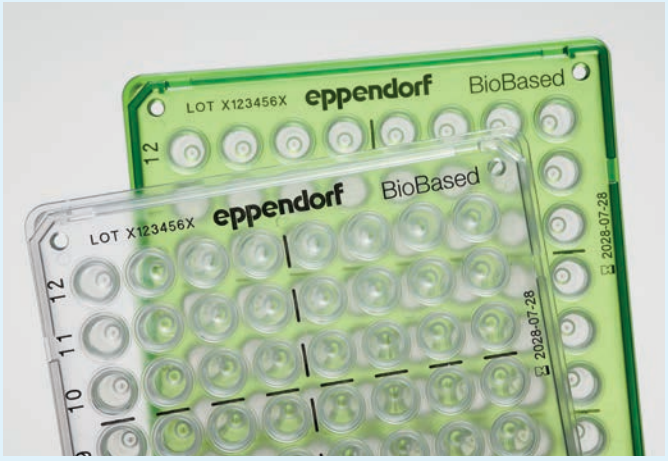
WHITE PAPER No. 134

CO_2e-Savings of BioBased PCR Plates and Deepwell Plates

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As scientists, we're committed to tackling the climate crisis and finding solutions that make a real difference. Yet, we know that our own work – especially the use of disposable plastics in the lab – leaves a mark on the environment. These materials are vital for scientific progress, but they present a challenge we can't ignore. That's why we're taking action.

By shifting from fossil-sourced materials to biobased alternatives, we can help reduce our carbon footprint without compromisingon quality. In this White Paper, we present a clear comparison of the carbon footprint of plates made from both fossil-sourced and biobased materials. We show how much greenhouse gas emissions can be saved with the switch.



Sustainability in the laboratory is more important than ever. More and more scientists are taking the first steps to make their laboratory work more sustainable. Obviously, one major concern of almost everyone working in the laboratory is the large amount of plastics waste generated by the use of single-use plastic consumables. Besides the pure waste load, the carbon footprint of the production and the disposal of the plastics have a significant impact on their sustainability evaluation. The simple answer could be: Avoid plastic and use glass. The reality is, we can't avoid plastics entirely. Single-use items help to avoid contamination (which may occur if they are re-used), they ensure the quality of scientific results by providing reliable product quality, and they often simply save valuable time of every one of us.

Additionally, polypropylene can circumvent downsides of glass-lab ware like sample loss due to sample adsorption to surfaces. How can we tackle the challenge of reducing the carbon footprint in our labs otherwise? Finding ways to use less plasticware isn't easy – especially when reliability and safety are at stake. One promising step is to rethink the materials we use for single-use plastics. By choosing alternatives with a lower carbon impact, we can make meaningful progress together.

Switching from primary fossil oil-sourced plastics (hereinafter shortly referred to as "fossil-sourced") to biobased materials (second generation material) offers a real opportunity to reduce greenhouse gas emissions by the laboratories.



Figure 1: Eppendorf portfolio of biobased consumables

The first biobased products for laboratories are available. Since 2022, we have introduced a range of biobased products (following the mass-balance-approach*): biobased tubes, biobased PCR plates, biobased deep well plates (DWP), biobased pipette tips, and biobased Safe-Lock tubes—with more to come. But the key question for the scientists remains:

How much greenhouse gas emissions can I actually save by making the switch?

And what can we learn to shape the next generation of sustainable products? In this White Paper, we take a closer look at our plates BioBased: PCR plates and DWP. By comparing their carbon footprint to that of traditional fossil-sourced options, we hope to uncover new ways to help you—and us—to make an even greater impact.

Life cycle analysis and carbon footprint

Every product leaves an environmental footprint at every stage of its life cycle—from sourcing raw materials, to manufacturing and use, all the way to disposal whether through incineration, landfill or ideally, recycling (goal: re-use/refurbishing).

We calculated the Product Carbon Footprint (PCF) using mathematical rules and data methodologies similar to those in a Life Cycle Assessment (LCA). The standards, scope, and boundaries we choose shape the final results. While an LCA looks at a range of environmental impacts, a PCF focuses solely on climate change – specifically, greenhouse gas emissions.

