LIFE CYCLE ASSESSMENT

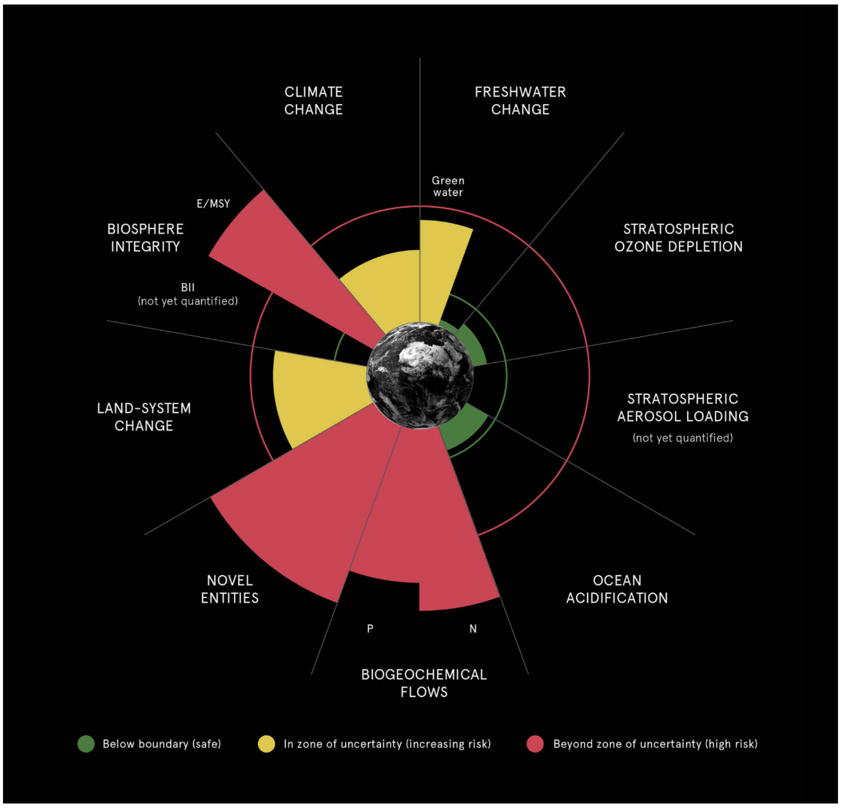
LCA WHITE PAPER

As the first European venture capital fund, Planet A relies on its own scientific team to assess the environmental and climate impact of an innovation. Prior to an investment, a life cycle assessment, like this one, is conducted and integral part of the investment decision. All assessments as well as the methodology is published for maximum transparency.

Contents

1. Why assess the impact of investment decisions?

Since 2009, researchers at the Stockholm Resilience Centre have identified [nine quantitative planetary boundaries] within which humanity can continue to develop and thrive for generations to come. [Crossing these boundaries] increases the risk of generating large-scale abrupt or irreversible environmental changes. As of 2023, we have already transgressed six of the nine planetary boundaries.



We started Planet A because we believe in the power of collaboration between entrepreneurs and scientists to create a sustainable economy within these planetary boundaries. That is why we have our own team of researchers: to ensure venture capital (VC) drives innovation that has a scalable and positive impact on our planet.

Impact is at the core of our investment decisions and is anchored into every step of our investment process. We strive to make scientific impact investing the new standard in VC. Therefore, we are fully transparent in the methods and results of our scientific work. We also engage in public discourse to promote the inclusion of scientific (environmental) impact assessment into investment decisions that shape our future.

Along [Ashoka]'s concept of *targeted systems change*, we focus on highly innovative start-ups that will change entire industries. We only invest in start-ups that can demonstrate a quantifiable impact in at least one of the four key areas: climate change mitigation, resource efficiency, waste prevention, or biodiversity protection.

By partnering with scalable impact pioneers, we aim to contribute to the transformation to a more sustainable, circular economy which is needed to reach the 2030 United Nations Sustainable Development Goals and shape an economy that operates within the planetary boundaries.

