



WHITEPAPER

A comparative synthesis of various Life Cycle Assessment methods

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Abstract

Environmental impacts need to be assessed to manage and reduce them. There are various methodologies available to account for these impacts. The Greenhouse Gas (GHG) accounting is the most commonly used method: it is based on relatively accessible data and results are easy to communicate as it is only about GHG. However, this methodology has **one important limitation**, it doesn't consider any of the other environmental impacts, besides greenhouse gases. **To obtain a holistic view of a product or activity footprint**, another methodology must be used. **One of the most comprehensive is Life Cycle Assessment**, as it considers all life cycle steps and up to fifteen environmental indicators. This provides a wealth of details on the distribution of impacts.

This document aims to **furnish an overview** of both LCA and GHG Protocol **and compare them**. It also details the **various types of LCAs**, their specificities and examples. Eventually, it offers a set of questions to choose the best LCA methodology related to one's context.

[Louise Aubet](mailto:louise.aubet@resilio.tech) - louise.aubet@resilio.tech

[Astrid Dhénain](mailto:astrid.dhenain@resilio.tech) - astrid.dhenain@resilio.tech

[Matheo Godenzi](mailto:matheo.godenzi@resilio.tech) - matheo.godenzi@resilio.tech

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Introduction

Human activities have ushered in the **Anthropocene** epoch, characterised by a significant **human imprint on Earth's environment**. As a consequence, global temperatures have risen by approximately 1.2°C above pre-industrial levels, with atmospheric CO₂ concentrations surpassing 425 ppm¹. Species extinction rates are estimated to be between 100 and 1'000 times higher than the natural background rate². Deforestation persists at an alarming rate of approximately 10 million hectares per year³. Plastic pollution contributes to the entry of 8 to 10 million metric tons of plastic into the oceans annually⁴, while air pollution leads to approximately 7 million overall deaths worldwide⁵. Moreover, close to 4 billion people lack access to safely managed drinking water services due to freshwater scarcity⁶.

This observation is a **call to action**. Disregarding these crises will only exacerbate their severity, potentially culminating in a cascade of insurmountable issues in the future. To undertake drastic changes and aim for sustainability, **environmental impacts quantification is critical**.

This document begins by describing greenhouse gas (GHG) accounting and Life Cycle Assessment (LCA) standards to outline their **differences** and emphasize the **shortcomings** of the former. It then aims at presenting **possible variations of the LCA method**, which is considered the **most holistic and comprehensive environmental assessment method available**. Indeed, this method considers **all life cycle stages** of the system studied, and models all its environmental or social impacts. Finally, it provides relevant examples of **LCA applications** in the digital sector. Specific technical sheets, created by Resilio, will help you gain competences to conduct all types of LCA on IT systems.

1 Carbon Dioxide concentration, NASA Global Climate Change. Climate Change: Vital Signs of the Planet, 2024, https://climate.nasa.gov/vital-signs/carbon-dioxide/?_hsenc=p2ANqtz-8HpRVv9oVuSC-F0VZQsQUZzqFhGtlYw06Pme5RT0S-5vbMKKeT7887JYALC3WjAsIKVkc

2 How many species are we losing? WWF, https://wwf.panda.org/discover/our_focus/biodiversity/biodiversity

3 Global Forest Resource Assessment, Food and Agriculture Organisation of the United Nations, 2020, <https://www.fao.org/forest-resources-assessment/2020/en>

4 Marta Fava, Ocean plastic pollution an overview: data and statistics, Ocean Literacy Portal, 2022 <https://oceanliteracy.unesco.org/plastic-pollution-ocean>

5 Roser, Data review: how many people die from air pollution? Our World in Data, 2024, <https://ourworldindata.org/data-review-air-pollution-deaths>

6 Water scarcity, UNICEF, <https://www.unicef.org/wash/water-scarcity>

I. Environmental impact assessment methods

Many different methodologies allow to assess environmental impacts. This first part presents the two most commonly used frameworks: the Greenhouse Gas Accounting and the Life Cycle Assessment.

1. Greenhouse Gas Accounting and Reporting

Following the 2015 Paris Agreement ratified by 195 countries, mandatory Greenhouse Gas (GHG) accounting is making its way to legislative corpuses worldwide. It entails the **collection, analysis, and disclosure of Greenhouse Gas emissions data by facilities or companies to governmental or regulatory bodies.**

This practice is crucial for addressing climate change, as it provides governments with essential information to develop and monitor environmental policies and track progress towards emission reduction goals. Various countries and regions, such as the United States, the European Union⁷, Australia, and South Africa, have implemented mandatory reporting schemes with specific thresholds and requirements for reporting emissions data⁸. These initiatives aim to hold businesses accountable for their environmental impact and encourage transparency in emissions management.

By reporting their emissions, companies contribute to global efforts to combat climate change and can also identify opportunities to improve operational efficiency and reduce costs.

Definition

The Greenhouse Gas Accounting method aims to **standardize the process of measuring and reporting greenhouse gas emissions**, helping organisations understand their environmental impact and develop strategies to reduce emissions.

GHG Accounting is **applicable to organisations of all types and sizes, across various sectors** including business, government, academia, and non-profit organisations.

It comprises three scopes, known as Scope 1, Scope 2, and Scope 3 emissions, which encompass different categories of emissions sources:

1. Scope 1:

Direct emissions from sources that are owned or controlled by the reporting entity.

2. Scope 2:

Indirect emissions resulting from the generation of purchased electricity, heat, or steam consumed by the reporting entity.

3. Scope 3:

Indirect emissions from sources not owned or directly controlled by the reporting entity.