Range of assessment

When assessing a product's carbon footprint, we can choose between two main life cycle scenarios:

- In a cradle-to-grave approach, greenhouse gas emissions across the entire life cycle – from raw material sourcing to end-of-life are calculated.
- In a cradle-to-gate scenario, the focus is on the early stages: sourcing, pre-processing, and manufacturing.

We might select the cradle-to-gate approach if we want to concentrate on the beginning of the product's journey, or if data for later stages – like use or disposal – are not reliable or not available. Choosing the right scenario helps us, and you, to gain the most relevant insights for making sustainable decisions.

*More information about biobased available at **www.eppendorf.com/biobased**

Once we have defined the functional unit, scenario, geographical boundaries, and further key assumptions in detail, you need to gather all the data. This means looking closely at every part of the process, i.e., the energy flows, services, and material inputs and outputs of the process:

All these data must be obtained either from the manufacturer, suppliers or, if this is not possible, from databases. It is essential to note whether original data were used in the analysis or whether data had to be modeled using proxy data from databases (e.g. distances). Data quality must also be checked and assured.

With all the data in hand, we calculate the greenhouse gas impact using emission factors – numbers that tell us how much CO_2-equivalents (CO_2e) is released for each material, service, or energy source. These factors can come from suppliers (primary data) or trusted databases (secondary data). By converting everything into CO_2e, we can clearly see where improvements are possible and identify the best opportunities to reduce emissions.

The carbon footprint of fossil-sourced and biobased plates

Microplates are used in laboratories around the world. Due to their enormous quantities used in the global scientific world, switching to a biobased product can have a real impact on reducing the carbon footprint in the laboratory work. See also [1-3].

To make informed decisions on which plate to chose, we need reliable data. We partnered with an independent external agency to calculate and compare the carbon footprints of our PCR plate and deepwell plate (DWP) products: For both product types, one subgroup is made from fossil-sourced plastic, the other subgroup is made from biobased material. The PCR plates are made of polypropylene (PP) for the wells and polycarbonate (PC) for the frame. The DWP are made
of PP.

The sourcing of the biobased material is based on second generation material, such as oil waste from the food industries (= recycling of previously used material). Our biobased plates are made with a specific biobased share, based on the mass-balance-approach.

- PCR plates: 100 % biobased for PP, 77 % biobased for PC, combined 86 % biobased
- DWP2000: 95 % biobased for PP

To ensure transparency and trust, both our supply chain of the biobased material as well as the Eppendorf factory are checked and verified by ISCC (International Sustainability & Carbon Certification) PLUS. The biobased plates (PCR and DWP) as products are checked and validated by the ACT® label of My Green Lab®.

Functional units

The carbon footprint was calculated according to the ISO 14067 guidelines. The functional unit on which the PCF calculation is based is defined as follows:

a) Functional Unit: twin.tec® PCR plates 96 skirted BioBased (#0030 129 849)

- 25 plates, colorless, PCR clean
- 5x bags with 5 plates each
- Packaging material including the primary plastics and secondary cardboard packaging for the individual containers and tertiary packaging cardboard box

b) Functional Unit: twin.tec PCR plates 96 skirted, fossil-sourced (#0030 128 648)

- 25 plates, colorless, PCR clean
- 5x bags with 5 plates each
- Packaging material including the primary plastics and secondary cardboard packaging for the individual containers and tertiary packaging cardboard box

c) Functional Unit: Deepwell Plates 96/2000 µL, BioBased (#0030 501 012)

- 20 plates, PCR clean and protein-free, wells clear
- 5x bags with 4 plates each
- Packaging material including the primary plastics and secondary cardboard packaging for the individual containers and tertiary packaging cardboard box

d) Functional Unit: Deepwell Plates 96/2000 µL, fossil-sourced (#0030 501 306)

- 20 plates, biobased, PCR clean, wells clear
- 5x bags with 4 plates each
- Packaging material including the primary plastics and secondary cardboard packaging for the individual containers and tertiary packaging cardboard box

The carbon footprint was calculated based on a cradle-to-grave concept. The cradle-to-grave scenario included raw material sourcing, manufacturing, a sterilization step as well as transportation between different sites, transportation to the user, use-phase, and end-of-life.