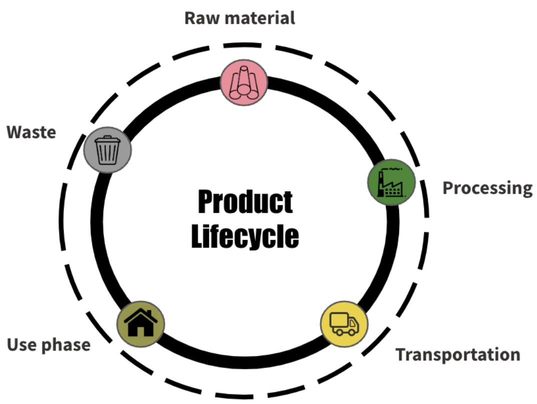
This requires a clear vision of the direction and magnitude of change. The assessment of the impact in our investment decisions is a key requirement of informed decision-making. Therefore, we assess the environmental impact of all our investment opportunities, use impact assessments to identify champions of change, support our portfolio companies in understanding and improving their positive impact, and, last but not least, track and forecast the impact of our VC portfolio.

2. Assessing environmental impact with Life Cycle Assessments

To make impact quantifiable, comparable and understandable, we need a versatile method that can be applied across disciplines. Life Cycle Assessment (LCA) offers a holistic, science-based, detailed, and robust environmental impact assessment. We are the first European VC fund to have a dedicated science team who use LCAs as a tool to support our decision-making ex ante.

What are Life Cycle Assessments?

LCA is a proven method to reliably quantify environmental impacts associated with human activities and processes. It can be used to assess the environmental implications of any (economic) activity, such as a product or a service. In addition, this tool can be used to evaluate more complex problems, such as the consequences of specific decisions or changes within the economy.



At Planet A, we use LCAs to assess the environmental impacts associated with all stages of a product's or service's life cycle - from raw material extraction through materials processing, manufacture, distribution, and use phase all the way to end-of-life.

Besides analysing environmental impacts, the many applications of LCAs include generating relevant knowledge about impact, identifying optimisation potential, and providing quantitative metrics to support decision-makers. LCAs offer the possibility to assess multiple environmental impacts, not just greenhouse gas (GHG) emissions, as commonly done in carbon footprint analyses.

2.1. Fundamentals of Life Cycle Assessments

LCAs are standardised in the **ISO 14040 and 14044 standards** which provide common standards for industries and practitioners on how to conduct LCAs. These ISO norms define four distinctive phases of an LCA:

1) Goal and Scope Definition

In the first phase of an LCA, the general conditions are defined. First of all, the goal and the reason for executing the LCA are specified. Furthermore, the intended audience, the assessed system boundaries and the temporal scope must be defined. In addition, important assumptions and parameters must be reported, such as the defined functional unit, the applied principle on how to account for multi-output processes, applied cut-off criteria, or data sources. The most important aspects are:

- The *system boundary* defines the assessed system. It determines which unit processes will be included in the LCA and which will be excluded. As a Life Cycle Assessment is an abstraction of reality, choices need to be made about what should be included in the modeled system.

> *Example:* Depending on the scope of the study, the system boundary can contain processes such as material extraction, processing, transportation processes, energy supply and end-of-life of a product, if a product system is assessed. In more complex LCAs, the LCA could also include other processes and activities that are not directly related to the assessed product but to other processes and activities in the economy that change because of a change in a product system.