⁷ See CSRD section for more details on the regulation

⁸ For more detail visit this address: <https://www.climatewatchdata.org/>

The following Table 1 provides examples for each scope:

	Scope 1 Direct emissions	Scope 2 Indirect emissions	Scope 3 Indirect emissions
Definition	Direct emissions that are owned or controlled by a company	Indirect emissions that come from where the energy is produced	Indirect emissions that are a consequence of the company's activities
Examples	Transportation of materials, waste or employees with company owned vehicles Electricity, heat or steam from sources owned or controlled by the company	Purchased electricity for owned or controlled equipment or operations	Leased assets Employee commuting Processing of purchased or sold goods and services Investments Etc.

Table 1 – Definition and examples of GHG Protocol scopes.

Implementation Methodology

The GHG protocol comes with a methodology to help organisations achieve the assessment. Steps are outlined as follow:

- **Identification of Emission Sources:** Organisations identify and categorize their emission sources into the three scopes outlined in the GHG Protocol.
- **Measurement and Data Collection:** Quantitative data on emissions from each source category are collected.
- **Calculation:** Emissions are calculated using emission factors specific to each source category or through direct measurement where feasible.
- **Reporting:** Once emissions are calculated, organisations report their findings in accordance with GHG Protocol guidelines, including clear explanation of the results, emission reduction targets, as well as trend analysis over time.
- **Verification:** third-party verification is recommended to ensure the accuracy and reliability of GHG emissions data.

Standards and international references

The GHG Protocol is the first international standard⁹ for corporate GHG accounting and reporting, published in 2001. The International Organisation for Standardization (ISO) worked with the GHG Protocol authors to publish the ISO 14064¹⁰ standard for greenhouse gas accounting and verification in 2006. The GHG Protocol has also been used for various other carbon accounting frameworks.

Comparison to the French BEGES v5

BEGES (standing for 'Bilan des Emissions de Gaz à Effet de Serre', Greenhouse Gas Emissions Assessment) is the **French standard for greenhouse gas accounting**. The main differences are the emission subdivisions in 6 categories in BEGES, instead of 3 scopes. Also, in BEGES, emissions of fixed assets are depreciated over lifetime, whereas all emissions are taken into account in the year of acquisition or construction of the asset in GHG Protocol. Finally, French governmental and private entities must assess their emissions under BEGES standards¹¹, where GHG Protocol isn't mandatory for any organisation.

⁹ GHG Protocol standards, <https://ghgprotocol.org/standards-guidance>

¹⁰ ISO 14064-1:2018 Greenhouse gases, <https://www.iso.org/standard/66453.html>

¹¹ Comment établir le bilan carbone d'une entreprise ? Ministère de l'économie, des finances et de la souveraineté industrielle et numérique, <https://www.economie.gouv.fr/cedef/bilan-carbone-entreprise>

Table 2 provides an exhaustive presentation of the two frameworks' differences.

Aspect	GHG Protocol	BEGES v5
Framework	International Standards	French Standards
Emission Categories	<ul style="list-style-type: none"> - Scope 1: Direct Emissions - Scope 2: Indirect Emissions (Energy) - Scope 3: Other Indirect Emissions 	<ul style="list-style-type: none"> - Category 1: Direct Emissions - Category 2: Indirect Emissions (Energy) - Category 3: Indirect Emissions (Transport) - Category 4: Indirect Emissions (Purchased Products) - Category 5: Indirect Emissions (Sold Products) - Category E: Other Indirect Emissions
Subdivisions	Scope 3 divided into 15 categories	Categories divided into sub-categories/regulatory entries
Energy Emissions	Market-based and location-based approaches required	Only location-based approach used
Capital Goods	Emissions not amortized	Emissions amortized over lifespan
Employee Meals	Not accounted for	Accounted for
Visitor/Customer Transport	Not accounted for	Accounted for
Other Indirect Emissions	Reported separately, not included in total GHG	Specific category included

Table 2 – Table of discrepancies between GHG protocol and BEGES v.5¹²

2. Life Cycle Assessment Methodology

Definition

The Life Cycle Assessment (LCA) is a methodology that **evaluates the environmental impacts of all stages of a product's life cycle, from raw material extraction through production, use, and disposal** (Figure 1).

It is a comprehensive approach that considers **various environmental indicators** such as energy consumption, global warming potential, water usage, emissions of fine particles, acidification, etc.

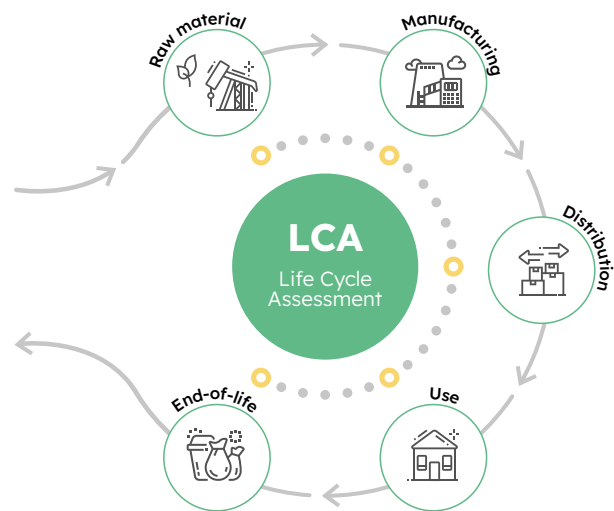


Figure 1 – Diagram of a product typical life cycle stages.

