WHITE PAPER No. 093

Life Cycle Analysis of a 5 mL Tube – Insights into Environmental Impacts and Learnings

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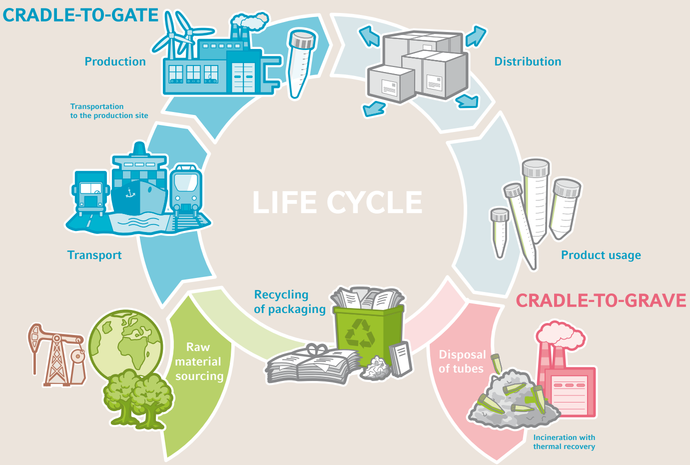
Executive Summary

The first biobased plasticware appears in the laboratories. They are made from renewable sources and have a better carbon footprint. But how much better are they compared to their fossil counterparts? And where are the significant levers to improve the environmental performance of these products? Eppendorf investigated these questions for their biobased tubes using a Life Cycle Analysis (LCA). This provided valuable insights into the ecological performance of the product. In addition, the whole process provides ideas to enhance the product's life cycle and where to focus for imminent improvements.



Introduction

Plastic derived from biobased sources sounds nice and sustainable. But is it genuinely better? And if so, how much better is it compared to plastic made from crude oil?

To answer these questions, it is not enough to rely solely on the intuition that tells you that biobased products are always the best option. A comprehensive view of the entire life cycle of a product is essential in order to understand and quantify environmental impacts. Such life cycle thinking is crucial both in designing new products and in sustainable improvement of existing ones. A key aspect of making informed and sustainable decisions is the collection of comprehensive life cycle data to identify the areas with the greatest potential to improve a product's environmental performance.

The Life Cycle Analysis (LCA) is a method to assess the most important environmental impacts across the whole life cycle of a product. [1]

An LCA analysis of the biobased 5 mL Eppendorf screw-cap tubes has been performed to answer the following questions:

1) What are the major environmental impacts across the whole life cycle?

2) Which are the key levers to further reduce the environmental impact?

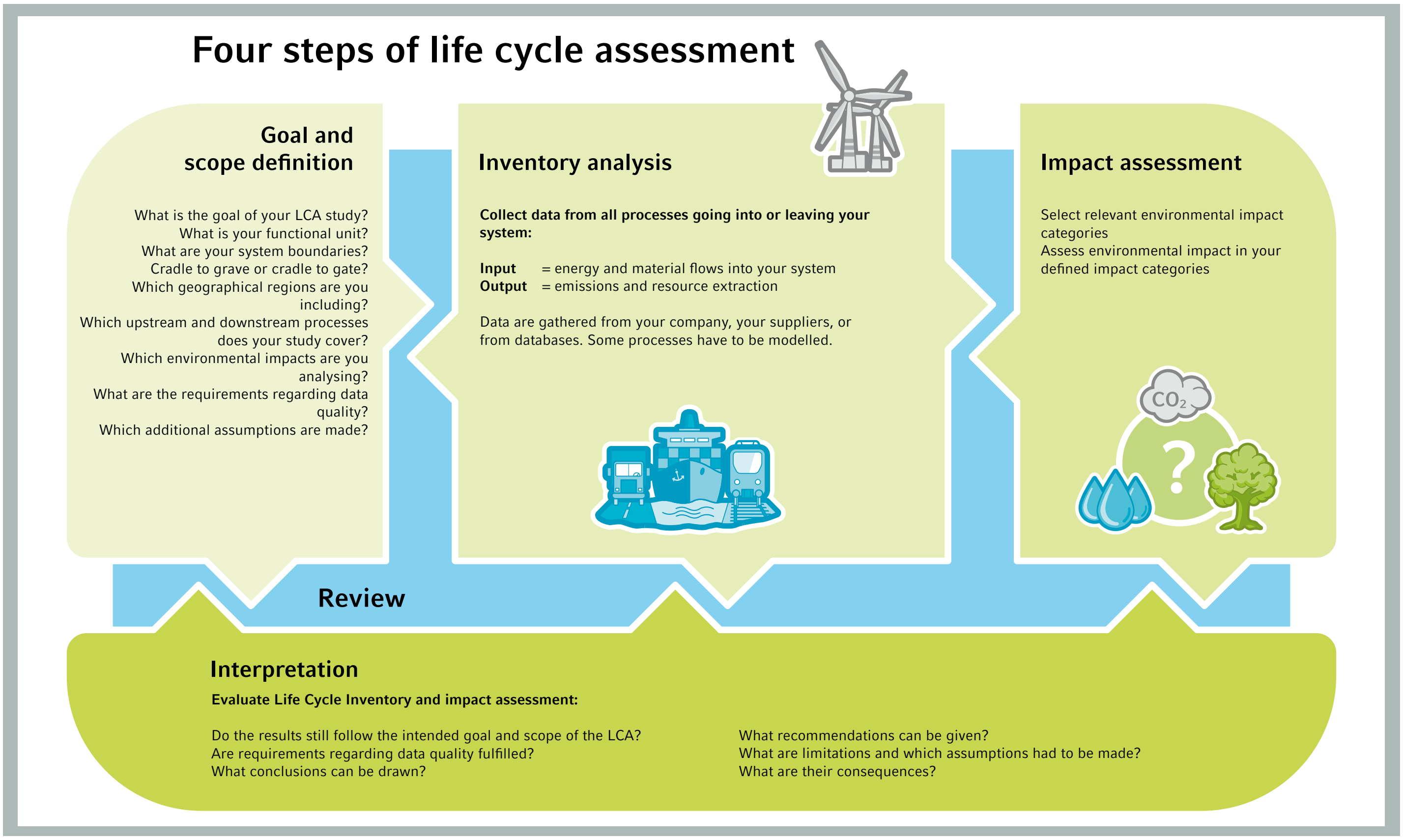
3) How much CO_2e is saved in comparison to the standard tubes made from fossil oil?

4) Which scenarios should be pursued for future products? Which product designs are best in terms of their environmental footprint?

This white paper explains in detail the methodology of an LCA as well as the outcomes of an LCA of the new biobased tubes compared to its fossil oil counterparts and possible scenarios for future improvements.

