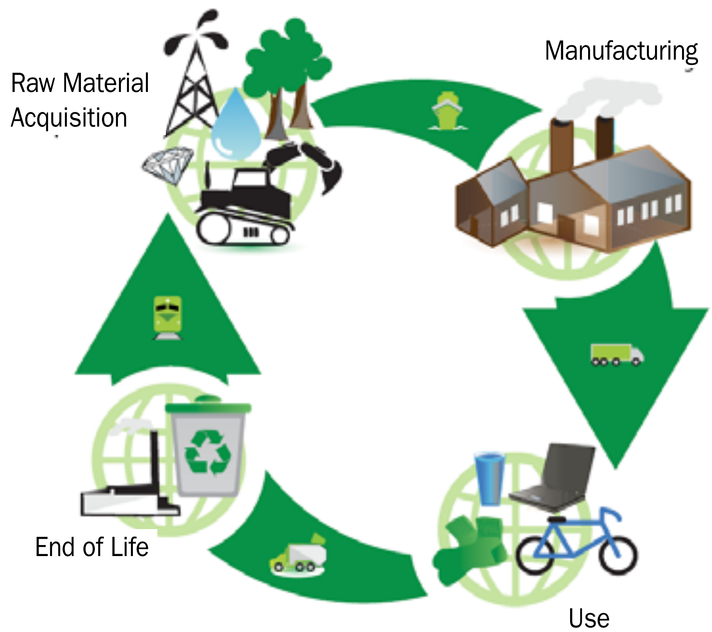
Thus the four parts of an LCA were identified:

- Goal and Scope
- Inventory Analysis
- Impact Assessment
- Interpretation.

It wasn't until ISO developed an Environmental Management series of standards, which included a technical committee charged with developing an LCA standard, that a global LCA standard became available.

The culmination of this effort was a voluntary international standard that stands today as the standard for conducting an LCA. Figure 3 shows the iterative process of life cycle—from raw material extraction through end of life.

Figure 3: Life Cycle—From Raw Material Acquistion to Disposal



Why it is important to conduct LCAs in accordance with ISO 14040?

- Credibility: Assurance that an LCA is complete, conducted in conformance with ISO standards and reproduceable helps users have confidence in the results.
- Global in nature: While LCA is a "snapshot," the concept of continuous improvement and greening the global economies with sustainable materials management and consumption has its roots in LCA.
- Regional adoption of a global standard: Countries around the world have adopted versions of LCA for platforms and data development for their specific regions. Under the United Nations Environment Programme (UNEP)/Society for Environmental Toxicology and Chemistry (SETAC) Life Cycle Initiative, the concept of life cycle thinking using regional LCA data, life cycle costing information, and social LCAs are emerging.
- Economies of scale: Used in developing and sharing publicly LCA information for all stakeholders to use.

ISO International Organization for Standardization

Commonly Used LCA Metrics

While life cycle methodology has been applied to all three pillars of sustainability—economic[1], social[2] and environmental—the U.S. Environmental Protection Agency (EPA) Report,[3] *Life Cycle Assessment: Principles and Practice*, provides a summary table of commonly used LCA metrics, as well as information on their use. Some of these metrics are explained in more detail below:

- **Cumulative Energy Demand (CED):** Total energy consumed over the whole life cycle in delivering the functional unit (including end-of-life waste management).
- **Cumulative Fossil Energy Demand (CFED):** This is a subset of CED and describes the total life cycle fossil fuel-based energy consumed in delivering the functional unit (including end-of-life waste management). Fossil fuels include coal, crude oil and its derivatives, natural gas, peat.
- **Cumulative Renewable Energy Demand (CRED):** This is a subset of CED and describes the total life cycle renewable (non-fossil fuel)-based energy consumed in delivering the functional unit (including end-of-life waste management). Renewable energy includes solar, photovoltaic, hydro, wind, wave, geothermal.
- Global Warming Potential (GWP), also referred to as Carbon Footprint: A category that reflects climate change impact over a fixed time period, normally 100 years, in terms of the total emissions of greenhouse gases, such as carbon dioxide (CO_2), and other CO_2 equivalents, including methane (CH_4), and nitrous oxide (N_2O), to air across the life cycle of a product used to deliver a unit of service (the functional unit), including end-of-life waste management.

---

1. For more information see reference: Hunkeler, D., Lichtenvort, K., Rebitzer, G.; "Environmental Life Cycle Costing"; SETAC; May 2008; ISBN: 978-1-880611-83-8.

2. For more information see reference: United Nations Environment Programme; "Guidelines for Social Life Cycle Assessment of Products"; Benoît, C., Mazijn, B. (Editors); 2009; ISBN: 978-92-807-3021-0.