¹² GHG Protocol vs BEGES v5 - Quelles différences ? | Centre d'aide, <https://intercom.help/colibris/fr/articles/8232916-ghg-protocol-vs-beges-v5-quelles-differences>

Implementation of the Methodology

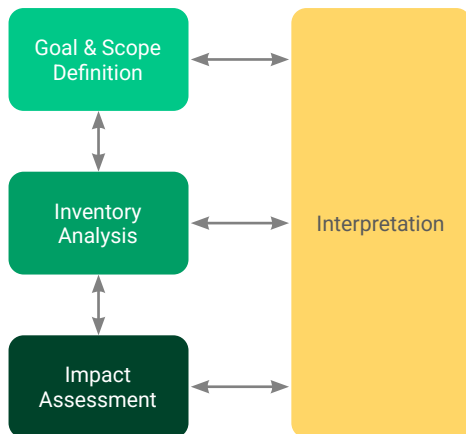


Figure 2 – Diagram of the implementation processes of an LCA

The steps allowing to carry an LCA are shown in Figure 2 and described as follows, as an iterative process:

1. **Goal and Scope Definition:** The first step of conducting an LCA is **defining the goal and scope** of the study clearly. This involves identifying the **purpose** of the assessment, defining the **system boundaries**, determining the **functional unit** (e.g., the quantity of product or service in a defined timeframe), and specifying the life cycle stages to be included.
2. **Life Cycle Inventory (LCI):** In this phase, inputs and outputs data are associated with each stage of the product's life cycle steps are **collected and quantified**. This includes raw material extraction, transportation, manufacturing processes, distribution, use, and end-of-life disposal. The data collected typically includes energy consumption, material inputs, emissions to air, water, and soil, and waste generation.
3. **Life Cycle Impact Assessment (LCIA):** Once the inventory data is collected, it is converted into potential environmen-

tal impacts using impact assessment methods. These methods **quantify the effects of resource consumption and emissions on various environmental categories** such as climate change, acidification, eutrophication, or human health.

4. **Cutoffs:** During LCIA, cutoff criteria are applied to **exclude processes or inputs with negligible environmental impacts or considered outside the system boundaries**. Cutoffs streamline the assessment and focus on the most significant aspects of the life cycle. For example, processes or inputs contributing less than a certain percentage (e.g., 1%) to the total environmental impact may be excluded from further analysis.
5. **LCA Results Interpretation:** The results of the impact assessment are interpreted to draw conclusions and identify areas for improvement. This step involves comparing alternative scenarios or products, identifying hotspots where environmental impacts are most significant, and considering trade-offs between different impact categories. This allows to improve the current study.

Sensitivity Analyses: During results interpretation, sensitivity analysis is crucial in LCA to examine the **robustness** of results to **changes in assumptions, parameters, or methodologies**. It helps assess the uncertainty and reliability of LCA results and identify key factors driving environmental impacts. Sensitivity analyses involve varying input data, system boundaries, allocation methods, impact assessment models, or other parameters to evaluate their influence on study outcomes boundaries, allocation methods, impact.

Standards and international references

LCA is mainly defined by two international ISO standards:

1. **ISO 14040: Environmental management - Life cycle assessment - Principles and framework**¹³:

This standard, published by the International Organisation for Standardization (ISO), outlines the **general principles, framework, and requirements for conducting LCA studies**. It provides guidance on defining the goal and scope of the assessment, conducting inventory analysis, assessing the impact, and interpreting the results. ISO 14040 serves as the foundation for LCA methodology and ensures consistency and reliability in LCA practice.

2. **ISO 14044: Environmental management - Life cycle assessment - Requirements and guidelines**¹⁴:

Another standard developed by ISO, ISO 14044 builds upon ISO 14040 and provides **detailed requirements and guidelines for conducting specific phases of the LCA process**. It offers guidance on data collection, allocation procedures, impact assessment methods, sensitivity analysis, and reporting of results. ISO 14044 helps to ensure the quality and transparency of LCA studies and facilitates comparability between different assessments.

Adhering to ISO 14040 and ISO 14044 is a first step towards **rigorous and standardized LCA studies, enhancing the credibility and reliability of their findings**. Other regional norms and frameworks including but not limited to PEF¹⁵ and the ILCD Handbook¹⁶ (developed by the Joint Research Centre (JRC) of the European Commission) allow for better precision and comparability between studies, precisifying methods for various industrial and economic domains.

Overall, LCA provides a **systematic framework** for assessing the environmental performance of products and informing decision-making processes to promote sustainability and resource efficiency. By incorporating **cutoffs** and conducting **sensitivity analyses, LCA studies can enhance the credibility and usefulness of their findings**.

¹³ International Organisation for Standardization (ISO). (2006). ISO 14040: Environmental management - Lifecycle assessment - Principles and framework. <https://www.iso.org/standard/37456.html>

¹⁴ International Organisation for Standardization (ISO). (2006). ISO 14044: Environmental management - Life cycle assessment - Requirements and guidelines. <https://www.iso.org/standard/38498.html>

¹⁵ PEF Method, European Commission, https://green-business.ec.europa.eu/environmental-footprint-methods/pef-method_en

¹⁶ ILCD International Life Cycle Data system, European Commission, <https://eplca.jrc.ec.europa.eu/ilcd.html>

3. Example of results

The two impact assessment methods studied here provide different results in terms of both content and form. GHG Protocol results only provide CO₂ eq. emission distribution where LCA results presents various indicators and life cycle steps. These differences are detailed here with the example of an information system of a company.