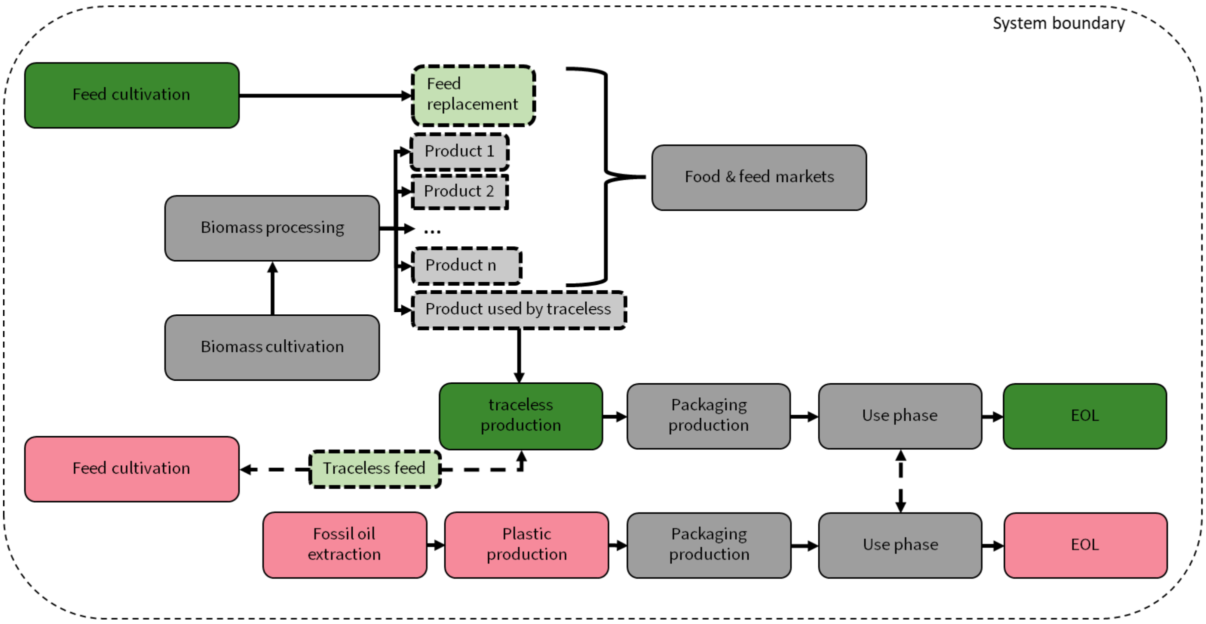


Illustration: System boundaries of Planet A's portfolio company traceless materials

- The *functional unit* provides a reference to which the input and output data are normalised. It defines the function or output of the assessed system that is analysed. For example, transporting a certain good over a certain distance, the production of a specific product or the overall impact from the production, use and disposal of a packaging item. The functional unit must be clearly defined to allow a comparison of an assessment with other studies.

> *Example:* The functional LCA can relate either to products, such as *the provision of 1kg of a plastic substitute including production, use, end-of-life* or *producing 1t of cement* or it can relate to activities, such as *washing 1kg of laundry*, or *travelling 1 km by train*.

- The methodological approach on how to deal with multi-functionality is the one of the most important aspects to consider. The most common ways to handle product systems and processes that produce several outputs or functions are either *allocation* or *substitutions/system expansion*. The choice of method is closely linked to the two most commonly applied approaches discussed in Section 2.4.

The choices made at this stage highly influence the outcome of the LCA. They should be made in accordance with the key question to be answered in the LCA.

2) Life Cycle Inventory

The life cycle inventory (LCI) is the collection of all data of an LCA model. An LCA model comprises individual processes linked with each other. Each process contains inputs and outputs. Inputs could be natural resources, e.g., water or land, and material or service flows from other processes, e.g., electricity, aluminium or transportation. Outputs are material or service flows feeding into other processes, e.g., wastes going to a waste treatment process or energy supplied to a process using the energy, or are emissions emitted to the environment, e.g., substances emitted to air, water and land. According to this description, all input and output flows belong to either of the following categories:

- *Elementary flows* are materials entering the system boundaries without previous human transformation or leaving the system boundaries without subsequent human transformation. For instance, resources such as minerals, water or land are elementary flows entering the system; emissions to air, water and soil, such as GHGs, nutrients, toxic compounds, waste heat etc. are elementary flows leaving the system. All elementary flows will be linked with environmental impacts in the life cycle impact assessment phase (see below).
- *Intermediate flows* are all flows within the system boundaries. These flows connect individual processes. For example, a process uses electricity, which is supplied by another process or produces waste that is transported to a waste treatment facility.

The LCI contains all relevant flows within the system boundaries (intermediate flows) and all flows entering and leaving the system boundaries (elementary flows). Most commonly, LCA practitioners model the processes of interest based on primary data and use databases to model all other processes somewhere downstream or upstream in the value chain. Commercially available databases contain thousands of processes, including material extraction and processing, many manufacturing and production processes, energy supply, transportation services, waste treatment processes, etc. With the help of these databases, LCAs include all relevant processes that are required to provide the function of the system as defined by the functional unit.

Most analysed systems comprise thousands of processes from raw material extraction, transportation, processing, use and waste treatments. All materials used in a process need to be provided, demanding additional activities to supply these materials. All processes and activities required in these processes and activities again require other processes and activities. After all data is collected, the total elementary flows entering and leaving the system are calculated.