To calculate the PCF, we began with a detailed Bill of Materials (BoM) that listed every part, material, and weight of each component needed for production.



Figure 2: Functional unit of PCF – twin.tec® PCR plates 96 BioBased, skirted, PCR clean, colorless, with 5 bags of 5 plates each (#0030 129 849) resp. twin.tec® PCR plates 96 fossil-sourced, skirted, PCR clean, colorless, with 5 bags of 5 plates each (#0030 128 648)

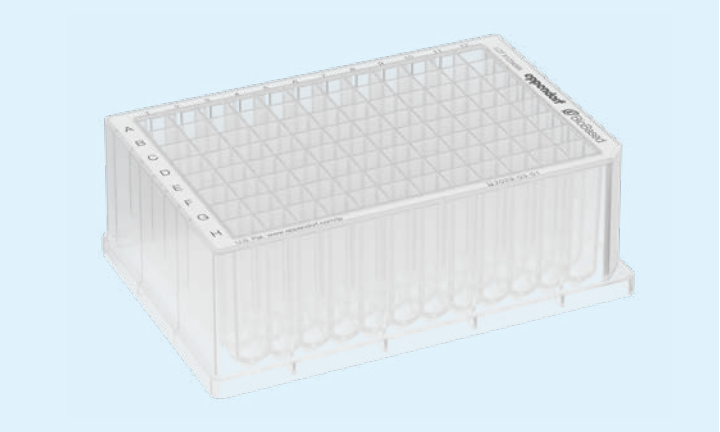


Figure 3: Functional unit of PCF – Deepwell Plates 96/2000 µL, BioBased, PCR clean, colorless, with 5 bags of 4 plates each (#0030 501 306) resp. Deepwell Plates 96/2000 µL, fossil-sourced, PCR clean, colorless with 5 bags of 4 plates each (#0030 501 306)

Manufacturing

We produce our plates in Oldenburg in Holstein, Germany, and store and prepare them for shipping in Hamburg. Each PCR plate is made from polypropylene and polycarbonate granulate, each DWP is made of PP, both using injection molding. We measure the electricity needed for molding and packaging per sales unit and calculate the energy demand per plate by dividing the energy used in one production cycle by the number of active cavities. Both our production and storage facilities run on 100 % renewable electricity from Norwegian hydro power, verified by certificates. We send any production waste from injection molding to recycling companies. Because the quantity and value of reject material is comparatively low, we do not treat it as a co-product, and no environmental impact is allocated to these rejects.

Transportation

We measured and documented transport routes (market for transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 | transport, Cutoff, S – RER) for each material.

Packaging material

Packaging material accounting for one weight-percentage or more of the total packaging was considered:

- Folding box (made from at least 92 % recycling material), containing one sales unit of plates packed in five PE bags and wrapped in one large PE bag
- PE packaging film for PE bags
- Shipping carton (made from 100 % recycling material) containing twelve folding boxes for Eppendorf internal logistics

Labels, thermal transfer ribbon, and seals were excluded due to very small impact compared to efforts.

Distribution

We modelled transport using Ecoinvent data sets for road, air, and sea. When country-specific data wasn't available, we relied on "rest of world" data sets. Our market mix reflects values provided by us. For inland transport, we assumed all goods travel by heavy truck. Since detailed information on truck types in different regions was unavailable, we made informed assumptions about emission standards and truck capacities. For overseas shipments to the US, we estimate that 95 % are transported by ship and 5 % by aircraft, based on our current distribution data.

Cut-off criteria

We consider all material and energy flows needed for production. However, we make exceptions for those that contribute less than one percent to the process output, or that together make up less than five percent of the total mass or energy flows across the entire life cycle. We never exclude any material known to have significant environmental impacts. When we do exclude materials based on these criteria, we document them carefully.

