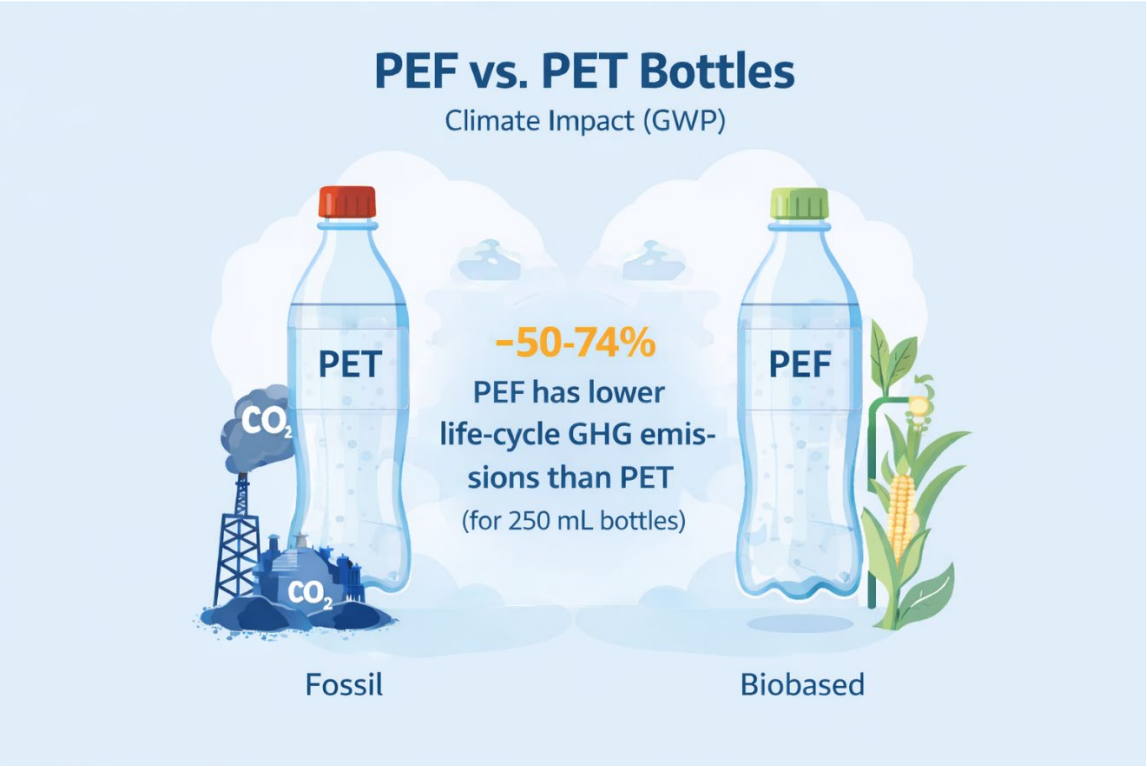
The global warming potential and the material utility of PET and bio-based PEF bottles over multiple recycling trips.



This study compares 250ml PET and PEF bottles for on-the-go consumption of carbonated drinks in the Netherlands. This is the cradle-to-grave study, and four end-of-life scenarios were considered.

The four scenarios are:

1) Baseline: Mechanical recycling (38%) and incineration (62%)

2) DRS Mechanical: DRS and mechanical recycling (85%), incineration (15%)

3) DRS Chemical: DRS and chemical recycling (85%), incineration (15%)

4) Incineration only: Incineration (100%).

In addition, the study has modelled the benefits of multiple recycling loops for closed-loop recycling. In this study, closed loop refers to PET-to-PET and PEF-to-PEF recycling, while PEF-to-PET is considered open loop. The maximum number of end-of-life trips (recycling loops) varies by waste management scenario: 10 for scenarios Baseline and DRS Mechanical, 15 for DRS Chemical, and 1 for Incineration only.

Overall climate impact - PEF vs. PET Bottles:

The study found that the lifecycle greenhouse gas (GHG) emissions of the PEF bottle are 50–74% lower than those of PET (for 250 ml bottles) under equivalent waste management scenarios.

This reduction is driven by two primary factors:

- **Reduced Weight:** The material properties of PEF allow for a 46% lighter bottle.
- **Bio-based Content**: Bio-based carbon has a lower impact.

The maximum reduction (-74%) is achieved in DRS-based scenarios with low contamination and a high collection rate.

However, the PEF's carbon advantage depends on the end-of-life scenario. If PEF were recycled less than PET or incinerated, its carbon advantage over PET would diminish.

End-of-life scenarios and recycling loops - PEF and PET Bottles:

Of the four end-of-life scenarios, scenarios 2 (DRS with mechanical recycling) and scenario 3 (DRS with chemical recycling) showed the best results for both polymers.

Mechanical Recycling resulted in the lowest overall GHG emissions, especially scenario 2 (low contamination, high collection rate, and more recycling loops) for both polymers.

Chemical Recycling (scenario 3) maximises **material utility**[1] and allows more recycling loops than mechanical recycling. However, higher energy use led to worse GHG performance than in scenario 2.

In addition, the study considered options for PEF-to-PEF recycling, and a more open option in which PEF is recycled within the PET stream and demonstrated that benefits are maximised when PEF is recycled back into PEF.

Multiple recycling loops can help to achieve cumulative net-negative GHG emissions from avoided virgin production for the end-of-life part of the life cycle. High collection rates (including those achieved by DRS) dramatically increase the climate benefits of recycling as the number of loops increases.

Material Utility (Circularity) - PEF and PET Bottles:

Material utility was calculated for both PET and PEF. Since the same waste management assumptions apply, the results are equivalent.

- Chemical recycling achieves ~500% material reuse, equivalent to 5.7 bottles produced from one. Chemical recycling maximises circularity but increases GHG emissions.
- Mechanical recycling achieves ~300% material reuse, equivalent to 3.8 bottles. Mechanical recycling minimises emissions but has fewer high-quality recycling loops for both polymers.

The full study provides multiple insights into how production processes, end-of-life systems, and material properties affect the overall environmental performance of the drink bottle.

[1] Material utility is a measure of material use intensity as the % of additional material use achieved from the initial virgin plastic material use over 10-15 recycling trips.

This study is part of our five-part Bio-based LCA Blog series. We will explore other topics in the upcoming blog posts. If you have any particular topic, you would like us to cover, please reach out at lca@recoup.org

Disclaimer: *The summary reflects the article's findings, which apply only to the products or systems studied and are based on the data and assumptions used by the research team. A single LCA study's results do not represent a comprehensive comparison of materials or processes and are specific to the scenario analysed. For questions about these findings, consult the article and contact the research team directly. Always cite the original study when referencing it. BPF and RECOUP support independent research and recommend reading the full study.*

Study Link: The global warming potential and the material utility of PET and bio-based PEF bottles over multiple recycling trips - ScienceDirect