3. EPA/600/R-060, May 2006, *Life Cycle Assessment: Principles and Practice.*

- **Ozone Depletion Potential (ODP):** A category that reflects the relative effect of total emissions of gases that deplete stratospheric ozone across the life cycle of a product used to deliver a unit of service (the functional unit), including end-of-life waste management. Stratospheric ozone exists as a layer of naturally occurring gas in the upper atmosphere that protects living cells from over-exposure to solar ultraviolet (UV) radiation; over-exposure to UV radiation can cause, for example, skin cancer and reduced crop yields.
- **Acidification Potential (AP)**: A category that reflects the relative effect of total emissions of acidic gases (e.g., sulphur oxides (SOx), nitrogen oxides (NOx), hydrochloric acid (HCl), hydroflouric acid (HF), ammonia (NH_4)) to air across the life cycle of a product used to deliver a unit of service (the functional unit), including end-of-life waste management. Deposition of these emissions can acidify water bodies and soils, and can cause building corrosion.
- **Eutrophication Potential (EP)**, also called **Nutrification Potential (NP)**: A category that reflects the overgrowth of algae caused by emissions of limiting nutrients (compounds containing phosphorus or nitrogen) directly or indirectly to water bodies (lakes, slow moving rivers, estuaries, etc.) and soil across the life cycle of a product used to deliver a unit of service (the functional unit), including end-of-life waste management.
- **Photochemical Ozone Creation Potential (POCP)**: A category that reflects the relative effect of total emissions of volatile organic compounds (VOCs) and oxides of nitrogen across the life cycle of a product used to deliver a unit of service (the functional unit), including end-of-life waste management. Emissions of VOCs (non-methane hydrocarbons) in the presence of nitrogen oxides and sunlight can lead to chemical reactions that form ozone (O_3) close to ground level (so-called photochemical smog).

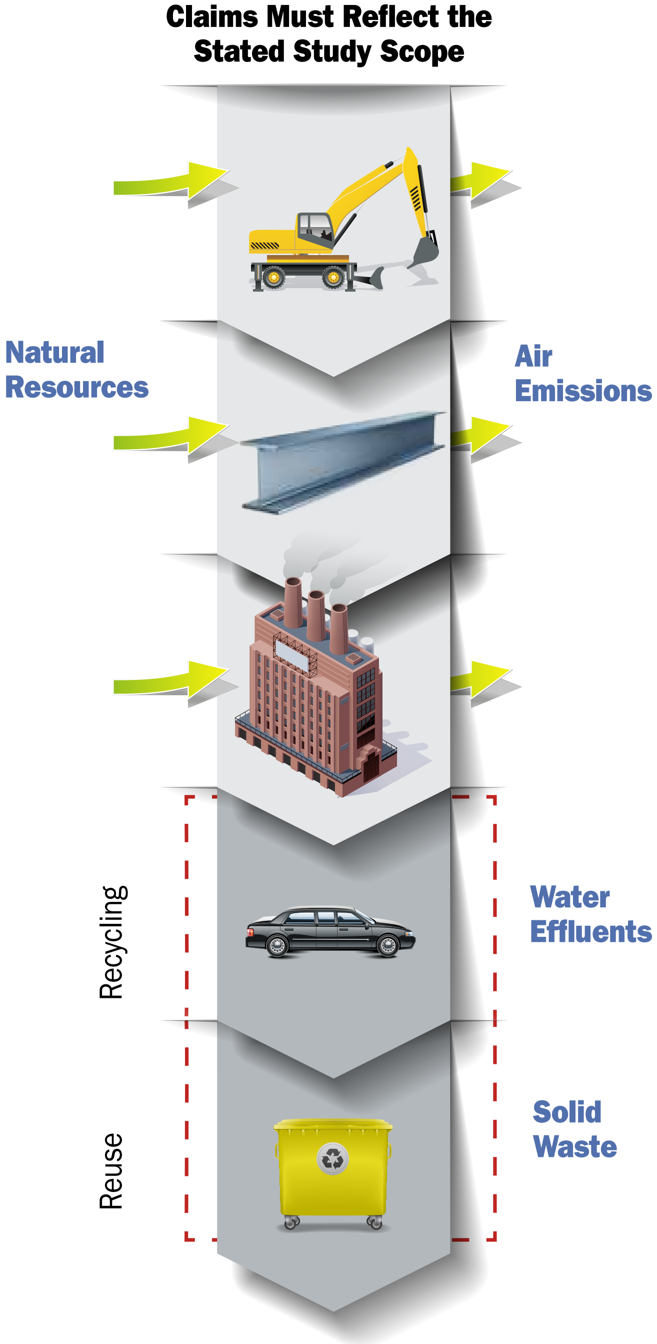
- **Consumptive Water Footprint and Water Emissions Footprint**: This describes the total life cycle requirement of water necessary for delivering the functional unit, including end-of-life waste management. It is often subdivided into fresh water and sea or brackish water; by source (river, lake, well, sea).
- **Eco and Human Toxicity Assessment**: Toxicity assessment models, such as the USEtox™ model, provide consensus-based, chemical-specific characterization factors that quantify the environmental fate of chemical emissions and their impact on human health and on ecosystems, by assessing exposure and effect.
- **Direct land use change (LUC)**: An important indicator currently under development associated with conversion of land from its 'original' state (forest, grassland, pasture, cropland, degraded land, etc.) to an altered state for the production of agricultural or forestry products (e.g., biofuel feedstock), with resulting changes in GHG emissions and carbon stocks on that land.
- **Indirect land use change (ILUC)**: An important indicator currently under development that accounts for secondary land use change that is the result of primary land use change displacing a commercial crop, which is consequently grown in a different location leading to further land being altered from one state to another, with resulting changes in GHG emissions and carbon stocks on that land.