Data collection is among the most time consuming and, at times, challenging parts of an LCA. Conducting an LCA of innovative technologies at an early stage can be challenging. In our LCA studies, we use primary data from start-up companies, data published in scientific literature or industry reports, commercial LCA databases and our data derived from our models. Once data is compiled for each individual process and checked for validity and plausibility, the overall system can be constructed in the model. Validity and plausibility can be checked by comparing data with published data, data gathered in our extensive LCA assessments, modelling of technical processes etc.

3) Life Cycle Impact Assessment

The third phase of the LCA is the Life Cycle Impact Assessment (LCIA) where the LCI is linked to environmental impacts. Once all elementary flows entering and leaving the system are known, these elementary flows can be linked with environmental impacts. There are numerous methods describing different environmental impacts. Most LCIA methods use so-called *midpoint* and *endpoint indicators* to express the impact on the environment.

At first, indicators are selected and defined reflecting environmental impacts, e.g., climate change, eutrophication, acidification, toxicity, resource uses. The choice of indicators depends on the impacts that are of interest to the study.

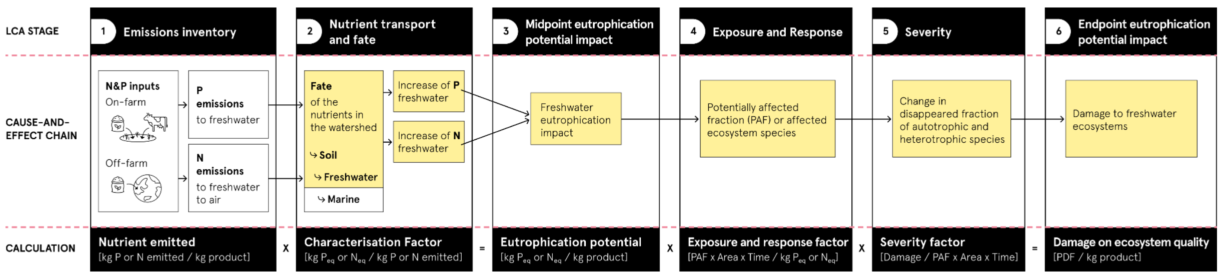
Afterwards, the elementary flows of the LCI are linked with *midpoint indicators*. This is accomplished by using characterisation factors. The characterisation factors express the contribution of an elementary flow to a specific environmental mechanism or impact, e.g., climate change, eutrophication, or water use.

Examples of characterisation factors to determine the impact on climate change and resource extraction

The total quantity of a resource use or an emission (e.g., the resource copper) used in a product system or a GHG that is emitted, is multiplied by a characterisation factor that expresses this contribution in relation to a reference substance, such as CO_2 in case of the global warming potential (climate change), and a metal, such as antimon in case of the CML abiotic depletion method (a commonly used Life Cycle Impact Assessment method).

For instance, the characterisation factor of methane expresses how much solar radiation methane absorbs over a specific period of time (e.g., 100 years) in relation to CO_2. The characterisation factor expresses the increase in radiative forcing over the specific time horizon. Analogously, the resource demand in the CML abiotic depletion method expresses the resource use compared to the resource use of antimon (Sb). In this case, the abiotic depletion potential of all resources, such as copper and the reference substance antimon, is an expression of how much of the remaining reserve is annually extracted. It is calculated using the actual resource extraction rate of each metal divided by the ultimate reserve of each metal squared. The result of the metal of interest (e.g., copper) is then divided by the result of antimon, resulting in the desired unit kg Sb-eq. More information and explanations on the global warming potential and the abiotic depletion can be found here and here.

These characterisation factors include additional considerations, such as the fate of a substance in the environment, the transformation a substance might undergo in the environment and the state and characteristics of the receiving entity or environment. Since environmental impacts and the underlying mechanisms act on different scales, some characterisation models depend on location and time, whereas others characterisation factors are independent of location and temporal considerations. For example, characterisation factors used for GHG emission to express the contribution to climate change are independent of where a specific quantity of a GHG is emitted but the impact on climate is most often assessed for a specific timeframe, e.g., 100 years. In contrast, other impacts are highly dependent on local conditions, e.g., the impact of water usage or the emission of acidifying substances are determined using local characterisation factors.