GHG accounting result

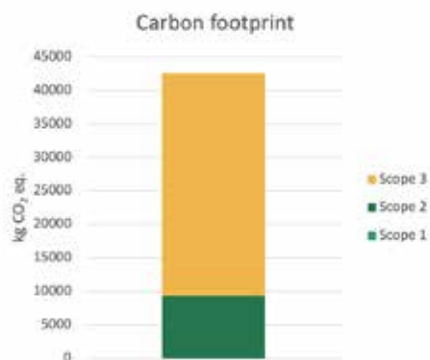


Figure 3 – Result example for GHG accounting

Global warming potential impacts are shared between the three scopes.

LCA result

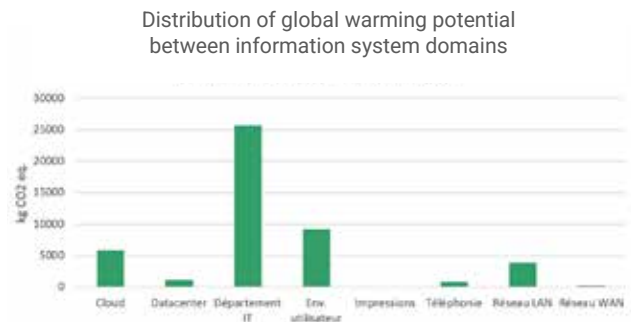


Figure 4 – Result example of an LCA study

Global warming potential impacts are shared between the IT system domains.

Global Warming Potential shared between the life cycle step



Figure 5 – Distribution of each life cycle step impacts for all environmental indicators.

LCA also provides relative environmental impacts of all life cycle steps for each environmental indicator. Results are normalized to 100%.

4. Limitations and comparison

LCA and carbon accounting are both methods used to evaluate environmental impacts, particularly associated to greenhouse gas emissions, however they differ in scope and focus:

1. Scope:

- **LCA: Life Cycle Assessment** assesses the environmental impacts associated to a product, process, or activity throughout its **entire life cycle**, from raw material extraction to production, use, and disposal. It considers **various environmental indicators** beyond just greenhouse gas emissions, such as energy use, water consumption, and pollution.
- **Carbon accounting** specifically focuses on quantifying and reporting **greenhouse gas emissions** generated by an organisation, business, or territory. It provides a detailed breakdown of emissions sources and sectors contributing to the total greenhouse gas footprint.

2. Application:

- **LCA: Life Cycle Assessment** is commonly used in product design, manufacturing, and decision-making processes to identify opportunities for environmental improvement and to optimize resource use efficiency. It helps **assess the overall environmental sustainability of products and services**.
- **Carbon accounting** is primarily used by organisations, companies, and governments to measure, track, and report their greenhouse gas emissions over time. It is often a **mandatory or voluntary reporting requirement for entities seeking to understand and manage their carbon footprint**.

3. Timeframe and Granularity:

- **LCA: Life Cycle Assessment** typically considers long-term environmental impacts and provides a holistic view of a product or activity's sustainability. It involves detailed analysis and data collection across **various stages of the life cycle**, often requiring substantial time and resources.
- **Carbon accounting** focuses specifically on quantifying greenhouse gas emissions within a **defined reporting period**, usually on an **annual basis**. It offers a snapshot of emissions sources and trends within a particular organisation or territory.

In summary, while both LCA and carbon accounting are methods used to assess environmental impacts, LCA includes a **broader scope** and is applied to **products and processes**, whereas carbon accounting specifically targets greenhouse gas emissions and is used for organisational or territorial **reporting purposes**.

Moreover, LCA and GHG accounting are not the only ones, many more environmental impacts assessment methods exist. We can cite:

- **Environmental Risk Assessment (ERA)**¹⁷ assesses the likelihood and consequences of adverse environmental effects due to specific activities or substances. Key components include hazard identification, exposure assessment, risk characterization, and management strategies.
- **Cost-Benefit Analysis (CBA)**¹⁸ compares the costs and benefits of a project or policy to determine its overall value. It emphasizes the monetization of environmental impacts, weighing positive and negative effects.

¹⁷ Guidelines for Ecological Risk Assessment, 1998, United States Environmental Protection Agency, <https://www.epa.gov/risk/guidelines-ecological-risk-assessment>

¹⁸ Boardman et al., Cost-Benefit Analysis: Concepts and Practice, 5th edition, 2018, https://www.researchgate.net/publication/326678227_Cost-Benefit_Analysis_Concepts_and_Practice_5th_edition

- **Material Flow Analysis (MFA)**¹⁹ analyses the flow of materials within a system, emphasizing resource efficiency and waste reduction.

5. Sustainable Reporting Norms

Once identified and understood, the environmental impact of IT needs to be **reduced** to ensure that the digital and ecological transitions converge. **Legal measures** have been introduced to encourage companies and organisations to take this approach. The CSRD is one of the standards that is having the greatest impact at the moment.

CSRD standards

CSRD Regulations: What's Changing in 2024?

The European Union is transitioning from the **Non-Financial Reporting Directive (NFRD)** to the **Corporate Sustainable Reporting Directive**²⁰ (CSRD). Initially introduced in 2017, the NFRD mandated extra-financial reporting for EU-based companies. Since 2020, the European Commission has been revising this directive to enforce **more detailed environmental data reporting applicable to a broader spectrum of companies to monitor their direct and indirect impacts on the environment**, a proposal endorsed by the European Parliament in March 2022.

from the CSRD:

- Starting from the 2024 fiscal year, the reporting obligation extends to companies with over 250 employees and a turnover exceeding €40 million, or a balance sheet total of €20 million or more, compared to the previous threshold of 500 employees.
- Companies operating within Europe are subject to these obligations regardless of their geographical location, significantly broadening the scope to include approximately 50'000 entities, up from the 10'000 covered by the NFRD.
- The revised reporting will focus on providing **more detailed insights into risks and impacts, emphasizing the integration of Environmental, Social, and Governance (ESG) criteria**. This includes addressing sustainability risks and negative impacts through strategic plans, aligning with the principle of double materiality, which considers both the company's impact on the environment and vice versa.

