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Institut für angewandte Ökologie
Institute for Applied Ecology

Climate impact of pyrolysis of waste plastic packaging in comparison with reuse and mechanical recycling

Commissioned by Zero Waste Europe and the Rethink Plastic alliance

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Executive Summary

The present study compares seven scenarios for the future of plastic packaging in the European Union (EU) from a climate perspective, following the projected amounts of recycled plastics needed by 2030.

In the context of the revision of the *Packaging and Packaging Waste Directive (PPWD),* the European Commission (EC) commissioned Eunomia, a British consulting firm, to consider the possible introduction of recycled content targets for plastic packaging by 2030. Based on the estimated future recycling content targets in plastic packaging, Eunomia determined recyclate quantities that must come as outputs from chemical recycling or mechanical recycling. Chemical recycling, in this case, means thermo-chemical (i.e. pyrolysis) recycling.

Two scenarios were proposed for plastic recycled content targets: medium (30%) and ambitious (40%). In the medium and ambitious scenarios for the recycled content, they estimated the necessary recycling capacities and gave them as an output of material. In this context, Eunomia considered chemical recycling as the only solution for the production of recyclate for use in contact-sensitive packaging. However, there are also ways to achieve this through mechanical recycling.

With this study, we calculate the impact of Eunomia's proposed scenario regarding greenhouse gas (GHG) emissions and carbon loss and compare it to other possible scenarios. These other scenarios include two aspects: the reduction of the total amount of plastic packaging waste, and a shift from Eunomia’s proposed scenario based on chemical recycling towards more mechanical recycling. **In this study, mechanical and chemical recycling technologies are combined in the best possible way to respect the Paris Agreement commitments to limit global warming to 1.5 degrees Celsius.** This means that in addition to non-recyclable plastics, sorting residues from mechanical recycling are also fed into chemical recycling. For this, different scenarios were developed:

- “Chemical recycling scenario” (numbers as proposed by Eunomia);
- “Reduction scenario” (reduction of the total volume of plastic packaging);
- “Mechanical recycling scenario” (shift to more mechanical recycling);
- “Mixed scenario” (reduction plus shift to more mechanical recycling).

To **reduce the amount of packaging**, various measures were identified:

- Reduction of unnecessary packaging;
- Reducing packaging through innovation;
- Development of systems for reuse of packaging.

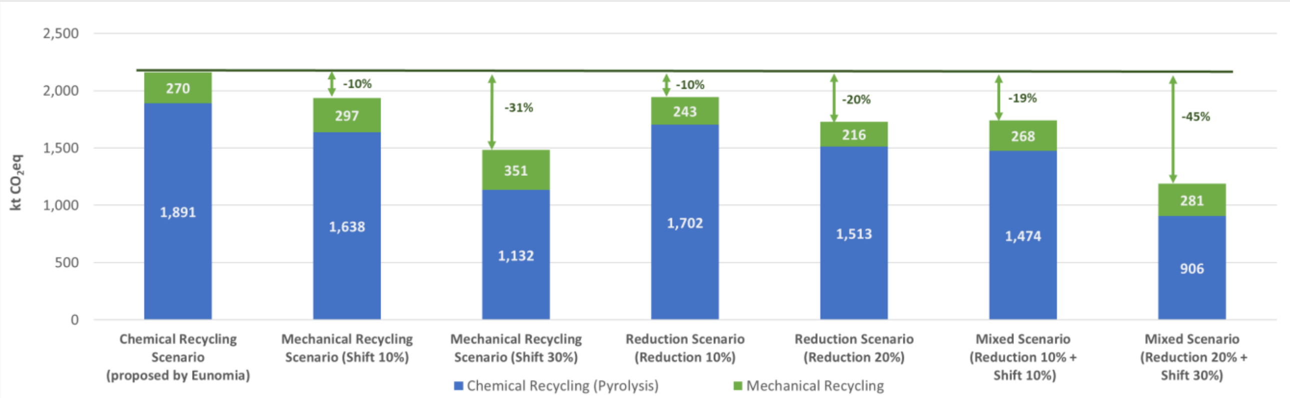
To achieve a **shift from** Eunomia’s proposed scenario based on **chemical recycling towards more mechanical recycling**, the following measures were identified:

- Design for recycling;
- New collection systems;
- Innovation, e.g., layering systems.