What Can LCA Do?

LCAs can do a number of things, and are useful for:

- Supporting decision-making, highlighting efficiency opportunities along a value chain.
- Understanding the industrial systems involved in manufacturing products and delivering services to end-users.
- Optimizing industrial systems by identifying operations within a market chain that have the greatest opportunity for improvement, often referred to as "hot spots."
- Ensuring that changes made to improve one part of an industrial system do not "shift the burden," by moving a problem, or creating a new issue in another part of the chain.
- Informing decision makers about the trade-offs that a decision will have on the balance of impacts across the environmental impact categories, such as, implementing a particular technology to reduce GHG emissions that may result in increased water usage.
- Comparing two systems that deliver the same service/product as defined by the functional unit. Here it is important to note that:
  - Differences of less than approximately 10 percent are within the typical error of good quality LCAs; meaningful differences must be much larger.
  - LCAs can only meaningfully compare products or services that deliver the same functional unit; comparison of dissimilar products is meaningless.
- Indicating whether an improvement investment at one part of a market chain will have any significant improvement effect over the whole life cycle.
- Benchmarking one organization's processes against an industry average of similar processes to identify improvement possibilities.
- Providing footprinting data, such as carbon footprints.
- Environmental claims should be supported by LCA data, as shown in Figure 4.

Figure 4: Environmental Claims and LCA



What Doesn't LCA Do?

Think of an LCA study as a "snapshot in time" measure of burdens. The lower the burdens across the life cycle of a product or system, the smaller the footprint. An LCA measures burdens—what goes in (how much energy and raw materials it takes to make a product), and what goes out (how much waste, water pollution and emissions to air) across the product life cycle.

Okay, so what does an LCA not do?

- For one thing, it doesn't measure the performance of a product or its constituents—it doesn't tell you if the product you are analyzing will perform any better or worse than another product. It will tell you the life cycle inputs and outputs to make that product.
- And another thing, an LCA has nothing to do with compliance with environmental laws. Compliance is usually taken as the assumed baseline—there is no litter or excess solid waste, no violation of air pollution standards or water permits—and LCA assumes the product system you are measuring meets applicable local and regional environmental standards.
- An LCA typically does not include the "bricks and mortar" of capital equipment in the manufacturing facility where your product is made. The energy and wastes associated with manufacture of capital equipment, including equipment to manufacture buildings, motor vehicles, and industrial machinery, also are not usually included.
- LCA typically does not include an analysis of support personnel requirements, nor the energy and wastes associated with research and development, sales, and administrative personnel or related activities.
- LCAs also do not normally measure building space conditioning. The fuel and power use to heat, cool and light manufacturing facilities are omitted from the calculations in most cases. For manufacturing plants that carry out thermal processing or otherwise consume large amounts of energy, space conditioning energy is quite low compared to process energy.
- An LCA generally does not include every single material, such as catalysts, pigments, or other additives that total less than one percent by weight of the net process inputs. These minor contributions are typically not included in the assessment, unless inventory data for their production are readily available or there is reason to believe the materials would make significant contributions to energy use or environmental impacts.
- An LCA typically does not provide information about employee direct impacts. Travel to and from work, travel for work and lunchroom waste, for example, are typically not included in the LCA study.
- Another thing an LCA does not do is provide the same level of exposure calculations as a risk assessment analysis. For instance, an LCA on a particular foodservice package will provide some LCA impact data, possibly including human and environmental toxicity. But a risk assessment that looks at the exposure of a particular chemical in foodservice packaging, including a rigorous measure of migration and consumption factor calculations to measure dietary exposure and acceptable daily intake, is beyond the scope of an LCA.
- LCA does not define what specific course of action to take. LCA provides results that will help stakeholders make better decisions, based on evaluated trade offs.

How to Decide if an LCA is the Right Tool

If you are looking to examine more than one environmental or energy attribute of a product, and you need to examine trade-offs in making changes that can help identify places to reduce the overall footprint of a product system, it might make sense to consider the broader approach that an LCA presents.