Life cycle analysis – a standardized approach to assess the environmental impacts of a product

LCA is a method to identify the environmental impact of a product, a process, or a service during its life cycle. This starts at the sourcing of the basic compounds, the production, the use, the fate at the end of life, and the transport between the different life cycle stages. The analysis also includes the connected upstream processes like extraction and production of raw materials as well as downstream processes like recycling or incineration at the end of life. [1]



Four steps of life cycle assessment

Goal and scope definition

What is the goal of your LCA study?
What is your functional unit?
What are your system boundaries?
Cradle to grave or cradle to gate?
Which geographical regions are you including?
Which upstream and downstream processes does your study cover?
Which environmental impacts are you analysing?
What are the requirements regarding data quality?
Which additional assumptions are made?

Inventory analysis

Collect data from all processes going into or leaving your system:

Input = energy and material flows into your system
Output = emissions and resource extraction

Data are gathered from your company, your suppliers, or from databases. Some processes have to be modelled.

Impact assessment

Select relevant environmental impact categories
Assess environmental impact in your defined impact categories

Review

Interpretation

Evaluate Life Cycle Inventory and impact assessment:

Do the results still follow the intended goal and scope of the LCA?
Are requirements regarding data quality fulfilled?
What conclusions can be drawn?

What recommendations can be given?
What are limitations and which assumptions had to be made?
What are their consequences?

Figure 1: The four steps of a life cycle assessment (according to ISO14040).

Executing a life cycle analysis is a challenging approach – and the question is how to perform it in detail. International standards support by providing guidance and ensuring that the same steps for different LCAs are followed. The ISO standard 14040 and the ISO 14044 define how to perform an LCA in a standardized manner and give guidance on how to do it. [2,3] According to the ISO 14040, four different stages have to be followed [Figure 1]:

1. **Definition of the goal and the scope**
2. **Life cycle inventory**
3. **Impact assessment**
4. **Interpretation**

Stage 1: Definition of the goal and the scope

Defining the goal and scope is crucial as it provides the baseline for the LCA. Initially, several questions need to be addressed before data collections can start.

What precisely is the goal of your LCA? Do you want to determine the environmental impact of a specific product, or do you want to compare several products and their impact and discover which product has the better environmental performance?

What exactly will be investigated? The definition of the functional unit is of crucial importance - regardless of whether it is a single product (e.g. a tube) or a packaged unit with a certain number of tubes.

What are your system boundaries? ISO 14040 and ISO 14044 distinguishes two cases. The first case is referred to as the "cradle-to-grave" scenario. In this scenario, the entire life cycle of a product is defined with a determined usage scenario. This is the preferred case.
The "cradle-to-gate" scenario evaluates the sourcing stage until the product leaves the manufacturing site. The latter scenario is preferable if the focus is on the environmental impact in these first phases of the life cycle or if data on the use phase and/ or the end of life are very different (global distribution) or even missing. In this context, the focus on a cradle-to-gate scenario proves to be advantageous, as numerous assumptions can lead to uncertainties in a life cycle analysis. Ultimately, this may even lead to misleading assumptions. However, compliance with the ISO standard requires that the reasons for the exclusion of certain life cycle stages are stated.

What other assumptions have been made? What other boundaries have been set? What geographical boundaries have been defined? Is the focus on one country, one region (such as Europe, the USA, or Asia) or the whole world? Which upstream products, auxiliary products, and upstream and downstream processes are included in your analysis? Will you also consider the environmental impact of producing, e.g., the trucks used to transport the goods, or will the focus be solely on emissions generated during transportation? Usually, the environmental impact of truck production is excluded, and the focus is instead on the emissions generated during transportation.

What are the requirements regarding data quality? [4] The data must certainly meet criteria such as precision, completeness, representativeness, consistency, and reproducibility. It must also cover the geographical regions covered by your analysis and be up to date. Since the data comes from different sources and databases, it is essential to define quality criteria and approaches for dealing with uncertainties.

What environmental impacts do you analyze? As a rule, an LCA study covers greenhouse gas emissions and their impact on climate change. However, it does not always include the impacts of nitric oxides on soil and water, eutrophication or the effects of acidification of forests through the emission of SO_2 into the air.

Finally, you have to make additional assumptions. For example, the exact composition of an intermediate product may not be known for reasons of confidentiality, or the exact transportation routes of a raw material may not be known. In this case, assumptions must be made that lead to uncertainties. These must be explicitly stated and taken into account in the subsequent steps.

Stage 2: Performing the Life cycle inventory (LCI)

Stage 2 primarily involves data collection. This involves analyzing the input of energy and material flows into your defined system as well as their output. This includes a detailed analysis of the energy requirements for production, transportation, product use and one or various end-of-life scenarios. Moreover, all materials and their quantities must be listed. This includes the Bill of Material (BoM) of the product itself as well as by-products, auxiliary materials and all waste generated during production and at the end of life.

In the next step, the output of all processes in the various stages of the life cycle is considered. Outputs include emissions to air, soil and water as well as extraction of resources from nature. This includes, for example, estimating CO_2 emissions in the various transportation phases. Raw materials must be transported to the production facility, the finished product to logistics centres, and then on to the customers. At the end of the utilization phase, the product is sent to a recycling facility or a waste incineration plant. Furthermore, the assessment covers not only the product but also its packaging, involving additional transportation routes. This illustrates the complexity of a life cycle inventory.

Data from all processes must be retrieved, either from the manufacturer, the suppliers or from databases. But not all data is available or can be provided, for example, the exact composition of preliminary products coming from the suppliers. The route of your product to the customer has to be modeled by assuming an average mode of transportation. All these uncertainties and assumptions must be explicitly documented.

Stage 3: Life cycle impact assessment (LCIA)

Once the life cycle inventory has been completed, all data have to be assessed according to their potential environmental impact. It is essential to emphasize that the impact assessment does not directly capture the actual damage, but instead quantifies inputs and outputs, that have the potential to cause damage.

The data is categorized into specific environmental impact categories and category indicator results. These categories are then subdivided into input-related, output-related, and toxicity-related impact categories. [5,6,7]

One of the very well-known category indicator results is the CO_2 equivalent. Greenhouse gas emissions such as methane, CO_2, or nitrous oxide are converted into CO_2 equivalents. Their environmental impact is assessed in categories such as 'global warming potential' or 'climate change', which reflects their contribution to global warming. Further environmental impact categories are eutrophication due to overfertilization, nitrogen oxide emissions by industry and traffic, or abiotic resource consumption. Table 1 provides an overview of the various impact categories. [8]