Data

Once all the data was collected, emission factors were assigned or estimated. The reference year for the specific data is 2025. Some suppliers were already able to provide us a PCF for their specific raw material or component, but most of the raw material data still had to be researched in databases (primarily Ecoinvent 3.11). The overall quality of data is considered high. We do not expect any environmental impact during the use phase of our PCR plates, so we did not include this phase in our modelling. At the end of their life, we assume that all PCR plates are incinerated. Based on these emission factors, the agency calculated the product carbon footprints by using the LCA Software openLCA (version 2.6). Be aware, the scale-up calculation from single plates to complete functional units and vice versa can lead to rounding errors, as many values are very small. To clearly mark the fundamental differences between both products in the two groups, we split the carbon data into two groups:

- Analyzing the raw material impact only to show the real impact of the biobased material.
- Analyzing the complete product: This value is important for your own calculation in the laboratory as the total product value represents the real CO_2e savings compared to the fossil-sourced material.

Biogenic Carbon

Biogenic carbon emissions were addressed in this calculation. Biogenic carbon emissions take into account the fact that plant material absorbs CO_2 as it grows and releases exactly the same amount when it burns or decomposes. This results in net zero emissions - no additional CO_2 is released into the atmosphere. In contrast, non-biogenic fossil materials release CO_2 during combustion, increasing the total amount of CO_2 in the atmosphere. If you compare fossil-based materials to plant-based materials, you save exactly this amount of CO_2 emissions by using the plant-based material.

Biogenic carbon significantly increases the CO_2e savings until the "Gate" and decrease appropriately until the "Grave", resulting in +/- zero. The inclusion of biogenic carbon in the calculation of the carbon footprint is still under discussion in the community.

Following the standards, we decided to provide both values wherever possible: The carbon footprint including and excluding biogenic carbon.

Raw material only

Based on supplier data, it is possible to calculate and compare carbon values of a plate based on the raw material, as the plates in both product groups (PCR/ DWP for both raw materials) are exactly the same and only differ in the feedstock (incl. biogenic carbon).

The raw material of:
- a single 96 well PCR plate made from biobased material has a carbon footprint of -24 g CO_2e incl. biogenic carbon and +63 g CO_2e excl. biogenic carbon (#0030 129 849)
- a single 96 well PCR plate made from fossil-sourced material has a carbon footprint of +92 g CO_2e (#0030 128 648) (incl./ excl. biogenic carbon)

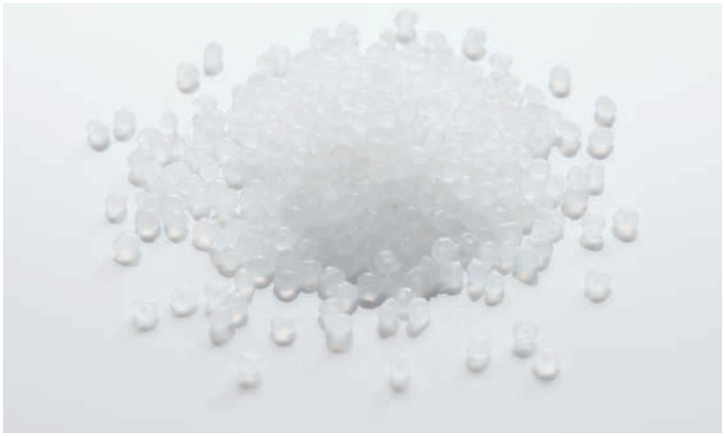


Figure 4: Biobased raw materials for Eppendorf laboratory consumables

Switching from fossil-sourced to biobased material saves 116 g CO_2e emission per PCR plate incl. biogenic and 29 g CO_2e excl. biogenic carbon. Extrapolated, these are 2,900 g resp. 725 g CO_2e savings per package of 25x. Keep in mind that this is the limited view on raw material, only.