LCA is a "systems analysis" tool that examines the whole system required to deliver services (primarily through the use of products) to end-users (consumers or end-user organizations). Several life cycle stages, unit processes and flows may be taken into consideration, as shown in Figure 5, for example:

- Inputs and outputs in the main manufacturing/ processing sequence;
- Distribution/transportation;
- Production and use of fuels, electricity and heat;
- Use and maintenance of products;
- Disposal of process wastes and products;
- Recovery of used products (including reuse, recycling and energy recovery);
- Manufacture of ancillary materials;
- Manufacture, maintenance and decommissioning of capital equipment;
- Additional operations, such as lighting and heating;
- Other considerations related to impact assessment (if any).

It is helpful to describe the system using a process flow diagram that shows unit processes and their interrelationships. This basic flow diagram shows what specific unit processes for the system being examined are included in every step of the life cycle:

An LCA and its results should be relative to a "functional unit." ISO defines a functional unit as the quantified performance of a product system for use as a reference unit in an LCA study.

Another way to better understand the term is to think of the functional unit as the equivalent measurement, or "function," that will be the heart of the LCA study. It is what allows you to compare really disparate things to see trade-offs. For example:

- A 1-liter quantity of milk available at a supermarket in Madrid.
- One square meter of recyclable, stain-resistant carpet with a 10-year life expectancy, suitable for a high-wear office corridor.

Figure 5: LCA Systems Approach

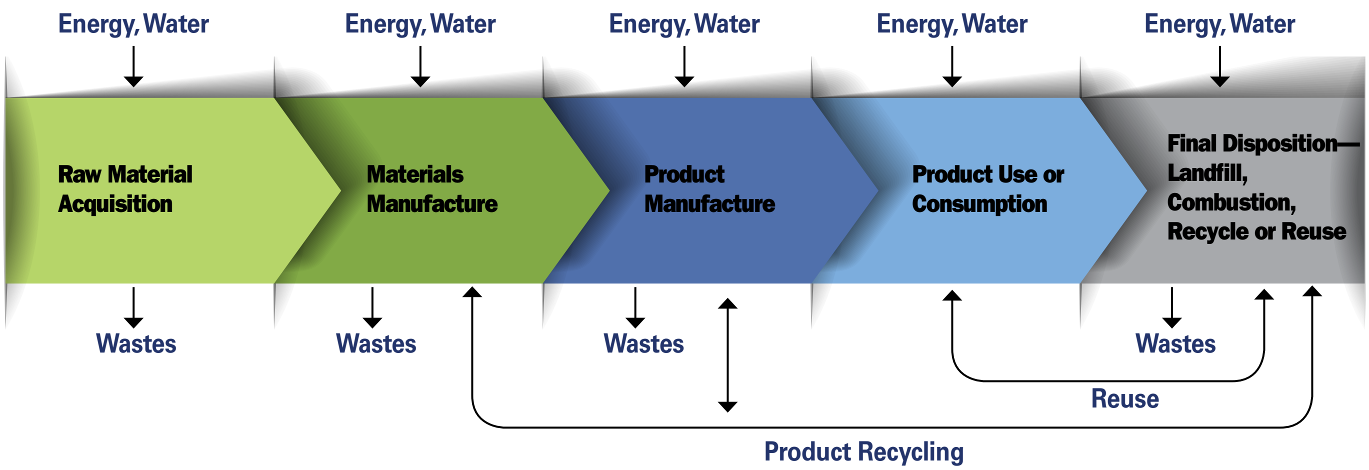
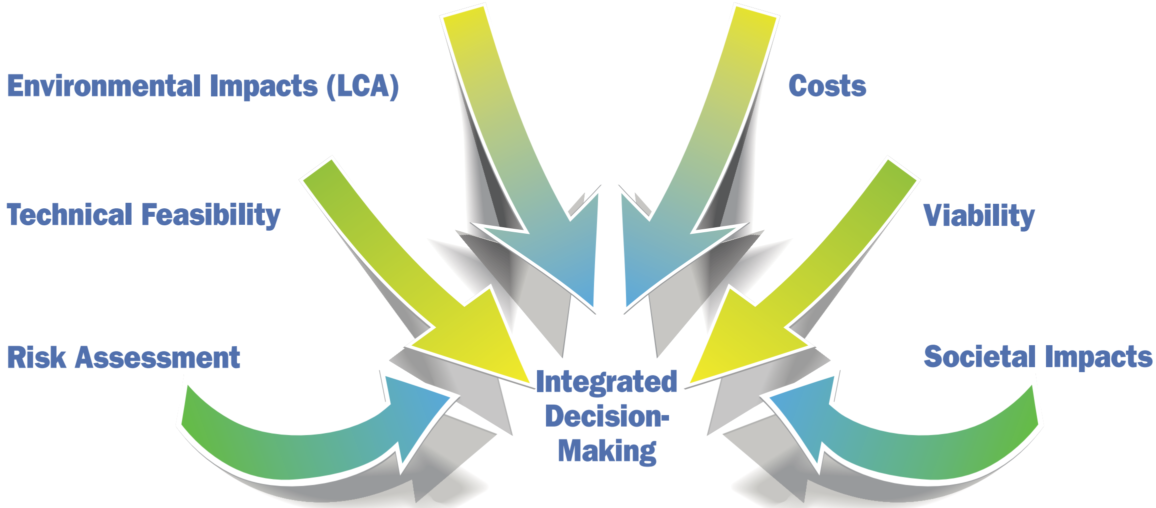