Environmental Impact Categories	Description
Climate change potential (GWP)	Direct and indirect environmental impacts on global warming through the release of anthropogenic emissions, indicated by the "global warming potential" (GWP) for a time horizon of 100 years and expressed in kg CO_2e / functional unit*
Acidification potential	Anthropogenic impact on aquatic and terrestrial ecosystems through acidification; impacts include damage to plants (e.g. needles), animals like fish or entire ecosysteme through increased leakage of nutrients or heavy metals from soils. Acidification potential is expressed in SO_2e/functional unit
Abiotic resource consumption **Abiotic resource consumption - fossil**	Describes which non-renewable resources are extracted from the environment. As these resources are lost for future generations, scarcity was assumed as the impact indicator, expressed as kg antimony (Sb) e/kg functional unit. Fossil abiotic resource consumption refers to the use of black coal, brown coal, crude oil and natural gas to generate energy. The impact indicator refers to the energy content, expressed in crude oil equivalents and measured in MJ e/functional unit
Land use	Describes the degree of naturalness which has an impact on biodiversity, structure, and function of ecosystems and ecosystem services. Land use is expressed as „degree of naturalness" giving direct information on the degree of naturalness (according to defined categories) and indirect information on biodiversity (e.g. by the number of species, rare species) or soil quality. This impact category is expressed by the „Distance-to-nature potential" (DNP) in m^2e*1a/functional unit.
Eutrophication potential	Anthropogenic impact on terrestrial and aquatic ecosystems through the excessive release of nutrients (anorganic phosphorus and organic nitrogen compounds) leading to the excessive production of biomass. Aquatic ecosystems are affected mainly by algae growth which leads to oxygen depletion whereas in terrestrial ecosystems, the availability of water and other elements except nitrogen is lowered. As a result, plants that specialize in nutrient-poor conditions could be displaced. Eutrophication potential is expressed in PO_4^{3-} e/functional unit
Particulate matter	Describes the effect of particulates, formed directly or from precursors like nitrous oxides or SO_2, with an aerodynamic diameter of less than 2.5 µm (abbreviated as 2.5 PM) and leading to respiratory disease and negative effects on the immune system. Particulate matter is expressed in PM e / functional unit.
Stratospheric ozone depletion potential (ODP)	Anthropogenic impact on the depletion of naturally present ozone molecules in the stratosphere leading to increased levels of UV-B radiation reaching the Earth thus damaging certain natural resources and human health. ODP is expressed in kg trichlorofluoromethane (CFC-11) e/functional unit
Photo-Oxidant Formation (summer smog)	Describes the photochemical creation of reactive substances (mainly ozone) near the ground by nitrogen oxides and volatile organic compounds (VOCs), affecting human health and ecosystems. Photo-oxidant formation is expressed in kg O_3 e/functional unit

Table1: Selection of environmental impact categories

*** e = equivalents**

It is important to mention that not all impact categories are necessarily considered in a life cycle analysis. Rather, certain impact categories are selected depending on the objective and scope of the study. The non-existence and/or quality of data may be a reason why certain impact categories are not considered. However, it must always be explained why certain impact categories are considered and others are not.

Stage 4: Interpretation

In the fourth and final stage, all the results of the life cycle inventory and assessment are evaluated. Are these results aligned with the intended goal and scope of the LCA? What conclusions can be drawn and what recommendations can be formulated based on these findings? Equally important is the identification and explanation of limitations, including the necessary assumptions and their consequences.

These stages are not run through one after the other; rather, the LCA functions as an iterative process. The different stages are reviewed several times to ensure that the scope and goal are still within reach. If not, adjustments must be made. Moreover, the review process involves revisiting the nature and quality of the data to avoid misleading interpretations and recommendations.

Biobased tubes compared to fossil-sourced tubes – are they better and how much?

In 2022, Eppendorf launched 5 mL screw-cap tubes made from biobased plastic. [9] Currently, at least 90% of the material of these tubes are crafted from biobased polypropylene (PP)*, sourced from waste streams within the food industry. 10% of the PP still relies on fossil resources. The lid in particular is made from 100% fossil-sourced HDPE.

Before we look into the life cycle analysis and address the question whether and to what extent biobased tubes are better than their fossil-sourced counterparts, let's closely examine the various types of biobased plastic. Biobased plastic consistently originate from renewable resources, but can be categorized according to their source (White Paper 92: Bioplastic Explained [10]). [Figure 2]

*based on mass-balance approach

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Figure 2: The different sources for biobased plastic

1st generation biobased plastic is crafted from agricultural sources such as sugar corn, sugar beet, potatoes, or corn. Most of today's biobased plastics come from these sources. They generally have a lower carbon footprint compared to fossil-sourced plastics. However, there are also negative impacts, such as alterations in land use, the shift from natural landscapes like forests or meadows to farmland, and the increased use of fertilizer and pesticides.

Therefore, the emphasis is placed more on 2nd generation biobased plastic. This type is crafted from waste streams, such as food waste, wheat straw from agricultural sources, or wastewater streams. The adverse impacts associated with 1st generation materials are reduced. The biobased plastic of Eppendorf is based on 2nd generation material.

3rd generation biobased plastic stems from seaweed and brown or red algae. These organisms produce polysaccharides which are the basis for various plastic materials.
It is important to remember that biobased raw materials can be converted into building blocks for conventional plastics like HDPE, LDPE, PP, PET, etc. The look, feel, and properties of biobased plastic products are identical to those of their fossil-sourced counterparts.

The life cycle analysis of Eppendorf Tubes® BioBased

The LCA was executed according to ISO 14040/ ISO 14044 standards as described previously. The study made the following preconditions and specific conclusions were drawn based on its findings.

Goal and scope of the study

First of all, the question has to be answered: why conduct an LCA – study? This study pursued the following objectives and was intended to answer the following questions:

1. Are there environmental advantages to use biobased PP and biobased HDPE compared to their fossil-sourced counterparts?
2. By how much are biobased PP and biobased HDPE better (or worse) than their fossil-sourced counterparts and in which environmental categories?
3. This study aimed to identify environmental hotspots along the product life cycle.
4. Also, this study aimed to identify improvement potentials along the product life cycle.
5. This study was intended to compare different scenarios regarding material choices.
6. In addition, different scenarios for the choice of means of transportation should be compared.
7. It was the overall goal to generate verified environmental data for biobased and fossil-sourced tubes.

The functional units were defined as follows:

> Bag with 200 x 5 mL sterile screw-cap tubes, **biobased**, split into two bags
> Bag with 200 x 5 mL sterile screw-cap tubes, **fossil-sourced**, split into two bags