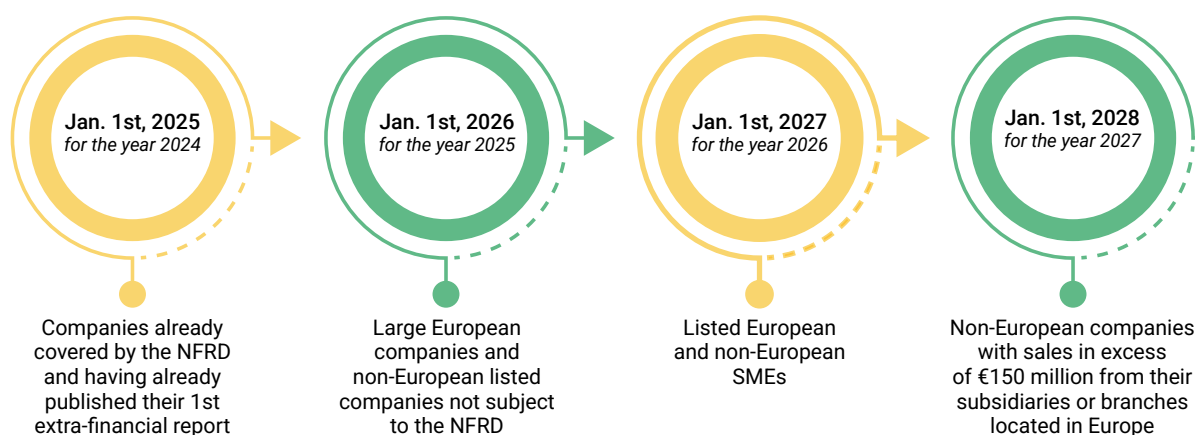


Figure 6 – Timeline of the implementation of the CSRD for the different groups of companies concerned

Key Changes

¹⁹ Brunner & Rechberger, *Practical Handbook of material flow analysis*, 2004, <https://link.springer.com/article/10.1007/BF02979426>

²⁰ Corporate sustainability reporting, European Commission, 2024, https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

II. The different types of Life Cycle Assessments

Now that we have set the context and defined LCA, let's dive into the subtleties of this method, as it is the principal assessment method for ICT sector. We can distinguish four main types of LCA, that are adapted to different types of issues. Let's look at them in more details:

- Attributional & consequential LCA
- Social LCA
- Parametric LCA

1. Attributional and consequential LCAs

The two most commonly known types of LCAs are:

- **Attributional LCA (ALCA)**, also called accounting or descriptive approach
- **Consequential LCA (CLCA)**, also called change-oriented approach

Definitions

Following UNEP-SETAC²¹ (United Nation Environmental Program and Society of Environmental Toxicology and Chemistry) definition, widely accepted in the literature²²:

- **Attributional LCA** is a "System modelling approach in which inputs and outputs are attributed to the functional unit of a product system by linking and/or partitioning the unit processes of the system according to a normative rule"
- **Consequential LCA** is a "System modelling approach in which activities in a product system are linked so that activities are included in the product system to the extent that they are expected to change as a consequence of a change in demand for the functional unit"

We often see the diagram illustrated in Figure 7:

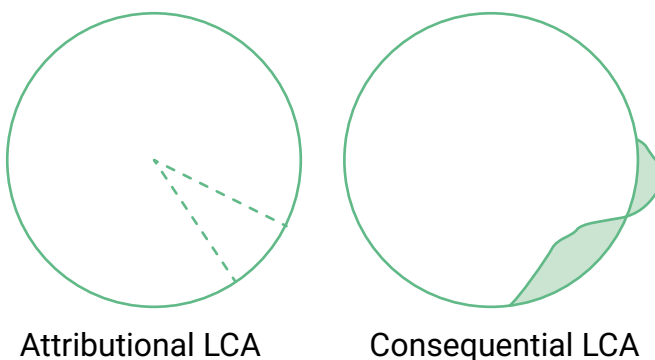


Figure 7 - Diagram illustrating the differences between attributional, on the left, and consequential approach, on the right²³

The circle represents the **total global environmental burden**. In the left circle, ALCA seeks to estimate the piece with dotted lines, i.e. the **share of the global burden that belongs to a specific product**. On the right, CLCA seeks to estimate the **change** in environmental exchanges **that occur as a consequence of adding or removing a specific human activity**. Standards

ISO 14040-14044 reports make no exact distinction between ALCA and CLCA, the terms "attributional" and "consequential" are not mentioned.

²¹ Global Guidance Principles for Life Cycle Assessment Databases, A Basis for Greener Processes and Products, 'Shonan Guidance Principles', UNEP-SETAC, 2011, <https://www.lifecycleinitiative.org/wp-content/uploads/2012/12/2011%20-%20Global%20Guidance%20Principles.pdf>

²² chaubroeck et al., Attributional & Consequential Life Cycle Assessment: Definitions, Conceptual Characteristics and Modelling Restrictions, 2021, <https://www.mdpi.com/2071-1050/13/13/7386>

²³ Weidema, Market information in life cycle assessment, 2003, https://www.researchgate.net/publication/259645192_Market_Information_in_Life_Cycle_Assessment

Implementation methodology

ALCA describes the environmentally relevant **physical flows** and partition of the impacts between the life cycle steps. Thus, the sum of the environmental impacts of all sub elements of the final product per life cycle step equals the total environmental impact.