Figure 6: Integrated Decision-Making



LCA takes a holistic view of service provision by measuring inputs to, and outputs from, all unit operations invoked by delivering a service to an end-user. Inputs include raw materials, facilitating substances, components and energy, while outputs include products, co-products and wastes. These material and energy flows are both upstream of the consumer and downstream (e.g., waste management) and are compiled in the analysis in terms of the functional unit. An LCA, by definition, does not focus on one environmental parameter but examines all relevant aspects.

Due to the holistic nature of LCAs, they may not be the best tool for assessing single operations within an industrial system or the risk aspects of product use. Figure 6 shows how LCA is one of several tools to consider in the integrated decision-making process. In such cases, site-specific assessments of risk or environmental parameters and product risk assessments are recommended over LCAs. LCAs are useful for identifying major system impacts on society and the environment.

Companies also may wish to develop gate-to-gate inventories to assist in an industry-wide LCA study. For example, plastic resin producers may wish to develop the data needed for a cradle-to-gate resin LCA. Repetition of such studies may provide tracking systems for environmental programs at the facility level as well as at the industry level.

Strengths of an LCA

- Analytical, data-based method.
- Considers the full life cycle of a product or process.
- Highlights trade-offs.
- Variety of impact assessment methods available makes the tool robust by considering different perspectives.
- Flexible.
- Supports decision-making.

Limitations of an LCA

- Data intensive.
- Snapshot view—doesn't account for changes over time.
- Provides input for decision making but not the definitive answer (due to trade-offs).
- Cannot calculate impacts for topics for which numerical models do not exist.
- There is no absolutely scientific basis for reducing LCA results to a single overall score or number. However, aggregation methods are available that can be used for normalizing and weighting environmental results.

Life Cycle Approaches

What Works Best

Life cycle approaches can contribute to environmental protection and sustainable development, to help you overcome global challenges. Figure 7 shows the repetitive nature of the product improvement process most industry uses in bringing products to market. So what "type" of life cycle approach should you take?

You should begin with the most basic questions:

- What are you trying to accomplish with your LCA?
- What questions are you answering?
- What decisions are you trying to support?
- Who will read the study?
- Who will use the results?

This section addresses the different types of LCAs and tools that are derived from LCAs. Depending on the five questions listed above, a number of studies involving LCAs may need to be commissioned. These could range from a "scoping" or screening LCA for those who want to do a "rough first look" at trade-offs, to a full LCA that may or may not compare different product systems.

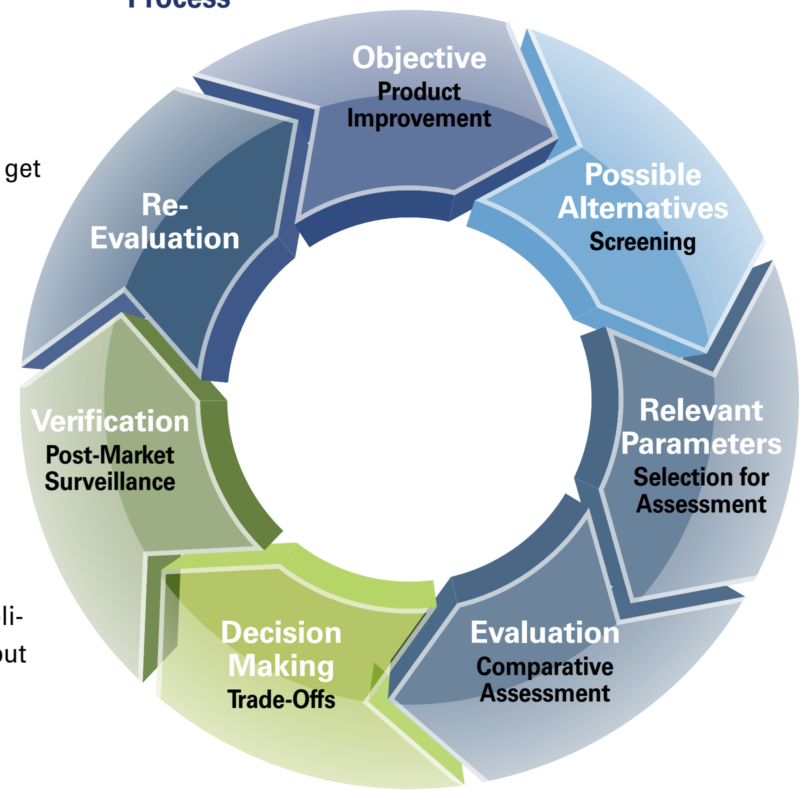
Scoping, Screening and Simplified LCAs

Perhaps you are a first timer to LCA and want get an idea of the key burdens (energy, air, water, solid waste) across the life cycle of your product system that might give you the best opportunity, both upstream and downstream, to make improvements and lower your product's footprint. Screening or scoping LCAs are rough and ready studies that make a lot of assumptions and use approximate/surrogate data to give an overall (directional) indication of the results to be expected from a study that uses a full LCA methodology. A simplified LCA uses specific and defined simplifications to come to a more complete result, but not one as rigorous as a full LCA.