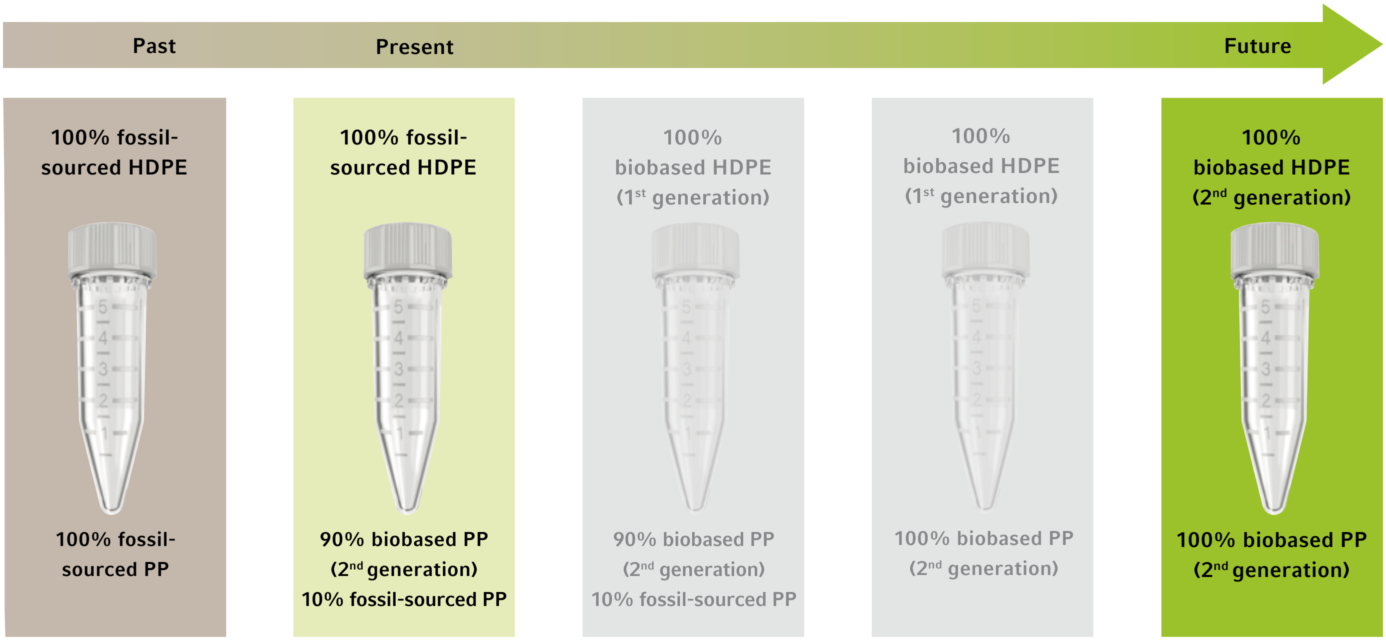


Figure 3: Five different scenarios have been analysed (3 and 4 are only of theoretical nature and out of scope for this white paper)

Different scenarios have been analysed [Figure 3]. The first one is defined as classic reference. This represents the past with tube and screw-cap made of 100% fossil-sourced PP respectively HDPE whereas the second one represents the current version with at least 90% biobased PP for the tube and 100% fossil-sourced HDPE for the lid. Three other scenarios for the future product were formulated where scenario 5 is the one that is being aspired to. The other two are theoretical approaches.

1. Past scenario: screw-cap tubes – 100% fossil-sourced PP (tube) and 100% fossil-sourced HDPE (lid)
2. Current scenario: 90% biobased/10% fossil-sourced PP (tube) and 100% fossil-sourced HDPE (lid)
3. Future scenario 1: 90% biobased/10% fossil-sourced PP (tube) and 100% biobased HDPE (lid) – 1st generation biobased HDPE (made from sugar cane)
4. Future scenario 2: 100% biobased PP (tube) and 100% biobased HDPE (lid) – 1st generation biobased HDPE (made from sugar cane)
5. Future scenario 3: 100% biobased PP (tube) and 100% biobased HDPE (lid) – 2nd generation biobased HDPE

The geographical scope covered the production site and distribution centre, both situated in the North of Germany. [Figure 4] The tubes manufactured in Oldenburg (Germany) are transported to the distribution centre in Hamburg (Germany). From here, screw-cap tubes are distributed globally. Five destinations, representing the main markets, were chosen to estimate the environmental impact of transportation. Beyond Europe, where a weighted average of transportation routes has been chosen, destinations such as New York, Tokyo, Beijing, and Seoul were included in the assessment.

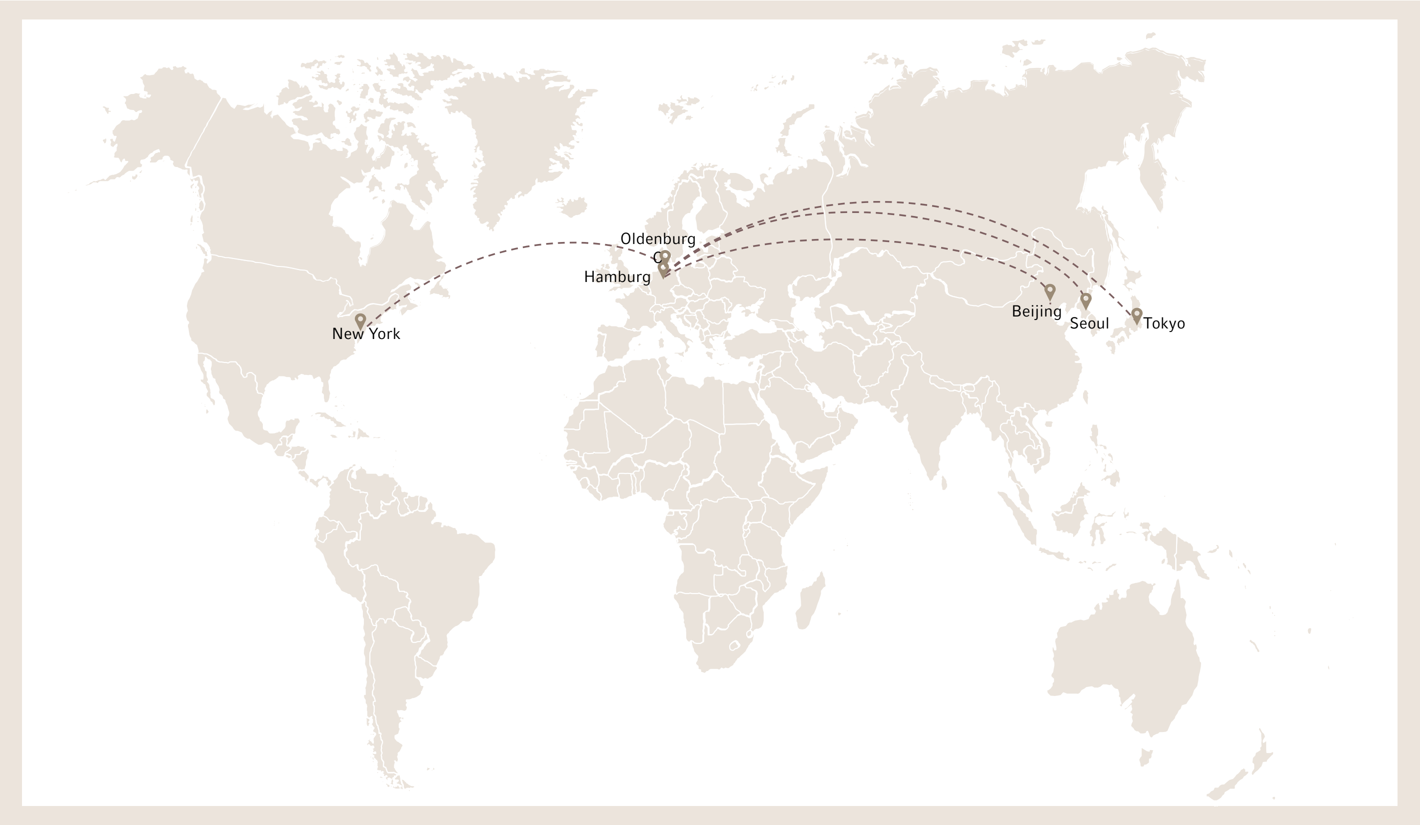


Figure 4: Transportation routes to different destinations worldwide

As 2021 was the reference year, air transport had a higher share than before or today due to the COVID-pandemia. In 2021, all produced tubes, tips, and plates were sent to the laboratories worldwide right after production to support the fight against COVID.

