LIFE CYCLE ASSESSMENT

Life Cycle Assessment (LCA) is an iterative technique to evaluate the value chain of a product, service or system and to know the possible impacts associated with its manufacture and consumption. It is a powerful tool for making holistic comparisons of systems and for their optimization (Curran, 2017). LCA can be used to identify opportunities to improve environmental performance of products and services, inform decision makers, select relevant environmental performance indicators, or as part of a market strategy (ISO 14040, 2006).

This type of analysis includes four phases (Fig. 1):

1. **Definition of the objective and scope**: includes the definition of the limit of the system to be analysed, functional unit and use that will be given to the study.

2. **Inventory analysis**: contemplates the creation of an inventory with the input and output data to the study system that helps to understand its structure, key elements and function.

3. **Impact assessment**: seeks to provide additional information that helps to evaluate the system from the inventory and better understand its relationship with the environment.

4. **Interpretation**: presents the summary of results, including a conclusion and recommendations based on the objective and scope of the study.

This approach to LCA is known as “attributional”.

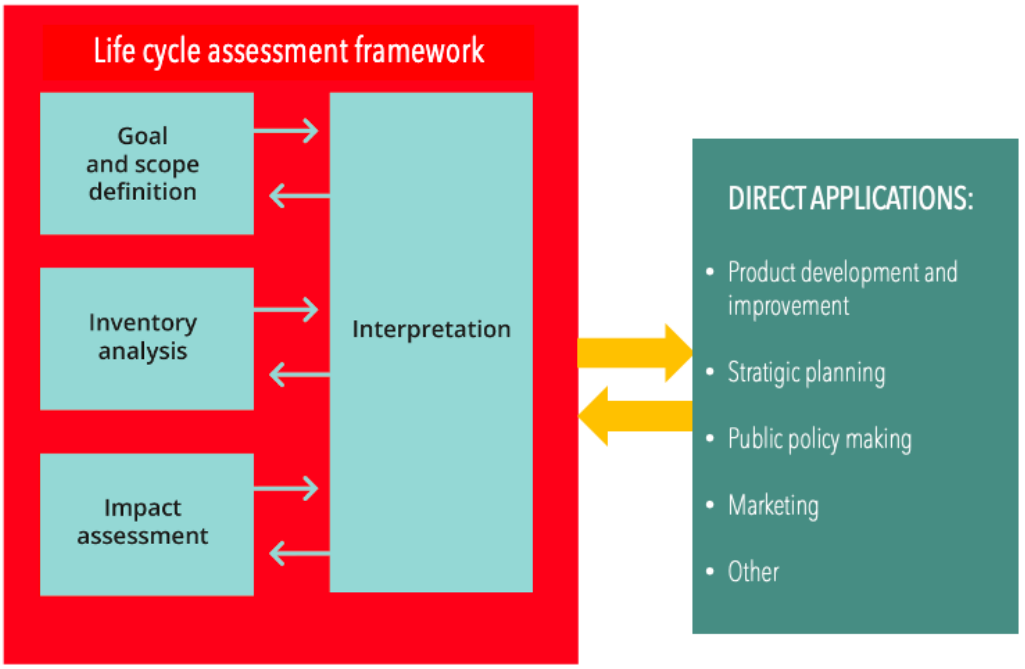


Figure 1. Phases of an LCA (ISO 14040, 2006).

Another approach is the "consequential" LCA, which analyses how the activities of a system or product are linked and the transformations that can be generated as a consequence of a change in the demand of the functional unit (Brander, Burritt and Christ, 2019). Compared to attributional LCA, consequential LCA aims to quantify the changes caused by a decision or intervention in a system, which is relevant for decision-making or assignment of responsibilities.

Although there are differences between these approaches, it is important to identify the purpose for which you want to perform an LCA and choose the most appropriate model. They can also be combined to better understand the behaviour of a system (Table 1).

Attributional LCA	Consequential LCA
Describes the environmentally relevant physical flows of a product or service. It uses the **average data** of a system to produce a unit of the good or service (Finnveden and Potting, 2014).	Describes how the system flows a product or service will change in response to possible changes or decisions. It uses **marginal data** on the production of the good or service (Finnveden and Potting, 2014).
Its objective is to quantify and assign absolute emissions / reductions to a specific entity or element (Brander, 2016).	Its objective is to quantify the change in emissions / marginal reductions resulting from a decision or action (Brander, 2016).
It is a **static process**, independent of the context (Plevin et al., 2014).	It is an ideally **dynamic process**, specific to the context (Plevin et al., 2014).
Inventories do not capture all "organization-relevant and material emission sources" if the intention is to mitigate climate change (Brander, 2018).	The consequent LCA tends not to show short-term impacts, nor does it show the transition from short-term to long-term impacts (Brander, 2018).

