Plastics Europe position on complementarity of chemical[i] and mechanical recycling[ii]

To meet the plastic circularity objectives and optimize the availability of resources for future generations, the contribution of all recycling technologies is required. They will only altogether allow Europe to reach its ambitious sustainability targets[iii].

Plastic waste comes in many different types, quantities, and qualities[iv] and applications for recycled plastics require different quality and performance levels. All types of recycling technologies (mechanical including dissolution, chemical and organic/ biological) complement each other on waste side (input) and on product side (output). Following messages focus on the interaction between mechanical and chemical recycling that is strongly debated in today's discussions.

Mechanical recycling is an efficient recycling technology for waste streams that can be sorted into single thermoplastic polymer streams and for end-applications not always requiring recycled plastics of virgin-like quality.

Chemical recycling is aimed at being applied to waste streams that cannot generate, by mechanical recycling, the quality of recycled plastics required by the market, e.g. waste streams currently sent to incineration or landfilling[v]. Chemical recycling is highly suitable for end-applications requiring recycled plastics of virgin-identical quality, such as regulated applications (food-contact, medical) or for very technically demanding and safety critical applications (automotive, etc.).

Relevant waste streams for chemical are:

- waste with intimately mixed components and containing different thermoplastics polymers difficult to sort (e.g., some types of multi-layered packaging, automotive or electronic shredder residues)
- waste with (high-level of) impurities ("ocean plastic waste" including fishing gear, waste with adhesives or grease, contaminated industrial packaging, etc.)
- sorting residues (e.g., small streams or product sizes)
- mechanical recycling residues
- thermosets (polyurethane mattresses, fridge insulation, etc.)
- end-of-life products containing plastics that have been mechanically recycled multiple times with a progressive depletion of their properties
- waste containing restricted substances which need to be extracted from the recycled plastics

As mentioned above, the two recycling technologies are developed to address different waste streams and/or to produce recycled plastics for potentially different applications. However, in the case that mechanical and chemical recycling could technically address the same waste streams and provide the same expected properties of recycled plastics, the economics of the two technologies are different[vi]. In particular, mechanical recycling is anticipated to have the lowest cost and will be chosen by market forces. Furthermore, GHG footprint, calculated gate-to-gate for both technologies, tends to be lower for mechanical recycling[vii].

While taking actions to increase the capability of future plastic products to be recycled under the most sustainable conditions (by improving safe and sustainable product design[viii], increasing separate collection, improving sorting and recycling technologies), taking advantage of the specific (technical, economic, and environmental) strengths of each recycling technology allows to optimize plastics circularity[ix]. In all cases, it is key to ensure that the combination of recycling technologies applied to the different waste streams provides the best environmental footprint such as GHG overall, in particular versus a situation where energy recovery or incineration is the alternative option[x].

Please contact:

Plastics Europe
Hervé Millet
Director Climate and Production
herve.millet@plasticseurope.org

+33 (0)6 44 26 06 12

Plastics Europe is the pan-European association of plastics manufacturers with offices across Europe. For over 100 years, science and innovation has been the DNA that cuts across our industry. With close to 100 members producing over 90% of all polymers across Europe, we are the catalyst for the industry with a responsibility to openly engage with stakeholders and deliver solutions which are safe, circular and sustainable. We are committed to implementing long-lasting positive change.

---

[i] Mechanical recycling covers recycling technologies, including dissolution, not significantly changing the chemical structure of the material

[ii] Chemical recycling covers various technologies changing the chemical structure of the plastic waste: depolymerization/ solvolysis (hydrolysis, glycolysis, alcoholysis, etc.) and thermal processes (pyrolysis, gasification, hydrogenation, etc.)

[iii] Significant gaps exist between EU targets and current performances for plastics, almost exclusively based on mechanical recycling:

Metrics	**EU target**	**2020 performance (source: PlasticsEurope / Conversio)**
Plastic packaging recycling rate	55% by 2030 (Packaging and Packaging Waste Directive))	estimated 32%
Recycled content in beverage bottles	30% by 2030 (Single Use Plastics Directive)	6,6% in plastic packaging
Recycled content in plastic packaging	Setting mandatory target announced under Circular Economy Action Plan 30% by 2030 supported by PlasticsEurope for the revised Packaging and Packaging Waste Directive	
Recycled content in automotive and B&C products	Expected to be set in 2022-2023	16,5% in building and construction products 2% in automotive
Recycled content used in EU plastic products	10 Mt by 2025 (Circular Plastics Alliance) for various applications	4,6 Mt
Landfilling rate	< 10% for municipal waste by 2030 (landfill directive)	23%

[iv] Plastic waste can be found in streams of separately collected light weight household packaging, in streams of plastic beverage bottles collected through deposit return systems (DRS), in end-of-life vehicles, in waste from electrical and electronic equipment, in building and construction, in dedicated streams of industrial & commercial packaging, in municipal mixed solid waste, etc. The possibility to sort the different components of the plastics waste depends on the composition of the used plastic product and the kind of waste it is collected with.