Comprehensive Complete LCAs

If you wish to not only quantify the energy and raw materials in, and emissions (air, water, waste) through an LCI, but also perform a full impact analysis of the effects of those energy and material inputs and outputs, such as climate change, acidification, photochemical smog or fossil fuel depletion, you should consider conducting a full LCA compliant with ISO 14040 standards. "Full LCA" study is always a cradle-to-grave or cradle-to-cradle study and is always based on a defined unit of service delivered to an end user.

Figure 7: Product Improvement—A Repetitive Process



Product Comparisons

The ISO 14040 standards were developed anticipating that LCAs would be conducted to compare products or systems and that claims from these LCAs would most likely be made. If you are going to conduct a "comparative assessment" LCA, make sure you are familiar with the ISO standards requirements for such a study. These include:

- Identification of all stakeholders early in the process;
- Use of third-party/external critical review (peer review) throughout the process, including addressing peer review comments; and
- Making the full LCA study (excluding clearly confidential data) publicly available to all parties (not just selected summary points for specific results).

Following these rules can help you undertake a comparative LCA that will provide information that both critics and supporters of your analysis can replicate or refute.

Attributional LCAs (ALCA) and Consequential LCAs (CLCA)

ALCA answers the question, "What are the total emissions from the processes and material flows used during the life cycle (production, consumption and disposal) of a product, at the current level of output?", whereas CLCA seeks to answer the question, "What is the change (either positive or negative) in total emissions which results from a marginal change in the level of output (and consumption and disposal) of a product?"

Tools for Communicating LCA Results:

Environmental Product Declarations (EPDs)

An ISO 14025 standard that forms the basis for Environmental Product Declarations (EPDs) has its roots in traditional LCA studies. An EPD is a declaration that discloses the life cycle environmental performance of products and services. It is not a claim of environmental superiority (not to be confused with a comparative assertion LCA), and it is also known as a Type III environmental declaration, or a Type III eco label.

Why should you care about EPDs? Several countries, like France, are demanding EPDs be done. In the United States, legislation for carbon footprints, which are part of an EPD, is being contemplated. EPDs are based on LCA and will contain a summary of certain key LCA results (carbon footprint, acidification, depletion of fossil fuel and other resources: so-called abiotic depletion, global warming), along with other environmental components—recycled content, energy, chemical-free statements, and possibly a logo (if it is for a company).

Product Category Rules (PCRs)

A prerequisite to conducting an EPD is establishment of a Product Category Rule (PCR) for the particular product or system you are contemplating, according to ISO 14025.

The process for developing a PCR is to assemble a team of multi-stakeholder experts that represent the affected industries and other interested parties. PCRs have recently been developed for food products, insulation products and auto parts.

A PCR should be a "how-to" guide for conducting future LCAs, aimed at supporting the production of an EPD specific for the sector or products in question. The purpose is to set some clear and reproducible "ground rules" for what must be in the scope of the LCA and how the LCA is done, so that everyone preparing an EPD for their product is generating an LCA in a controlled and consistent way. The PCR is reviewed by a team of independent experts, and a "program operator" is appointed to manage the EPD scheme and its associated PCR. Any EPD based on the PCR is validated under the scheme (usually by a third-party review and verification) and, on receiving approval, can then be made available as a registered EPD for that manufacturer's product.

Water Footprint

The Water Footprint Network (www.waterfootprint.org) aims to promote the transition toward sustainable, fair, efficient use of fresh water resources worldwide by advancing the concept of the "water footprint," increasing water footprint awareness among communities, governments and businesses, and encouraging forms of water governance that reduce the negative ecological and social impacts of water use.

The Water Use Assessment within Life Cycle Assessment from the UNEP/SETAC Life Cycle Initiative aims to provide a coherent framework within which to measure and compare the environmental performance of products and operations regarding freshwater use, and related environmental consequences.

ISO 14046—Water Footprint standard (under development) focuses on:

- Terms and definitions.
- Water inventory and elementary water flows calculation.
- Water impact assessment and water footprint profile requirements.
- Reporting and critical review.