Table 1. Comparative methodological implications between attributional and consequential LCA

In practice, an LCA always makes a comparison of products or systems that have the same function or objective. Due to the information that an LCA study can provide, it has become an indispensable analytical tool to support sustainable management that continues to evolve (Finnveden and Potting, 2014).

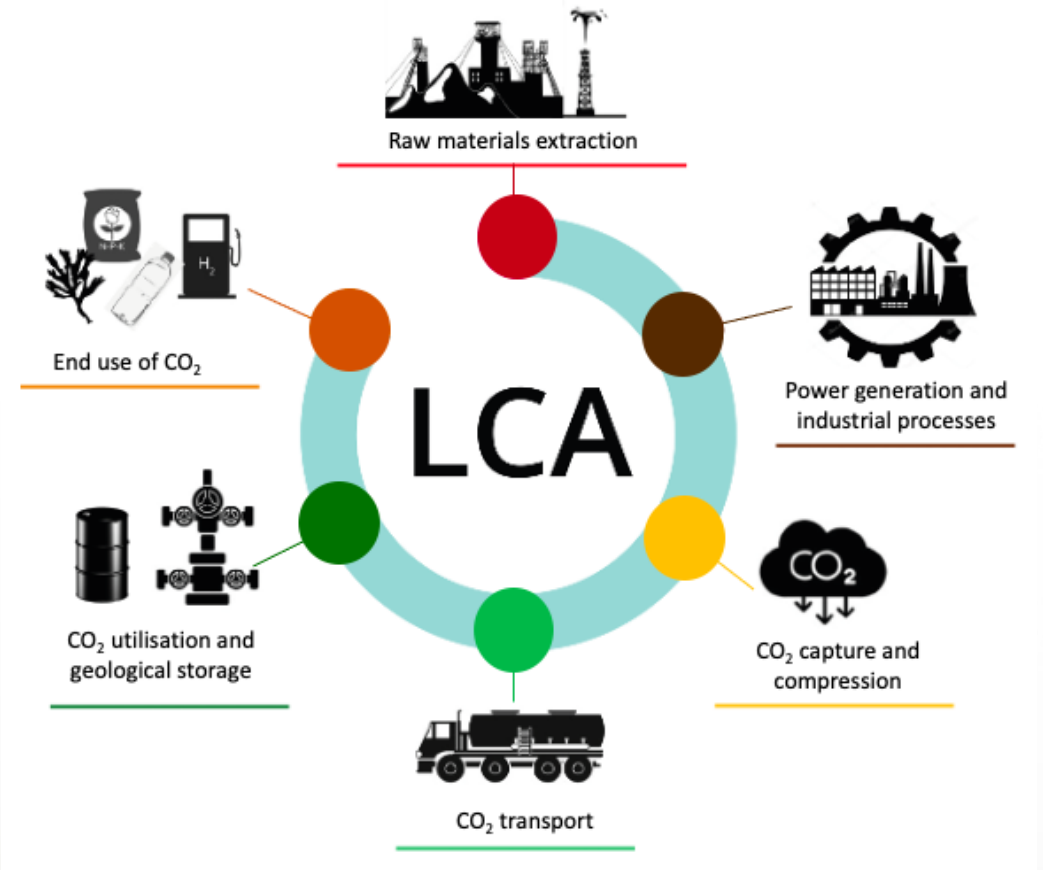
EXAMPLE

Several LCA (attributional) studies have been carried out related to CCUS projects, which analyze different limits of the technology value chain (Aycaguer et al., 2001; Suebsiri et al., 2006; Hertwich et al., 2008; Jaramillo et al., 2009; Cooney et al., 2015; Azzolina et al., 2016; Núñez-López et al., 2019). In the literature, there is only one LCA study (consequential) carried out by Brander and Ascui in 2019 for a CCUS project in a steel plant in China.

In general, there are still challenges to carry out this type of studies, which are mainly associated with access to data and selection of the functional unit, interest in analysis of CCUS projects and adoption of these tools such as part of the strategy to measure the impact of projects (Fig. 2).

In Mexico, studies of LCA (attributional) can be found in the works of:

- Lacy et al., 2015 "Life-cycle GHG assessment of CCUS for linked primary energy and electricity production"
- Morales et al., 2016 "Life cycle assessment of carbon capture and utilization from ammonia process in Mexico"
- Morales et al., 2020 "An integrated approach to determining the capacity of ecosystems to supply ecosystem services into LCA for a carbon capture system"



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