In a subsequent step, the midpoint indicators can be linked with so-called *endpoint indicators*. These endpoint indicators express the final impact at the end of a cause-effect chain on a more aggregate level. For instance, several midpoint level indicators contribute to other impacts, e.g., climate change, acidification, eutrophication, toxicity, and many more impacts usually expressed by using midpoint indicators contribute to biodiversity loss. Most commonly endpoint indicators express the impact on ecosystem quality (biodiversity), human health and resource depletion. These effects are highly local and depend on many environmental mechanisms. Optional elements of the LCIA phase include normalisation, e.g., normalising results relative to a reference such as impact per capita, grouping, ranking, and weighting.

4) Interpretation

In this phase of the LCA, the results from the previous phases are discussed. Then, conclusions and recommendations for decision-making are deducted according to the goal and scope of the study. An evaluation in regard to completeness and consistency of data and included processes, as well as sensitivity of results and influence of most crucial parameters should be included in this section. Limitations of the study are pointed out and discussed. The interpretation of results is commonly conducted throughout the assessment process. For instance, results, system boundaries, and scope are checked continuously and potential adjustments are made in other phases, if required.

2.2. Data sources and software we use

At Planet A, we use first-hand industry data, process modelling, scientific literature, industry reports to gather LCI data and commercial LCA data sets (see the latest version of the Ecoinvent database). Planet A uses economic data and market reports to identify the most likely substitutes (including the country of origin). We run our LCA models on the open source software OpenLCA.

The Ecoinvent database applies substitution to resolve multi-functionality and the in the consequential system model. Different data sets cannot be compared and analysed correctly when they are not equivalent to one another (see Williams, 2009, p. 4). Therefore, when using different data sets factors like source, age, or data type must be considered.

2.3. Two different Life Cycle Assessment approaches: Attributional and consequential

The goal and scope of an LCA study influence how a system should be modelled. For instance, an LCA serving certification purposes or identifying environmental hotspots within a supply chain requires a different approach than the assessment of how environmental impacts change as a consequence of one specific decision. The most common approaches to deal with different types of requirements and goals are attributional and consequential LCA.

2.3.1. Attributional LCA

Attributional LCA looks at an isolated product system that is strictly delimited from the rest of the economic system, e.g., the life cycle of a product containing all processes from raw material extraction to the end-of-life. The inputs and outputs are attributed to the functional unit of a product system, which is investigated isolated from its environment by using the normative cut-off rules. Most commonly these types of LCA are used for certification purposes, e.g., to certify alternative fuels, or calculate the environmental impacts of the supply of a product. Most commonly, average production processes are considered in such a study. This also implies the use of average production data. Often, assessed systems provide many services and products, e.g., combined heat and power production. In an attributional LCA, all flows and impacts of processes providing multiple outputs of products or services, are allocated to the products and services according to a method defined in the goal and scope phase. For example, impacts of a combined heat and power process could be allocated to heat and power according to the energy output of heat and power of the process. Instead of the energy content of products, other physical properties, such as exergy, weight etc. or monetary values (e.g., prices) could be used to allocate emissions. The idea behind this approach is to assign environmental impacts to a specific product or service. The assessment comprises the shares of emissions of processes and services that are required to provide the functional unit.