Additional assumptions had to be made due to a lack of data. The absence of suitable LCA datasets for the biobased variants of PP and HDPE required the modelling of specific manufacturing processes. Furthermore, confidentiality restrictions on the part of suppliers prevented access to primary data concerning the processes, inputs and outputs related to the biobased materials. Therefore, information from available literature was used to model and calculate the processes, inputs and outputs associated with the biobased raw materials.

The life cycle analysis was conducted by a third party (iPoint) and validated by an external reviewer (DEKRA) according to ISO 14071.

Performing the Life Cycle Inventory

Once the study's goal and scope were defined, the life cycle inventory was executed, evaluating production, transportation, use phase, and end of life. [Figure 5]

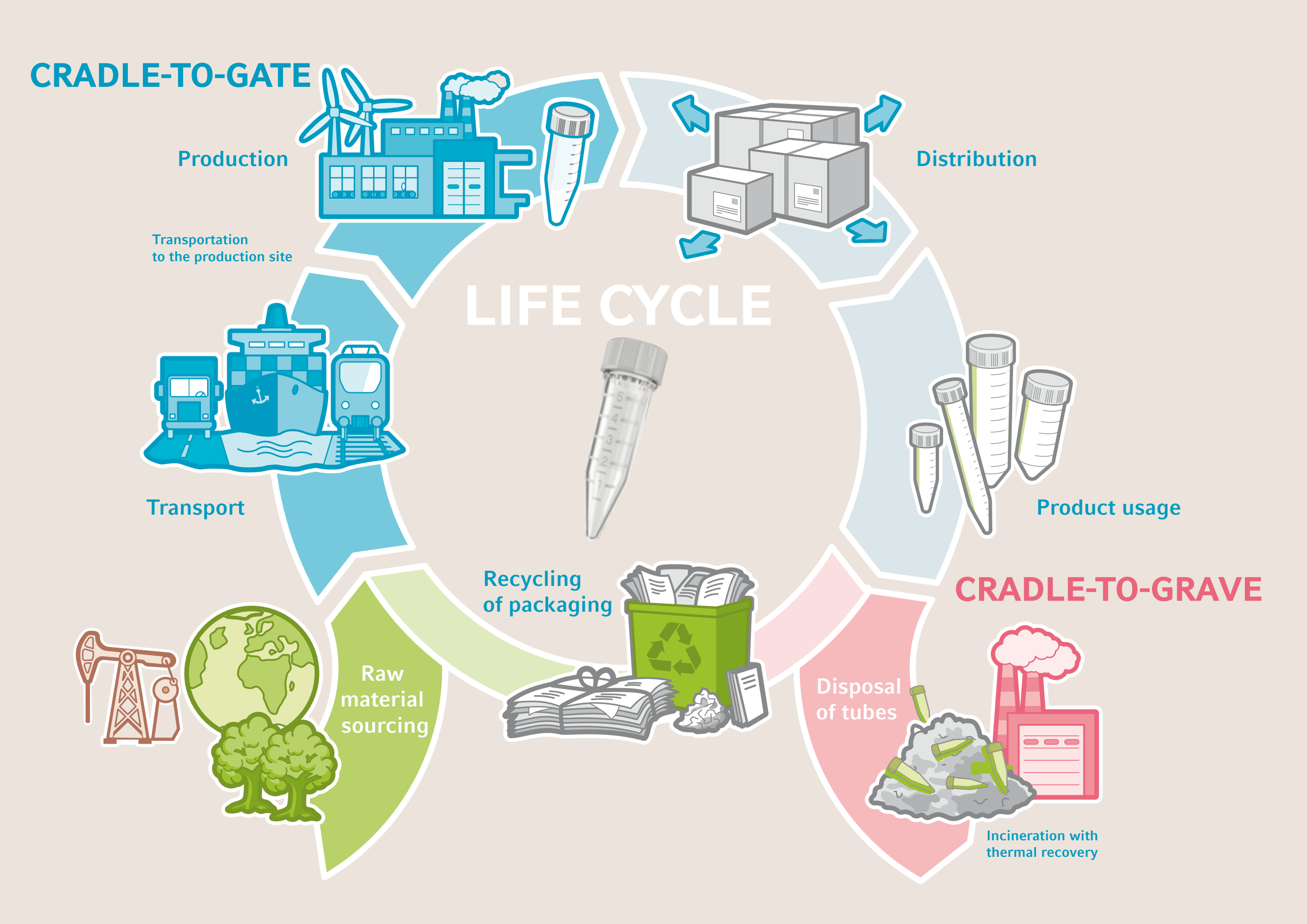


Figure 5: Life cycle stages of a screw-cap tube

Whenever possible, Eppendorf provided original data. However, at certain life cycle stages, information was sourced from databases (e.g. to simulate end-of-life scenarios) or data was estimated as it was difficult to retrieve them. This encompassed data from suppliers, as previously indicated.

Stage 1: Raw Materials

	Packaging Type	Component composition	Total weight of component (g)	Weight (g) per functional unit (100x tubes/ bag; 2x bags)	Geographical sourcing
Tube Lid	Product	HDPE	1.3	260	Europe
Tube	Product	PP	3-4	680	Europe
Biobased Tube Lid	Product	Biobased HDPE	1.3	260	Europe
Biobased Tube	Product	Biobased PP	3.4	680	Europe
Flat Film	Primary Packaging	PET/PE, 12/75 µm	16	32	Europe
Zipper	Primary Packaging	LDPE	5	10	Europe
Label	Secondary Packaging	Paper	0.5	0.5	local
Folding Carton	Secondary Packaging	Folding Boxboard Carton	171	85.5	local
Folding Carton Seal	Secondary Packaging	PE	0.2	0.2	local
Corrugated Board Box	Tertiary Packaging	Corrugated Board Box	126	52.4	local
Label	Tertiary Packaging	Paper	1.8	0.08	local
Package Tape	Tertiary Packaging		0.4	0.02	regional
Pallets	Tertiary Packaging	Wood	21,000	729.2	local
Packaging Foil	Tertiary Packaging	PE	600	2.08	regional
epPoints®	Others	PP	0.2	0.1	local
Thermal Transfer Tape	Others	Carbon Film	0.1	0.05	local

Table 2: Bill of Materials for screw-cap tubes and packaging

In the raw materials stage, all parts are incorporated according to the recipe, i.e. the Bill of Materials (BoM) of the products. This includes tubes, all packaging material as well as auxiliary material like labels or tape. The respective sourcing region of each part is considered. [Table 2]

Stage 2: Transport

This stage considers the transport of raw material parts to the production site in Oldenburg (Oldenburg i.H.).