Carbon Footprint

A carbon footprint is the climate change indicator that is calculated by a full LCA. It represents the total life cycle sum of all GHG emissions (including carbon dioxide, methane, nitrous oxide and other greenhouse gases) resulting from the manufacture, use and end of life waste management of a product. There are specific carbon footprint standards that are based on the standards for LCA (Reference: http://www.pre-sustainability.com/product-carbon-footprint-standards-which-standard-to-choose):

- The British Standards Institution (BSI) developed PAS 2050 in October 2008. PAS 2050 has already been applied by many companies worldwide and was revised in October 2011.
- The WRI/WBCSD developed the GHG Protocol product standard, which was road- tested by 60 companies in 2010 and launched in October 2011.
- ISO DS 14067 is under development, and it is likely to appear as a technical report in 2013.

All three standards provide requirements and guidelines on the decisions to be made when conducting a carbon footprint study. Decisions involve LCA issues, like goal and scope definition, data collection strategies, study boundaries, and reporting. Moreover, these standards provide requirements on specific issues relevant for carbon footprints, including land-use change, carbon uptake, biogenic carbon emissions, soil carbon change, assessment time frame and green electricity.

cLCA and Avoided Emissions:

Carbon Life Cycle Assessment (cLCA) is a methodology used by the Japan Chemical Industry Association to communicate the carbon footprint of a product in a way that indicates the emissions that are avoided by the use of chemical products.

- International organizations such as WBCSD and WRI, as well as national associations, have recognized the need to establish uniform accepted "criteria" that enable the development of a common method and standard among (chemical) industries for calculating the "avoided emission" that can be realized by a (chemical) product or technology.
- This methodology is equivalent to the difference between the carbon life cycle emissions of two different alternatives for achieving the same user benefit.
- Once these avoided emissions criteria are developed in a consensus process, it is expected the criteria will be another measurement tool along with traditional LCAs.

Key Considerations:

Data Availability, Quality and Sources

LCA study data can be collected at source; a company can use its own data (primary data), or the study could be more generic using public or purchased data (secondary data).

In all studies, the following additional data quality requirements should be considered in a level of detail depending on the Goal and Scope of the LCA study:

- Accuracy: Measure of the variability of the data values for each data category expressed (e.g., variance).
- Completeness: Percentage of locations reporting primary data from the potential number in existence for each data category in a unit process.
- Representativeness: Qualitative assessment of degree to which the data set reflects the true population of interest (i.e., geographical coverage, time period and technology coverage).
- Estimation of time in the data collection process: The process for collecting primary data is usually the most time consuming part of an LCA. It's important to find the right balance between the amount of time and resources for the study accuracy in order to get the most appropriate information to help in your decision-making process.
- Consistency: Qualitative assessment of how uniformly the study methodology is applied to the various components of the analysis.
- Reproducibility: Qualitative assessment of the extent to which information about the methodology and data values allows an independent practitioner to reproduce the results reported in the study.

When a study is used to support a comparative assertion that is disclosed to the public, it is recommended that all data quality requirements described in this sub-clause is included in the study. Additionally, attention is also being given to addressing aspects of data uncertainty (e.g., ranges, statistical distributions). Figure 8 represents the stages and impacts needed in a comprehensive LCA study.

Figure 8: Life Cycle Assessment: The Holistic Yardstick of Environmental Performance

Key Considerations:

Professional Expertise/Requirements to Perform LCAs

When we do our income taxes, we often hire a certified public accountant to guide us through the tax laws, and when we seek medical attention, we see a physician trained to address our particular ailment. So where should you go if you are an LCA novice? Well, to an LCA professional, of course, who is knowledgeable about all things of LCA.

Since the invention of eco-profiles (now known as life cycle inventory data) in the late 1960s, the LCA field has become a commodity database business. What does that mean for you, the commissioner of an LCA study? It means you can concentrate on the LCA application—what is it you want to learn, compare, or illustrate through an LCA study.

LCA software is based on years of processes and data. Databases, impact assessment methods and LCA software tools are readily available today—a life cycle professional can assist you in making the rights choices for your needs.

So how do you find a trained life cycle professional? Is there a Yellow Pages directory? No, but the LCA community knows it is important to provide training and certification for current and future LCA professionals. Therefore, in 2007, the LCACP (LCA Certified Professional Program) was developed as the first certification program for LCA professionals in the world. To maintain certification, LCA Certified Professional must continue to be active in the field and gather continuing education units.

Advice to Those Thinking About Commissioning an LCA

- Know what you want.
- Do consult a life cycle professional.
- Do use resources from regional life cycle centres around the world, such as the Brazilian Association for Life Cycle (ABCV), the American Center for Life Cycle Assessment (ACLCA), and the European Platform on Life Cycle Thinking. These are good resources and are often multi-stakeholder groups you can participate in.
- Do ask your potential life cycle professional consultant if he/she:
  - Is conversant with and follows the ISO 14040 series of LCA standards; and/or other best practice guidance, e.g., ILCD.
  - Can provide an explanation on how he/she will follow the four LCA pillars.