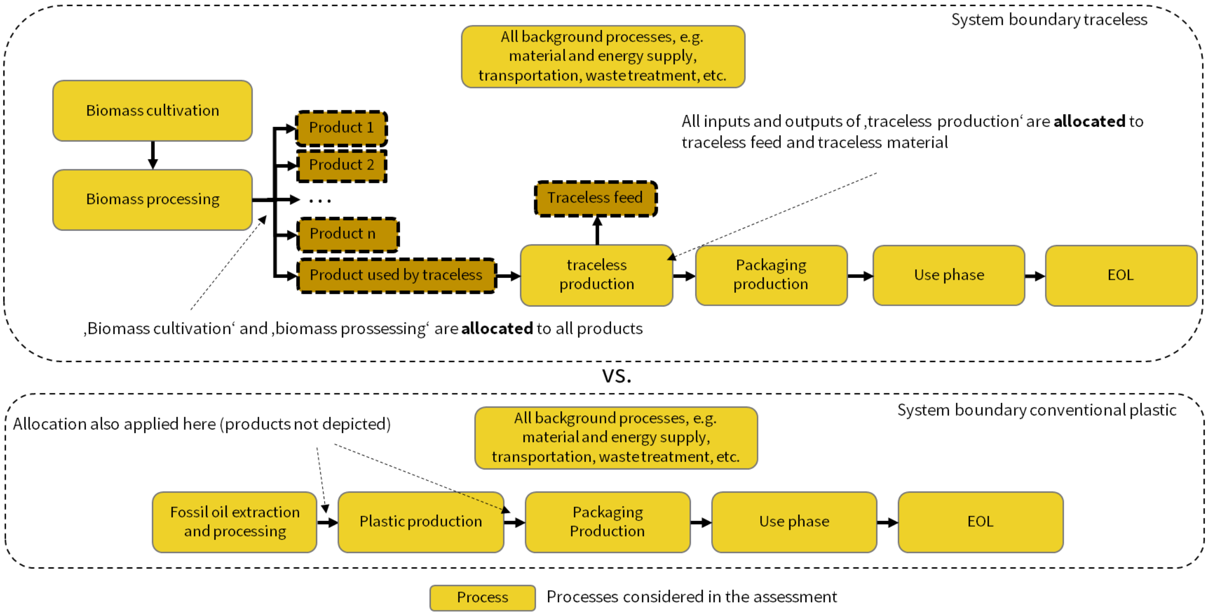


Illustration: An exemplary depiction of how traceless could be assessed following an attributional LCA approach. The attributional LCA approach allows a comparison of two product systems. All process inputs and outputs are allocated in case a process produces more than one product. Such assessments usually compare average product systems and do not include any changes in the system, e.g., changes occurring in response to a change in the market. Subtracting results from one system, e.g., traceless, from another system, e.g., the conventional plastic system, does not provide any meaningful results, mainly due to the allocation procedure applied. Instead, the approach can be used to identify hotspots within a system or to make a comparison between two established/average systems without providing insights into how the impact changes in response to a change in the system, e.g., the scaling or market entry of a start-up.

2.3.2. Consequential LCA

In a consequential LCA, the consequences of specific changes following specific decisions are at the centre of interest. The assessment of changes implies several aspects that differ from the previously described attributional LCA approach:

- The product system is not an isolated system but connected to the entire economy. The assessment of changes in the environmental impacts includes changes occurring in processes within a supply chain but also changes occurring elsewhere. Such changes include decreases and increases in supply, and changes in how materials are processed, treated, or disposed of.

- Change in demand or supply: A change in demand for a material or service results in more (increase in demand) or less (decrease in demand) activities and services providing the respective material or service. For example, providing electricity to the grid using solar photovoltaic power eventually results in less electricity provided by another electricity provider (if demand is to remain constant). A specific supplier will produce less as a response to another supplier entering the market.
- Change in how materials are processed or treated: For example, the scaling of a waste-based new product results in wastes being used in production processes instead of previous waste treatment processes. Instead, the new material will be disposed of and waste treatment might be differ from the previous waste treatment of the waste that is no longer treated but used as a feedstock for production.

- The assessment of these changes requires certain considerations:

    - Marginal supply: This consequential approach requires the use of data sets reflecting a marginal change in production. For instance, if the demand for a product or service increases, specific suppliers will decrease their supply and demand, which are not necessarily the same as an average producer. For example, providing solar photovoltaic power to the electricity grid will displace the marginal electricity supply at a specific point in time and location. Likewise, demanding more electricity from the grid will result in a marginal supplier providing the electricity. In all cases, the processes changing are different from the average supply in the market. Therefore, the impact associated with a change in supply of the marginal supplier and not the average supplier is of interest.

    - Constrained markets: Many processes produce more than one product. Increasing the demand for one product that is the major economic driver of the process will result in more of the byproducts, too. Similarly, higher demand for a byproduct of the production process with very low economic significance to the process will not result in an increase in production. In such cases, using the material or services that comes from a constrained supply is likely to result in other unconstrained processes to supply products or services to the market that fulfil the same function. For example, conventional bioethanol production produces a high protein animal feed as a byproduct. If the demand for bioethanol increases because of a decision (that is assessed by the LCA), the production of the feed product will increase, too. This is likely to trigger other market participants to produce less animal feed (if demand remains constant). If the demand for the protein feed increases due to a decision assessed by the LCA, e.g., through an increase in meat consumption or farmers deciding to feed more of the protein feed, the increase in demand will not be met by existing ethanol production facilities because bioethanol is the main product determining the overall output of bioethanol and the protein feed. The protein feed supply from bioethanol is constrained. Instead, other animal feeds suppliers will provide animal feed to the market.