The raw material of:
- a single 96 well DWP 96/2000 plate made from biobased material has a carbon footprint of -285 g CO_2e incl. biogenic carbon and +63 g CO_2e excl. biogenic carbon (#0030 501 012)
- a single 96 well DWP 96/2000 plate made from fossil-sourced material has a carbon footprint of 184 g CO_2e incl./ excl. biogenic carbon (#0030 501 306)

Switching from fossil-sourced to biobased material saves 469 g CO_2e emission per DWP plate incl. biogenic and 121 g CO_2e excl. biogenic carbon. Extrapolated, these are 9,380 g resp. 2,420 g CO_2e savings per package of 20x. Keep in mind that this is the limited view on raw material, only.

Total product (cradle-to-gate)

The functional unit (one sales unit with 25x PCR plates) requires for (see Table 1):
- biobased plate -0.5 kg CO_2e (incl. biogenic carbon) and 2 kg CO_2e (excl. biogenic carbon)
- fossil-sourced plate 1.7 kg CO_2e for (incl. biogenic carbon) and 1.8 kg CO_2e (excl. biogenic carbon)

The functional unit (one sales unit with 20x DWP) requires for (see Table 1):
- biobased tubes -4.8 kg CO_2e (incl. biogenic carbon) and 2.6 kg CO_2e (excl. biogenic carbon), see also Table 1
- fossil-sourced plate 4.5 kg CO_2e for (incl. biogenic carbon) and 4.7 kg CO_2e (excl. biogenic carbon)

The cradle-to-gate approach clearly shows the challenge of biobased material excl. biogenic carbon when limiting the analysis to cradle-to-gate.

Order number	Plate	Material	Volume	Quantity per sales unit	Incl. biogenic carbon (kg CO_2e)	Excl. biogenic carbon (kg CO_2e)
0030 129 849	PCR	Biobased	96 well, skirted	25 x	-0.5	2
0030 128 648	PCR	Fossil	96 well, skirted	25 x	1.7	1.8
0030 501 012	DWP	Biobased	96/2,000	20 x	-4.8	2.6
0030 501 306	DWP	Fossil	96/2,000	20 x	4.5	4.7

Table 1: Comparison of cradle-to-gate evaluation for Eppendorf twin.tec PCR plates 96 skirted as biobased or fossil-sourced; Eppendorf DWP 96/2000 µL as biobased or fossil-sourced; calculation based on ISO 14067 (functional unit = sales unit)

Total product (cradle-to-grave)

The functional unit (one sales unit with 25x PCR plates) requires for (see Table 2):
- biobased PCR plates 3.3 kg CO_2e (incl. biogenic carbon) and 3.2 kg CO_2e (excl. biogenic carbon)
- fossil-sourced PCR plates 5.5 kg CO_2e (incl. biogenic carbon) and 5.4 kg CO_2e (excl. biogenic carbon)

The functional unit (one sales unit with 20x DWP) requires for (see Table 2):
- biobased DWP 5.3 kg CO_2e (incl. biogenic carbon) and 5.0 kg CO_2e (excl. biogenic carbon)
- fossil-sourced DWP 14.6 kg CO_2e (incl. biogenic carbon) and 14.2 kg CO_2e (excl. biogenic carbon)

Order number	Plate	Material	Volume	Quantity per sales unit	Incl. biogenic carbon (kg CO_2e)	Excl. biogenic carbon (kg CO_2e)
0030 129 849	PCR	Biobased	96 well, skirted	25 x	3.3	3.2
0030 128 648	PCR	Fossil	96 well, skirted	25 x	5.5	5.4
0030 501 012	DWP	Biobased	96/2,000	20 x	5.3	5.0
0030 501 306	DWP	Fossil	96/2,000	20 x	14.6	14.2

Table 2: Comparison of cradle-to-grave evaluation for Eppendorf twin.Tec skirted BioBased, clear PCR-clean as biobased or fossil-sourced; Eppendorf DWP 96/2000 µL as biobased or fossil-sourced; calculation based on ISO 14067 (functional unit = sales unit)

Learnings

1. The major positive impact within biobased feedstock is caused by biogenic carbon. The biobased total product (PCR) has a 40 % lower carbon footprint (cradle-to-grave). The biobased total product (DWP) has a 73 % lower carbon footprint (cradle-to-grave).