[v] Several studies evaluate the development potential of chemical recycling through the evaluation of waste streams that cannot be treated by mechanical recycling:

a) Reshaping Plastics (SystemiQ – 2022): "Three waste streams are considered feedstock for chemical recycling in this study: plastic losses from mechanical recycling, plastic losses from formal sorting, and plastic waste collected and sorted from within the mixed waste stream".
b) Roadmap chemical recycling of plastics 2030 in NL (VNO-NCW – August 2020): "The feedstock (for chemical recycling) in the Netherlands is determined by the volume that is not (yet) recycled mechanically in the Netherlands". The study focuses in particular on mattresses and plastic textile waste generated in NL, as well as on collected plastic packaging waste in surrounding countries (UK, Germany, Denmark, Belgium) currently sent to landfilling or incineration.

[vi] Achieving net-zero greenhouse gas emission plastics by a circular carbon economy (Raoul Meys et al. – Science – Sept 2021).

Table S12
Price ranges for each resource supply and the waste treatment (*30, 36, 47*).

<table>
<tr><th>Resource / Waste volume</th><th>Oil</th><th>Biomass</th><th>CO_2</th><th>Electricity</th><th>Mech. recycling</th><th>Chem. recycling</th><th>Energy recovery</th></tr>
<tr><th>Unit</th><th>GJ oil-eq</th><th>GJ</th><th>t</th><th>MWh</th><th>t</th><th>t</th><th>t</th></tr>
<tr><td>Lower price/cost in USD per unit</td><td>8.78</td><td>5</td><td>30</td><td>20</td><td rowspan="2">200</td><td rowspan="2">510</td><td rowspan="2">140</td></tr>
<tr><td>Higher price/cost high in USD per unit</td><td>12.5</td><td>15</td><td>142</td><td>60</td></tr>
</table>

[vii] Studies showing the different GHG impact (gate-to-gate) of mechanical and chemical recycling:

a) Verkenning chemische recycling (CE Delft – September 2018): “For techniques such as pyrolysis and gasification, (climate impact) has previously been estimated at about -0.2 to -0.8 tons CO2-eq./ton input, while for techniques that break down polymers less far, such as depolymerization and solvolysis, this has been estimated at approx. -1.5 tons CO2-eq./tonne input. For reference: incineration of discarded plastics in an MSW comes at approx. +1.6 tons CO2-eq./ton input, and mechanical recycling at approx. -2.3 tons CO2-eq./ton input

b) Chemical recycling and its CO_2 reduction potential (CE Delft – January 2020): figures 3 and 4 show the comparative carbon footprints of treating respectively PET trays and mixed plastics “DKR 350” by mechanical recycling and by chemical recycling. For both waste streams, carbon footprint (in tonne CO_2 eq./tonne input), is lower for mechanical recycling than for alternative existing chemical recycling technologies.

[viii] CPA work on eco-design, Sustainable Product Initiative

[ix] Some certification schemes for chemical recycling ensure the complementarity with mechanical recycling, by having specific criteria on that aspect:

- **ISCC**: Chemical recycling should be applied where mechanical recycling is not technically feasible, economically viable, leads to low-quality products or has a higher negative environmental impact (System document “ISCC PLUS version 3.3” page 15)
- **RSB** requires evidence that all practical and cost-effective efforts to remove (mechanically) recyclable material have been made or that (mechanical) recycling would result in poor product properties or in a higher environmental impact.

[x] Several studies show the positive GHG impact of combining chemical recycling and mechanical recycling

a) “Techno-economic Assessment and Comparison of Primary Plastic Production with Different Plastic Recycling Pathways” (KIT – 2021)
“The combined mechanical and chemical recycling (pyrolysis) of Light Weight Packaging waste shows considerable saving potentials in Global Warming Potential (0.48 kg CO2e/kg input), Cumulative Energy Demand (13.32 MJ/kg input), and cost (0.14 €/kg input) and a 16% higher carbon efficiency compared to the baseline scenario with state-of-the-art mechanical recycling in Germany.”

b) Chemical Recycling: Greenhouse gas emission reduction potential of an emerging waste management route (Quantis – Cefic)
“Plastic can become a fully circular material at a large scale through a smart combination of mechanical and chemical recycling.”

c) Chemical Recycling of Polymeric Materials from Waste in the Circular Economy (ECHA – RPA Europe – August 2021)
“State-of-the-art in comparative analysis of chemical recycling technologies”: “… Qureshi et al. (2020) … However, when plastic is rejected/refused from mechanical recycling and sent to incineration or pyrolysis, the latter could be a more favourable option in terms of environmental impacts.” And “In summary, different LCA studies and reviews suggest treating chemical recycling as a complementary technique to mechanical recycling rather than a standalone option for waste management.”