For the GHG emissions no new life cycle assessments (LCA) were carried out, but data from representative and comparable LCAs are used. The data of the chemical recycling processes are taken as an average from two LCAs by Sphera commissioned by industry players with an interest in chemical recycling (The Consumer Goods Forum and BASF). The data must be viewed with caution, as the concept of chemical recycling on a commercial scale has not matured yet, and the data is based on a variety of assumptions which have not yet been proven, e. g. the one-to-one replaceability of virgin naphtha with pyrolysis oil. For mechanical recycling, this study used 2022 data from Oeko-Institut.

The present study shows that, in all scenarios considered, over 75% of the total GHG emissions are attributable to chemical recycling. This can be explained by the fact that **the emissions from mechanical recycling are lower than those from chemical recycling by a factor of 9**. Mechanical recycling causes a total of only 0.311 kg CO_2eq per kg of recyclate, while chemical recycling causes 2.91 kg CO_2eq per kg.

Another key finding is that shifting the output of chemical to mechanical recycling by 30%[1] would result in 31% of GHG emissions savings compared to the scenario based on data from Eunomia (henceforth known as "chemical recycling scenario"). Combining this shift with a reduction of 20% of packaging would result in a 45% reduction of GHG emissions compared to the "chemical recycling scenario".



GHG emission results for all seven scenarios - Based on the medium scenario from Eunomia (2020) (own representation)

In addition to the emissions of the recycling processes, the avoided production of new plastic is considered. The resulting GHG emissions savings are credited to the respective recycling processes. Given the current qualitative differences between recyclates from chemical recycling and mechanical recycling, a discount of 20% is applied to the credit of recyclates from mechanical recycling. **Despite this discount for the lower recyclate quality, the scenarios with a greater share of mechanical recycling lead to greater climate change mitigation than the scenarios with a lower share.** For example, **a shift of 30% from chemical to mechanical recycling leads to a 61% higher contribution to climate change mitigation** (illustrated by Figure 4 of this study)**.**

Another important result is the difference in carbon efficiency and the amount of carbon loss during the recycling processes. Taking the data from the aforementioned LCAs, **over half of the carbon is lost during the chemical recycling process (53%). For mechanical recycling, the loss amounts to 31%.** When calculating the overall carbon efficiency of the seven scenarios, the **"chemical recycling scenario" ends up with a total efficiency of 65%. By increasing the**

[1] Due to the higher share of mechanical recycling output in the medium chemical recycling scenario, this means that the output of chemical recycling is decreasing by 40%.

amounts of mechanical recycling by 30% (and simultaneously reducing the amount of chemical recycling), a total efficiency of 74% can be achieved.

The results of this study clearly show that **mechanical recycling should be preferred to chemical recycling wherever possible.** Measures such as design for (mechanical) recycling - i.e. monomaterial, simpler format, no hazardous chemicals - and other innovations must be facilitated to achieve this goal. In addition, it is important to reduce the overall amount of packaging to lower the GHG emissions in this sector **as it is not possible to achieve a zero-emission economy by recycling alone.**

If a chemical recycling industry is established in the coming years, this will affect the possibilities for treating plastic in the future. For as long as regulations do not introduce safeguards, the industry will use the cheapest and most easily material available (feedstock that can be actually recycled through mechanical recycling). Without adequate regulations, **efforts to strengthen mechanical recycling will be severely hampered**. Legal equality of chemical and mechanical recycling processes for packaging waste must therefore be prevented. **As such, the climate impact of different recycling technologies should be considered when setting targets for recycled content.**

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