2. The cradle-to-gate approach is critical for the calculation of biobased material excl. biogenic carbon. The same process "to-grave" provides a positive impact of biobased feedstock. Biogenic carbon has no impact on the total PCF but overlays the PCF of the single phases or processes.

The overall data quality is regarded as high: the main flows were measured by Eppendorf, namely the amount of materials and energy used. Also transport distances of raw materials were highly accurate, while assumptions had to be made regarding distribution distances and the means of transport used in the final market destinations. The assumption with the highest impact on the results considers the end-of-life treatment. 100 % incineration was assumed, both in the EU and for the US market. While incineration of laboratory products is very plausible for the EU-market, the reality in the US market might be different, but reliable data are missing. As the decomposition of PC and PP in landfills is slow, only a low amount of bound carbon is released during the covered 100-year period, when compared to incineration. As good practice in LCA, the most conservative assumption of 100 % incineration was chosen.

Be aware, the three calculation types (raw material only, cradle-to-gate, and cradle-to-grave) show only a limited linear/direct relationship to each other and should not be treated as directly comparable.

The largest part of the PCF can be attributed to five main contributions. These are the production of the polymer and its precursors, the waste treatment of plates, the production of the packaging and finally the air and road transport for sales units sold to markets outside Germany. The production of the plates and the transport of raw materials for their production have minor impacts.

The highest reduction potential within the fraction of own operations is expected from further increasing the proportion of products made from 2nd generation biobased polymers in the Eppendorf portfolio. A further reduction of the material thickness (polymer per unit) is no option due to the needed stability of the plates. Additional savings can be achieved by further reducing packaging material and the already low proportion of air transport.

Both absolute values (raw material as well as total product) seem to be small when checking the single plate. The emission savings are increasing when being upscaled to real laboratory scale. How many plates do you use per week, per month, or per year? In addition, you probably use further plate formats with different volumes like semi-skirted, 384-well, 500/ 1,000 µL.

Lessons learned and outlook

We need to reduce carbon emissions, and we need to know our impact reduction potential. The first step is to have reliable data on the carbon footprint of a product. Based on this data, laboratories can calculate their carbon impact and carbon reduction potential related to a specific product. This use case clearly shows the major levers in product design and logistics that lead to a 40 % reduction in carbon emissions for the PCR twin.tec plate BioBased compared to the fossil-sourced plate. The DWP BioBased show a 73 % reduction for the biobased version compared to fossil-sourced DWP. This was achieved by changing to a biobased material.

However, the aim of a PCF for a company is not to stop at the results, but to draw conclusions for the future. In this case, additional optimization levers were identified. These include further regionalization for materials and services as well as further reduction of fossil-sourced materials. Such a reduction does not only include the switch to biobased materials but also the switch to other materials with a lower carbon footprint, such as recycled polymers for packaging materials. What are the prospects for the future? These four PCFs as some further ones for other plasticware are just the beginning and many more product carbon footprints must and will follow.

The ecodesign regulation (EU) 2024/1781, also known as ESPR, will request many product data to be published, not limited to carbon emissions. With the product carbon information, laboratories will be able to choose the most ecological product in terms of carbon emissions – and companies can identify the biggest levers to improve their manufacturing and product design.

References

[1] Whitepaper No. 093: Life Cycle Analysis of a 5 mL tube [https://www.eppendorf.com/product-media/doc/en/11622498/Sustainability_White-Paper_093_Sustainability_Tubes-5-mL-LCA_Life-Cycle-Analysis5-mL-Tube-Insights-into-Environmental-Impacts-Learnings.pdf]
[2] Whitepaper No. 114: PCF of epT.I.P.S. BioBased [https://www.eppendorf.com/product-media/doc/en/12465527/Sustainability_White-Paper_114_Sustainability_Small-Tips-Big-Impact-Carbon-Footprint-Biobased-Pipette-Tips.pdf]
[3] Whitepaper No. 129: PCF of Safe-Lock tubes BioBased [https://www.eppendorf.com/product-media/doc/en/17412609/Sustainability_White-Paper_129_Sustainability_Small-Tubes-Big-Impact-Carbon-Footprint-Safe-Lock-Tubes-BioBased.pdf]

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