Concerning CLCA, the first step consists in modelling a general, basic version of the studied system. Then, according to defined market, behaviour, regulation, etc., **changes are applied to the system**. The environmental consequences are given as the **difference of impacts between the basic system and the under-changes system**.

The choice between ALCA and CLCA impacts the whole LCA process: input data, system boundaries, allocations.

Example

Let's take a concrete example, to make the difference between the two methods more explicit. An ALCA would estimate the environmental impacts of an already built smartphone, whereas a CLCA would estimate the environmental impacts of manufacturing one more new smartphone.

ALCA: In this case, the smartphone already exists.

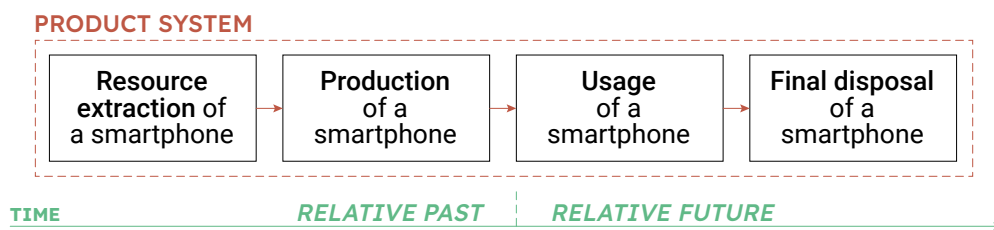


Figure 8 – Diagram of a smartphone as product system of an ALCA²⁴

CLCA: In this case, we focus on the effects of the decision of building a new smartphone. The smartphone doesn't exist yet.

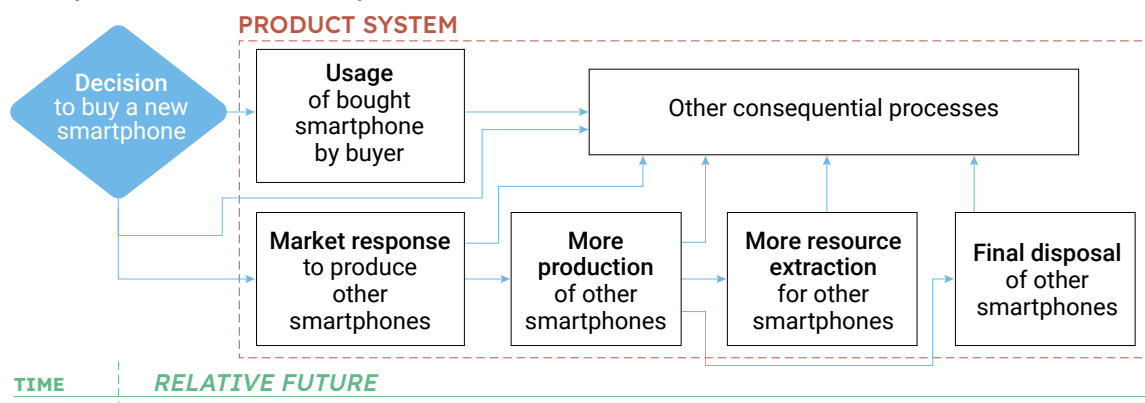


Figure 9 - Diagram of a smartphone as product system of a CLCA²⁴

As you can see comparing the diagrams, ALCA is more analytical whereas CLCA is more systemic but is harder to calculate as it is not always possible to evaluate all the consequential processes, etc.

²⁴ Figure inspired by Schaubroeck et al., *Attributional & Consequential Life Cycle Assessment: Definitions, Conceptual Characteristics and Modelling Restrictions*, 2021, <https://www.mdpi.com/2071-1050/13/13/7386>

2. Social LCA

Definition

Social Life Cycle Assessment (SLCA) is similar to an environmental LCA, but with a focus on **social and sociological criteria**. Environmental LCAs do not take any social criteria into account. The 2 types of LCAs are therefore complementary. The main objective of Social LCA is to preserve the health and well-being of individuals

Standards

The United Nations Environment Programme (UNEP) provided guidelines for the assessment of social and socio-economic impacts of products life cycles²⁵ in order to evaluate the consequences of social changes of a product, a service or an organisation.

Implementation methodology

Impact indicators are based on categories of “stakeholders” (e.g. society, workers, etc.) and sub-categories (child labour, working hours, fair salary, etc.).

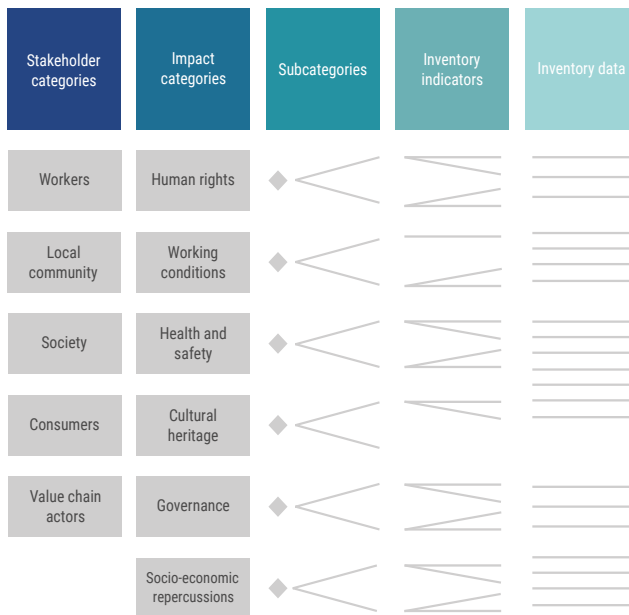


Figure 10 – Social LCA Framework²⁶

Social LCAs use generic and site-specific data, that can be **quantitative, semi-quantitative or qualitative**. However, the field of research is still open and recent, and there are not as many resources available as for environmental LCAs, for example. Social criteria are often more qualitative than quantitative.