Key Considerations:

Using and Communicating LCA Results

LCA has the potential to provide a new model for regulations, one based on a holistic view of environmental impacts rather than focusing on chemical risk management. The iterative LCA process, along with the fact that it measures and weighs multiple parameters—energy, raw materials, emissions, effluents, impacts—makes this a powerful tool.

The outcome of an LCA depends to a large extent on the people involved in the study—you, your peers, the LCA consultant—and how they all work together.

Globally, many private and public sector organizations (multinationals, small and medium-sized enterprises, cities, regional governments, among others) have committed to improving their social and environmental performance by adopting life cycle approaches. Many individuals are using life cycle information available in stores and on the Internet to make purchasing decisions.

What should you consider before conducting an LCA and ultimately using the results?

- Be as accurate as possible—Use the latest data (primary data you need to collect, or databases relevant to your region and processes).
- Goal and scope—Make sure you know the boundaries of your study.
- "Garbage In = Garbage Out"—Don't take shortcuts. Being comprehensive on data quality and data collection on the front end means a good representative result for a final report.
- Communications—An LCA can help substantiate claims; claims about a product or systems environmental performance; claims about comparisons. But remember, green washing and "cherry picking" certain results of an LCA study, while not disclosing everything results in ineffective and potentially unethical communications.
- Green Marketing—Beware of green washing. Do not use results out of context, be transparent, and make sure your environmental claims can be substantiated.
- An LCA study is a detailed undertaking—Adequate in-house resources (engineers, process managers/operators, and links to suppliers) will be needed to assist the LCA practitioner to build robust datasets for your process and systems. Remember that LCA is not really a 'fit-and-forget' commission. Strong commitment to in-depth interactions between LCA client and LCA practitioner is the best way to yield high-quality, relevant and valuable studies.

The UNEP/SETAC Life Cycle Initiative members and its network of stakeholders believe that the transition to a sustainable economy can only be successfully accomplished if the decisions are based upon solid, science-backed information. If the Green Economy is to bring the necessary changes to guarantee a future for life on Earth, decision-making on sustainable products, investments, and policies must be made using life cycle thinking and operationalized through life cycle management, approaches, and tools.

An on-line PDF of the study, *Greening the Economy Through Life Cycle Thinking: Ten Years of the UNEP/SETAC Life Cycle Initiative*, presented at Rio+20 in 2012, is available at: http://www.unep.fr/shared/publications/pdf/DTIx1536xPA-GreeningEconomythroughLifeCycle-Thinking.pdf

Importance of Critical Review (Peer Review)

For internal studies, LCA critical reviews are optional, although recommended. However, when a study is developed to make a comparative assertion that is later disclosed to the public, a critical review shall be conducted as presented in ISO 14040:2006, 7.3.

The critical review aims to verify whether an LCA study has met International Standard for Methodology, Data and Reporting requirements to ensure the validity of the results. Thus, it is important to understand the aim of the study, to determine what should be included in the Goal and Scope phase and whether the study has been subject to the formal Critical Review process in accordance with ISO 14040/44. Key aspects that the review will focus on and report are transparency and completeness for the study and on its consistency with the stated Goal and Scope (the Critical Review report must also be made available alongside the LCA report under the requirements of the ISO standards).

The review process can be carried out as:

- A one-stage process (the data are reviewed and validated at the end of the study).
- An on-going process (e.g., the data are reviewed in three different stages of the process—Goal and Scope, LCI and LCA—and validated at the end to ensure accuracy and transparency).

The critical review panel is typically composed of two to three experts, led by a chair who produces a peer-reviewed report. The panel also should include other interested parties affected by the conclusions drawn from the LCA study, such as government agencies, NGOs, or competitors.

Conclusion

This brief Executive Guide is designed to help educate industry executives—and a much broader audience—on life cycle thinking and how and when to commission a full life cycle assessment.

The guide hopefully strikes a balance between providing the reader enough information about the advantages of using Life Cycle Thinking – taking account of the environmental, social and economic impacts of a product over its entire life cycle – and just enough detail of how to know if and when it's time to commission an LCA.

We hope this guide will help you along in picking and choosing a number of LCA and related tools to help you analyse and make good sustainable decisions based on the very latest information and methods out there. Remember, keep researching – new tools and new developments are always on the horizon!

Acknowledgements

ICCA would like to thank the ICCA LCA Task Force, led by Juhan Robberts, ExxonMobil Chemical Europe, and the ICCA Executive Guide Project Team, led by Mike Levy, American Chemistry Council, Plastics Division, and team members Beatriz Visconti Luz, Braskem S.A.; David Russell, Sustainable Business Innovation (former Dow Chemical Company Europe); and Jenny Heumann, American Chemistry Council Communications, for their role in the development and overall management of this guide. This effort would also have been impossible without the knowledge, review and feedback provided by ICCA members and elected external stakeholders during the development of the guide.