These aspects and changes depend on several factors, such as the scale of a change in the market and market conditions; e.g., changes in supply and demand are governed by price elasticities and regulatory boundary conditions.

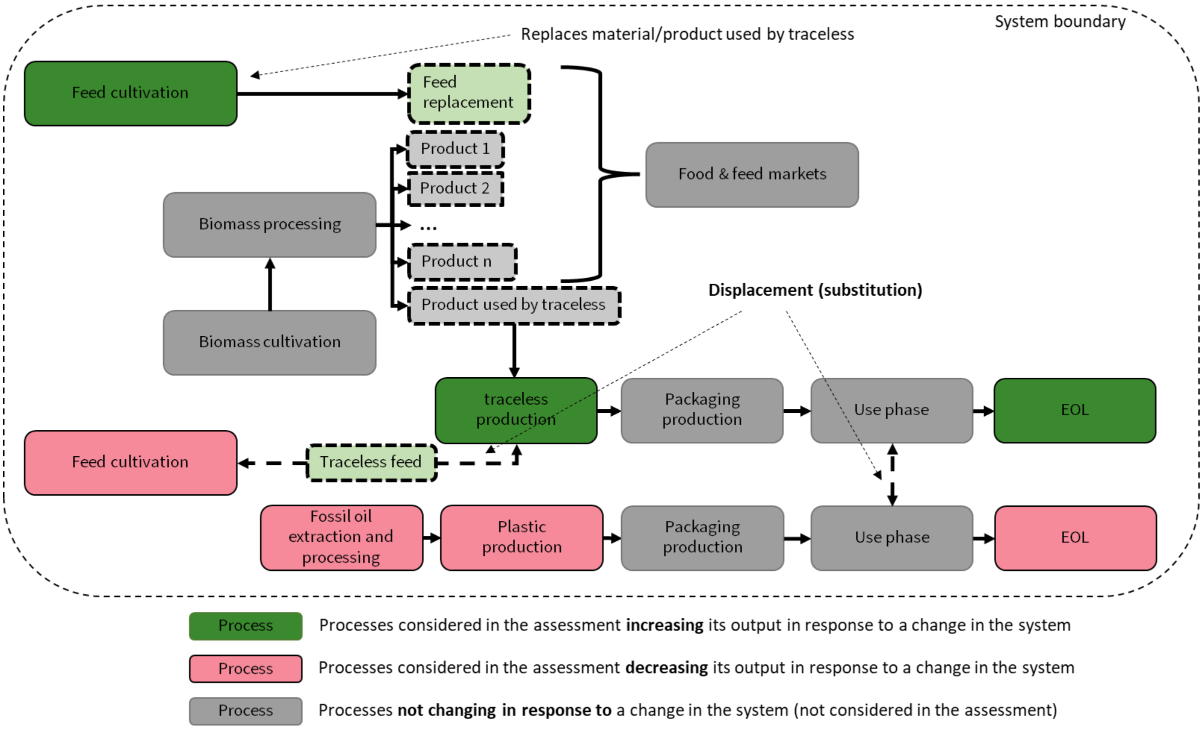


Illustration: An exemplary depiction of how traceless could be assessed following a consequential LCA approach. The consequential LCA approach allows for an assessment of how the environmental impacts are altered by a change in the system: A change in the system triggers a change in the demand for certain processes (increase or decrease) and might even result in the establishment of new processes. If processes producing more than one product increase or decrease their output, the co-produced products (and even wastes) are often affected, too. The change in supply of one co-product affects other market participants: They might switch to other materials and services (which results in an increase in the demand for the supplying processes) or might reduce the demand for a material (resulting in a decrease in demand for the supplying processes). If the demand for a certain product increases that is a co-product of a process providing several other products, the supply might be inflexible. For instance, traceless uses a low value/waste stream produced by existing industries. These industries will not produce more of this low value stream just because traceless increases the demand for this material. Instead, another supplier in the market is likely to provide a product that is able to fulfil a similar function. In consequential LCAs, processes that are unlikely to be affected by the assessed change in the system are not included in the assessments. Due to these methodological approaches, consequential LCAs provide insights into how environmental impacts change in response to a change in the market, e.g., the scaling or market entry of a start-up.