Main databases are SHDB²⁷ and PSILCA²⁸ that evaluate social impacts through risk assessment.

As the spectrum of item to study is very large, it is recommended to concentrate on 3 or 4 impact sub-categories. Choice can be made by the importance of the value chain, controversies or regulation.

Example

Social LCAs are conducted by organisations when developing new products, assessing actual value chain or when they want to communicate to their customers. This exercise has not yet been applied to digital activities according to our knowledge, at the time of writing this White paper.

25 Social Hotspots Database (SHDB), 2022, New Earth b, <http://www.socialhotspot.org/>

26 Guidelines for Social Life Cycle Assessment (S-LCA) : <https://www.lifecycleinitiative.org/activities/life-cycle-assessment-data-and-methods/global-guidance-for-life-cycle-impact-assessment-indicators-and-methods-glam/guidelines-for-social-life-cycle-assessment-solca/?preview=true>

27 Social Hotspots Database (SHDB), 2022, New Earth b, <http://www.socialhotspot.org/>

28 PSILCA Database, 2022, <https://psilca.net/>

3. Parametric LCA

Definition

The **parametric life cycle assessment (PLCA)** approach combines parameterization techniques with simplified LCA methods. It can help designers evaluate and compare the environmental and social performances (ALCA and SLCA respectively) or potential consequences (CLCA) of systems of products and/or services across different design scenarios early in the development process. This method is particularly beneficial because once a parametric model is established, creating additional design alternatives requires minimal effort.

Parameters such as material composition, energy usage, transportation distances, lifespans, etc., are adjusted to **analyse how their changes affect the overall environmental or social performance**. Multi-criteria optimization requires prioritizing objectives. Usually, not all parameters can reach their optimum simultaneously and trade-offs must be found. Table 3 below shows some examples of parameters and their quantification variables.

Parameter category	Parameters	Variables
Product design parameters	Density Weight Volume	Material type Composition Size
Product functional parameters	Resource consumption Durability	Material Design
Production process parameters	Process time and volume Energy consumption Waste quantity	Electricity consumption Rejection rates Time

Table 3 – Examples of parameters and quantification variables for PLCA²⁹

Implementation methodology

This type of assessment begins with one of the LCA method described above, which results are used to identify environmental parameters and develop LCA models. The detailed steps are:

- 1. Development of Preliminary Information:** This step creates reports detailing the product's characteristics and life cycle processes at the unit process level.
- 2. Development of Process Flow Diagram and Life Cycle Inventory Summary:** This step involves detailing unit processes, their inputs and outputs, and understanding life cycle stages. A process flow diagram (PFD) illustrates manufacturing processes, and a life cycle inventory summary quantifies exchanges throughout the life cycle.
- 3. Identification of Key Environmental Parameters:** This step identifies and analyses parameters influencing the environmental or social performance of the system, such as design and manufacturing process parameters.

²⁹ Kamalakkannan et al, Optimization of eco-design decisions using a parametric life cycle assessment, Sustainable Production and Consumption, 2021, <https://www.sciencedirect.com/science/article/abs/pii/S2352550921000798>

4. **Development of the Parametric Life Cycle Assessment Model:** The PLCA model considers each life cycle step, defining independent variables based on sensitivity analysis and secondary data. The total environmental impact is computed using these variables and constants.
5. **Optimization of the Parametric Life Cycle Assessment Model:** Optimization minimizes the overall environmental or social impact while meeting criteria and constraints, identifying optimal parameter values for eco-design.
6. **Interpretation of the Optimized Parametric Life Cycle Assessment:** Analysing results provides insights into environmental impacts at each life cycle phase, the influence of variables, comparison of design scenarios, environmental hotspots, and optimal parametric values. This approach will help in the decision-making process during design and development.

This approach is effective for both existing and future systems, though challenges include data reliability and proper assumptions. Overall, PLCA offers a structured method to assess and optimize environmental and social performance in system design and development.

Figure 11 below illustrates the applied methodology:

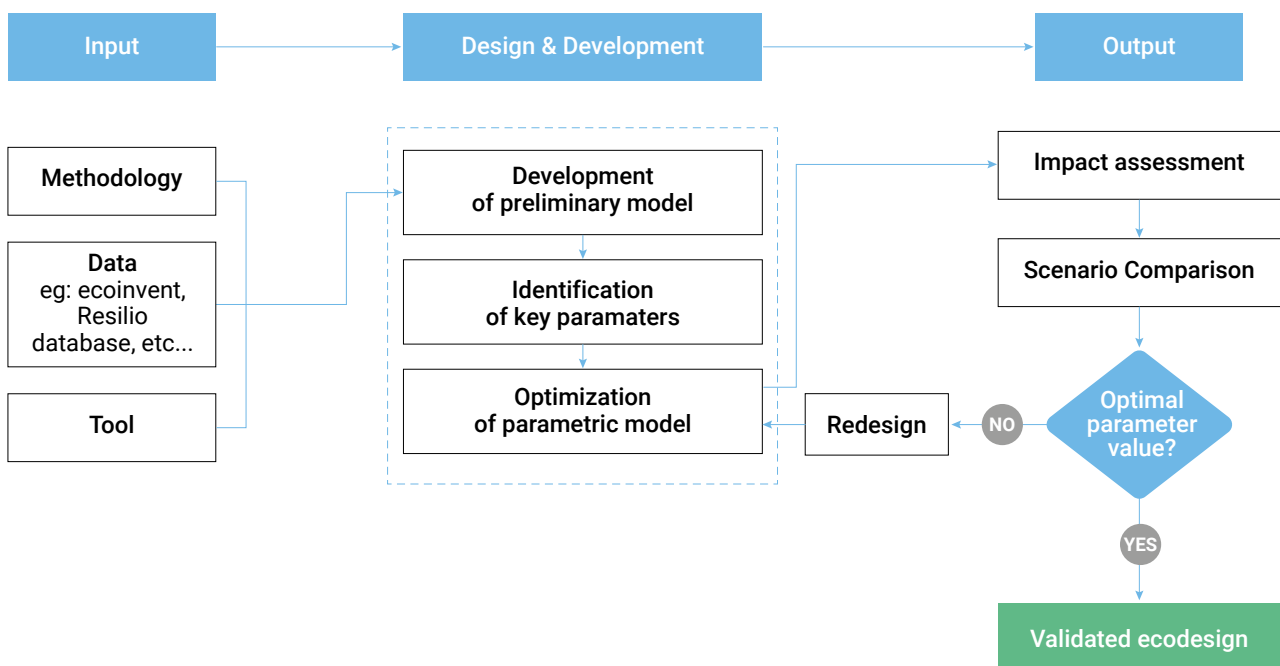


Figure 11 – Flowchart of a typical implementation methodology for PLCA

4. Which type of LCA in which case?

We have described the various existing types of LCAs. Each has its own unique characteristics. The table below summarizes the various types and their main objective, to facilitate the selection process of the different types of LCAs.

LCA type	LCA objectives
Attributional LCA	Provides information on what portion of global environmental burdens can be associated with a product
Consequential LCA	Provides information on the environmental burdens which occur, directly or indirectly , as a consequence of a decision
Social LCA	Provides information on what portion of social and sociological burdens can be associated with a product
Parametric LCA	Provides information on what optimizes a system's (product or service) life cycle depending on a chosen goal.

In practice, here is an example of various LCAs that could be carried out on an organisation's Information System (IS).

In all cases, the product considered is the same: the information system of any organisation.

LCA type	Example of question
Attributional LCA	What are the environmental impacts associated to the provision and usage of the information system for 1 year?
Consequential LCA	What are the environmental impacts of transferring digital tools and data from an on-premise data centre to the cloud?
Social LCA	What are the social and sociological impacts associated to the provision and usage of the information system for 1 year?
Parametric LCA	What design elements of my information system can I modulate to reach my environmental goals throughout its life cycle?

Conclusion

The main environmental impact assessment methods are **GHG Accounting** and **Life Cycle Assessment**. GHG Accounting is a relatively simple method, which doesn't require a lot of data and its **implementation is relatively simple**. There is a downside to its accessibility: it gives a partial view of the impacts of the product or service assessed.

On the contrary, Life Cycle Assessment is a **holistic method**, providing detailed environmental impacts on several indicators. Moreover, it can be applied according to different frameworks, allowing to **answer to various types of problems**. Several types of LCAs are described in this document, allowing the method to be applied in different contexts. This methodology makes it possible to study environmental or social impacts, either descriptively or prospectively. **International standards** also are important for this methodology credibility and results reliability and comparability.

Environmental and social impacts assessment methodology importance is increasing with global crisis. The first step to reduction of impacts is **being aware of these impacts** and thus measuring them. Conducting this type of study should be a reflex when developing products or services to **reduce our impact** and **enable human activity to respect planetary boundaries**.

To find out more:

Discover the technical sheets, and get started with an LCA!

If you feel you need more support, find out more about [Resilio's LCA training](#).

Glossary

Ppm: parts per million, fraction used to express very small quantities.

Global warming potential (GWP): unit kg CO₂ eq. It corresponds to induced changes in climate, including increases in global average temperatures and sudden regional climate changes, because of emissions into the atmosphere of greenhouse gases such as CO₂, CH₄, and N₂O.

Abiotic depletion potential – non fossil (ADPe): unit kg Sb eq. It corresponds to the global impact related to the decreased availability and potential scarcity for future generations of the total reserves of mineral and metal resources.

ADPf (fossil): unit MJ. It corresponds to the global impact related to the decrease in availability and potential scarcity for future generations of the total reserves of fossil resources.

Acidification (AP): unit mol H⁺ eq. It corresponds to the regional environmental impacts on changes in soil acidity due to the emission and deposition of acids (and compounds that can be converted to acids) in the environment.

Fine particles (PM): measured in disease occurrences. It corresponds to the impact on human health caused by increased ambient concentrations of fine particulate matter, due to emissions of primary and secondary particulate matter (i.e. precursors, NO_x, SO₂).

Fossil fuels: carbon or hydrocarbon containing material formed naturally by fossilization of organic matter in a certain area of Earth. There are mainly coal, oil and natural gases.

Greenhouse gas: any gas contributing to the greenhouse effect, by absorption of infrared radiation. For example, carbon dioxide, methane, water, etc.

Eutrophication: pollution of ecosystems by nitrogen or phosphorus inducing increased algae growth and reduced oxygen and/or nutrient availability.



resilio-solutions.com

+41 78 673 77 18

+33 6 84 29 53 30

contact@resilio.tech



Resilio SA - EPFL Innovation Park, Bâtiment C, 1015 Lausanne, Suisse – CHE-256.900.000

A comparative synthesis of various Life Cycle Assessment methods

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