Stage 3: Manufacturing

The production of screw-cap tubes as well as sterilization of the final product including packaging and storage is assessed.

Stage 4: Distribution

This stage considers the distribution of the final product from the distribution centre in Hamburg to five representative destinations. [Table 3]
These included the following target countries, ordered by business impact:

1. Europe – most important region, transport by truck on average 950 km
2. New York – transport by ship or airplane (on average 6,700 km or 6,100 km respectively)
3. Tokyo – transport by ship or airplane (on average 21,200 km or 9,000 km respectively)
4. Beijing – transport by ship or train (on average 21,000 km or 9,000 km respectively)
5. Seoul – transport by ship or airplane (on average 20,500 km or 8,200 km respectively)

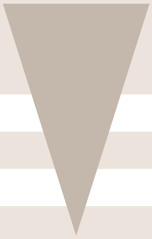
From	to	Sea [km]	Air [km]	Truck [km]	Train [km]	Business Impact
Hamburg	EUROPE (weighted average of 15 destinations)			950		
	New York	6,7000	6,100			
	Tokyo	21,200	9,000			
	Beijing	21,000			9,000	
	Seoul	20,500	8,200			

Table 3: Selected destinations and their distances, ordered by business impact

Stage 5: Consumer Use

This stage considers the use of the product by end consumers.

Stage 6: End-of-Life

In the end-of-life stage, disposal and recycling after the product´s use is assessed.

Again, several assumptions regarding the fate of the product and its packaging at the end of its life have been made. [Table 4] The tube and lid will be incinerated due to contamination whereas the packaging material may be recycled, incinerated, or may go to landfill, depending on the region.

Material flow of plastic	Recycling	Incineration	Landfill
Europe (Europe Plastics, 2021)	35%	42%	23%
USA (US EPA, 2021)	8%	16%	76%
Japan (Yusuke Inoue, 2018)	25%	67%	8%
China (Xiaomeo Jian et al. 2022)	27%	32%	34%
South Korea (Lee MY, 2021)	70%	25%	5%

Paper EoL Shares	Recycled	Non-Recycled
Europe (Statista, 2022a)	82%	18%
USA (Statista, 2022)	68%	32%
Japan (Paper Recycling in Japan, 2022)	81%	19%
China (Statista, 2022b)	47%	53%
South Korea (Statista, 2022c)	48%	52%

Table 4: Different end-of-life scenarios, according to country and material

Key findings

With the complete dataset from the life cycle inventory, the impact assessment was conducted, revealing three key findings.

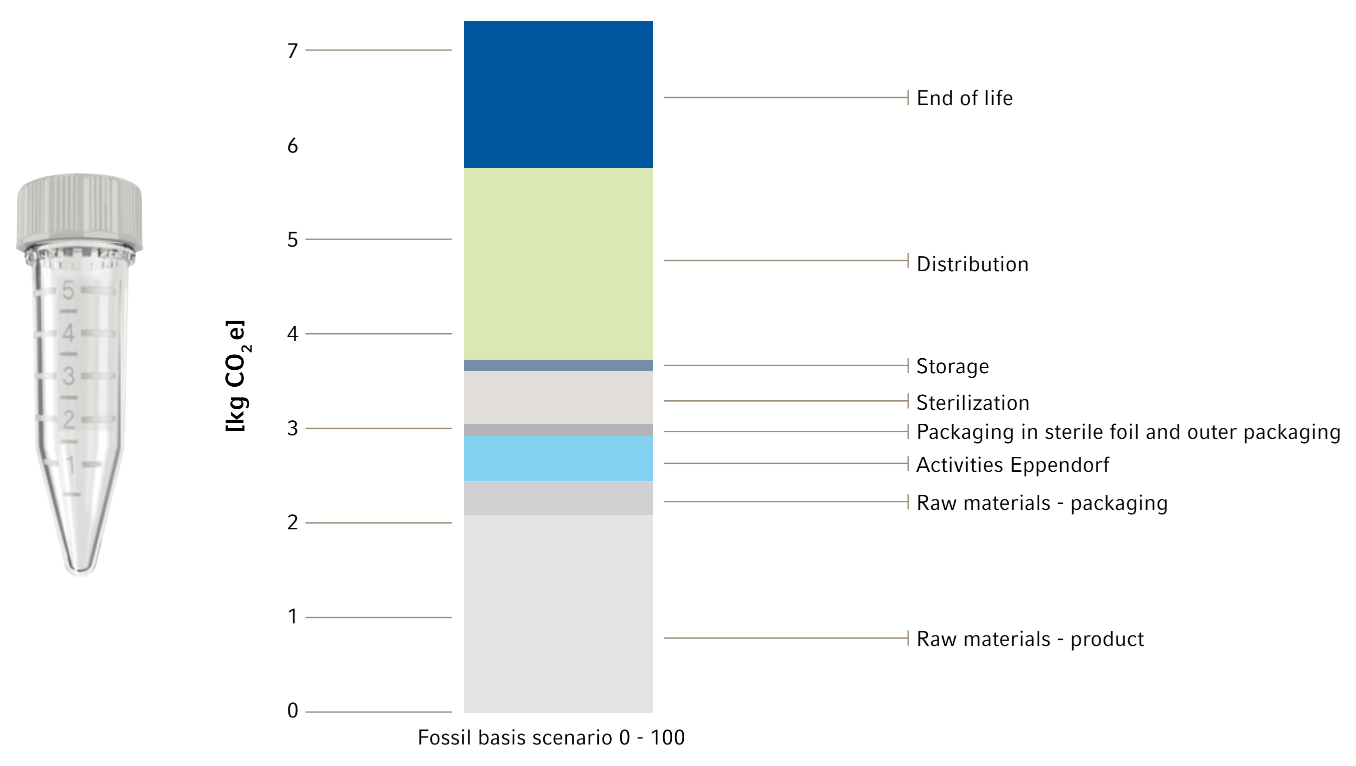


Figure 6: Raw materials, distribution, and end of life contribute most to CO_2e emissions

First finding:
Raw materials of the product, distribution and end of life contribute the most to CO_2e emissions. These are also the biggest levers for improvement. [Figure 6]

The choice of **raw materials** has a big impact on CO_2e emissions and other environmental impact categories. A higher share of biobased material, especially second-generation material, reduces CO_2e emissions and decreases hereby the impact on global warming. It also leads to better results in the environmental impact category “use of abiotic fossil resources” as much fewer resources are depleted, and gives better results in the environmental impact category freshwater eutrophication. Less pollutants like nitrous oxides are released when changing to biobased material.
But there is also a negative impact on the environment. A higher share of biobased material leads to worse results in freshwater ecotoxicity, but compared to other categories, only small deviations have been stated.