2.4. Why we chose consequential LCA

Both of the presented approaches have certain advantages and limitations arising from different methodological aspects and from the underlying principles applied. The approach chosen should depend on the intention of the LCA study (more information can be found here). New technologies and business models have the potential to disrupt existing business models. The implementation and scaling of novel technologies change existing processes within the economy and affect the demand and supply for products and services. Therefore, the consequential LCA method is capable of assessing the environmental implications of all these changes. An insightful comparison of the two approaches and a reasoning that all responsibility paradigms require a consequential LCA approach can be found here.

We at Planet A invest in companies with the highest potential to change the environmental implications of our economic activities for the better. We are interested in how environmental impacts change if a certain business model or technology scales. This includes changes outside of the supply chain of our portfolio companies. **That is why we apply a consequential LCA approach in our due diligence.**

2.5. Limitations and uncertainties of (consequential) LCA

LCA is the most commonly used tool to evaluate the environmental impacts of products and services. Nevertheless, LCAs have certain limitations and uncertainties that are important to consider when interpreting results. The following (non-exhaustive) lists the major limitations and uncertainties we are dealing with in our work:

- No model can be a complete picture of reality as reality is too complex. Therefore, models always show a simplification of reality. Further, the scope is always limited since it is practically impossible to consider all details connected to the product system.
- Data might be missing, uncertain, or inaccurate. This is specifically relevant when assessing novel technologies.
- Technologies, markets, regulation, and values change. Ex ante assessments need to deal with the uncertainty of future developments in all these aspects.
- Identifying and quantifying change in demand and supply as a response to a change in the market is challenging: Rebound effects might buffer certain effects, and regulation and market conditions affect the marginal supply.

We are well aware of these limitations and uncertainties and we do not seek to predict future outcomes. Rather, we intend to support our investment decision-making process with the best possible assessment of a range of potential changes in environmental impacts. Therefore, we conduct sensitivity analyses and use scenarios and Monte Carlo simulations to consider a range of potential developments:

- Scenario analysis is used to develop alternative possibilities in the future to show how different decisions may play out. This helps us tackle uncertainties and allows us to explore possible consequences of change. Here, the question is not what would be the most likely scenario but what would be the consequences of different possible scenarios and the response if a certain scenario plays out.
- Monte Carlo simulations help mimic complex systems by using random sampling and statistical modelling for data analysis. Applying these approaches does not reduce uncertainty but instead provides us with a possibility to deal with it. This ensures that only companies that are very likely to result in substantial improvements in environmental impacts are considered an investment opportunity for Planet A. Additionally, we frequently update our LCAs to ensure that the most recent data is used, that recent market developments are included, and that the assessed business model reflects the latest developments of our portfolio companies.

2.6. Scale matters

Commonly, LCAs provide results corresponding to the chosen functional unit (see Section 2.2.). How the environmental impacts change in absolute terms as a consequence of a new technology or business model entering the market depends not only on the net improvement in impacts related to the functional business unit, but also on how new technologies are adopted by the market or how much they disrupt a market. Therefore, we combine the impact perspective with our business perspective to provide insights into the absolute net change in environmental impacts.

Combining the consequential LCA approach with our business perspective provides us with the following equation on the impact potential ofany innovation:

IMPACT = improvement × scale

improvement: Impact Perspective; scale: Business Perspective

3. Benefits of LCAs for investors and founders

Oftentimes, investors are missing the ability to assess the environmental impact of their investments. LCAs give us the opportunity to quantify and compare the potential positive and negative impacts of such investments. LCAs have proven to be extremely powerful in our context:

- **We identify winners.** LCAs help us spot champions of change, the start-ups that apply the biggest levers.
- **We take informed investment decisions.** Impact has a seat at our investment committee table. We will only invest if the LCA results are positive.
- **We know how to quantify success.** Our impact KPIs are defined on the basis of LCAs.
- **We support founders.** The LCAs provide founders with the quantitative evidence of their impact, allowing them to understand, mitigate, and communicate their impact, thus providing them with a competitive edge over their competitors. We regularly update our LCAs to empower founders with the most up-to-date impact data.
- **We create transparency.** All our scientific insights are publicly available, turning the black box of impact measurement into a glass box. This is an important step for making impact comparisons across products, companies, sectors, and investors. Additionally, providing our insights distinguishes us from others making sustainability claims without evidence.
- **We engage in political and scientific debates.** We want to make impact investing the new normal. Scientific and data-driven impact quantification is key to creating a common ground on which impact can be understood and compared in the investment space and beyond.

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