The comparison of first and second-generation biobased material showed, that using second-generation HDPE is better than first-generation HDPE.

Choice of **transportation** has impacts on several environmental impact categories. As expected, using air distribution increases the release of greenhouse gases and therefore contributes to global warming. In addition to negative results in the impact category global warming potential, two other impact categories (resource use-fossil and freshwater ecotoxicity) also have worse results.

End-of-life treatment of plastics, which includes incineration, has a major impact on global warming. However, as data about end-of-life scenarios in different countries was partly incomplete and not comparable, only estimations on various end-of-life scenarios were possible and the degree of uncertainty was considered too high to be taken into consideration.

Second finding:
The goals of the study had to be slightly adapted

Throughout the iterative review process, the goal and scope of the study had been slightly adjusted.

First, the decision was taken to focus only on greenhouse gas emissions and to skip other environmental impacts due to their inherent complexity and associated uncertainties. Moreover, CO_2e emissions and their impact on global warming are widely acknowledged as the most important environmental impact.

Secondly, a cradle-to-gate approach was analyzed in detail. Eppendorf has the biggest influence and potential for improvement in these first stages of the product life cycle. Furthermore, the data regarding end-of-life scenarios in different countries was incomplete and not comparable, as previously mentioned.

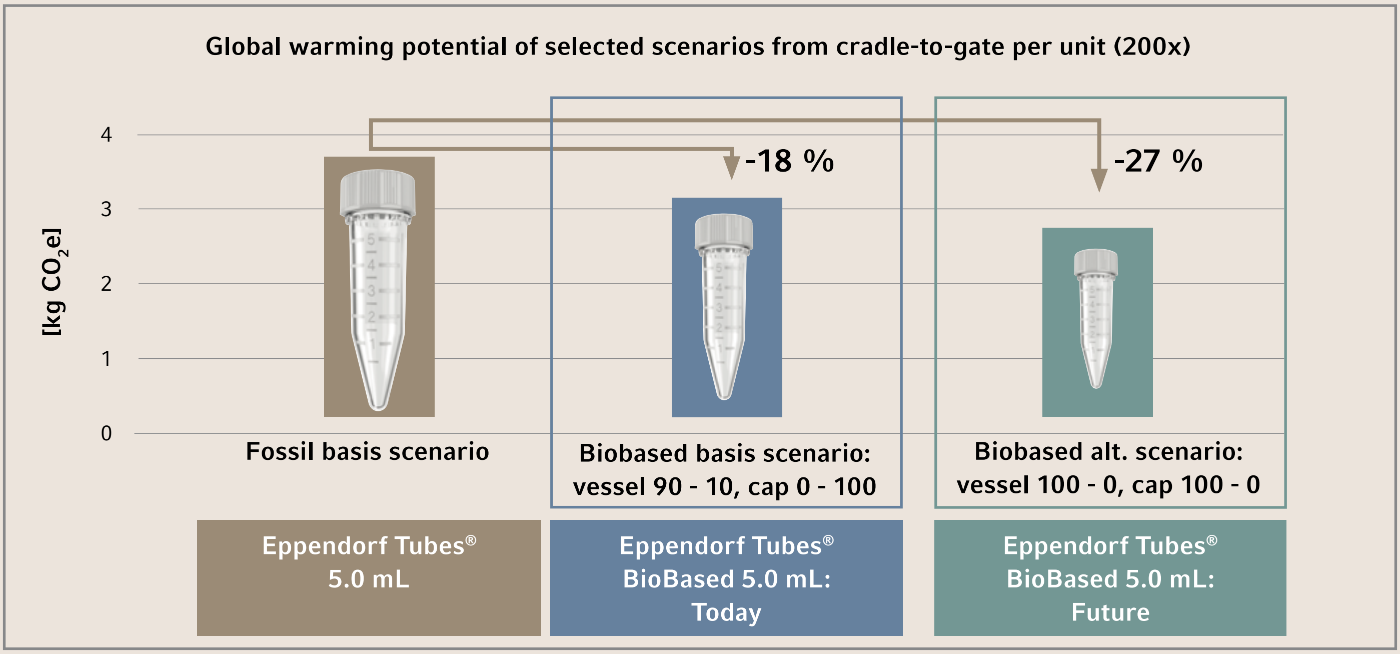


Figure 7: Switching to bio-based material reduces greenhouse gas emissions

Third finding:
Greenhouse gas emissions can be reduced by switching from fossil-sourced to biobased scenarios.

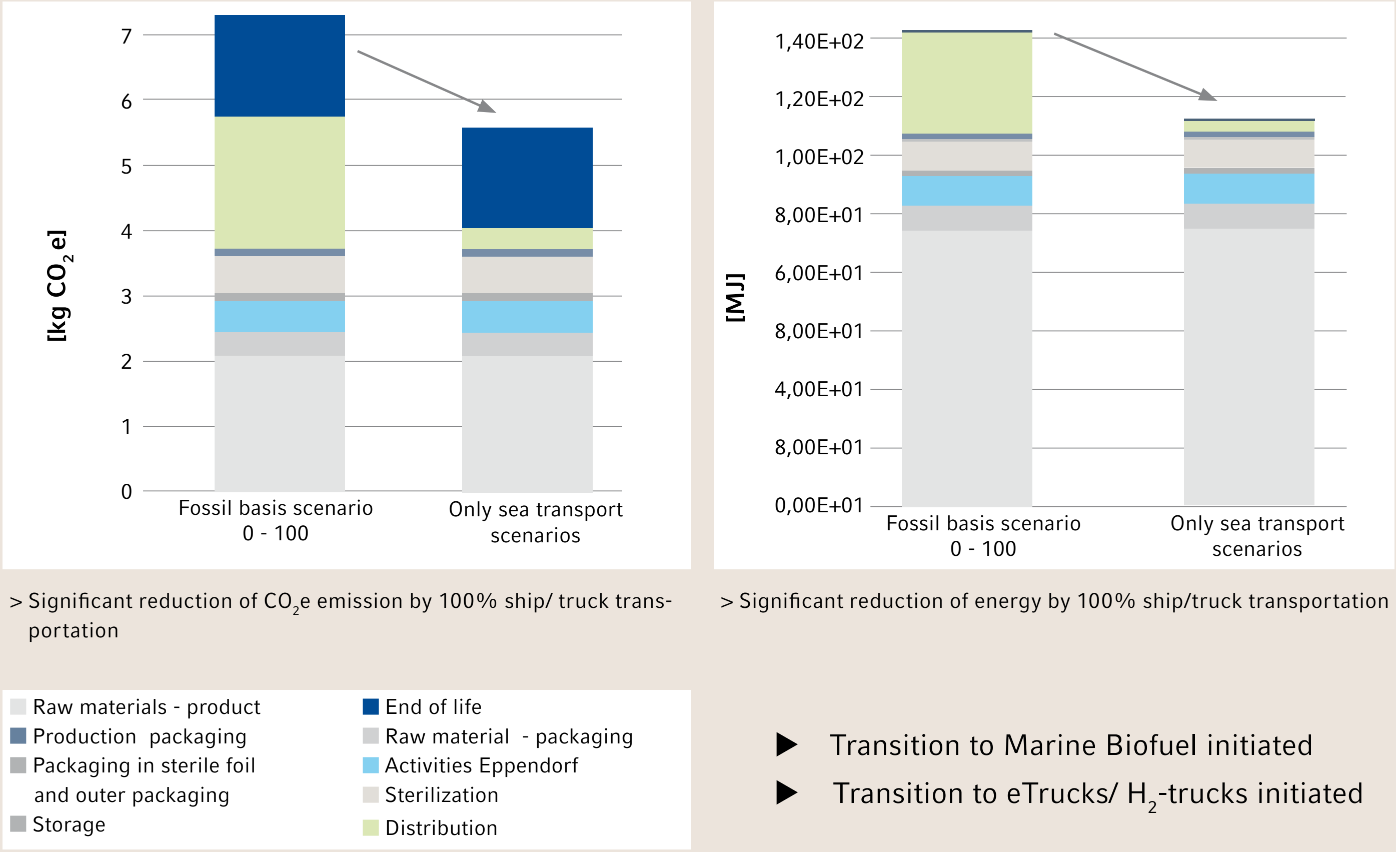
A detailed analysis of various cradle-to-gate scenarios demonstrated how much greenhouse gases are saved by using biobased material. [Figure 7]
Today's biobased 5 mL tubes already show a 17.8% decrease in greenhouse gas emissions compared to their fossil-sourced counterparts.
Based on the LCA of the 5 mL tubes, we calculated the CO_2e savings for the other tube volumes regarding the biobased raw materials.

Tube volume	CO_2e saving per tube for the biobased raw material
5 mL	3.3 g
15 mL	5.6 g
25 mL	6.7 g
50 mL	11.1 g

Switching to 100% biobased 5 mL tubes manufactured from second-generation PP and 100% biobased HDPE can yield a 27% reduction in greenhouse gas emissions.

Learnings and next steps

This life cycle analysis provided valuable learnings and helped to focus on the biggest levers which can be directly influenced by Eppendorf. The next steps and the challenges identified are described below:



> Significant reduction of CO_2e emission by 100% ship/ truck transportation

> Significant reduction of energy by 100% ship/truck transportation

▶ Transition to Marine Biofuel initiated

▶ Transition to eTrucks/ H_2-trucks initiated

Figure 8: The choice of transportation can reduce CO_2e emissions and energy use significantly

1. Reduction of air freight

Air freight has already been reduced and will be further minimized. Ships and trucks will be used primarily instead of transportation by air. This measure can reduce both CO_2e emissions and energy consumption. [Figure 8] Furthermore, the transition to use of alternative fuels like marine biofuel and electrical trucks/hydrogen trucks is being driven forward.

2. Improvements and challenges in the context of biobased material:

The tube currently contains 10% fossil-sourced PP. Eppendorf is working with its supplier to switch to 100% biobased PP in the future.

This study also revealed that raw material for biobased PP is sourced globally, resulting in a higher than necessary carbon footprint. Here too, Eppendorf is working with its supplier to find ways that the raw materials will be sourced primarily from Europe.

Ensuring the availability of biobased feedstock poses challenges due to intensifying competition. Biobased feedstock from food waste is also utilized in other industries, such as biofuel for aircraft.

The price of biobased PP is higher than that of fossil-sourced PP, resulting in higher production costs for biobased products. However, the list price for biobased tubes is only slightly higher than that for fossil-sourced tubes to engage scientists to improve their laboratory carbon footprint.

3. Other aspects which will or shall be improved, but with a minor priority as they have a minor impact:

The Eppendorf production is based on 100% green power contracts and obtains hydropower from Norway, saving hereby 100% carbon emissions. However, the generation of hydropower has been found to have a negative impact on freshwater eutrophication. This underlines the necessity of considering not only carbon emissions but other environmental impacts as well. Nevertheless, it is important to note that while this impact category exists, its significance was much lower compared to other environmental impacts.

The detailed analysis of supplier activities revealed that the service supplier responsible for tube sterilization, operates on a 57% fossil-based energy mix. Moreover, precise details regarding power consumption were not available. Eppendorf intends to encourage the supplier to switch to renewable energy sources and analyse its energy consumption for potential efficiency improvements. However, Eppendorf has limited influence at this point.

The packaging material, comprising an LDPE bag and PE packaging foil, is sourced from Europe. Still, the sourcing could be further improved and there are plans to enhance and optimize the sourcing process in the future.

This LCA study provided a detailed understanding of Eppendorf's supply chain and its environmental impact. Going forward, it will be further reviewed and optimized.

The final aspect addresses the end-of-life of the tubes. Currently, tubes have to be incinerated due to contamination issues but emerging technologies like chemical recycling could present an alternative to disposal. The development of such alternatives will be closely followed.

4. Learnings from the process

Several lessons can be learned from the process described, which will prove valuable for future projects.

First of all, performing an LCA study is complex, even for seemingly "simple" products like tubes containing only two different materials (HDPE, PP). It will be even more complex for instruments which involve a lot more materials and extensive supply chains.

Second, carrying out an LCA study is time-intensive due to the extensive data retrieval and the numerous review processes.

Third, LCA studies cannot be carried out for all products due to its complexity and time intensity. Instead, key products should be primarily examined in order to draw general conclusions that apply to an entire product range.

Outlook

This LCA study demonstrates that the carbon footprint of the current biobased screw-cap tubes is 18% better compared to its fossil-sourced counterpart. Even though this may appear to be only a modest improvement of 18%, it is a first step in the right direction: replacing fossil oil in laboratory consumables. Further improvements of the product could yield greenhouse gas emissions savings of up to 27%. So this progress does not mark the end point, but only the beginning of further improvements throughout the process, from material sourcing to the end of the product's life. And it also marks the beginning of the development of further biobased-products for the laboratory.

References

White papers deliver arguments that one particular technology, product or method is superior for solving a specific business problem. They may also present research findings, list a set of questions or tips about a certain business issue, or highlight a particular product or service.

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Since 1945, the Eppendorf brand has been synonymous with customer-oriented processes and innovative products, such as laboratory devices and consumables for liquid handling, cell handling and sample handling. Today, Eppendorf and its approximately 5,000 employees serve as experts and advisors, using their unique knowledge and experience to support laboratories and research institutions around the world. The foundation of the company's expertise is its focus on its customers. Eppendorf's exchange of ideas with its customers results in comprehensive solutions that in turn become industry standards. Eppendorf will continue on this path in the future, true to the standard set by the company's founders: that of sustainably improving people's living conditions.

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